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2020 ENVIRONMENTAL RISK ASSESSMENT FOR THE DARLINGTON NUCLEAR SITE

D-REP-07701-00001-R002

Report prepared for:

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LIST OF ACRONYMS AND SYMBOLS

ACRONYMS

AAQC	ambient air quality criteria
ACB	Air Contaminants Benchmarks
AEO	alcohol ethoxylates
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee's Dispersion Model
ALARA	as low as reasonably achievable
ATSDR	Agency for Toxic Substances and Disease Registry
BB	Boiler Blowdown
BCF	bioconcentration factor
BC MOE	British Columbia Ministry of the Environment
BM	Birds and Mammals
BTEX	benzene, toluene, ethylbenzene, and xylenes
BV	benchmark value
CAAQS	Canadian Ambient Air Quality Standards
CANDU	CANada Deuterium Uranium
CCME	Canadian Council of Ministers of the Environment
CCW	condenser cooling water
CDWG	Canadian Drinking Water Quality Guideline
CFU/100mL	colony forming units per 100 millilitres
CLM	Chronic Lethal Methodology
CN	Canadian National Railway Company
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group
COPC	contaminant of potential concern
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
COSSARO	Committee on the Status of Species at Risk in Ontario
CSM	Conceptual Site Model
CSQG	Canadian Sediment Quality Guidelines
CTM	Critical thermal methods
CSA	Canadian Standards Association
D ₂ O	deuterium oxide (heavy water)
DC	dose coefficient
DF	dilution factor
DFO	Department of Fisheries and Oceans Canada
DN	Darlington Nuclear
DNGS	Darlington Nuclear Generating Station
DNNP	Darlington New Nuclear Project
DQO	data quality objectives
DQRA _{CHEM}	detailed quantitative risk assessment for chemicals
DRHD	Durham Region Health Department

DRL	derived release limit
DSC	dry storage container
DUFDS	Darlington Used Fuel Dry Storage
DWMF	Darlington Waste Management Facility
DYEC	Durham York Energy Centre
EA	environmental assessment
EC	Environment Canada
ECA	environmental compliance approval
ECCC	Environment and Climate Change Canada
EER	Ecological Effects Review
EcoRA	ecological risk assessment
EIS	Environmental impact statement
EMP	environmental monitoring program
ERA	environmental risk assessment
ESA	Endangered Species Act
ESDM	Emissions Summary and Dispersion Modelling
ESL	Effects Screening Levels
EV	exposure values
FCSAP	Federal Contaminated Sites Action Plan
FEQG	Federal Environmental Quality Guideline
FFAA	fuelling facilities auxiliary areas
FUMP	Follow-Up Monitoring Program
HC	Health Canada
HHRA	human health risk assessment
HQ	hazard quotient
HT	elemental tritium
HTO	tritium oxide
HTS	heat transport system
HU	hydrostratigraphic units
HVAC	heating, ventilation and air conditioning system
IAD	inactive drainage
IAEA	International Atomic Energy Agency
IARC	International Agency for Research on Cancer
ICRP	International Commission on Radiological Protection
ICSQC	Interim Canadian Soil Quality Criteria
IFB	irradiated fuel bay
ILCR	incremental lifetime cancer risk
ILT	incipient lethal temperatures
ILW	intermediate level waste
IPP	Integrated Implementation Plan
IRIS	US EPA Integrated Risk Information System
Imfp	radioiodine mixed fission products
ISO	International Organization for Standardization
JSL	jurisdictional screening levels

LAS	linear alkylbenzene sulphonates
LCV	lowest chronic value
LC ₅₀	median lethal concentration
LEL	Lowest Effect Level
LLW	low level waste
LOAEL	Lowest Observed Adverse Effect Level
LOEC	lowest observed effect concentration
logK _{ow}	hydrophobicity
LSA	local study area
MECP	Ministry of Environment, Conservation, and Parks
MISA	Municipal/Industrial Strategy for Abatement
MNRF	Ontario Ministry of Natural Resources and Forestry
MOE	Ontario Ministry of the Environment
MOECC	Ontario Ministry of the Environment and Climate Change
MOEE	Ontario Ministry of Environment and Energy
MT	metric tonnes
MWAT	maximum weekly average temperatures
NCRP	National Council on Radiation Protection and Measurements
NEW	nuclear energy worker
NND	New Nuclear-Darlington
NOAEL	No Observed Adverse Effect Level
NSCA	Nuclear Safety and Control Act
OBT	organically bound tritium
ODWS	Ontario Drinking Water Standards
OMNR	Ontario Ministry of Natural Resources
OPG	Ontario Power Generation
O.Reg	Ontario Regulation
OTR ₉₈	Ontario Typical Range
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PHC	petroleum hydrocarbons
PHTS	primary heat transport system
POI	point of impingement
POR	point of reception
PQRA	preliminary quantitative risk assessment
PRA	probabilistic risk assessment
PSO	Plants and Soil Organisms
PSQG	Provincial Sediment Quality Guidelines
PWMF	Pickering Waste Management Facility
PWQO	provincial water quality objective
QA	quality assurance
QSAR	Quantitative Structure-Activity Relationship
RBE	relative biological effectiveness
RCO	Refurbishment and Continued Operation

RfD	Reference Dose
RLW	Radioactive liquid waste
RLWMS	Radioactive Liquid Waste Management System
ROP	Records of Proceedings
RSC	Record of Site Condition
RSL	Regional Screening Level
RWC	Retube Waste Containers
RWSB	Retube Waste Storage Building
SAR	species at risk
SARA	Species at Risk Act
SARO	Species at Risk in Ontario
SG	Standby Generator
SHTS	secondary heat transport system
SIO	safety improvement opportunities
SQGE	Soil Quality Guidelines for Environmental Health
SSA	site study area
SPS	Sewage Pumping Station
SQG	Soil Quality Guideline
SWMP	Storm Water Management Planning and Design Manual
TCEQ	Texas Commission on Environmental Quality
TF	transfer factor
THQ	target hazard quotient
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TRC	total residual chlorine
TRF	Tritium Removal Facility
TRV	toxicity reference value
TSD	technical support document
TSS	total suspended solids
UCLM	upper confidence limit on the arithmetic mean
UF	uncertainty factor
UILT	upper incipient lethal temperature
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
US EPA	United States Environmental Protection Agency
VEC	valued ecosystem component
VOC	volatile organic compounds
WHO	World Health Organization
WSP	water supply plant
WTP	Water Treatment Plant
WWMF	Western Waste Management Facility

SYMBOLS

Human Non-radiological Parameters

C	=	concentration of contaminant in drinking water (mg/L)
IR	=	receptor intake rate (L/d)
RAF _{GIT}	=	absorption factor from the gastrointestinal tract (unitless)
D ₂	=	days per week exposed • (7 days) ⁻¹ (d/d)
D ₃	=	weeks per year exposed • (52 weeks) ⁻¹ (wk/wk)
D ₄	=	total years exposed to site (years) (for carcinogens only)
BW	=	body weight (kg)
C _{foodi}	=	concentration of contaminant in food i (mg/kg)
IR _{foodi}	=	receptor ingestion rate for food i (kg/d)
RAF _{GITi}	=	relative absorption factor from the gastrointestinal tract for contaminant i (unitless)
D _i	=	days per year during which consumption of food i will occur (d/a)
365	=	total days per year (constant) (d/a)
LE	=	life expectancy (years) (for carcinogens only)

Ecological Radiological Dose Parameters

D _{int}	=	internal radiation dose (μGy/d)
D _{ext}	=	external radiation dose (μGy/d)
DC _{int}	=	internal dose coefficient ((μGy/d)/(Bq/kg))
DC _{ext}	=	external dose coefficient ((μGy/d)/(Bq/kg))
DC _{ext,s}	=	external dose coefficient (in soil) ((μGy/d)/(Bq/kg))
DC _{ext,ss}	=	external dose coefficient (on soil surface) (μGy/d)/(Bq/kg))
C _m	=	media concentration (Bq/L or Bq/kg)
C _f	=	average concentration in food (Bq/kg fw)
C _w	=	water concentration (Bq/L)
C _s	=	soil/sediment concentration (Bq/kg fw)
C _t	=	whole body tissue concentration (Bq/kg fw)
C _x	=	concentration in the ingested item x (Bq/kg fw)
OF _w	=	occupancy factor in water (unitless)
OF _{ws}	=	occupancy factor at water surface (unitless)
OF _s	=	occupancy factor in soil/sediment (unitless)
OF _{ss}	=	occupancy factor at soil/sediment surface (unitless)
BAF	=	bioaccumulation factor (L/kg or kg/kg)
BMF	=	biomagnification factor (unitless)
I _x	=	ingestion rate of item x (kg fw/d)
TF	=	ingestion transfer factor (d/kg)
DW _a	=	dry/fresh weight ratio for animal products (kg-dw/kg-fw)
1-DW _a	=	water content of the animal (L water /kg-fw)
1-DW _p	=	water content of the plant/food (L water /kg-fw plant)
BAF _{a_HTO}	=	aquatic animal BAFs for tritium (L/kg-fw)

BAF_{p_HTO}	=	plant BAF for tritium (L/kg-fw)
k_{af}	=	fraction of food from contaminated sources
k_{aw}	=	fraction of water from contaminated sources (assumed to be 1)
f_{OBT}	=	fraction of total tritium in the animal product in the form of OBT as a result of HTO ingestion
f_{w_w}	=	fraction of the animal water intake derived from direct ingestion of water
f_{w_pw}	=	fraction of the animal water intake derived from water in the plant feed
f_{w_dw}	=	fraction of the animal water intake that results from the metabolic decomposition of the organic matter in the feed
$P_{HTOwater\_animal}$	=	transfer of HTO to animals through water ingestion (L/kg-fw)
$P_{HTOfood\_animal}$	=	transfer of HTO to animals through food ingestion
S_a	=	stable carbon content in the aquatic animal/invertebrate/plant (gC/kg-fw)
S_w	=	mass of stable carbon in the dissolved inorganic phase in water (gC/L)
S_p	=	stable carbon content in the food (gC/kg-fw)
$BAFa_{C14}$	=	C-14 BAF for aquatic animals, invertebrates, and plants (L/kg-fw)
$P_{C14food\_animal}$	=	transfer of C-14 from food to animals

Ecological Non-Radiological Parameters

C_x	=	concentration in the ingested item (x) (mg/kg)
D_{ing}	=	dose from ingestion pathway (mg/kg body weight/d)
I_x	=	ingestion rate of item x (kg/d)
W	=	body weight of consumer (kg fw)
ΔT	=	change in temperature (°C)

EXECUTIVE SUMMARY

The following document is the Environmental Risk Assessment (ERA) for Darlington Nuclear (DN), meeting the requirements of the Canadian Standards Association (CSA) N288.6 standard on environmental risk assessment for Class I nuclear facilities (CSA, 2012). The standard calls for both human health risk assessment (HHRA) and ecological risk assessment (EcoRA), for both radiological and non-radiological parameters and physical stressors. The results of the ERA inform the environmental monitoring programs (EMP) and effluent monitoring programs, as per N288.4 (2010, 2019) and N288.5 (2011). These programs can also inform the ERA by providing information on effluent concentrations and loadings, and by providing environmental data to assist in model calibration and validation.

The DN site is located in the Municipality of Clarington, on the north shore of Lake Ontario at Raby Head. The DN site is about 5 km southwest of the Town of Bowmanville and about 10 km east southeast of the City of Oshawa. The DN site is comprised of the DN Generating Station, with four CANada Deuterium Uranium (CANDU) pressurized heavy water generating reactors, the Tritium Removal Facility (TRF), the Darlington Waste Management Facility (DWMF), the Darlington New Nuclear Project (DNNP) Lands, and all other land under OPG ownership within the property boundary at DN.

OPG has safely operated the DN Generating Station since 1990, meeting all regulatory, federal and provincial guidelines, including regulatory dose limits. OPG operates the DN Generating Station in a manner that ensures the health and safety of employees, the public and the environment.

This ERA focuses on activities that occurred on the DN site during the 2016 to 2019 period that encompass normal operations at DN during the operations and refurbishment phases of the facility.

The overall goals of this ERA are:

- To establish an updated baseline condition for the DN Site.
- To update the ERA in general accordance with the CSA N288.6-12 Standard.
- To provide focus for the environmental monitoring program on relevant chemicals and radionuclides (also known as contaminants of potential concern, or COPCs), media, and ecological and human receptors.

The specific objectives of this ERA, consistent with CSA N288.6-12 are:

- To evaluate the risk to relevant human and ecological receptors resulting from exposure to COPCs and stressors related to the DN site and its activities.
- To recommend potential further monitoring or assessment as needed based on the results of the ERA.

Environmental data for the ERA were generally obtained from existing DN environmental assessments (EAs), Emission Summary and Dispersion Modelling (ESDM) reports from 2016 to 2019, Environmental Compliance Approvals (ECAs) from 2016 to 2019, the 2016 effluent characterization study, and environmental monitoring data from 2016 to 2019, including environmental monitoring data collected to support Darlington New Nuclear Project (DNNP) licence renewal.

Human Health Risk Assessment (HHRA)

Predicted exposures to sources from DN were evaluated on the basis of toxicological effects from non-carcinogenic COPCs, potential cancer risk from carcinogens, and potential radiation exposure from radionuclides.

Human Receptors

Human receptors evaluated in both the radiological and non-radiological assessment included off-site members of the public, specifically those potential critical groups used for dose calculations in the OPG Annual EMP Reports, including:

- Urban Residents (Oshawa/Courtice, Bowmanville, West/East Beach)
- Farm
- Dairy Farm
- Rural Resident
- Industrial/Commercial Worker
- Sport Fisher
- Camper

On-site receptors were not addressed in the HHRA, since human exposures on the site are kept within safe levels through OPG's Health and Safety Management System Program and Radiation Protection Program.

Screening of COPCs for Human Health

As is the case with many industrial facilities, the DN facility emits some chemicals and radionuclides to air, water, soil, and groundwater in the normal course of operations, which are closely monitored and measured against applicable regulatory limits and recommended guidelines. For this ERA, measurements and modelled concentrations of these chemical and radiological parameters (also known as COPCs) were screened according to the CSA N288.6-12 process, against available screening benchmarks that are protective of human health to determine if any parameter required further study in the context of human health risk assessment. Table ES-1 provides a summary of the parameters carried forward for further quantitative assessment in the HHRA.

Selected radiological stressors are considered of public interest and therefore are carried forward quantitatively in the HHRA and do not undergo a formal screening assessment.

The radionuclides identified as the limiting radionuclides based on their Derived Release Limits (DRLs) were considered appropriate for assessment in the HHRA.

Table ES-1: Summary of COPCs Selected for Human Health Risk Assessment

Category	Radiological COPC	Chemical COPC
Air	C-14, Co-60, HT, HTO, noble gases, I(mfp)	Nitrogen oxides
Surface water	C-14, gross beta gamma (Cs-134), HTO	Hydrazine, lithium, zirconium
Soil	C-14, Co-60, Cs-134, HTO, I-131	None
Groundwater	HTO, I-131	None
Sediment (beach sand)	C-14, Cs-134, HTO	None
Other Stressors	None	

Results of HHRA

Radiological HHRA

For exposure of human receptors to radiological COPCs, the relevant exposure pathways and human receptors (potential critical groups) were those presented in the annual OPG EMP reports. Radiological dose calculations followed the methodology outlined in CSA N288.1-14. The 2016 to 2019 public dose estimates for the critical groups are at most approximately 0.08% of the regulatory public dose limit of 1 mSv/a, and at most approximately 0.06% of the dose from background radiation in the vicinity of DN. Demonstration that these critical groups are protected implies that other receptor groups near DN are also protected.

Non-radiological HHRA

The complete exposure pathways that were assessed in the non-radiological HHRA included:

- Inhalation for all potential critical groups;
- Water ingestion for the Urban Residents, Rural Resident, Industrial/Commercial Worker, and Camper; and
- Fish ingestion for the Sport Fisher, Urban Residents, Rural Resident, Farm, Dairy Farm, and Camper.

Potential risks to human receptors were characterized quantitatively in terms of Hazard Quotients (HQs) for non-carcinogens (nitrogen oxides, lithium, zirconium) and Incremental Lifetime Cancer Risks (ILCRs) for potential carcinogens (hydrazine). Consistent with CSA N288.6-12, the acceptable risk level is 0.2 for non-cancer risk (HQ) and an incremental lifetime target cancer risk level of 10^{-6} (ILCR). The hydrazine risks were estimated based on concentrations in effluent as well as measured lake water concentrations.

In summary, there are no health risks for human receptors due to exposure to hydrazine, lithium, and zirconium in drinking water and in fish. There are no long-term risks due to inhalation of nitrogen oxides for any of the receptors.

The detailed results of the quantitative HHRA are as follows.

- Hazard quotients were below the target for non-cancer risk for all potential critical groups based on modelled annual average air concentrations for nitrogen oxides. However, there is uncertainty around the short-term (1-hr) air concentrations at the potential critical group locations. Based on available data in the ESDM reports and location of potential critical groups, a hazard quotient for short-term exposure was calculated for the Sport Fisher, which exceeded the target for non-cancer risk. Since other potential critical groups are farther away, it is anticipated that the hazard quotient for the other receptors will be lower than that for the Sport Fisher. To provide a more realistic interpretation of risk, NO₂ data from air quality monitoring planned to be initiated at the DN site in 2021 can be used to refine the risk estimates.
- No risk to human receptors is expected resulting from exposure to lithium and zirconium in drinking water. The target for non-cancer risk for all receptors was not exceeded.
- Health risks to human receptors are not expected due to exposure to hydrazine in drinking water. The acceptable cancer risk level was not exceeded for all receptors based on exposure to the UCLM hydrazine concentration in drinking water (based on hydrazine released with the effluent and hydrazine measured in Lake Ontario).
- The Sport Fisher and Camper were conservatively assumed to eat all of the fish portion of their diet and half of the fish portion of their diet, respectively, from Lake Ontario fish caught at DN. The acceptable cancer risk level was not exceeded for any human receptors due to exposure to UCLM concentrations of hydrazine in fish.

Ecological Risk Assessment (EcoRA)

Valued Ecosystem Components

The assessment for the EcoRA focused on the nearshore Lake Ontario (generally in the area surrounding the outfall from the DN diffuser) and the DN site and surrounding area. The assessment has been divided into polygons (AB – Coot's Pond, C, D – Treefrog Pond, and E), generally consistent with past EcoRAs, but with an update to the boundary of Polygon E to allow the assessment of the Darlington New Nuclear Project lands separately from the existing DNGS.

Valued ecosystem components (VECs) were selected for dose and risk analysis because they are known to exist on-site, and/or are representative of major taxonomic/ecological groups, major pathways of exposure, or have a special importance or value. The VECs selected were based on previous ecological assessments for the DN site (the 2016 DN ERA, the New Nuclear-Darlington (NND) EA, and the Refurbishment and Continued

Operation (RCO) EA), updated based on consideration of new species observed during the 2016 to 2019 period.

The model used for assessment of dose and risk is either specific to the selected VEC species, or is a more generic biota assessment model that is appropriate to a number of VECs with similar exposure characteristics. Table ES-2 shows the selected VECs and the assessment models used in estimating their COPC exposure, dose and risk. Protection of the VECs implies that other species in the same VEC category are also protected.

Table ES-2: Summary of VECs and their Assessment Models used in the EcoRA

VEC Category	Assessment Model	VEC
Fish	Bottom Feeding Fish	Northern Redbelly Dace
		Round Whitefish
		White Sucker
		American Eel
	Pelagic Fish	Alewife
		Lake Trout
Reptiles and Amphibians	Bottom Feeding Fish	Turtles
		Frogs
Aquatic Plants	Aquatic Plant	Aquatic Plants
Aquatic Invertebrates	Benthic Invertebrate	Benthic Invertebrates
Riparian Birds	Bufflehead	Bufflehead
	Mallard	Mallard
	Green Heron	Green Heron
Riparian Mammals	Muskrat	Muskrat
Terrestrial Invertebrates	Soil Invertebrate	Earthworm
Terrestrial Birds	American Robin	American Robin
	Bank Swallow	Bank Swallow
	Song Sparrow	Song Sparrow
	Yellow Warbler	Yellow Warbler
Terrestrial Plants	Terrestrial Plant	Grass
	Terrestrial Plant	Sugar Maple
Terrestrial Mammals	Eastern Cottontail	Eastern Cottontail
	Meadow Vole	Meadow Vole
	White-tailed Deer	White-tailed Deer
	Common Shrew	Common Shrew
	Raccoon	Raccoon
	Red Fox	Red Fox
	Short-tailed Weasel	Short-tailed Weasel

A number of species at risk have been identified within the DN Site Study Area during the 2011 to 2019 time period, including Monarch, Bank Swallow, Barn Swallow, Bobolink, Eastern Meadowlark, Wood Thrush, Canada Warbler, Little Brown Myotis, Northern Myotis,

Butternut, and American Eel. For those species at risk not selected as VECs, each of these species was considered by reference to a representative species already assessed in the EcoRA.

Assessment endpoints are attributes of the receptors that we wish to protect in environmental programs (Suter et al., 1993). Consistent with CSA N288.6, the assessment endpoint for all receptors (other than species at risk) in this ecological risk assessment is population abundance. The assessment endpoint for the identified species at risk is the individual, since effects on even a few individuals of species at risk would not be acceptable.

Screening of COPCs for Ecological Assessment

The same monitoring data sources previously screened for the HHRA were screened for the EcoRA using the more conservative of available federal and provincial guidelines and objectives as screening criteria. If there was no such guideline or objective, screening criteria were obtained from literature, and/or derived using federally and/or provincially accepted methods. For COPCs where these criteria are not available, conservative toxicity benchmarks (e.g., no effect levels) or upper limit of background concentrations are used as screening criteria. Maximum measured concentrations of parameters in air, surface water, soil, and sediment are compared to the selected screening criteria to determine the list of COPCs. Parameters are also retained as COPCs if no screening criteria are available or if they are considered of public interest (e.g., radionuclides). Table ES-3 provides a summary of the COPCs carried forward for further quantitative assessment in the EcoRA.

Thermal stressors and entrainment and impingement were carried forward for assessment in the EcoRA since they are widely recognized as being of primary concern in nuclear power plants, as recommended by CSA N288.6-12 (CSA, 2012). Other physical stressors such as noise, wildlife strikes with vehicles, and bird/bat strikes on buildings are screened out and were not carried forward for further assessment in the EcoRA.

Table ES-3: Summary of COPCs and other Stressors Selected for the Ecological Risk Assessment

Environmental Medium	Radiological COPC	Chemical COPC
Air	C-14, Co-60, HT, HTO, I(mfp)	Nitrogen oxides
Surface water	C-14, Cs-134, Cs-137+, Co-60, HTO, I-131	pH, Total suspended solids, Ammonia, Barium, Zinc (Lake Ontario, including COPCs from effluent and Stormwater) pH, Ammonia, Barium, Iron, (Polygon AB – Coot's Pond) Ammonia, Barium, Iron (Polygon D – Treefrog Pond)

Environmental Medium	Radiological COPC	Chemical COPC
Soil	C-14, Co-60, Cs-134, Cs-137+, HTO, I-131	Strontium (all ecological receptors in Polygons AB, C, D, and E) Arsenic, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Molybdenum, Nickel, Selenium, Sodium, Tin, Zinc, PHC-F4 (all ecological receptors in Polygon E) Free cyanide (birds and mammals in polygon E)
Groundwater	None	None
Sediment	C-14, Cs-134, Cs-137+, Co-60, HTO, I-131	Total Kjeldahl Nitrogen, Phosphorus, Cesium, Strontium, PHC F3, Benzo(a)pyrene, Chrysene, Dibenzo(a,h)anthracene, Phenanthrene, Pyrene (Lake Ontario); Total Kjeldahl Nitrogen, Total organic carbon, Cadmium, Chromium, Copper, Iron, Manganese, Nickel, Phosphorus, Vanadium, Zinc (Polygon AB) Total Kjeldahl Nitrogen, Total organic carbon, Cadmium, Copper, Phosphorus, Selenium, Vanadium (Polygon D)
Other		
Other Stressors	Thermal effects, entrainment, and impingement	

Note:

Cs-137+ refers to Cs-137 including progeny

Results of the EcoRA

Radiological EcoRA

Radiation dose benchmarks of 400 µGy/h (9.6 mGy/d) and 100 µGy/h (2.4 mGy/d) (UNSCEAR, 2008) were selected for the assessment of effects on aquatic biota and terrestrial biota, respectively, as recommended in the CSA N288.6-12 standard (CSA, 2012).

Polygons AB, C, D, E, and Lake Ontario

There were no exceedances of the radiation dose benchmarks for aquatic and terrestrial receptors located in polygons AB, C, D, E, and nearshore Lake Ontario.

Darlington Waste Management Facility

The maximum dose rate to any ecological VEC residing in close proximity (5 m) to the DWMF could be up to 0.024 mGy/d, lower than the 2.4 mGy/d radiation benchmark for terrestrial biota. The dose also remains below the radiation benchmark if the maximum dose from the DWMF is combined with the dose to ecological VECs from being exposed to radionuclides through other existing DN operations.

Non-radiological EcoRA

The potential for ecological effects was assessed by comparing exposure levels to toxicological benchmarks, and characterized quantitatively in terms of HQs. A HQ greater than 1 indicates a need to more closely assess the risk to the concerned VEC.

DNGS Site - Air COPCs

No significant effects are expected from nitrogen oxides (NO_x) to ecological receptors at the DN site. Nitrogen oxides exceed the short-term air screening benchmark (MECP AAQC), based on the 2016 ESDM modelled maximum POI ½ hour value of 639 µg/m³. Adverse effect levels for NO_x under long term exposure are 5,000 µg/m³ for plants (Doull et al., 1980) and 47,000 µg/m³ for dogs (Heck, 1964). It is rather conservative to use the modelled maximum ½ hour concentration to estimate long-term effects. However, as the maximum POI concentrations during 2016 to 2019 are all below these adverse effect levels in small mammals and plants, no significant effects are expected from NO_x.

Lake Ontario

Fish in Lake Ontario are not at toxicological risk from DN operations. The UCLM water concentration did not exceed the fish benchmark for ammonia.

Sediment in Lake Ontario is transient and the invertebrate community is mainly epifaunal. This suggests that the sediment exposure pathway is unlikely to be the primary exposure route for benthic invertebrates in Lake Ontario. Although a few benthic invertebrates may experience nutrient enrichment effects at the maximum Total Kjeldahl Nitrogen (TKN) level in sediment, the benthic community as a whole is not expected to be affected. Since benthic invertebrates cannot move around, exposure to maximum sediment concentrations is appropriate, since a few benthic invertebrates may experience prolonged exposure at the maximum. Maximum sediment concentrations exceeded the benchmark for TKN and phosphorus for benthic invertebrates, whereas the UCLM sediment concentrations did not exceed the benthic invertebrate benchmark for TKN, but did exceed the benthic invertebrate benchmark for phosphorus.

The American Eel, a species at risk, is not at toxicological risk from DN operations. The American Eel is identified as a species at risk; therefore, the assessment endpoint is the health of the individual. Fish benchmarks were not exceeded for UCLM water

concentrations of ammonia. UCLM concentrations are considered representative of fish exposure as fish are mobile around a wide area

As the Lake Ontario sediment is not depositional, and the invertebrate community is mainly epifaunal (Ecometrix, 2020), the risk for riparian birds to be exposed to toxic levels of PAHs is very low. There were no toxicological data to determine PHC F3 or PAH benchmarks for birds. Toxic effects of PHCs are not expected for birds. These compounds are readily metabolized by vertebrates, and are not anticipated to accumulate in birds and mammals, especially at environmental concentrations (CCME, 2008). The major pathway for riparian birds to be exposed to PAHs is through ingestion of benthic invertebrates and sediment. The maximum PAH concentrations in sediment in Lake Ontario exceeded the CCME sediment quality guideline during one sampling event at Darlington Harbour. No exceedances were identified in all other sampling events from sampling areas within the lake in the vicinity of DN.

Polygon AB

An aquatic and terrestrial assessment of VECs located in Polygon AB (Coot's Pond) was performed.

The results of the aquatic assessment in Coot's Pond showed exceedances of the HQ of 1 for:

- Ammonia for fish, and turtle/frog based on maximum concentration in water; and
- TKN, TOC, cadmium, chromium, copper, iron, manganese, nickel, phosphorus, vanadium, and zinc for benthic invertebrates based on maximum and UCLM concentrations in sediment.

Although potential risks were identified for aquatic receptors at Coot's Pond from a number of COPCs, the source of these COPCs in Coot's Pond is not the result of emissions from the DN site, but is attributable to the pond having been designed as a settling pond for stormwater runoff, and to being adjacent to a licensed landfill section of the site. OPG has an Environmental Compliance Approval (ECA) for the landfill and conducts and reports on quarterly monitoring and semi-annual inspections. The chemical signature in Coot's Pond is characteristic of landfill runoff (maximum concentrations above benchmarks for ammonia and iron, in water, plus metals and phosphorus in sediment). Based on field studies conducted during the environmental studies to support Darlington New Nuclear site preparation licence renewal, the 2009 Darlington NND EA and subsequent biodiversity studies, Coot's Pond has provided and continues to provide valuable habitat and breeding areas for fish (e.g., Northern Redbelly Dace), amphibians, birds, and mammals (Golder and SENES, 2009).

The results of the terrestrial assessment in Polygon AB showed that, where data were available, the HQ of 1 was not exceeded for terrestrial biota.

There were no data to determine strontium benchmarks for birds; however, if the mammal benchmark was used as the benchmark value for birds, there would be no exceedances. Additionally, strontium concentrations in soil in Polygon AB fall within the range of background concentrations for the continental USA (Dragun and Chiasson, 1991) between 5 to 3000 mg/kg.

Adverse health effects are not expected from elevated levels of iron in surface water and sediment. Iron is generally present in surface water as salts in its trivalent form (Fe^{3+}) when the pH is above 7 (HC, 1978). Iron salts are typically insoluble and settle to or bind to the sediments. Therefore, most iron in surface water is associated with particulate matter and not bioavailable. In the sediment, iron is mainly present in the form of particulates, and is not bioavailable. Absorption of iron in the body (mammals and birds) is regulated, and very little is metabolised. Iron ingested from drinking water is efficiently expelled from the body (HC, 1978).

Polygon C

Where data were available, the HQ of 1 was not exceeded for terrestrial biota for strontium. No risks were identified for terrestrial biota for Polygon C.

There were no data to determine strontium benchmarks for birds. As discussed above, when the strontium benchmark values for birds are conservatively set to strontium benchmarks for mammals, there are no exceedances for Polygon C.

Polygon D

An aquatic and terrestrial assessment of VECs located in Polygon D (Treefrog Pond) was performed. Where data were available, the HQ of 1 was not exceeded for aquatic biota for COPCs identified in Treefrog Pond or terrestrial biota in Polygon D. No risks were identified for aquatic or terrestrial biota in Polygon D.

There were no data to determine strontium benchmarks for birds. As discussed above and based on the study cited in Skoryna (1981) when the benchmark value for birds is set to the mammal benchmark, there are no exceedances for Polygon D.

Polygon E

Exceedances of the HQ of 1 for terrestrial receptors in Polygon E are localized and associated with elevated metals concentrations in soil in the yard waste and building materials storage area. The results of the terrestrial assessment in Polygon E showed exceedances of the HQ of 1 for:

- arsenic for Earthworm, terrestrial plants, Eastern Cottontail, Meadow Vole, Common Shrew, and Raccoon based on maximum soil concentrations;
- cadmium for Common Shrew based on maximum soil concentrations;
- cobalt for Earthworm and Terrestrial Plants based on maximum soil concentrations;

- copper for Earthworm, terrestrial plants, all terrestrial birds, Eastern Cottontail, Meadow Vole, White-tailed Deer, and Common Shrew based on maximum soil concentrations; and Earthworm, terrestrial plants, and Common Shrew based on UCLM soil concentrations;
- lead for Earthworm, terrestrial plants and all terrestrial birds based on maximum soil concentrations;
- molybdenum for Earthworm, terrestrial plants, and Common Shrew based on maximum soil concentrations;
- nickel for Earthworm and terrestrial plants based on maximum soil concentrations;
- selenium for terrestrial plants, all terrestrial birds, Common Shrew, and Raccoon based on maximum soil concentrations; and Bank Swallow, Yellow Warbler, and Common Shrew based on UCLM soil concentrations;
- tin for terrestrial plants based on maximum soil concentrations; and
- zinc for all terrestrial VECs based on maximum soil concentrations; and Earthworm, all terrestrial birds, and Common Shrew based on UCLM soil concentrations.

There were no data to determine strontium benchmarks for birds. As discussed above, when the strontium benchmark value for birds is set to the mammal benchmark, there are no exceedances for Polygon E.

It is unlikely that there would be adverse effects on soil invertebrates due to tin, because the maximum tin soil concentration in Polygon E is 108 mg/kg dw, below the derived sediment effects concentration of 130 mg/kg dw (used as a surrogate for soil). There were no data to determine tin benchmarks for soil invertebrates. As such, there are uncertainties associated with the effects assessment for soil invertebrates exposed to tin concentrations in soil.

Birds and mammals usually move around, and are likely to see exposures similar to UCLM concentrations as they move around the area. Exceedances of the HQ of 1 for UCLM concentrations for some birds and mammals were identified for copper, selenium, and zinc. These results suggest that there is potential for adverse effects to some birds and mammals due to exposure to soil in the vicinity of the yard waste and building materials storage area.

Bank Swallow is identified as a species at risk, and is known to nest in the banks along the shore of Lake Ontario, south of Polygon E. HQs above 1 based on maximum soil concentrations (copper, lead, selenium, zinc) and UCLM concentrations (selenium, zinc) in Polygon E were identified for Bank Swallows. While Bank Swallows do not nest at the yard waste and building materials storage area, they may spend some time there foraging. It is understood that a soil characterization study of the yard waste and building materials storage area is currently being undertaken by OPG, and next steps for soil management will be determined based on the results of the soil characterization study.

Thermal Effects

No adverse thermal effects have been demonstrated and none are anticipated based on numerous thermal effects studies conducted.

An assessment of thermal effects from the warm cooling water discharged by DN was conducted in 2011 and 2012 by Golder (2012a) at 31 locations in and around the discharge, and at reference (ambient) locations. These data indicate that a ΔT of 3°C is a rare occurrence within the mixing zone, and never occurs outside this zone.

The Golder (2012a) assessment of thermal effects focused on the Round Whitefish because its sensitive embryonic life stage is expected to be present in the diffuser area from January through March. Eggs are typically deposited sometime in December, at water depths of 5-10m, and hatch in late March or early April. After hatch, the larvae move inshore to feed over the summer, and then move offshore in the fall. Golder cited an optimal temperature range of 1°C to 5°C for Round Whitefish embryos (Wismer and Christie, 1987) and a continuous ΔT of 3.5°C or a periodic (6h/day) ΔT of 5°C (Griffiths, 1980) as being consistent with adequate embryonic survival.

Since the studies by Griffiths used an unrealistic temperature regime (base temperature for 16 h/day followed by an abrupt shift to the increased temperature for 8h/day) and had relatively poor survival even at ambient temperature. the CANDU Owners Group (COG) funded new studies of Round Whitefish embryo survival using a naturally varying base temperature. In these studies (Patrick et al., 2014), survival was 99% under the ambient temperature condition. The COG study found that a reduction to 90% survival required a temperature increase of 3.7°C above ambient. In a more recent COG study, a delta T value of $\Delta 3^{\circ}\text{C}$ was recommended as a conservative benchmark for Round Whitefish, lower than the previously suggested 3.7 °C (COG, 2017). The ΔT values around the DN diffuser are well below this level.

Round Whitefish survival for any sequence of temperatures measured over the embryonic period can be predicted. The predicted survival over the winter of 2011-2012 was greater than 95%.

In 2016, OPG, with the assistance from Professor M. Pandey at the University of Waterloo, developed a hybrid thermal response model for early development of Round Whitefish using the lower temperature exposures from the COG (2014) study and the higher temperature exposures of the Griffiths (1980) study, to be included in the monitoring plan for the DNGS thermal study in 2017-2018. Additional model development was performed and based on the most realistic dataset, predicted a threshold temperature – corresponding to a 90% probability of survival – of 6.3 °C. Based on the result, ECCC, CNSC and OPG agreed on a conservative temperature threshold at 6.0 °C protective of Round Whitefish embryos. OPG (2017a) used this threshold as an action level in a follow-up thermal plume monitoring conducted during the winter 2017-2018 during a refurbishment outage. The average winter temperatures during this monitoring season were cooler than in 2011-2012 and were all lower than 6.0 °C. Consistent with the previous monitoring event, elevated

plume temperatures were observed relative to reference locations during the period of early and late Round Whitefish embryo development; however, temperature differences were well below the thermal benchmark of 3 °C above ambient. Therefore, no adverse effect is expected.

Impingement/Entrainment

In summary, when considering the Lake Ontario populations of the impinged species, fish losses due to impingement were considered negligible. Fish impingement sampling was conducted between May 2010 and April 2011 (SENES, 2011a). Thirteen fish species were taken at DN, with Alewife (non-native species) and Round Goby (invasive species) representing 97% of the counts. The estimated annual total was 274,931 fish impinged. By fish biomass, Alewife and Round Goby represented 97% of the biomass taken. The estimated annual total was 2,362 kg of fish biomass. Additionally, OPG has a Fisheries and Oceans Canada authorization related to operation of DNGS where, if required, offsetting measures are undertaken to counterbalance the impingement and entrainment of fish.

Studies of fish egg and larval entrainment at DN were conducted in 2004 (June – August) and 2006 (March – September), and to a more limited extent in April and July 2010 in the forebay. As a follow-up program to the environmental assessment for DN refurbishment and continued operation, more intensive studies of fish (eggs and larvae) and macro benthic invertebrate entrainment were completed in 2015/2016 and a benthic invertebrate community characterization study was completed in 2016 (Ecometrix, 2020).

In the 2015/2016 entrainment study, a total of 2,613 fish eggs were entrained, all collected from the end of April to early August, 2016, primarily identified as Alewife (90%), Walleye (9.2%), and Round Goby (0.4%). The estimated annual entrainment comprised of 94,482,521 eggs and 10,983,411 larvae. This number was higher than the 2004 and 2006 studies, likely because of the more robust sampling method used, which enabled observation of species not previously entrained (i.e., Deepwater Sculpin) and species of lower density (e.g., Walleye). The estimated annual biomass lost to entrainment in the 2015/2016 study was 589 kg, comprised mainly of Round Goby, Walleye, and Deepwater Sculpin. Overall, fish losses from entrainment were considered too low to measurably affect Lake Ontario fish populations. Results of the 2016 benthic invertebrate community characterization study showed no difference between benthic invertebrate communities near DN and the reference location; therefore, entrainment at DNGS is not having a negative impact on local benthic invertebrate communities.

Summary and Recommendations

Based on the results of the ERA some recommendations have been proposed for the monitoring programs or future ERAs.

1. Lake water samples should be collected along and at the outlet of the DN diffuser for hydrazine and compared against the human and ecological screening criteria

used in the ERA. While no exceedance was identified for UCLM concentrations, additional lake water data can be used as another line of evidence, in combination with CCW effluent concentrations, to confirm there is no effect of hydrazine on human receptors that may drink water or eat fish from Lake Ontario and to help characterize the influence of hydrazine in effluent on lake water concentrations. Lake water samples should be collected in 5 years, prior to the next DN ERA update. The need for subsequent lake water sampling can be re-evaluated at that time. The lowest detection limit available for hydrazine in surface water in the most recent study was 0.1 µg/L. A lower detection limit (e.g., 0.05 µg/L) should be used in future studies, if achievable. OPG currently monitors hydrazine in effluent in accordance with its provincial Environmental Compliance Approval (ECA) requirements, and operates below the prescribed ECA limits.

2. NO₂ data from air quality monitoring planned to be initiated at the DN site in 2021 should be used in the next ERA to refine the risk estimates for human and ecological receptors provided in this ERA and provide a more realistic interpretation of risk.
3. The results of the soil characterization study should be used to determine the next steps for management of soil from the yard waste and building materials storage area (identified as location DN6 and DN6A in Figure B-4, Appendix B, and zone F15 in (OPG, 2018a)).

In summary, the DN site is operating in accordance with approved limits and measures are taken to ensure regulatory compliance is maintained. OPG has a comprehensive Environmental Monitoring Program that provides data to confirm that it is operating in a manner that is protective of human and ecological receptors residing in the surrounding area.

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1.0 INTRODUCTION

1.1 Background

The *Nuclear Safety and Control Act* (NSCA) mandates the Canadian Nuclear Safety Commission (CNSC) to regulate the nuclear industry in a manner that prevents unreasonable risk to the environment and makes adequate provision for environmental protection, in conformity with international obligations. This mandate is reflected in the General Nuclear Safety and Control Regulations under the NSCA, and in the CNSC (2001) Regulatory Policy on Protection of the Environment. This policy indicates that licence applicants will be required to “demonstrate through performance assessments, monitoring, or other evidence, that their provisions to protect the environment are adequate”.

In 2012, the Canadian Standards Association (CSA) published the N288.6 standard on environmental risk assessment (ERA) for Class I nuclear facilities (CSA, 2012). The standard calls for both ecological risk assessment (EcoRA) and human health risk assessment (HHRA), for both radiological and non-radiological contaminants and physical stressors. The CSA also published the N288.4 (2010, 2019) and N288.5 (2011) standards on environmental monitoring programs (EMPs) and effluent monitoring programs. These standards recommend that effluent and environmental programs are designed, in part, to address risk issues identified by the ERA. These programs can also inform the ERA by providing information on effluent concentrations and loadings, and by providing environmental data to assist in model calibration and validation.

This ERA has been prepared to be compliant with CSA N288.6-12 and also meets the requirements for an ERA outlined in Section 4.1 of REGDOC-2.9.1 “Environmental Protection: Environmental Principles, Assessments and Protection Measures” (CNSC, 2017a). The ERA has been developed with current science and current regulatory attitudes in mind.

1.1.1 Summary of Previous Environmental Assessments, Environmental Risk Assessments, and Follow-up Monitoring Programs

ESG International Inc. prepared an Ecological Effects Review (EER) for the DN site in 2000 and 2001. This report considered potential ecological effects associated with construction and operation of the DN site. Existing monitoring data, atmospheric dispersion modelling, and surface water dilution calculations were used in the report to develop a conclusion that no risks to biota were expected due to chemical or radiological exposure (SENES, 2009a).

OPG conducted an Environmental Assessment (EA) in 2002 and 2003 for the Darlington Used Fuel Dry Storage (DUFDS), which was renamed the Darlington Waste Management Facility (DWMF) when it was built. The EA examined site preparation, construction and operation activities for three proposed fuel bundle storage buildings and a processing building. The Follow-Up Monitoring Program (FUMP) for this EA included four recommendations, which included the tasks presented in Table 1-1 (OPG, 2011a) and in

2012 the follow-up monitoring program was considered complete by the CNSC (CNSC, 2012).

Table 1-1: DUFDS EA FUMP Recommendations and Status (OPG, 2011a)

Environmental Component	Brief Description	Status
Terrestrial	If DUFDS Facility is located at Site B, and construction is planned between April and July, conduct a walkover survey by a qualified biologist to recommend mitigative actions should active bird nests be identified.	Complete. Two breeding bird surveys were undertaken in 2004 and 2005. The biologist recommended clearing the site between August and March and undertaking weekly surveys to minimize disturbances to active nests. The recommendations were followed.
Geology and Hydrogeology	Develop and execute a soil sampling and analysis program for areas where potentially contaminated soils will be disturbed or redistributed by construction (e.g. roadways sited to access the DUFDS Facility). Develop and execute a soil sampling and analysis program for the drainage ditch east of the parking lot.	Complete. A soil sampling program was carried out in 2005. All results were less than MECP Site Condition Standards for non-potable groundwater conditions.
Socio-economic Conditions	Develop a program to monitor public attitudes and the effectiveness of mitigation. Emphasize ongoing communication and consultation with members of the public. Public attitude research should provide results directly comparable to those from the 2002 survey. Research to be undertaken one year after Proclamation of Bill C-27 (Nov 2003), and one year prior to commissioning of the first storage building at the DUFDS Facility. Surveys of users of the sports fields and the Waterfront Trail on the DNGS property should be undertaken to identify any changes attributable to the DUFDS project in the use and enjoyment of these recreational amenities.	Complete. One public attitude research survey was completed in 2009. OPG and CNSC agreed that no further survey work was necessary.
Aboriginal Interests	Inclusion of six First Nation communities and Metis Nation of Ontario on the Darlington Nuclear Community Stakeholder list (Mississaugas of Scugog Island First Nation, Ojibways of Hiawatha First Nation, Alderville First Nation, Curve Lake First Nation, Chippewas of Georgina Island First Nation, Mississaugas of the New Credit First Nation, and the Metis of Ontario).	Complete.

In 2005, SENES prepared a risk assessment for the drainage ditch system south of the Bowmanville switching yard at the DN site. This risk assessment considered both human and ecological health. The approach was consistent with risk assessment provisions in the original (2004) version of Ontario's Record of Site Condition (RSC) regulation, Ontario Regulation 153/04, which was amended in 2011. The risk assessment concluded that potential risks may have been expected for warblers and Earthworms in the drainage ditch system, but subsequent field investigations indicated that the ecosystem in the area was fully functioning and healthy (SENES, 2009a).

As part of the EA conducted for the New Nuclear – Darlington (NND) project (SENES, 2009a), an ecological risk assessment (EcoRA) for the project was undertaken. The assessment of potential effects due to the project was undertaken in two steps: the first was a characterization of baseline concentrations of chemical contaminants and radionuclides in the environment around Darlington Nuclear (DN), whereas the second was a determination of potential incremental exposures due to the construction and operation of the NND project. Overall, this EcoRA followed a typical table of contents for an EcoRA, including Problem Formulation, Exposure Assessment, Hazard Assessment, and Risk Characterization. The EcoRA concluded that radionuclide doses to ecological receptors were all below reference dose rates, and that no ecological health risks would be expected in the existing environment. In addition, no adverse effects were predicted for ecological receptors due to radionuclide and chemical emissions from the operating NND project.

The NND EA also included a Human Health Technical Support Document (TSD), part of which was an HHRA for conventional contaminants (SENES, 2009b). The HHRA for radiological contaminants was part of the Radiation and Radioactivity TSD (SENES and AMEC, 2009). The HHRA for conventional contaminants concluded that although short-term exceedances of inhalation health benchmarks were identified for nearby human receptors during the proposed construction phase, no increase in health effects due to the NND project were predicted for the Site. The HHRA for radiological contaminants concluded that no residual effects from radiation doses to members of the public were anticipated as a result of the NND project.

In 2011, SENES conducted an EA for the Darlington Nuclear Generating Station Refurbishment and Continued Operation (RCO) project. An EcoRA formed part of this EA. This EcoRA referenced the 2009 EcoRA (SENES, 2009a) as a source of data, but used a study area consistent with Refurbishment and Continued Operation EA (SENES and MMM, 2011). This EcoRA also followed a typical table of contents for an EcoRA, including Problem Formulation, Exposure Assessment, Hazard Assessment, and Risk Characterization. The 2011 EcoRA determined that estimated radionuclide doses were below reference dose rates for ecological receptors, and that conventional Contaminant of Potential Concern (COPC) exposure would not result in any adverse effects to ecological receptors, as a result of Refurbishment and Continued Operation (SENES, 2011b).

The 2011 EA (SENES and MMM, 2011) also included a Human Health TSD (SENES, 2009b), in which the 2009 HHRA for conventional contaminants was summarized for

reference. No additional human health conclusions due to chemical contaminants or radionuclides were drawn in the 2011 Human Health TSD.

The EA for Refurbishment and Continued Operations concluded in March 2013, when the Record of Proceedings (ROP), including Reasons for Decision (CNSC, 2013) was published. The ROP (CNSC, 2013) reiterated the requirement for a follow-up program that had initially been raised by the CNSC and Department of Fisheries and Oceans Canada (DFO) in their EA screening report (CNSC and DFO, 2012). Moreover, the ROP (CNSC, 2013) required that the basis for the follow-up program be as described in the screening report (CNSC and DFO, 2012), which included broad spectrum characterization of DN liquid effluents to confirm EA predictions of no residual adverse effects on surface water. The follow-up program comprised the elements summarized in Table 1-2 (OPG, 2013a).

An effluent characterization study plan developed for the Darlington Nuclear Refurbishment and Continued Operation Environmental Assessment Follow-up Program – Effluent Characterization Sampling Program was designed to be consistent with the framework provided in the follow-up monitoring program (OPG, 2013a). The study included the effluent streams to be sampled, the parameters to be measured and the sampling frequencies. The study plan provided sufficient detail to guide the implementation of the sampled collections and was consistent with both the needs and requirements for liquid effluent characterization as identified in the CNSC and DFO (2012) screening report and the requirements and suggested format for an effluent sampling program as described by the CSA N288.5-11 standard on effluent monitoring for Class 1 nuclear facilities and uranium mines and mills (CSA, 2011). The effluent characterization study plan was submitted in May 2015. It was reviewed and accepted by CNSC prior to implementation of the program starting in March 2016.

In 2016, a DN ERA was prepared for the period 2011 to 2015, herein referred to as the 2016 DN ERA (Ecometrix, 2017), compliant with CSA N288.6-12, and incorporated the results of the Effluent Characterization Study as well as the environmental data from 2011 to 2015.

Table 1-2: RCO EA FUMP Recommendations and Status

Environmental Component	Brief Description	Timeline/Status
Surface Water	1. Review the DNGS effluent monitoring program relative to that of applicable CSA standards and subsequent confirmation through applicable ERA results to verify EA predictions related to liquid effluents. At a minimum, this shall include: a. broad spectrum characterization of effluents (parameters beyond those currently contained in license/permits). b. screening of the parameters for inclusion in the site's operational ecological risk assessment (ERA). c. review of the adequacy of existing effluent and environmental monitoring programs based on the site's ERA.	Effluent characterization study completed in 2016 and results incorporated into the 2016 DN ERA (Ecometrix, 2017).
Surface Water	2. Conduct a Stormwater Control Study for areas subject to refurbishment activities within the Protected Area during the Refurbishment of the first unit for two representative storm events (spring and summer storm) to confirm that the Project has not adversely affected stormwater quality. Analyze the stormwater based on historical findings, including, but not limited to, Municipal/Industrial Strategy for Abatement (MISA)	Stormwater monitoring completed in 2019 and subsequent report detailing results will be issued to the CNSC before the end of 2020 under IIP EA-011.
Aquatic Habitat / Biota	3. Monitor data on cooling water discharge temperature and plume characteristics and interpret in relation to fish habitat and susceptibility of Valued Ecosystem Component (VEC) species. Compare temperature criteria and other assessment metrics based on Griffiths (1980) with the results of the CANDU Owners Group study examining thermal effects to round whitefish eggs.	Two monitoring periods: One winter during Refurbishment Phase - Monitoring conducted in 2017-2018; One winter following restart of reactors

Environmental Component	Brief Description	Timeline/Status
Aquatic Habitat / Biota	4. Monitor entrainment and impingement mortality associated with DNGS intake. Three components make up this program: a. Entrainment monitoring with larger sample size and invertebrate component – prior to refurbishment outage. b. Benthic invertebrate community study – prior to refurbishment outage. c. Impingement and entrainment – two years of monitoring following restart of all reactors.	a. Completed. b. Completed. c. Will occur following restart of all reactors.
Malfunctions and Accidents	5. Design changes related to safety improvement opportunities (SIOs) will reduce accident frequency achievable. The assignment of probabilities to represent the SIO design changes is judged to be sufficient to approximate the reduction in accident frequency achievable. Per the requirements of CNSC S-294, the station PRA will be updated to reflect the detailed design and as-installed configuration prior to bringing refurbished units back on-line.	Prior to bringing refurbished units back on-line with updates provided to CNSC as part of this process. Unit 2: in progress.
Effects of the Environment on the Project	6. Undertake a full review of available documentation regarding fill materials and their liquefaction potential in the Protected Area. Should sufficient verification not be realized for the prediction of low liquefaction potential, undertake a liquefaction assessment of fill materials as appropriate (OPG, 2013a).	Complete.

1.2 Goals, Objectives, and Scope

The overall goals of this ERA are:

- To establish an updated baseline condition for the DN Site.
- To update the ERA in general accordance with the CSA N288.6-12 Standard.
- To provide focus for the environmental monitoring program on relevant chemicals and radionuclides (also known as contaminants of potential concern or COPCs), media, and ecological and human receptors.

The specific objectives of this ERA, consistent with CSA N288.6-12 are:

- To evaluate the risk to relevant human and ecological receptors resulting from exposure to contaminants and stressors related to the DN site and its activities.
- To recommend potential further monitoring or assessment as needed based on the results of the ERA.

The scope of the ERA encompasses normal operations at DN during the operations and refurbishment phases of the facility. It does not include decommissioning activities and does not address acute or high-level exposures resulting from accidents. The scope looks at the potential effects of releases from the DN facilities on the human and ecological environment, as well as physical stressors. The ERA focuses on the four-year period from 2016 to 2019, but incorporates other years of data when necessary.

Spatial boundaries define the geographical extent(s) over which likely or potential environmental effects will be considered. The spatial scale for humans includes identified human receptors (potential critical groups) within about 10 km of the DN site, as shown in Figure 3-12. This study area also includes a portion of Lake Ontario abutting the property and used by those communities for activities such as recreation and community water supply and waste water discharge.

The spatial scale for ecological receptors includes receptors on-site and within the immediate site boundary and the near-field receiving waters, known as the site study area (SSA) in past EAs. The SSA for the EcoRA is presented in Figure 4-1.

1.3 Changes to Facility since Last ERA

The 2016 Darlington Nuclear ERA (Ecometrix, 2017) was reviewed according to the recommendations in Clause 11 of CSA N288.6-12 for periodic review of the ERA. The purpose of the periodic review is to identify any new risks, changes to existing risks, or changes in risk assessment variables that need to be updated to reflect the new risk profile for the facility, considering various review elements. The results of the periodic review are summarized at a high-level in Table 1-3, with additional details provided in the referenced sections.

Table 1-3: Summary of Results of Periodic Review of the ERA

Periodic Review Element	Results from the 2016 to 2019 Period
Changes to site ecology or surrounding land use	New information is available and should be considered in the ERA with potential to impact the Problem Formulation due to changes in site ecology and surrounding land use: • Since the 2016 DN ERA additional terrestrial and aquatic community data have been collected, and should be evaluated for potential changes to the site ecology and their risk implications (see Section 2.3.5, 2.3.6, and 2.3.7). New information is available and should be updated in the ERA, but is not likely to modify risk implications: • As General Motors closed the Oshawa Plant in 2019, the description of the Durham Region urban land use is outdated (See Section 2.3.8.1). • The 2016 DN ERA presented data from the 2011 Census of Agriculture conducted by Statistics Canada to describe the agricultural production at the site. The most recent Census of Agriculture was conducted in 2016, and the new data is included in Section 2.3.8.2. • The 2016 DN ERA presented data from the 2011 Census of Population. The most recent Census of Population was conducted in 2016, and provides more updated information about the population distribution surrounding DN. The new data is included in Section 2.3.9. • The Oshawa Drinking Water System 2017 Annual Report provides updated water supply plant information, which is detailed in Section 2.3.8.3.
Changes to the physical facility or facility processes	A description of the physical facility and processes is provided in Section 2.2. No major changes have occurred since the last ERA that would impact releases to the environment.
New environmental monitoring data	New environmental monitoring data are available since 2015 and should be evaluated for potential changes that would modify risk implications: 1. Baseline monitoring to support Darlington New Nuclear Project (DNNP) site preparation licence renewal activities or to support ERA update: • An updated baseline monitoring program was conducted for DNNP to support site preparation licence renewal in 2019, which included the collection of water, sediment, and soil quality data (Ecometrix, 2020), • Stormwater data (Golder, 2020) • Acoustic data (OPG, 2020a) 2. Ongoing monitoring for OPG's Environmental Monitoring Program (EMP) at Darlington • Concentrations of radionuclides in air, lake water, vegetation, milk, fish, eggs, animal feed and poultry through the 2016-2019 EMP reports (OPG, 2017b, 2018b, 2019a, 2020b). Air emission of radiological COPCs through the period of 2016 – 2019 is available from OPG internal monitoring programs. Air emission of non-radiological COPCs in 2017

Periodic Review Element	Results from the 2016 to 2019 Period
	and 2018 were documented in the ESDM reports (OPG, 2018c, 2019b). These monitoring results are included in Section 3.1.2 and 4.1.4 for selection of COPCs. 3. Additional studies New sediment quality data (radionuclides and non-radionuclides) at the Darlington Harbour is available from a sediment characterization program in 2018 (Ecometrix, 2018, 2019). These monitoring results should be included in Section 3.1.2 and 4.1.4 for selection of COPCs. In 2015/2016, an entrainment sampling program was performed in the DN forebay area. The results and interpretation are provided in the risk characterization of the EcoRA in Section 4.4.4.2.
New or previously unrecognized environmental issues	- No new or previously unrecognized environmental issues have been identified. A review of radiological and non-radiological emissions data from 2016 to 2019 is presented in Section 3.1.2 and 4.1.4. - Spills that occurred during 2016 to 2019 were reviewed to determine any potential to modify risk implications. No Category A or Category B spills occurred at DN during the period from 2016 to 2019. Category C spills were recorded at the Darlington Nuclear (DN) Site in 2019 (no other spills were identified in other years): - In 2019, a calculated 378 kilograms of refrigerant leaked to the atmosphere from a chiller due to a failed seal. The leak was repaired. - In 2019, less than 0.5 L of hydrocarbon oil was released to the ground in an unpaved Project & Modifications parking area (west of Holt Road South, north of the Canadian Pacific Railway). The spilled oil migrated to a nearby wetland area due to rain and snow-melt conditions, which could not be recovered. Contaminated soil was removed for disposal.
Scientific advances	The CCME long-term water quality guidelines for the protection of aquatic life for manganese and zinc were updated in 2019 and 2018, respectively, as the result of new toxicology studies and new CCME assessments for these COPCs. The updated guidelines are lower (more stringent) than previously used guidelines; therefore, have potential to change existing risk implications. The updated guidelines are used in the selection of COPCs (Section 4.1.4) for the EcoRA. In 2020, CCME published an updated Ecological Risk Assessment Guidance Document (CCME, 2020). This document is used as additional guidance to this ERA update, in addition to the CSA N288.6 standard.
Changes in regulatory requirements	REGDOC 2.9.1, <i>Environmental Protection: Environmental Principles, Assessments and Protection Measures</i> was published in April 2017. While REGDOC 2.9.1 is a CNSC regulatory document that outlines the CNSC's approach to conducting environmental assessments, it also provides requirements and guidance for conducting ERAs. The

Periodic Review Element	Results from the 2016 to 2019 Period
	requirement is for a facility to conduct the ERA in accordance with CSA N288.6-12.

In summary, a large volume of new environmental monitoring data as well as terrestrial and aquatic community studies has been collected at the DN Site since the 2016 DN ERA. This information is used in an updated Problem Formulation for the HHRA and EcoRA to determine if there are changes to COPCs and receptors selected for the ERA which could potentially impact the risk profile at the DN Site.

1.4 Organization of Report

The main sections of the ERA report, generally consistent with the suggested table of contents in CSA N288.6 (CSA, 2012), are as follows:

- Section 2.0: Site Description
- Section 3.0: Human Health Risk Assessment
- Section 4.0: Ecological Risk Assessment
- Section 5.0: Conclusions and Recommendations
- Section 6.0: References

1.5 Quality Assurance/Quality Control

The ERA makes extensive use of effluent and environmental monitoring data. These data are derived from chemical and radiochemical analyses of samples collected from effluent streams and environmental media around the DN site.

The 2016 samples for the effluent characterization study were collected by the station chemistry laboratory, and analyzed by Maxxam Analytics (now Bureau Veritas Laboratories) which conforms to the quality assurance requirements of International Organization for Standardization (ISO) 17025.

Environmental samples collected as part of the environmental studies to support DNNP site preparation licence renewal (including water, sediment, soil, and stormwater) were collected by qualified staff and analyzed by Bureau Veritas Laboratories and Kinectrics, which both conform to the quality assurance requirements of ISO Standard 17025. In order to achieve desired detection limits, hydrazine analysis was performed by Eurofins Lancaster Laboratories Environmental in Lancaster, Pennsylvania, which is accredited to the ISO Standard 17025 as well as the United States National Environmental Laboratory Accreditation Program Standard.

The environmental data provided by OPG were collected by qualified staff and analyzed by qualified performing laboratories, such as the station chemistry laboratory and the Whitby Health Physics Laboratory. The EMP has its own quality assurance (QA) program that

encompasses activities such as sample collection, laboratory analysis, laboratory quality control, and external laboratory comparison (OPG, 2007). The station chemistry laboratory also has its own QA program and analyses sent externally utilize accredited laboratories.

Other environmental data collected to support the ERA, such as acoustic monitoring, past entrainment studies, and other environmental samples were part of sampling programs that had their own associated QA programs.

Throughout the planning and preparation of the ERA, all staff worked under an ISO 9001:2015 certified Quality Management System. All work was internally reviewed and verified. Reviews included verification of data and calculations, as well as review of report content and formatting. Comments have been dispositioned and addressed as appropriate by report revisions. The review process has been documented through an electronic paper trail of review comments and dispositions.

2.0 SITE DESCRIPTION

2.1 Site History

The DN site is located in the Province of Ontario, in the Regional Municipality of Durham, in the Municipality of Clarington, in the former township of Darlington, on the north shore of Lake Ontario at Raby Head. The DN site is about 5 km southwest of the community of Bowmanville and about 10 km east-southeast of the City of Oshawa. The site location and vicinity are shown in Figure 2-1.

The DN Generating Station is located on the DN site and is comprised of four reactor units, owned and operated by OPG. The reactors are CANada Deuterium Uranium (CANDU) pressurized heavy water generating reactors, commissioned according to the schedule presented in Table 2-1. The DN Generating Station has a total output of 3,512 MWe, providing about 20% of Ontario's electricity needs. Since they have been placed in service, all DN units have operated safely. In 2019, DN produced 19.9 terawatt hours (TWh) of electricity.

DN also operates the Tritium Removal Facility (TRF) since 1988, where tritium is extracted from tritiated heavy water, and the Darlington Waste Management Facility (DWMF) for used fuel dry storage and processing. The DN site also encompasses the Darlington New Nuclear Project (DNNP) Lands, and all other land under OPG ownership within the property boundary at DN.

The DWMF is located within its own protected area east of the DN Site. DWMF received its first operating licence in November 2007, and began operating in 2008 to provide storage for approximately 500 dry storage containers (DSCs) (or 192,000 used fuel bundles) in DSC Storage Building #1. There are currently two in-service storage buildings (DSC Storage Building #1 and #2). Storage Building #2 was placed into service in March 2016; the building has an approximate area of 2,820 m² and provides nominal storage capacity of 500 DSCs.

Table 2-1: In-Service Dates for Darlington Units 1 to 4

Unit #	Net Electrical Output (MWe)	In-Service Date
Unit 1	881	November 11, 1992
Unit 2	881	October 9, 1990
Unit 3	881	February 14, 1993
Unit 4	881	June 14, 1993

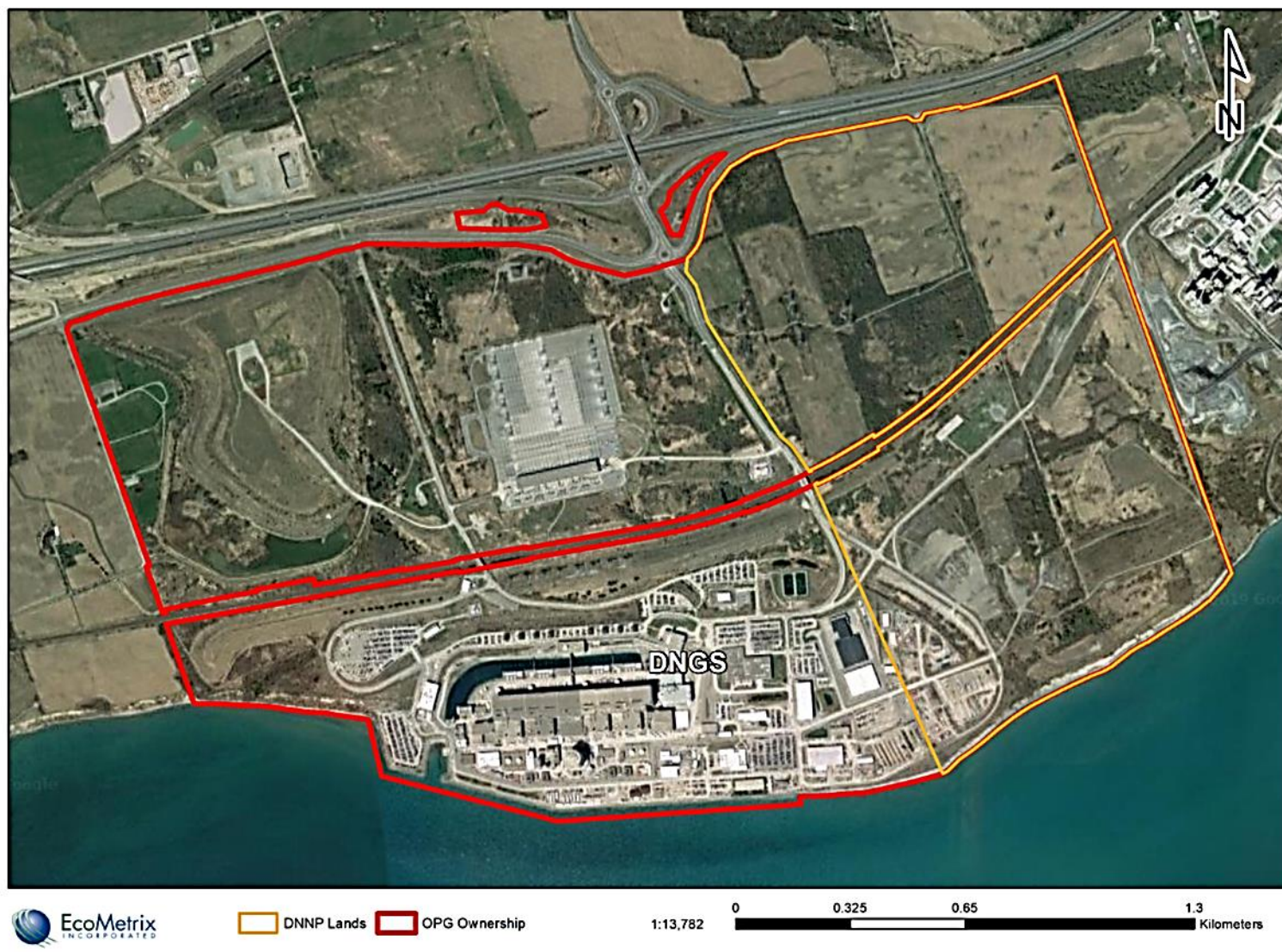


Figure 2-1: DN Site Location and Vicinity

2.2 Engineered Site Facilities

2.2.1 Site Overview

The DN site is comprised of a four-unit CANDU station, a TRF, and a DWMF, as discussed in Section 2.1. The DN site also includes a Visitor Information Centre, a Hydro One switching station (leased to Hydro One) connecting DN Generating Station to the 500 kV east-west transmission corridor, security facilities and technical and administrative support facilities. The DN site also accommodates recreational features outside the Protected Area that are available to the public, including soccer fields in the northwest corner and a 5.7-km section of the Waterfront Trail which traverses the DN site north of the rail line.

An overview of the facilities on the DN site is presented in Figure 2-2 and identifies the major facilities and structures on the DN site. During 2016 to 2019 DN Refurbishment activities included shutdown and refurbishment of Unit 2.

The principal DN buildings and a brief discussion of their purpose are described below. The majority of the description has been obtained from the DN Generating Station Refurbishment Project Environment Impact Statement (EIS) (SENES and MMM, 2011) with updated information from refurbishment activities where relevant (OPG, 2020c).

- Four Reactor Buildings (U1 to U4)
- Four Reactor Auxiliary Bays – adjacent to Reactor Buildings
- Two Fuelling Facilities Auxiliary Areas – one at each end of the station, including Irradiated Fuel Bays
- Powerhouse – housing for Turbine-Generator sets, Turbine Auxiliary Bays and a Central Service Area
- Vacuum Building – connected by a pressure relief duct to all four reactor units
- Four Standby Generators and associated fuel storage tanks
- Emergency Electrical Power and Water Supply Building including an Emergency Water Supply pumphouse
- Three Emergency Electrical Power Generator Sets and associated fuel management
- Four Pumphouses for combined cooling and service water
- Administration and Engineering/Operations Support Building
- Water Treatment Plant located between pumphouses P2 & P3
- Hazardous Material Storage Facility
- Flammable Materials Storage Building
- Gas Cylinder Storage Building
- Fire Hall
- Emergency Response Team Facility
- Security Buildings
- Switching Station
- Tritium Removal Facility (TRF) and Heavy Water Management Building

- Darlington Waste Management Facility (DWMF)
- Refurbishment Project Office
- Auxiliary Heating Steam Facility
- Retube Waste Processing Building
- Retube Waste Storage Building
- Retube and Feeder Replacement Island Support Annex
- Vehicle Screening Facility

Next to the Heavy Water Management Building, a Heavy Water D₂O Storage facility is presently being commissioned and expected to be in full operation in 2021. The systems that make up DN are housed within the buildings, facilities and structures listed above. A description of the major systems and components of the station are provided below.

Four Reactor Buildings (U1 to U4) and Reactor Auxiliary Bays

The DN reactors are housed in four rectangular, reinforced concrete Reactor Buildings that serve as a support and enclosure for the reactors and some of their associated equipment. The Reactor Vault is that portion of the Reactor Building which forms part of the containment envelope. The vault contains a Reactor Core consisting of the Reactor Assembly (a cylindrical reactor vessel with horizontal fuel channel assemblies) and a number of Reactivity Control Devices. A Reactor Auxiliary Bay containing reactor auxiliaries and secondary circuits of low temperature, low pressure and generally low radioactivity levels surrounds each Reactor Vault.

The containment envelope includes the four Reactor Vaults, a fueling duct connected to each Vault and running the entire length of the station, a pressure relief duct connecting the fueling duct to the Vacuum Building, and a fuel handling and service area at each end of the fueling duct.

Reactor Process Systems

The Reactor Process Systems comprise a number of auxiliary systems associated with reactor cooling and heat transport, moderator and heavy water management systems. The principal objective for the Primary Heat Transport System (PHTS) is to provide reliable cooling of the reactor. The PHTS circulates pressurized heavy water through the reactor fuel channels to remove the heat produced there. This heat is transferred to light water in the Steam Generators located inside the Reactor Building. The Moderator fluid, also heavy water, is circulated through the reactor vessel, entirely separate from the PHTS. The Heavy Water Management Systems includes heavy water supply, collection and transfer, cleanup and upgrading; and vapour recovery and resin handling systems. The TRF includes processes to remove tritium from the heavy water, and store the tritium that results. The Heavy Water Management Building and D₂O Storage Building provides heavy water storage for ongoing operation of the TRF and DN station.

Special Safety and Safety Related Systems

A multiple barrier system (based on the “defence-in-depth” concept) has been designed and built into the reactors and their support systems in order to prevent or control releases of radioactivity to the environment in the event of a malfunction or accident. DN reactors have four independent safety systems, including two emergency shutdown systems (SDS1 and SDS2), the Emergency Coolant Injection System, and the negative pressure Containment System. In addition, a number of other plant systems have important safety-related functions, including the Shutdown Cooling System, Emergency Service Water, and the Emergency Power System. Permanent fire water pumps have been installed to supplement the Emergency Service Water.

New and Used Fuel Handling

Each DN reactor includes 480 fuel channels, with each channel containing 13 fuel bundles (for a total of 6,240 fuel bundles per reactor). DN uses approximately 23,000 fuel bundles per year depending on the level and extent of station operation. New fuel is delivered to the station in special containers and stored within the Fuelling Facilities Auxiliary Areas (FFAAs), one of which is located at each end of the station. The DN reactors are refuelled on-power by remotely controlled fuelling machines which remove used (irradiated) fuel as new fuel is inserted into the reactor fuel channels.

The used fuel removed from the reactor is transferred by the fuelling machines to one of two Irradiated Fuel Bays located in the FFAAs. The used fuel is stored in these in-station bays for at least 10 years before being loaded into DSCs and transferred to the DWMF.

Secondary Heat Transport and Turbine-Generator Systems

The function of the Secondary Heat Transport System (SHTS) is to transport the steam produced in the secondary side of the Steam Generators (using heat delivered by the PHTS) to the Turbine-Generator set, causing the turbine and the attached generator to rotate. After passing through the turbines, the steam is condensed back to liquid form (water) in the main condenser. The Turbine-Generator sets comprise the power generating equipment of the station. They are located in the Powerhouse, which includes four Turbine Halls, four Turbine Auxiliary Bays, and a Central Service Area.

Central Service Area

The Central Service Area serves the entire station and is divided into two parts, Nuclear and Conventional. The Nuclear area includes facilities for fuelling machine service, treatment and storage of heavy water, spent ion exchange resins and other active wastes. The Conventional area includes stores, laboratories, workshops, electrical and air conditioning equipment. The Main Control Room is located above the Nuclear part of the Central Service Area.

Station Water Systems

Excluding the heavy water and Domestic Water Systems, water for all other purposes is drawn from Lake Ontario through the intake tunnel and into the forebay, which is common to all four units, and from the forebay through separate pumphouses to the individual unit. The Condenser Cooling Water (CCW) System and the Service Water System are served by separate pumps. In addition, a separate pumphouse at the southwest end of the forebay supplies water to the Emergency Service Water System. The main water systems supporting DN operations include the following:

- CCW System, including intake and discharge structures;
- Service Water System (including Powerhouse Upper-Level Service Water and Low-Pressure Service Water systems);
- Emergency Service Water System;
- Recirculated Cooling Water System (including Water Treatment Plant); and
- Domestic Water and Wastewater.

To support DN refurbishment and continued operation, the site water and sewer infrastructure have been upgraded and are now connected to the municipal system.

Electrical Power Systems

Power used internally at DN is supplied both from the reactor units themselves and from the electrical grid. Each unit has its own power distribution system which serves all loads directly associated with that unit. Station electrical loads, which are common to all units, are supplied from a common power distribution system. The electrical power system associated with DN includes the Main Transformers located adjacent to the Powerhouse through which the outputs from the generators are incorporated into the provincial 500 kV system (grid) via a Switching Station located immediately north of DN. Four Standby Generator sets provide back-up power in the event of loss of power from the grid and three independent generator sets (part of the Emergency Power System) provide emergency power to ensure safe shutdown of the plant if necessary.

Site Services and Utilities

In addition to the station water systems described above, site services and utilities include systems for active ventilation, radioactive and non-radioactive liquid waste management, stormwater management, the on-site road network and parking lots, security facilities (including fencing), fire protection, building services (lighting, heating, ventilation and air conditioning), compressed air, industrial gas (i.e., hydrogen, CO₂, nitrogen, etc.), mechanical handling equipment, maintenance facilities and shops, and miscellaneous systems such as communication facilities.

Infrastructure improvements to support DN refurbishment include a new Auxiliary Heating Steam Facility, Refurbishment Project Office, Retube Feeder Replacement Island Support

Annex, and Retube Waste Processing Building (Figure 2-3). The new Auxiliary Heating Steam Facility has been constructed to supply back-up heating steam to DN, and to support future containment and vacuum building outages. The Refurbishment Project Office is located on the west side of the DN station outside of the protected area and is a central location for construction staff to enter and exit the site during refurbishment and outage activities. The Retube Feeder Replacement Island Support Annex houses the reactor components prior to installation in the reactor and supports DN maintenance activities. The new Retube Waste Processing Building is located on the east side of the DN station, next to Unit 4. It provides volume reduction for removed reactor components during refurbishment, which are stored in retube waste containers and transferred to the Retube Waste Storage Building for storage.

Darlington Waste Management Facility

The DWMF consists of an amenities area, a DSC processing building, a retube waste storage building (RWSB) and up to four DSC storage buildings. There are currently two in-service storage buildings (DSC Storage Building #1 and #2). This facility is intended to provide interim site storage for the used fuel bundles until a long-term storage site for used fuel bundles is operational. Each storage building has the capacity to hold up to about 500 DSCs, equivalent to around 9 years of station operation (OPG, 2016a).

Lands have been reserved for the future construction of additional DSC Storage Buildings #3 and #4. Construction of additional DSC storage buildings will be staged as additional storage space is required (OPG, 2016a).

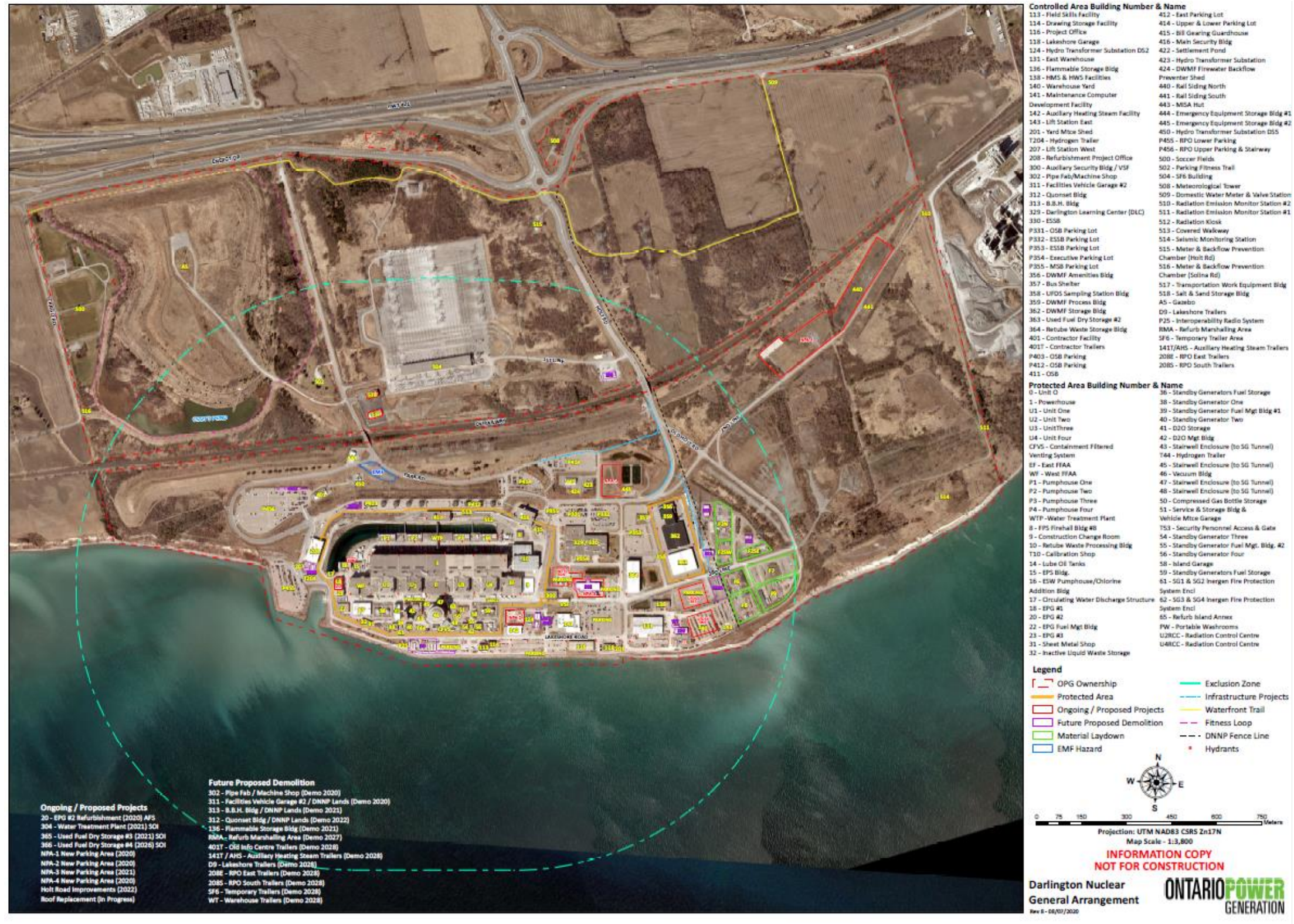


Figure 2-2: Darlington Nuclear Generating Station

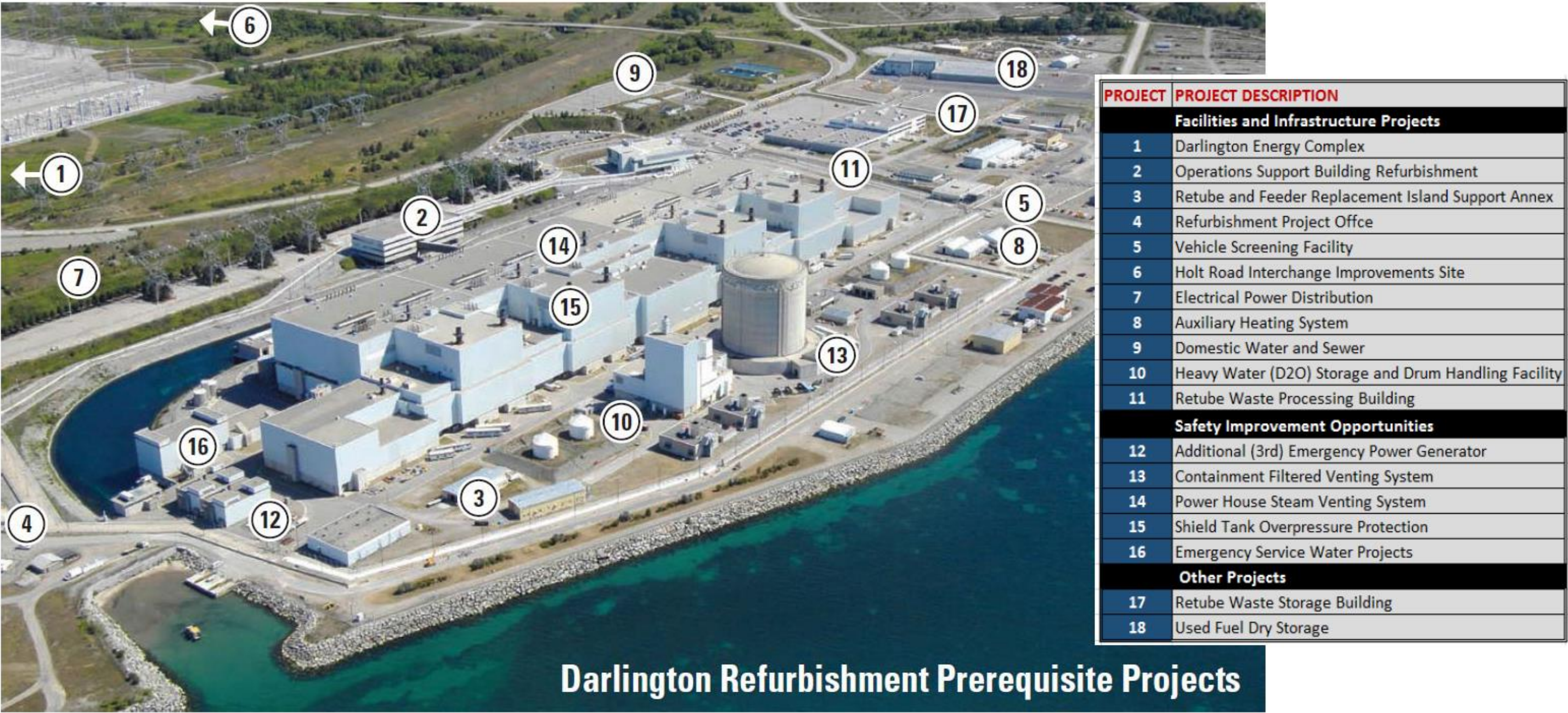


Figure 2-3: Darlington Refurbishment Prerequisite Projects

2.2.1.1 Site Drainage

Water on the DN site originates from the following systems:

- CCW System;
- Service Water Systems;
- Steam and Feedwater System;
- Water Treatment Plant (WTP);
- Radioactive Liquid Waste Management System (RLWMS);
- Inactive Drainage System;
- Sewage System (domestic); and
- Stormwater Management System.

All waterborne effluent from DN is discharged into the CCW system – either via the intake forebay or directly into the CCW discharge duct. The only exception is effluent from the domestic sewage system which is routed to the Courtice Water Pollution Control Plant, and stormwater which is discharged to Lake Ontario through storm sewers or drainage swales/creeks (Golder, 2011a). The site water balance is shown in Figure 2-4.

Condenser Cooling Water

Cooling water is drawn into the station from Lake Ontario through an intake structure located on the bottom of the lake via a tunnel and forebay. The water is pumped through travelling screens to remove debris and weeds before entering the CCW System. Cooling water is discharged back into Lake Ontario via the CCW discharge duct. During the winter, warm discharge water is redirected into the intake to prevent the development of frazil ice that may plug the travelling screens.

Service Water Systems

The service water systems include the Low-Pressure Service Water (LPSW) Open System, the Powerhouse Upper-Level Service Water, and the Recirculating Cooling Water System. Radioactive liquid waste from the Recirculating Cooling Water System drains to the active plant drainage system, and the other systems discharge back in the CCW discharge duct.

Steam and Feedwater System

The Steam and Feedwater System boils feedwater to produce steam for turbine operation. The primary source of liquid effluents from the Steam and Feedwater System is boiler/feedwater blowdown which is discharged directly to the CCW System. Boiler blowdown, which can be continuous or intermittent, is used to remove dissolved and suspended sediments and accumulated sludge from the system and aids in chemical control on the secondary side of the boiler. The blowdown from the four boilers at each unit is directed to a header, which then discharges from each unit to the CCW. Generally, one

to two hours of intermittent blowdown occurs on a station-wide basis daily and is most often related to start up or reduced power and process steam supply.

Water Treatment Plant

The WTP produces high-purity demineralized water by removing particulates and dissolved impurities from influent lake water. The demineralized water mainly supplies the make-up water for the Steam and Feedwater System of all four units at DN.

The demineralization system involves passing filtered water from the pretreatment step through an activated carbon filter (to remove chlorine), decarbonator, and a series of ion exchanger columns to produce demineralized water. The ion exchange columns are regenerated in-situ with sulphuric acid and sodium hydroxide.

The WTP Neutralization Sumps collect backwash water from regeneration of the ion exchanger columns. The backwash water is collected at the Neutralization Sumps and neutralized by addition of caustic or acid to ensure that pH is within administrative limits (6.5 to 9.0) prior to being released to the CCW. The two sumps (main and emergency) each have a volume of 1,585 m³ and are pumped to the CCW at a rate of 81 L/s. During the zebra mussel chlorination season, the emergency sump is dedicated for use as spill containment for the chlorination equipment located in the WTP.

Radioactive Liquid Waste Management System (RLWMS)

The RLWMS also consists of a series of floor and equipment drains, as well as sumps, pumps and piping, which collects normally radioactive liquid waste (RLW), segregated according to the degree of radioactivity and chemical composition, and directs the waste to the receiving tanks of the RLWMS. Sources of the RLW include Reactor Building, the Reactor Auxiliary Bay, the Central Service Area, the FFAA, the chemical laboratory Health Physics sink, the Heavy Water Management Building, and the TRF Annex chemical laboratory and laundry. Tanks in the RLW are individually discharged to CCW in batch mode reactor. The RLWMS includes filters and ion exchange columns to purify the waste. After treatment the waste is sampled and chemically analyzed to ensure it meets radioactive and chemical limits prior to discharge. The treatment can also include the addition of sodium bicarbonate and calcium bicarbonate for hardness adjustment and potassium hydroxide for pH adjustment, if required. To prevent anaerobic conditions, all tanks are aerated, with the exception of TK1.

Radioactivity monitors on the discharge piping automatically stop discharge flow if the detected activity is above prescribed limits.

Inactive Drainage System

Building effluents from inactive areas in all four units, and from the Central Service Area, are collected, and combined in a common header prior to discharging to two lagoons (each

approximately 4000 m³) operated in series. Forced aeration occurs in the first lagoon to promote mixing and reaction between air and low levels of hydrazine. The effluent from the first lagoon overflows to the second lagoon, which allows sufficient retention time for settling. The lagoon water eventually discharges to the Forebay by a polyvinyl chloride pipe, to be circulated with CCW and eventually discharged. The Building Effluent Treatment System was originally designed to include a treatment process for hydrazine through the addition of sodium hypochlorite followed by a dechlorination step using sodium bisulphate. Since this treatment system has not been needed as the lagoons are effective in managing hydrazine concentrations, the chemical addition tanks were emptied and removed from service.

Domestic Sewage System

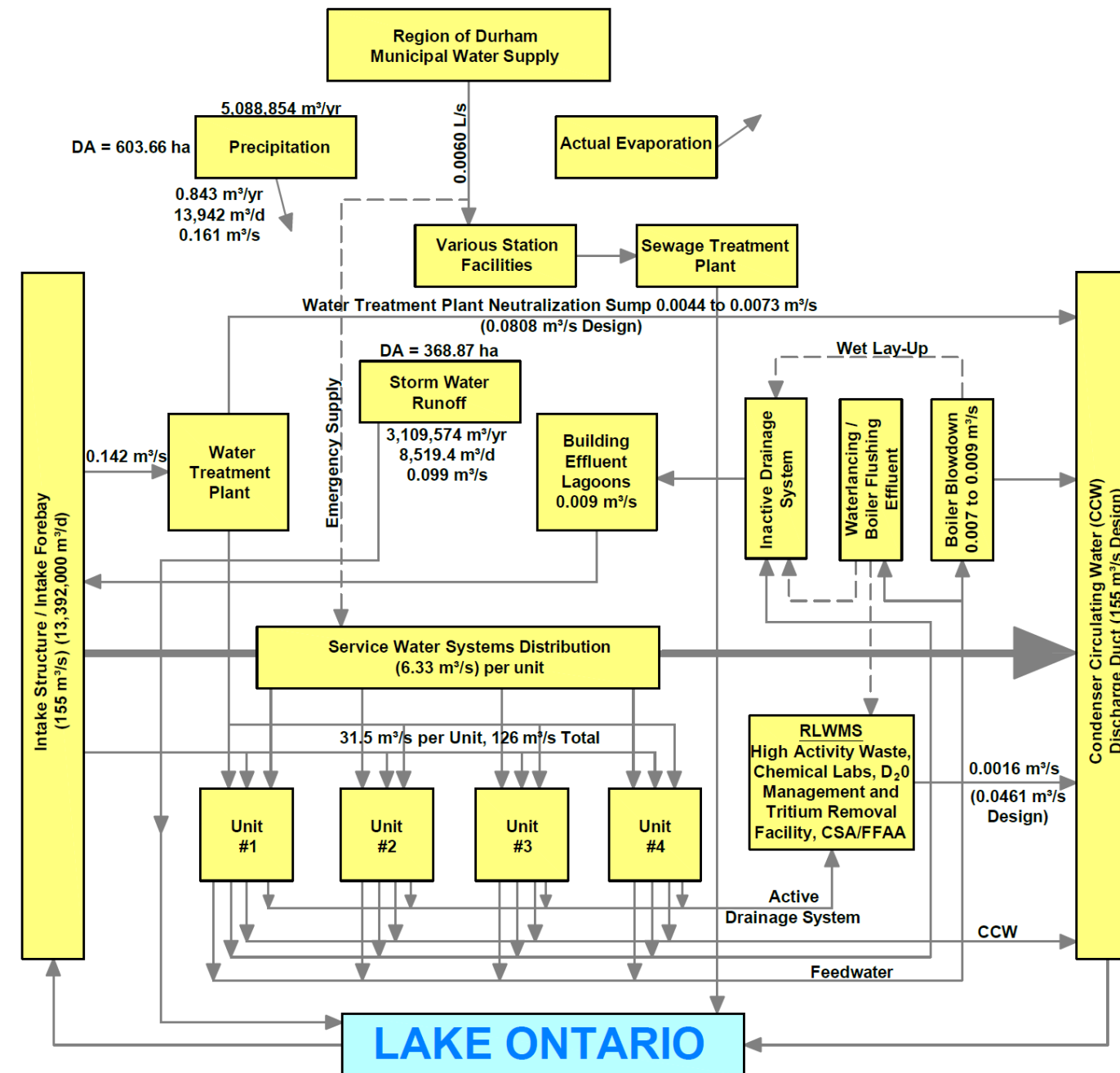
Under normal operating conditions, the Sewage System collects discharge by gravity from all washrooms, wash fountains, sinks inside workshops, drinking fountains, and showers (excluding the emergency showers). Sewage collected by gravity drainage at the various sump pumps is pumped to the gravity sewer system where it drains to either the East Sewage Pumping Station (SPS) or to the West SPS. The collected sewage from the East and West SPS is pumped north through forcemains to outlet manholes and gravity sewers north of the Canadian National Railway Company Railroad at Holt Road and Park Road, respectively. From there, it drains westerly to the Courtice Water Pollution Control Plant where it gets treated and discharged to Lake Ontario.

Stormwater Management System

The Stormwater Management System, or Yard Drainage System, collects storm runoff from the entire DN site and discharges to Lake Ontario either directly through the storm sewer drainage system or through drainage swales/creeks/retention pond via culverts which eventually discharge to the Lake.

Other Systems

Around the DWMF site, there is a grade of approximately 2.5 percent southwest to the lake. Perimeter ditches tie into existing site drainage ditches and discharge via a stormwater containment pond to Lake Ontario. Inactive drainage from the DSC storage areas is sent to the sewage system.



Notes:

1. RLWMS: Radiolactive Liquid Waste Management System.
2. CSA/FFAA: Central Services Area/Refueling Facility Auxillary Area.
3. DA: Drainage Area.
4. Flowrates are historical flowrates, not based on 2016-2019 data.

Figure 2-4: Darlington Site Water Balance (Golder, 2011a)

2.2.1.2 Heating and Ventilation

The heating systems are designed to provide comfort to individuals working in the plant, to prevent equipment from freezing, and to provide steam to process systems such as the D₂O upgrader, domestic water heaters, and CSA laundry (OPG, 2013a). Steam and electricity are used for heating. Ventilation and air conditioning systems control temperature, moisture, and atmospheric conditions as required for employees and plant equipment. The ventilation systems remove heat from various buildings/areas, provide general ventilation to all areas, and minimizes cross contamination of radioactive materials between zones. Exhaust from areas that may contain radioactive materials are filtered and monitored prior to discharge.

Steam is supplied from the common steam header running along the entire length of the powerhouse to various heating and air conditioning components. Steam is supplied from this header to various heating loads. Under normal operating conditions, turbine extraction steam supplies the Heating Steam System.

2.2.2 Materials Management

The DN site has a multitude of systems that are designed to manage both radioactive and non-radioactive materials. The main radioactive material managed at the DN site is heavy water.

The heavy water management system is used to store, transfer and recover heavy water for use in the heat transport system and moderator systems. The system includes the heavy water supply system as well as collection, cleanup, and vapour recovery systems (SENES and MMM, 2011). The collection system collects heavy water leakage from points in the Moderator and associated systems. Collected heavy water (D₂O) is either sent back to the Moderator for reuse or sent for upgrading.

The D₂O vapour recovery system is a closed loop system comprised of dryers, ductwork, heavy water collection tanks, transfer pumps and piping. Collected heavy water by the D₂O vapour recovery system is sent for upgrading. The upgrading process uses distillation to remove light water from the heavy water.

The D₂O clean-up processes remove impurities from heavy water collected from the air or water system using charcoal filters, ion exchange columns and an ultraviolet oxidation unit.

A brief summary of the use(s) and the associated management methods for chemicals used across the site is presented in Table 2-2.

Table 2-2: Chemical Usage and Disposal

Chemical	Use	Disposal
Gadolinium nitrate	Reactivity control in the moderator system.	Removed by ion exchange in the moderator purification system. For disposal, see Ion exchange resins, below.
Helium gas	A cover gas preventing the ingress of air for the moderator, liquid zone controllers, annulus gas, TRF.	Periodically purged to reactor building or TRF exhausts for chemistry control.
Oxygen gas	Cover gas for moderator, liquid zone control; annulus gas; TRF.	Consumed and emitted to reactor building or TRF exhausts.
Hydrogen gas	Added to remove oxygen gas from the heat transport system (HTS) and to cool generators, refrigerant and flame combiner (TRF).	Consumed in the HTS and vented to the reactor building exhaust. Vented to the atmosphere from the main generators. Burned in recombiner and vented to the atmosphere.
Argon gas	Used as cover gas in the TRF.	Vented to TRF exhaust.
Nitrogen gas	Used as cover gas during draining HTS to low level drained state (LLDS), used to purge heat transport (HT) D ₂ O Collection Tank; used for steam generator during lay-ups.	Vented to atmosphere or exhaust (TRF).
Liquid nitrogen	Used for cryogenic purposes, ice plugging activities.	Vented to atmosphere.
Hydrazine	Removes oxygen and used for pH control in the emergency coolant injection system, boiler feedwater, condensate feedwater, recirculating cooling water system, and end shield cooling water.	Consumed, but residual may be discharged to the atmosphere or to the lake. Ammonia is a breakdown product in feedwater.
Lithium hydroxide	Controls pH in the HTS, end shield cooling system, emergency coolant injection system, and the recirculating cooling water system.	Removed in ion exchange column or discharged.
Ion exchange resins	Used for pH control and removal of impurities in the moderator system, heat transport system, liquid zone control, irradiated fuel bay, radioactive liquid waste system, water treatment plant, stator cooling system, D ₂ O clean up system, end shield cooling, and recirculating cooling water system.	The resin is temporarily held within spent resin tanks and is placed in interim storage at the Western Waste Management Facility (WWMF) at the Bruce site.
Ion exchange resins (Sulphite)	Removes oxygen gas in the stator cooling water system.	Disposed as waste by licensed contractors based on analysis.
Granular activated carbon (charcoal)	Used in production of demineralized water at the water treatment plant, and to remove organics and residual chlorine in the active liquid waste systems and D ₂ O cleanup system.	Disposed as industrial waste by licensed contractors based on analysis. Radioactive waste from D ₂ O cleanup system placed in interim storage at the WWMF.
Filter sand	Used in production of demineralized water at the water treatment plant.	Disposed as waste by licensed contractors based on analysis.
Slaked lime (calcium hydroxide hydrate lime)	Used in production of demineralized water at the water treatment plant.	Disposed as waste by licensed contractors based on analysis.

Chemical	Use	Disposal
Sulphuric acid	Used in production of demineralized water at the water treatment plant.	Consumed during usage.
Sodium hypochlorite	Used in production of demineralized water and zebra mussel control in the low-pressure service water and WTP.	Consumed during usage in demineralized water production. When applied for zebra mussel control, it is consumed and the residual is discharged to Lake Ontario.
Sodium metabisulphite	Used in production of demineralized water and to de-chlorinate effluent.	Consumed during usage.
Sodium hydroxide; Aluminex-3; aluminum sulphate*	Production of demineralized water at the WTP.	Consumed during usage.
Carbon dioxide gas	Used in the annulus gas system as a carrier gas and in the generators as a purging gas.	Vented from the annulus gas system to the reactor building exhaust and vented to the atmosphere from the generators.
Morpholine	pH and corrosion control in the boiler feedwater and in the condensate feedwater.	Partly consumed in its usage and the balance is lost to atmospheric discharge and boiler blowdown.
Aqua ammonia	pH and corrosion control in the boiler feedwater and in the condensate feedwater.	Partly consumed in its usage and the balance is lost to atmospheric discharge and boiler blowdown.
Nitric acid	Used in moderator system to prevent gadolinium precipitation.	Consumed during usage.
Hydrogen peroxide	Process Total organic carbon (TOC) contaminated D ₂ O in heavy water management building, control algae and microbes in irradiated fuel bay (IFB).	Consumed during usage.
Potassium hydroxide	Electrolyte for deuterium production in TRF.	Consumed during usage.
Sulphur hexafluoride	Leak detection in the CCW system.	Released to Lake Ontario or air in small volumes.
CGSB-3.2 Type 1 stove oil	Fuel for standby generators and emergency power generators.	Consumed and results in waste gases including CO ₂ , NO _x , SO ₂ , etc.
Lubricating oil and generator seal oil	Lubrication and sealing of the turbine system and the generator system.	Reused and removed by licensed contractor.
Reolube Turbo fluid 46 (Fire Resistant Fluid)	Hydraulic fluid for turbine governor valves.	Reused or placed into drums for disposal by licensed contractors.
Insulating oil	Transformer cooling in the main output and service transformers.	Removed by licensed contractor.
Ethylene glycol	Air conditioners in the battery rooms, heating, ventilation and air condition (HVAC) systems.	Removed by licensed contractor.

Note:

* The new Water Treatment Plant, expected to be constructed in 2021, will no longer use these chemicals.

2.2.2.1 Waste Management

Waste Management Facilities

Non-radioactive solid, liquid, and gaseous waste, used fuel, radioactive solid waste, radioactive liquid waste, and radioactive gaseous waste are produced and safely managed on-site.

2.2.2.1.1 Non-Radioactive Solid Waste

Non-radioactive wastes are re-used or recycled where feasible. Hazardous wastes are handled in accordance with regulations by licensed disposal facilities. Non-hazardous solid wastes are disposed in an off-site landfill if landfill requirements are satisfied.

2.2.2.1.2 Non-Radioactive Liquid Waste

Aqueous liquid effluent, except for domestic sewage and stormwater drainage, from DN is discharged directly to the CCW discharge duct or the intake forebay. Stormwater drainage is directed to Lake Ontario, and domestic sewage is pumped to the east or west SPS for subsequent treatment at the Courtyce Water Pollution Control Plant.

Non-radioactive liquid emissions are controlled in accordance with the provincial Environmental Compliance Approval (ECA) requirements (formerly Certificate of Approval), and with the MISA program under O. Reg. 215/95 (Effluent Monitoring and Effluent Limits – Electric Power Generation Sector).

Under O. Reg 215/95 DN monitors the control points in use for MISA Compliance monitoring. The active control points and the parameters monitored at each point are presented in Table 2-3 and include the RLWMS Tanks, the WTP Neutralization Sump and the Building Effluent Lagoon (OPG, 2016b). The locations and parameters monitored for ECA requirements are presented in Table 2-4 and include the CCW duct and the boiler feedwater/blowdown (OPG, 2016c).

2.2.2.1.3 Non-Radioactive Gaseous Emissions

Non-radioactive gaseous emissions are controlled in accordance with ECA requirements. An Emissions Summary and Dispersion Modelling (ESDM) report is used to document and maintain compliance with O.Reg. 419/05 (Air Pollution – Local Air Quality) and forms the basis for the site's existing Environmental Compliance Approval (ECA LOF #8590-9GGMQ4).

The DN site is expected to have non-radioactive gaseous emissions including the products of fuel combustion, particulate matter, and volatiles. The ESDM lists maximum point of impingement (POI) concentrations for significant contaminants (OPG, 2020d). Contaminant concentrations on a ½ hour averaging period are determined based on the calculated

emission rates and the output from the approved dispersion model in compliance with O.Reg. 419/05. In 2018, the model was changed from the O.Reg 346 dispersion model to AERMOD.

Table 2-3: MISA and ECA (Sewage Works) Monitoring Requirements

Control Point ¹	MISA Monitoring Requirements ²	Monitoring Frequency	Daily Limit (mg/L)	Monthly Limit (mg/L)
Radioactive Liquid Waste Management Tanks (CP 0100)	Phosphorus ³	Weekly	-	1.0
	Residual Solid Particulates	Daily ⁴	73.0	21.0
	Zinc	Weekly	1.0	0.5
	Iron	Weekly	9.0	3.0
	Solvent Extractables	Weekly	36.0	13.0
	pH	Daily ⁴	6.0-9.5	-
	Acute Lethality/Toxicity	Quarterly	-	Non-toxic
Water Treatment Plant Neutralization Sump (CP 2200)	Chronic Toxicity	Semi-Annually	-	Non-toxic
	Residual Solid Particulates	Daily	70.0	25.0
	Aluminum	Weekly	13.0	4.5
	Iron	Weekly	2.50	1.0
	pH	4 hours	6.0-9.5	-
	Acute Lethality/Toxicity	Quarterly	-	Non-toxic
	Chronic Lethality/Toxicity	Semi-Annually	-	Non-toxic
Building Effluent Lagoon (CP 5000, 5100 back-up)	Acute Lethality/Toxicity	Monthly	-	Non-toxic
	pH	Weekly	6.0-9.5	-
	Ammonia plus ammonium	Monthly	-	-
	Hydrazine	Monthly	-	-
	Total Organic Carbon	Monthly	-	-
	Phosphorus	Monthly	-	-
	Residual Solid Particulates	Monthly	-	-
	Copper	Monthly	-	-
	Oil and Grease	Monthly	-	-
	Total Residual Chlorine	Monthly	-	-
	Tritium	Monthly	-	-

Notes:

¹ Only active control points are shown.

² Table is provided for reference purposes only. Current MISA monitoring requirements should always be verified against O.Reg 215/95.

³ ECA requirement.

⁴ ECA frequency is per discharge.

Table 2-4: ECA Monitoring Requirements

Location	ECA Monitoring Requirements	Monitoring Frequency	ECA Limit (mg/L)
Condenser Cooling Water Duct	Ammonia, unionized	Weekly	0.02
	Hydrazine	Weekly	0.1
	Morpholine	Weekly	0.02
	Total Residual Chlorine	Daily	0.01
	pH	Weekly	6.0-9.5
Boiler Feedwater/Blowdown	Total Ammonia	Monthly	20
	Hydrazine	Monthly	5
	Morpholine	Monthly	25
	pH	Monthly	-

Note:

Table is provided for reference purposes only. Current ECA monitoring requirements should always be verified.

2.2.2.1.4 Used Fuel

Used fuel bundles are initially stored in the irradiated fuel bays for at least 10 years and then transferred to DSCs for interim storage in the DWMF until a long-term waste management facility, being developed as part of a federal government program, becomes available. In the irradiated fuel bay, used fuel bundles are placed into 96-bundle storage modules. Modules with used fuel at least 10 years or older may be loaded into a DSC, which has the capacity to hold four storage modules. The DSC is loaded with the storage modules and then prepared for on-site transfer to the DWMF for further processing and subsequent interim storage (OPG, 2013a).

2.2.2.1.5 Radioactive Solid Waste

Radioactive Solid Wastes include both low and intermediate level wastes. Low and intermediate level waste is packaged in the station and transported to OPG's WWMF for processing and storage.

Low Level Waste (LLW) is defined as waste with contact radiation fields of less than 10 mSv/h at 30 cm. LLW is made of maintenance wastes from day-to-day reactor operations including cleaning materials, personal protective equipment, contaminated metal parts, metal sweepings, and miscellaneous items. LLWs are categorized as incinerable, compactable, or as non-processible.

The majority of incinerable LLW is collected in plastic bags, packed into shipping containers and transportation packages, and shipped off-site for incineration at the WWMF at the Bruce site.

Compactable LLW, including light gauge metals, welding rods, metal cans, insulation, metallic air filters, air hoses, small cables, and other assorted wastes, is collected in plastic bags and temporarily stored in the solid radioactive waste handling area before being shipped to the WWMF where it is compacted and stored.

Non-processible LLW includes lathe turnings and metal filings, heavy gauge metal and components, floor sweepings, glass, and larger electrical cables. This waste is packaged and shipped to the WWMF.

Intermediate Level Waste (ILW) is defined as waste with dose rates greater than 10 mSv/h at 30 cm. Materials categorized as ILW include spent ion exchange resins, disposable filters, and other non-processible radioactive wastes. This waste is placed in appropriate transportation packages and shipped to the WWMF.

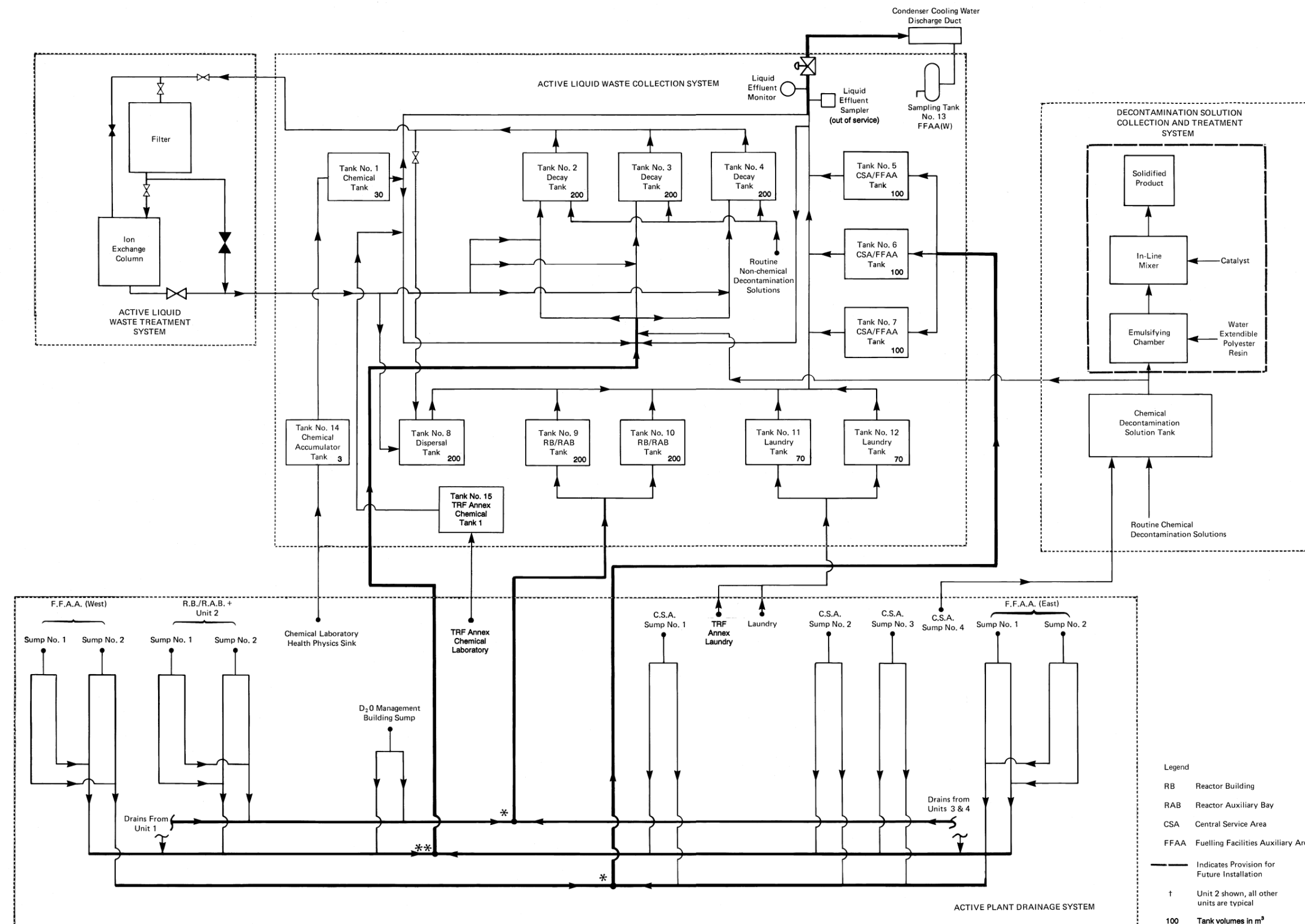
The Retube Waste Storage Building provides storage for retube waste containers (RWC) during refurbishment. It has a designed capacity of 490 RWCs.

2.2.2.1.6 Radioactive Liquid Waste

The RLWMS receives, treats and disposes of all potentially RLW streams not containing appreciable amounts of heavy water; these are directed to the system via the active drainage system. The activity in the liquid waste originates from contamination by mixed fission products, process system corrosion and activation products, and may include tritium, carbon-14, alpha and beta-gamma emitters. Gross beta-gamma is a gross measure of radioactivity and is inclusive of all non-volatile radionuclides in effluent, including for example cesium-137, cesium-134, and cobalt-60. RLW from the DWMF is not expected. A flow diagram of the RLWMS is shown in Figure 2-5.

Active or potentially radioactive liquid wastes are segregated into different tanks depending on activity levels. Active liquid waste with chemical contaminants are subject to pH adjustments in the active chemical waste tank and chemical decontamination solution tanks. All active liquid waste is sent for treatment in order to reduce radioactive and non-radioactive impurities. Following treatment and confirmation of sample results, the waste is then directed to a dedicated clean tank(s) where it awaits discharge. The effluent is sampled for radiological and chemical parameters prior to release and is discharged only if required specifications are met. In addition to meeting all active and non-radioactive limits, all discharges from the RLWMS must be non-toxic as directed by the MISA regulations. Radioactivity monitors on the discharge piping automatically stop discharge flow if the detected activity is above specified limits. If limits are met, treated wastes are discharged with the CCW to Lake Ontario through the diffuser.

Certain types of organic radioactive liquids such as contaminated oils are put through an oil and water separator. Other fluids are solidified and transported to the WWMF for storage and/or incineration (OPG, 2013c).



Note: the liquid effluent sampler is currently being upgraded.

2.2.2.1.7 Radioactive Gaseous Emissions

Tritium is produced in the reactor by the absorption of neutrons by the deuterium in the heavy water. Tritium emissions are in the form of tritiated water vapour and occur through the egress of heavy water from the moderator or heat transport system to the reactor building. The reactor vault, moderator auxiliary systems, and emission control rooms are also potential sources of tritium; however, ventilation systems with dryers are used to recover heavy water vapour. In addition to releasing tritiated water vapour, the TRF is the primary source for emissions of small amounts of elemental tritium.

The primary source of particulate emissions is the heat transport system where solid radionuclides originate from within the fuel bundles or from corrosion of system components. Additional radioactive particulate emissions include cesium-137 and cobalt-60 which primarily originate from the heat transport system where they are formed in the fuel bundles or from corrosion of the system components. Carbon-14 is released from the moderator cover gas system and the annulus gas system through the reactor building stack. The ventilation exhaust stacks are monitored for particulate and gaseous carbon-14 activity where necessary.

Radioactive iodine isotopes are formed as fission products and released from defects in fuel bundles. As a result, small amounts of radioiodine may be produced.

Gaseous wastes from potentially active areas are monitored for radioactivity before atmospheric release. When radioactive particulates and radioiodine may be present, gases from active ventilation stacks are filtered through absolute or charcoal filters prior to release.

Natural radioactive decay minimizes noble gas emissions. Noble gases from the annulus gas system, fueling machine head, and irradiated fuel discharge mechanism are processed in the Off-Gas Management System to delay release of radioactive noble gases by allowing natural radioactive decay (OPG, 2013a).

Radioactive gaseous emissions are modelled, for the purpose of public dose calculations, as one virtual source.

2.3 Description of the Natural and Physical Environment

This section will briefly describe meteorology and climate, site geology, hydrogeology, hydrology, vegetation communities, aquatic communities, human land use, and population distribution with a focus on DN site conditions. More detailed information can be obtained from the DNNP Supporting Environmental Studies document (Ecometrix, 2020), the TSDs for the Darlington Nuclear Generating Station RCO project EA (SENES and MMM, 2011) and for the New Nuclear – Darlington EA (SENES and MMM, 2009) with updates based on information from 2011 to 2020.

2.3.1 Meteorology and Climate

The DN site is located in southern Ontario on the north shore of Lake Ontario. It displays a humid continental climate with four distinct seasons. In Southern Ontario, the climate is highly modified by the influence of the Great Lakes which results in uniform precipitation amounts year-round, delayed spring and autumn, and moderated temperatures in winter and summer (Environment Canada, 1997, cited in (SENES and MMM, 2011)).

2.3.1.1 Temperature

The most recent Canadian Climate Normals available span the 1981-2010 period (ECCC, 2020). The meteorological stations at Oshawa and Bowmanville represent the local climate conditions at the DN site, while the meteorological station at Toronto's Pearson Airport represents the regional conditions. Table 2-5 displays monthly average temperatures and demonstrates that the highest mean temperatures, both regionally and locally, occurred in July, and the lowest mean temperatures occurred in January. The temperature data was normalized between 2016 and 2019, as shown in Figure 2-6. Temperature data from the DN meteorological tower was only used for 2017; therefore, temperature from the PN meteorological tower was used for the other years. There was an issue with the DN meteorological tower temperature probe which was resolved in August 2016 and in 2018 and 2019, PN meteorological tower temperature data was used to align with the Environmental Monitoring Program annual reports (OPG 2019a, 2020b). Similar to the local and regional conditions, the highest (21.5 °C) and the lowest (-4.1 °C) 4-year average temperatures at the DN site occurred in July and January, respectively. While the mean daily maximum temperature (23.0 °C) was recorded in August 2016, and the mean daily minimum temperature (-6.4 °C) was recorded in January 2019.

Table 2-5: Temperature Normals near Darlington Nuclear

Month	Daily Mean (°C)				Mean Daily Maximum (°C)				Mean Daily Minimum (°C)			
	Regional Study Area	Local Study Area		Site Study Area	Regional Study Area	Local Study Area		Site Study Area	Regional Study Area	Local Study Area		Site Study Area
	TOR ¹	OSH ²	BOW ³	DN ⁴	TOR ¹	OSH ²	BOW ³	DN ⁴	TOR ¹	OSH ²	BOW ³	DN ⁴
January	-5.5	-4.8	-5.6	-4.1	-1.5	-1.1	-1.4	-1.5	-9.4	-8.5	-9.9	-6.4
February	-4.5	-3.6	-4.4	-2.0	-0.4	0.1	0	-0.5	-8.7	-7.3	-8.8	-4.1
March	0.1	0.4	-0.2	-0.1	4.6	4.2	4.3	2.0	-4.5	-3.5	-4.6	-1.1
April	7.1	6.6	6.4	5.4	12.2	10.8	11.3	8.3	1.9	2.5	1.5	3.2
May	13.1	12.3	12.4	12.6	18.8	16.9	18	13.8	7.4	7.7	6.8	11.6
June	18.6	17.6	17.5	17.8	24.2	22.3	23.1	18.3	13	12.9	11.8	17.4
July	21.5	20.6	20	21.5	27.1	25.1	25.8	22.1	15.8	15.9	14.3	20.7
August	20.6	20	19.2	21.3	26	24.3	24.8	23.0	15.1	15.6	13.5	19.5
September	16.2	15.9	15	18.0	21.6	20.2	20.4	18.8	10.8	11.7	9.5	16.8
October	9.5	9.5	8.7	11.2	14.3	13.3	13.7	13.2	4.6	5.6	3.6	9.1
November	3.7	4.2	3.4	3.3	7.6	7.4	7.2	6.3	-0.2	1	-0.4	1.1
December	-2.2	-1.2	-2.2	-1.7	1.4	2.1	1.6	-0.1	-5.8	-4.4	-6	-5.2
Year	8.2	8.1	7.5	8.6	13	12.1	12.4	10.3	3.3	4.1	2.6	6.9

¹Toronto Lester B. Pearson International Airport, 1981-2010 (ECCC 2019).

²Oshawa OPG, 1981-2010 (ECCC 2019).

³Bowmanville Mostert, 1981-2010 (ECCC 2019).

⁴Darlington Nuclear, 2016-2019, 2017 data from DN on-site meteorological tower, 2016, 2018, 2019 from PN on-site meteorological tower.



Figure 2-6: Temperature between 2016 and 2019 near Darlington Nuclear

2.3.1.2 Precipitation

The Bowmanville climate station is the closest to the DN site. Precipitation data from the Bowmanville Mostert Station for the period from 1981-2010 has been used to characterize precipitation patterns for the DN site. During this time the Bowmanville station reported an average annual precipitation of approximately 866 mm. Snowfall represented less than 11% of total precipitation during the 1981-2010 period (Government of Canada, 2016). Total monthly precipitation averages range from approximately 50.5 mm in February to approximately 98.7 mm in September.

In comparison, other nearby climate stations reported annual total precipitation of approximately 800-900 mm during the same period, including: approximately 786 mm at Toronto's Pearson International Airport (1981 to 2010) and 872 mm at the Oshawa station (1981 to 2010) (ECCC, 2020). Table 2-6 and Figure 2-7 show that monthly precipitation within the local study area tends to follow the regional monthly precipitation trends.

Table 2-6: Precipitation at Bowmanville Mostert Station (1981 – 2010)

Month	Monthly Averages			Daily Extremes		
	Precipitation (mm)	Rain (mm)	Snow (cm)	Precipitation (mm)	Rain (mm)	Snow (cm)
January	63.1	32.2	31	46.2	46.2	29
February	50.5	32.8	17.7	42.2	42.2	19.4
March	55	41	14.1	47.6	47.6	20.8
April	70.6	68	2.6	43.4	43.4	10.2
May	75.9	75.9	0	36.4	36.4	0
June	83.8	83.8	0	50.6	50.6	0
July	63.2	63.2	0	51.1	51.1	0
August	78.1	78.1	0	81.2	81.2	0
September	98.7	98.7	0	84	84	0
October	70.8	70.6	0.1	48.6	48.6	12.2
November	88.6	83.1	5.6	71.4	71.4	15.5
December	68.1	46.1	22	41.1	41.1	24
Annual Total	866.4	773.5	93.1	-	-	-

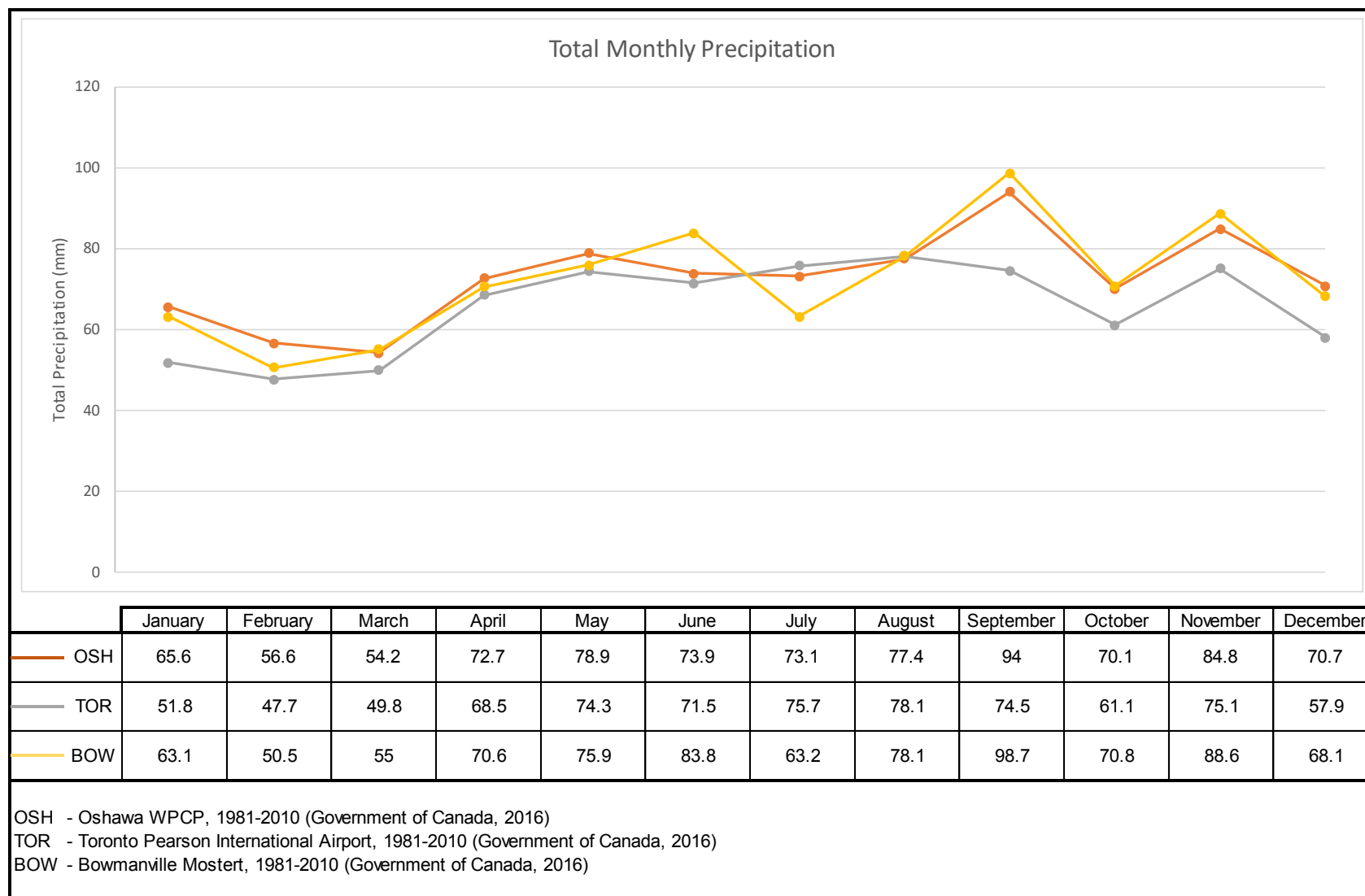


Figure 2-7: Comparison of Monthly Precipitation Normals (1981-2010) for Local and Regional Meteorological Stations

2.3.1.3 Wind

Wind data for the DN site meteorological station for the period 2013 to 2019 are presented as a wind rose in Figure 2-8. The DN meteorological tower was not available for much of 2018 and 2019; therefore, data from OPG's Pickering Nuclear Generating Station were used for those years consistent with the EMP reports. During this period, the average wind speed measured at a height of 10 m was approximately 2.4 m/s, calm winds less than 2 m/s were reported approximately 37% of the time. The prevailing winds blew from the north-west sector. The dominant wind direction was north (9.6% of the time), followed by the west direction (8.9% of the time). The distribution of winds at the DN site is generally similar to that reported for the region based on wind patterns reported at Pearson International Airport (2013 to 2019), where the wind direction is primarily from the north and the west (see Figure 2-9).

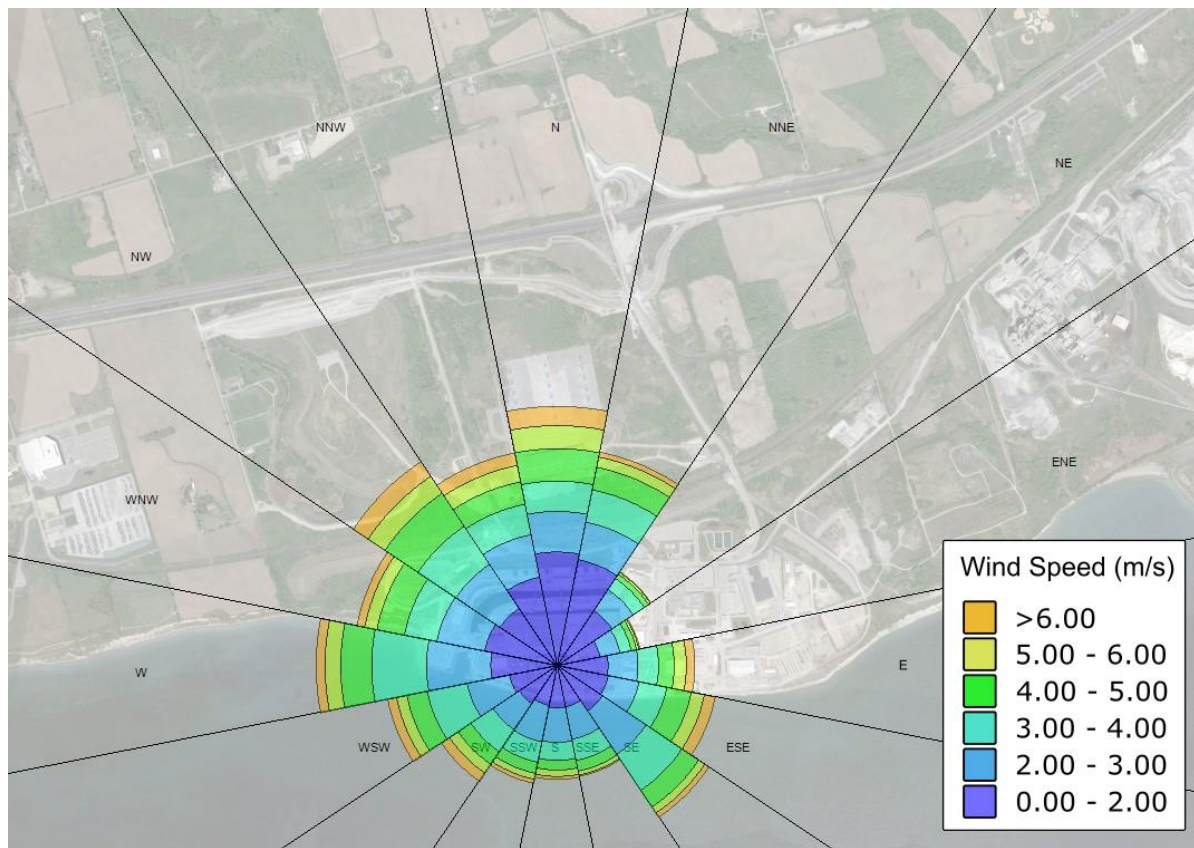


Figure 2-8: 2013 – 2019 Annual Average Windrose at 10-m Tower (2013-2017 DN and 2018-2019 PN)

Note: Direction is where wind blows from.

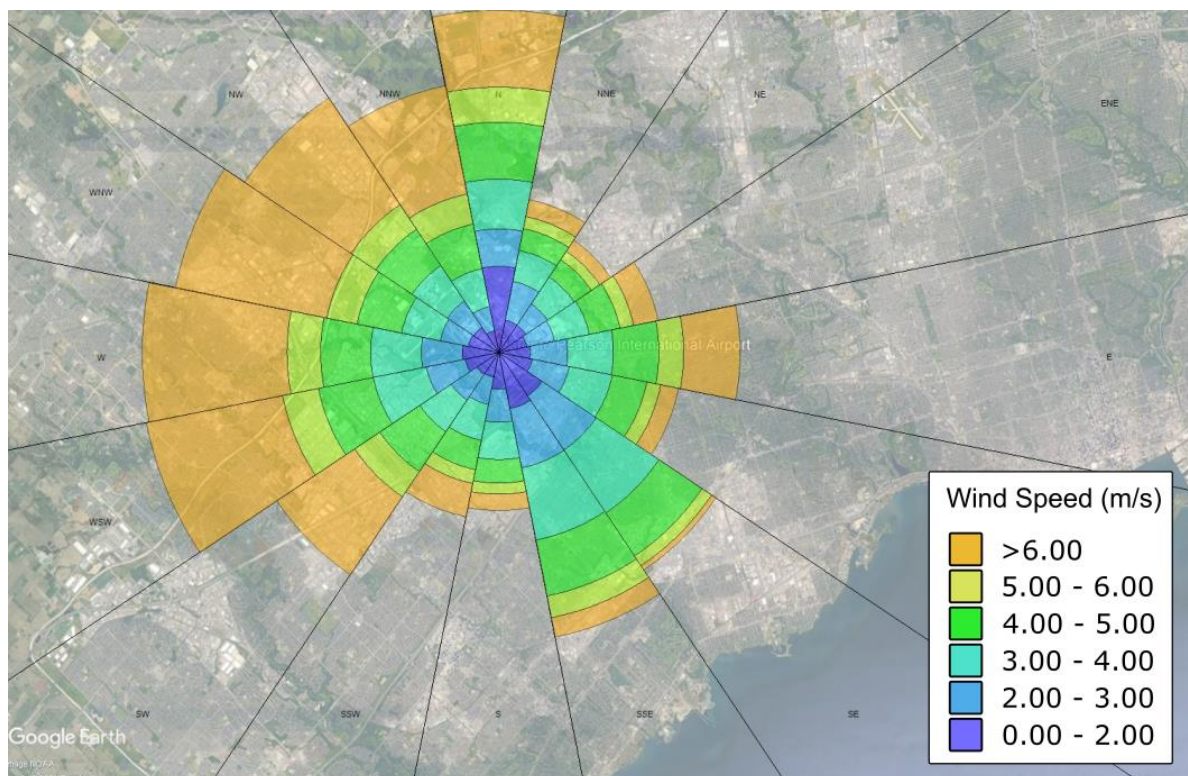


Figure 2-9: 2013 – 2019 Annual Average Windrose at 10-m Tower from Pearson International Airport

Note: Direction is where wind blows from.

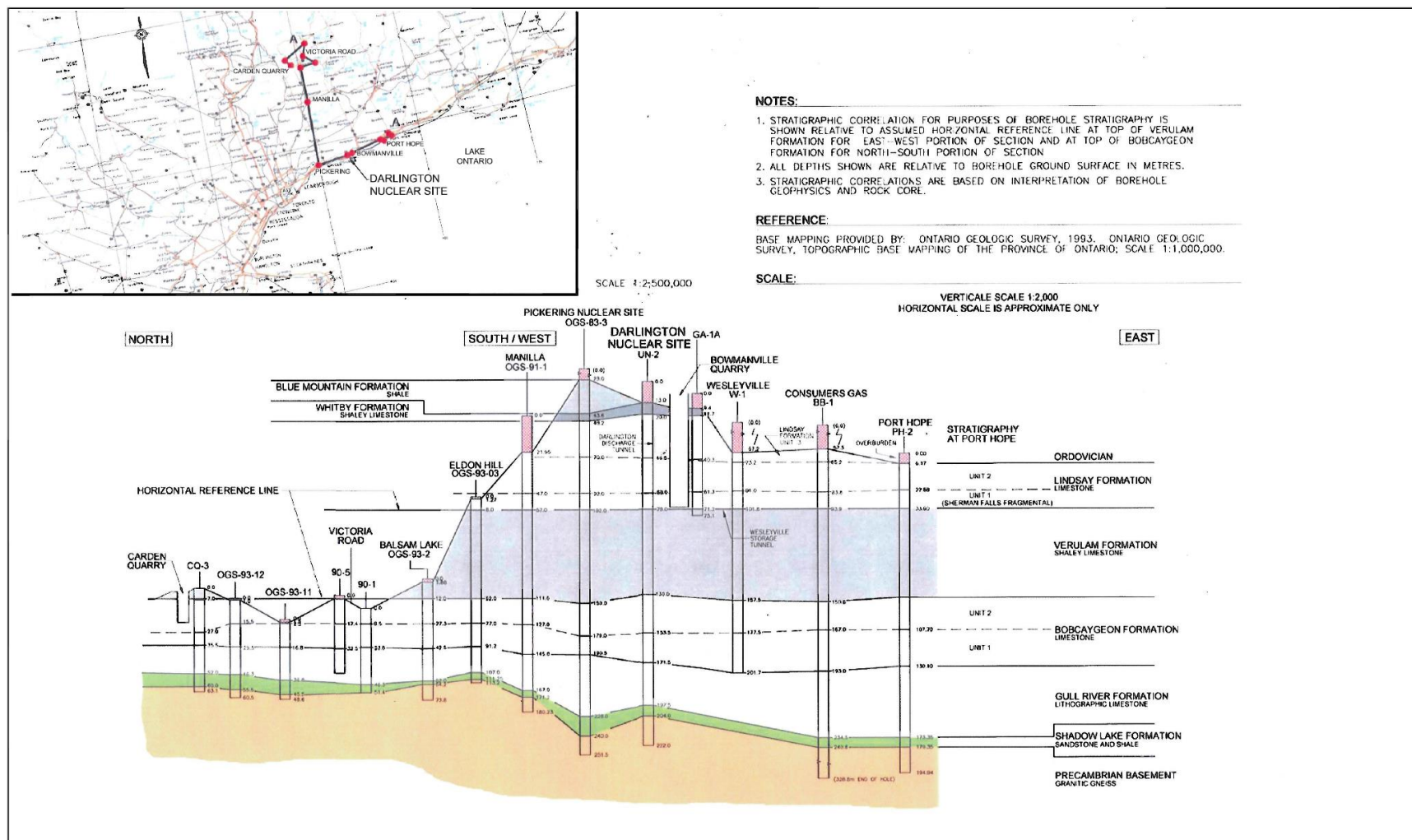
2.3.2 Geology

On a regional level, the bedrock is completely covered by Quaternary deposits and bedrock outcrops are found only in local quarries and other man-made excavations. The Oak Ridges Moraine is a major geologic/hydrogeologic feature in Southern Ontario, running along an east-west trajectory north of the DN site. The Oak Ridges Moraine consists of interbedded layers of glacial till and sand and gravel, and is a major source of groundwater recharge and a large number of creeks and rivers in the region are derived from groundwater discharge from it. The Oak Ridges Moraine divides the flow of groundwater to the north to Lake Simcoe and to the south to Lake Ontario. The Iroquois Plain is situated south of the moraine and extends 8 to 12 km to Lake Ontario. Shoreline deposits and glaciolacustrine sediments overlay the glacial tills in this area. The shoreline deposits include sand and gravel bars and beach terraces as well as some deltas from former rivers and creeks flowing into Lake Iroquois, a prehistoric proglacial lake formed approximately 13,000 years ago. In the area of the DN site, the Iroquois Plain contains drumlins with a southeast orientation indicating the northwest glacial advance. Overburden thickness varies from over 200 m in the Oak Ridges Moraine to about 10 m at the Lake Ontario shoreline (SENES and MMM, 2009).

2.3.2.1 Bedrock

From surface to depth, the bedrock at the DN site consists of shale and limestone of the Blue Mountain Formation, Lindsay Formation, Verulam Formation, Bobcaygeon Formation and Gull River Formation, shown in Figure 2-10. The Shadow Lake Formation, a sandstone and shale unit, lies non-conformably on the Precambrian Basement. Rock quality is noted to be good to excellent with few breaks or fractures. There is no evidence of karstic features in the local bedrock (SENES and MMM, 2009).

The limestone sequence has been found to extend to approximately 180 to 190 m in thickness. The Lindsay Formation is exposed at the surface in the St. Marys Cement quarry adjacent to the DN site which is a source of limestone for cement manufacture. The quarry has been developed in a series of four benches with the base of the quarry at an elevation of about 11 masl in 2009 (SENES and MMM, 2009); the current depth is unknown.



2.3.2.2 Surficial Geology

Surficial geology at the DN site consists of fill materials in places at surface, underlain by upper and lower till units with interglacial deposits in between (SENES and MMM, 2009). The overburden overlies either shale or limestone bedrock. The fill materials are variable in thickness and composition.

The site topography is shown in Figure 2-11. The Landfill located on the northwest portion of the DN site highest point of elevation at the DN site with an elevation of 133 metres above sea level (masl) at the top and 105 at the base. The Landfill was constructed mainly of native materials excavated from the Site construction with a small limited area where non-hazardous waste materials derived from the construction of DN Generating Station was deposited. The land generally slopes down to the southwest, to the south to Lake Ontario and to the east to Darlington Creek. The Canadian National Railway Company (CN) Railroad which cuts through the property from west to east is recessed into the ground through the central portion of the site with elevation differences of 5 to 10 m between the tracks and the adjacent ground.

2.3.2.3 Soil

Detailed soil properties (i.e. moisture, grain size, density, and porosity) were previously characterized and documented as part of the Geological and Hydrogeological Environment Existing Environmental Conditions TSD (CH2M Hill and Kinectrics, 2009). These characteristics are generally static and the baseline condition would remain unchanged.

The site generally consists of fill materials (sand and gravel) at surface followed by an Upper Till (dense, silty, fine sand till), Interglacial Deposits (grey silt or fine sand), and a Lower Till (dense, grey to dark, fine sandy silt till with medium to coarse sand and clay and trace fine gravel), on top of shale or limestone bedrock. The following characteristics were observed:

- Moisture content – ranged from 7.04 to 22.45 %
- Grain size – highly variable, high silt and fine sand content, clay content less than 25%
- Dry density – ranged from 1.86 to 2.1 g /cm³.
- Porosity – ranged in upper till from 20% to 28.5%

The soil type used in the IMPACT model is loam. This is consistent with the recommendation in CSA N288.1-20 to use a clay or loam soil type for Southern Ontario.

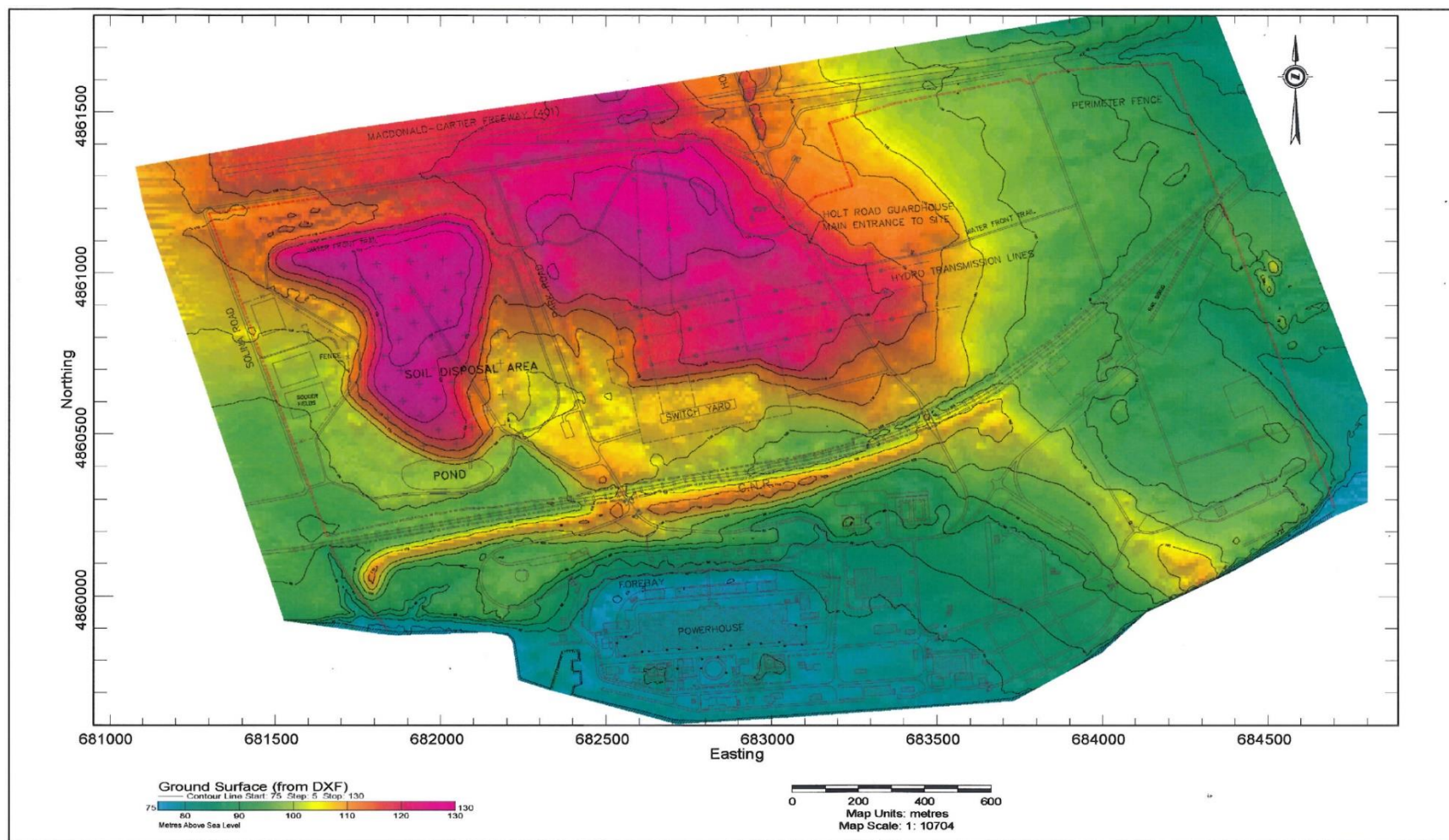


Figure 2-11: DN Site Topography (CH2M Hill and Kinectrics, 2009)

2.3.3 Hydrogeology

Groundwater in the region flows from the Oak Ridges Moraine to the south with discharge to local streams or to Lake Ontario. A number of creeks near the DN site, including Harmony, Bowmanville and Soper creeks, have their headwaters in the moraine. The intact bedrock is generally considered to be of low permeability and transmits very little water. Therefore, regional bedrock does not generally yield appreciable amounts of groundwater for water supply. However, within areas where the upper fractured surface of the bedrock is in contact with more permeable overburden materials, sufficient water for domestic water supplies may be available. South of the moraine, Interglacial Deposits lying between the till layers represent the primary source of water supply for rural areas north of the DN site which rely on groundwater for domestic water supply. Urban areas such as Bowmanville to the east and Courtice to the west rely on municipal water supply from a Lake Ontario-based source (SENES and MMM, 2009).

Groundwater aquifers at the DN site have been categorized into three hydrostratigraphic units (HU): Shallow/Water Table, Interglacial Deposits, and Shallow Bedrock. Groundwater flows in shallow/water table (overburden), interglacial deposit layers and shallow bedrock within the DN site area presented in Figure 2-12, Figure 2-13, and Figure 2-14, respectively (OPG, 2019c). The general flow pattern within each layer is south toward Lake Ontario, except for the northeast portion of the site which flows toward Darlington Creek and then to Lake Ontario.

Inside the protected area at Darlington Nuclear Generating Station (DN GS) (higher security area encompassing DN GS), groundwater flow is further influenced by anthropogenic subsurface features such as foundations, drain systems and sumps, and the vacuum building. Within the protected area, groundwater flows to the northwest toward the forebay. However, to the south of the powerhouse, there is groundwater flow from the east toward the forebay as well as southerly flow toward Lake Ontario. This likely occurs since the powerhouse extends to bedrock, inhibiting connection between groundwater flows at the north and south of the structure (OPG, 2019c).

Groundwater levels within the protected area were influenced by dewatering activities for building construction, especially the new Heavy Water Management Building south of Unit 2, as part of the Darlington Refurbishment Project. From 2013 to 2016, a lowering of groundwater levels was observed which began to recover in 2017. Flow patterns were slightly altered, with some groundwater in the protected area shifting flow direction back toward the building excavation rather than toward the forebay. Groundwater has since returned to previous levels as a result of discontinued dewatering activities (OPG, 2019c).

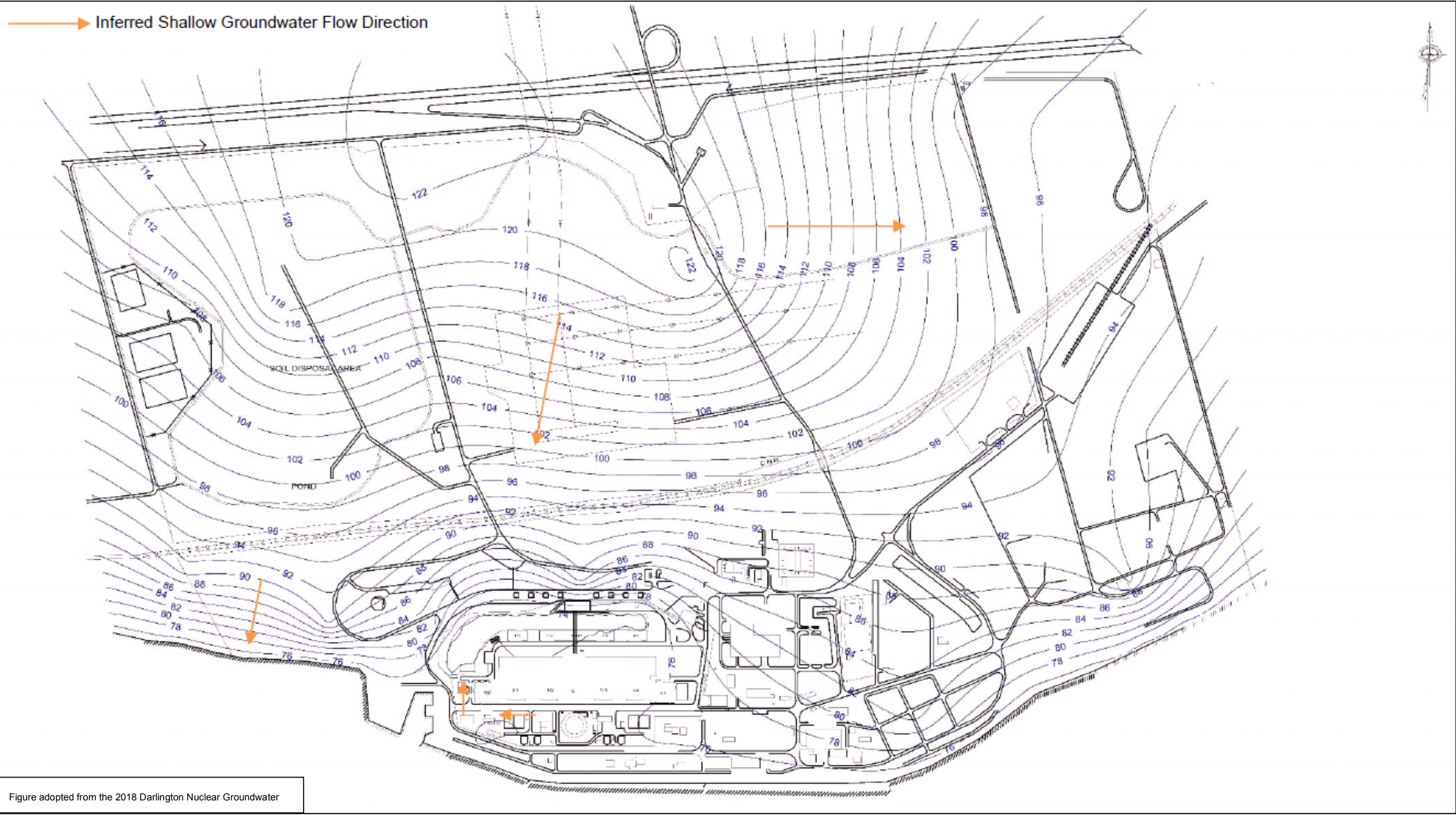


Figure 2-12: DN Site 2018 Q2 Groundwater Flows in Shallow Groundwater (OPG, 2019c)

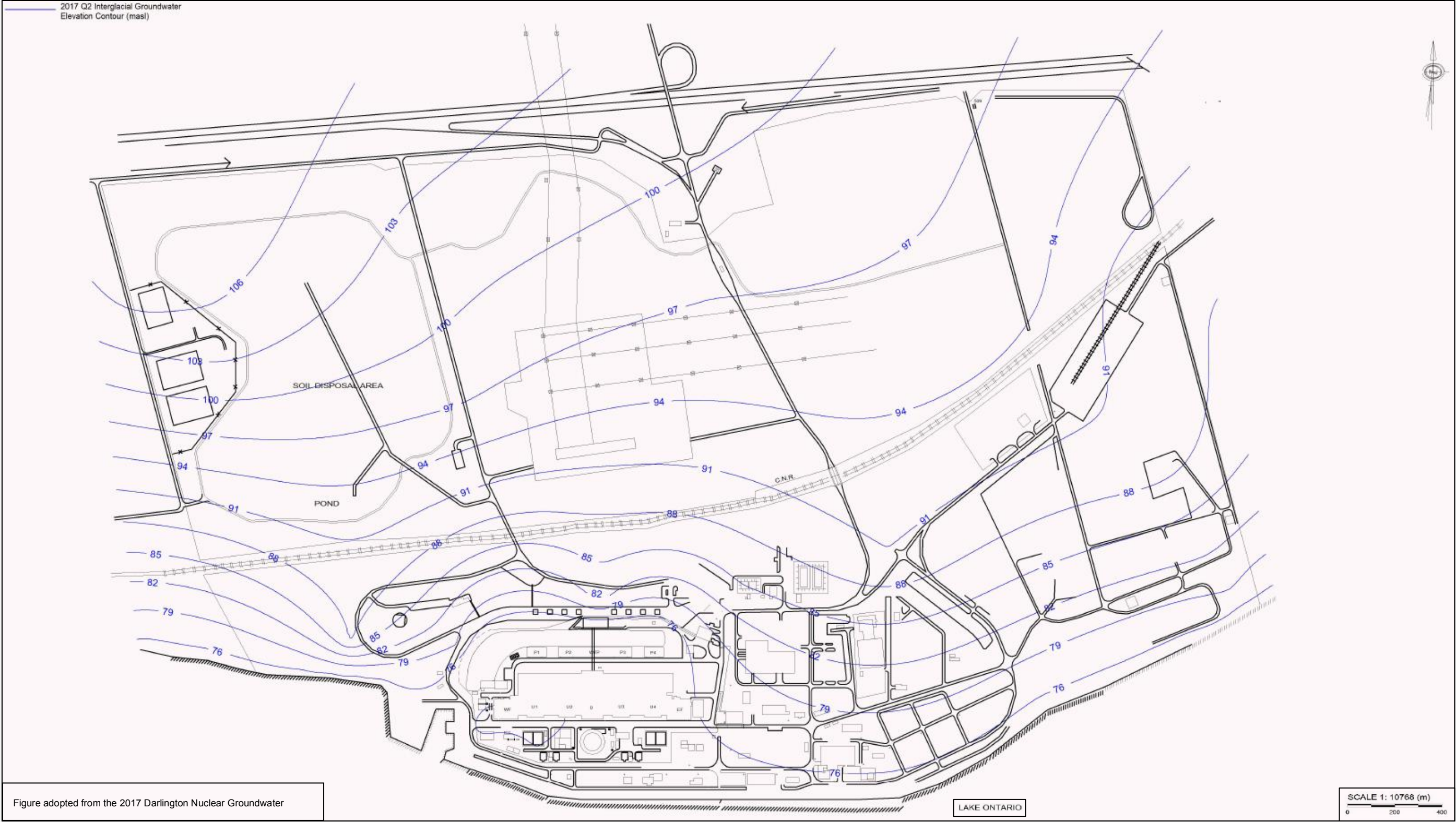


Figure 2-13: DN Site 2017 Q2 Groundwater Flows in Interglacial Deposit Layers (OPG, 2018d)

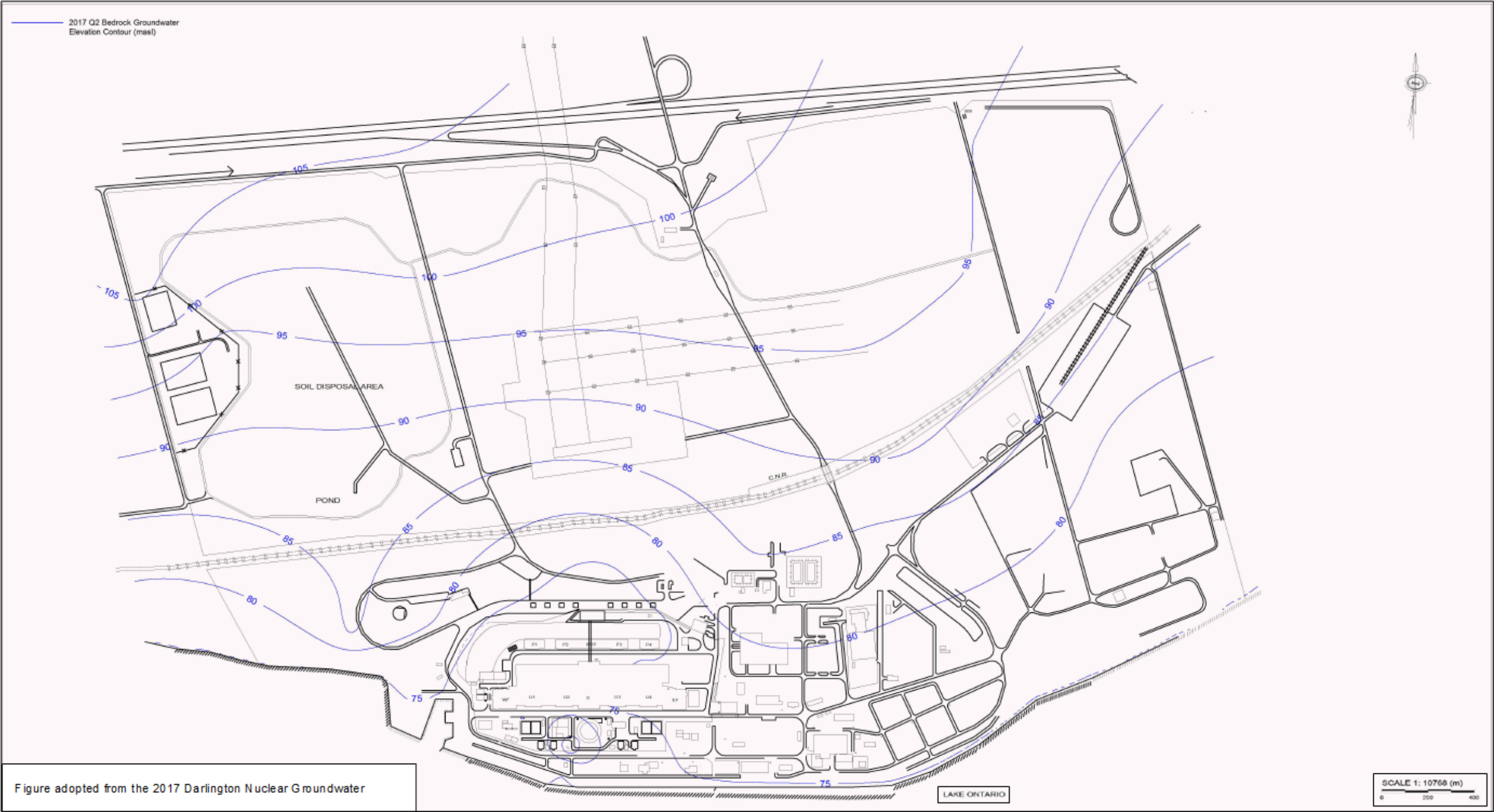


Figure 2-14: DN Site 2017 Q2 Groundwater Flows in Bedrock (OPG, 2018d)

Recharge of precipitation is expected to be low at the DN site in areas where till is encountered at surface. Within these areas most precipitation runs off to surface water ditches or yard drainage features (SENES and MMM, 2009)). In the developed parts of DN, stormwater is collected in ditches and storm drains and directed to Lake Ontario. A stormwater pond is located to the south of the Engineering Support Services Building and another pond is associated with the DWMF. Another stormwater pond is located north of the lagoons which collect runoff from adjacent parking lots and from the railroad tracks (CH2M Hill and Kinectrics, 2009).

Within the DN site, till units with relatively lower hydraulic conductivities act as aquitards, or confining layers, and restrict groundwater movement. Groundwater flow in these units is expected to be primarily vertically downward. Alternately, Interglacial Deposits between till units have moderate hydraulic conductivities and act as aquifers and transmit groundwater (SENES and MMM, 2009).

Recharge to depth is restricted for the Interglacial Deposits by till or clay-rich layers which act as confining layers. Consequently, groundwater flow in the Interglacial Deposits is primarily horizontal. Where the Interglacial Deposits are exposed at surface, such as in the northeast of the DN site, a significant groundwater recharge is likely as a result. There may be an upward flow component from the bedrock into the lower till unit (SENES and MMM, 2009).

Seepage water and precipitation into the St. Marys quarry collects in a sump from where it is pumped to Darlington Creek (by permit). The low flows in the dry months of the year indicate that there is very little groundwater seepage to the quarry and most of the accumulation in the quarry is the result of precipitation (SENES and MMM, 2009).

2.3.4 Hydrology

2.3.4.1 Lake-wide Circulation

The DN site is situated on the north shore of Lake Ontario. The lake-wide circulation is generally eastward from the Niagara River to the discharge to the St. Lawrence River and is influenced by meteorological conditions, primarily wind and seasonal temperature effects (Golder, 2011a).

There is very little net flow along the northern shore of Lake Ontario. However, the current in the nearshore region is overall easterly and is influenced by brief patterns of strong winds exerting stress at the water surface (Golder, 2011a). Seasonal factors related to temperature and vertical mixing influence the strength and direction of the nearshore currents. Reversals of the nearshore current direction along the northern shore are common following brief patterns of strong winds exerting stress at the water surface (Golder, 2011a). Locally, the DN discharge can act as a barrier to longshore water movement during low energy periods although this effect is reduced as current speeds increase (Golder, 2011a).

Table 2-7 and Table 2-8 summarize available Lake Ontario current data for 2012 to 2016 (OPG, 2018e). Table 2-7 shows the frequency of lake current flowing towards each direction and the maximum speed that occurred in each direction. Table 2-8 shows the depth averaged lake current direction and speeds. Average lake current data are summarized for easterly, NE, ENE, E, and ESE, and westerly, SW, WSW, W, and WNW, lake currents. The average easterly and westerly current speeds for 2012 to 2016 were 14.1 cm/s and 11.3 cm/s, respectively. Current speeds for all directions typically ranged from about 9 to 18 cm/s and were typically slower in spring and early summer, May through June, than during the late summer, fall and winter seasons, August through April.

Table 2-7: Summary of Lake Ontario Current Data from 2012 to 2016

Direction "To"	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Easterly	Westerly
Total Number of Measured Hours	0	0	154	3551	8681	4824	2478	1629	1581	2038	3508	7777	5392	372	16	0	17210	17049
Percent of Total Measured Hours	0.0%	0.0%	0.4%	8.5%	20.7%	11.5%	5.9%	3.9%	3.8%	4.9%	8.4%	18.5%	12.8%	0.9%	0.0%	0.0%	41.0%	40.6%
Average Speed (cm/s)	N/A	N/A	3.33	6.94	11.75	15.59	10.33	6.53	5.64	6.70	7.73	7.86	6.77	5.04	3.59	N/A	9.40	6.85
Maximum Speed (cm/s)	N/A	N/A	34.55	62.90	66.36	55.55	38.36	31.41	27.22	32.41	50.21	50.48	41.48	23.51	12.78	N/A	66.36	50.48

Notes:

Easterly includes NE, ENE, E, and ESE

Westerly includes SW, WSW, W, and WNW

Reference: (OPG, 2018e)

Table 2-8: Summary of Lake Ontario Depth Averaged Current Speed and Direction from 2012 to 2016

Month	Direction	Depth Averaged Speed – All Directions	Depth Averaged Speed – Easterly	Depth Averaged Speed - Westerly
	Degree from North	cm/s	cm/s	cm/s
January	142	17.5	20.6	12.4
February	145	16.2	18.9	13.1
March	159	13.5	15.5	12.7
April	165	11.8	12.7	12.3
May	181	9.4	12.0	7.8
June	177	9.5	10.5	9.7
July	183	13.3	16.0	11.4
August	193	10.9	12.2	11.1
September	196	9.9	10.3	10.9
October	170	11.8	13.0	11.9
November	159	11.5	13.2	9.8
December	169	12.9	14.4	12.5
Annual Average		12.4	14.1	11.3

Notes:

Easterly includes NE, ENE, E, and ESE

Westerly includes SW, WSW, W, and WNW

Reference: (OPG, 2018e)

2.3.4.2 Lake Water Temperature

Lake Ontario is generally classified as a dimictic lake because it undergoes a complete cycle of isothermal and vertically stratified conditions in a year. The thermal structure generally depends on the season because of large annual variation in surface heat fluxes. In spring and early summer, heating of the lake surface gradually results in potential formation of thermal stratification conditions, with warmer water at the surface layer and cooler water in the bottom layer. The depth of the summer thermocline generally ranges from 5 m to 10 m. Since nearshore water is heated up more rapidly than offshore water in spring, the depth of the thermocline in shallow water near the shore is greater than the depth of the thermocline in deep water offshore. The lake water is isothermal in fall and winter, or sometimes very weakly stratified in winter.

The division between the warmer nearshore waters and the cooler offshore waters is referred to as a thermal bar (i.e., the temperature gradients on the same horizontal plane). The thermal bar generally forms close to, within a kilometer of, the shoreline in April. As deeper water becomes stratified, the thermal bar moves progressively farther offshore, and it disappears when most of the lake is stratified sometime in June (Golder, 2011a).

Lake-wide surface temperatures typically range from freezing in the winter to approximately 20°C in the summer (Beak, 1990 cited in Golder, 2011a). Ice formation in the winter is typically limited to the nearshore areas at the eastern end of the lake within the Kingston Basin (Golder, 2011a).

Ambient water temperature data were collected during 2010 to 2012 as part of the DN Generating Station RCO project EA from 10 historical locations and 21 additional locations (Golder, 2012a). Locations are shown on Figure 2-15. Table 2-9 presents a comparison of historical ambient water temperatures to water temperatures observed during winter 2010 to 2011 and winter 2011 to 2012. Note that additional temperature monitoring (the most recent) includes follow-up thermal plume monitoring that was conducted during the winter of 2017-2018 (OPG, 2018f), which is discussed further in Section 2.3.4.4 and later in Section 4.4.3.

Average monthly ambient water temperatures during the winter of 2010-2011 are similar to the average monthly ambient water temperatures recorded during the historical period. While the average temperature in November 2011 was comparable to the historical maximum average November temperature (period of 1984 to 1996), the average monthly ambient water temperatures recorded during the winter of 2011-2012 are consistently higher than the maximum mean monthly ambient water temperature recorded during the historical period. On average, the water temperatures recorded from December 2011 to March 2012 in the Darlington Nuclear study area (average of 3.8°C) were 2.2°C and 1.7°C warmer than the historical average and the historical maximum monthly temperatures, respectively. On average, the water temperatures recorded from December 2011 to April

2012 in the Darlington Nuclear study area (average of 4.4°C) were 2.1°C and 1.6°C warmer than the historical average and the historical maximum monthly temperatures, respectively.

Considering the period of available ambient water temperature data (i.e., 1984 to 1996 and 2011 to 2012), the ambient water temperatures observed during the winter of 2011-2012 were the warmest recorded near the Darlington Nuclear study area while the ambient water temperatures observed during the winter of 2010-2011 can be considered similar to the historical average (measured between 1984 and 1996).

Table 2-9: Statistical Summary of Ambient Water Temperatures near Darlington Nuclear

Month	Historical (1984 to 1996)			Winter (2010-2011)	Winter (2011-2012)
	Minimum	Average	Maximum	Average	Average
November	4.9°C (1988)	6.0°C	7.7°C (1985)	na ¹	7.7°C
December	1.7°C (1995)	2.7°C	3.4°C (1993)	na ¹	4.5°C
January	0.4°C (1993)	1.1°C	1.5°C (1990)	0.5°C ¹	2.3°C
February	0.3°C (1993)	1.0°C	1.8°C (1991)	1.0°C	2.9°C
March	0.9°C (1992)	1.9°C	2.7°C (1995)	2.2°C	5.4°C
April	3.6°C (1992)	4.8°C	5.9°C (1987)	5.4°C	6.9°C
Jan-Feb ²	0.4°C (1993)	1.1°C	1.4°C (1991)	0.8°C ¹	2.6°C
Dec-Mar ³	1.2°C (1994-1996)	1.6°C	2.1°C (1994-1995)	1.5°C ¹	3.8°C
Dec-Apr ^{4,5}	1.9°C (1992-1993)	2.3°C	2.8°C (1991-1992)	2.7°C ¹	4.4°C

Notes:

1. No data collected before January 23, 2011.
2. Average ambient water temperature from January 1st to February 28th.
3. Average ambient water temperature from December 1st to March 31st.
4. Average ambient water temperature from December 1st to April 30th.
5. Historical data for November 1984 to April 1995 only. No data past March 1996

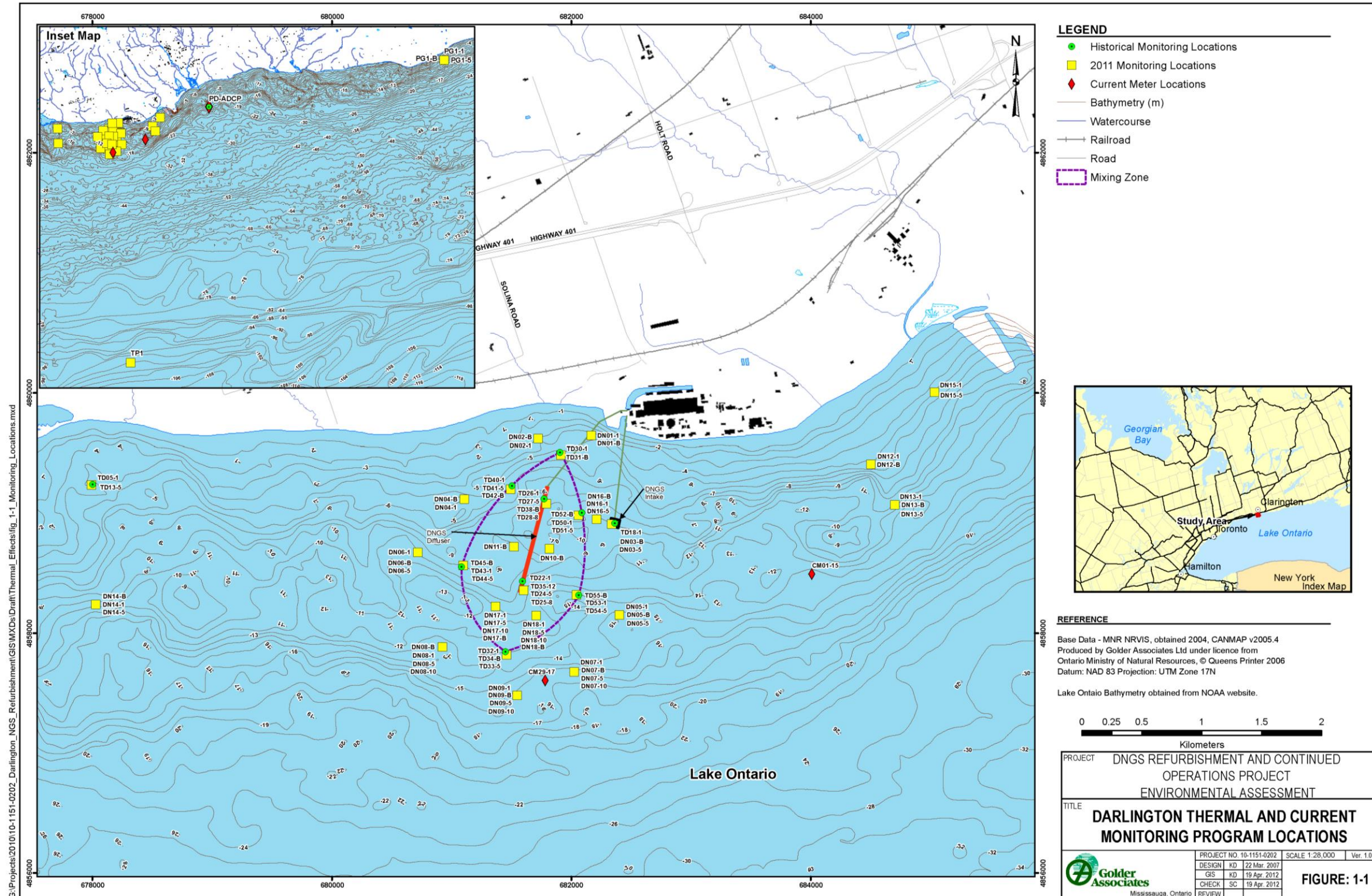


Figure 2-15: Thermal Monitoring Locations for Darlington Nuclear (Golder, 2012a)

2.3.4.3 Water Intake Drawdown

Water is drawn from the lake by DN via an 80-m diameter, porous bottom, submerged intake structure located at a distance of 700 m from the shoreline at a depth of approximately 10 m. Note that the DNGS intake was originally sited at ~10 m below mean water level; however, DNGS intake may currently sit deeper because of change in water level over time. The intake is primarily designed to mitigate fish entrainment and impingement by reducing the intake velocity. Drawdown effects of the intake are limited to 5 m above the intake. Disruptions in the thermal regime are limited to a distance of approximately 250 m from the intake (Golder, 2011a).

2.3.4.4 Thermal Plume Horizontal Characterization

Cooling water is returned to Lake Ontario from DN via a 900-m long submerged diffuser extending approximately 1,600 m from the shoreline. The diffuser is equipped with 90 individual 0.6-m diameter discharge ports that extend from 700 m to 1600 m that protrude through the lake bottom. The water depth along the diffuser ranges from 10 to 12 m (Ontario Hydro, 1997 cited in (Golder, 2011a)).

The discharged cooling water produces either a warm or a cold thermal plume upon release to the bottom of the lake. A warm plume is produced when the discharge temperature is higher than the ambient surface water temperature while a cold plume is produced when the discharge temperature at the bottom of the lake is less than the ambient surface water temperature. Warm plumes are more frequent at DN. Cold plumes are only possible when the plant intake is drawing water that is below the thermal stratification layer. Warm plumes tend to be positively buoyant and spread on the surface while cold plumes tend to rise to the surface due to discharge velocity or to buoyancy effects if the discharge temperature is less than 4°C. Cold plumes either mix vertically in the water column or form a diving plume.

Historical thermal plumes produced by DN were characterized by Burchat and Romanchuk (1997, cited in Golder, 2011a) using data from 33 synoptic plume surveys carried out between 1990 and 1995 by Ontario Hydro.

Additional surface water temperature data were collected in 2011/2012 for the Darlington Nuclear Thermal and Current Monitoring Program. One of the objectives of the program was to assess the potential thermal effects on aquatic species. Water temperatures were measured at several bottom locations where spawning of Round Whitefish potentially occurs. Follow-up thermal plume monitoring to further assess the period of Round Whitefish egg development was conducted during the winter of 2017-2018 to address commitment IIP EA-012 Tasks 4 and 5 of the DNGS Integrated Implementation Plan, as part of the DNGS Refurbishment Follow-up Monitoring Program (OPG, 2018f). The results of both the 2011/2012 and 2017/2018 programs are presented and discussed in Section 4.4.3.

2.3.4.5 Surface Drainage

2.3.4.5.1 Off-Site Drainage

Lake Ontario is the farthest downstream of the five Great Lakes. It is the smallest in surface area but is substantially larger in volume, 1,640 km³, than Lake Erie, which is located immediately upstream and empties into Lake Ontario via the Niagara River. The land area draining directly to Lake Ontario is approximately 64,030 km². The Niagara River constitutes the single most significant inflow to Lake Ontario. The natural outlet from Lake Ontario is the St. Lawrence River.

The watersheds that discharge into Lake Ontario along the shoreline east and west of the DN site are shown in Figure 2-16. These include the Bowmanville-Soper Creek, Westside Creek and Darlington Creek that discharge into the lake to the east of the DN site, and that Tooley Creek, Robinson Creek, Black/Harmony/Farewell Creek and Oshawa Creek flow into the lake on the west side of the DN site. The watersheds range in size from approximately 570 ha (Robinson Creek) to over 16,000 ha (Bowmanville/Soper Creek). The closest creeks east and west of the DN site are Darlington Creek and Tooley Creek, respectively (Golder, 2011a). The main streams and their respective drainage areas and flows are summarized in Table 2-10. The average annual volume of water flowing into Lake Ontario along the shoreline from Bowmanville/Soper Creek to Oshawa Creek is approximately 145 million m³. The risk of flooding at the DN site from natural waterways such as Darlington Creek and Tooley Creek is considered negligible based on historical flooding records and information collected from the local conservation authority presented in Table 2-10.

Table 2-10: Area and Flows for Watersheds East and West of DN (Golder, 2011a)

Location	Bowmanville/ Soper Creek	Westside Creek	Darlington on Creek	Oshawa Creek	Black Harmony/ Farewell Creek	Robinson Creek	Tooley Creek	Total
	East of DN	East of DN	East of DN	West of DN	West of DN	West of DN	West of DN	-
Drainage Area (ha)	16,590	573	1,636	12,048	10,720	570	1,050	43,187
Simulated Monthly Flows (m ³ /s)(1)								
January	2.53	0.09	0.26	1.66	1.67	0.08	0.16	6.5
February	2.89	0.12	0.34	1.94	2.06	0.11	0.22	7.7
March	3.55	0.10	0.28	2.23	2.18	0.10	0.18	8.6
April	2.76	0.07	0.18	1.61	1.45	0.07	0.12	6.3
May	1.13	0.04	0.09	0.72	0.65	0.03	0.05	2.7
June	0.70	0.03	0.06	0.45	0.45	0.02	0.04	1.8
July	0.42	0.02	0.03	0.25	0.27	0.01	0.02	1.0
August	0.60	0.03	0.06	0.42	0.45	0.03	0.04	1.6
September	1.00	0.05	0.10	0.62	0.68	0.04	0.06	2.6
October	1.11	0.04	0.08	0.66	0.61	0.02	0.05	2.6
November	3.03	0.09	0.25	1.86	1.76	0.07	0.15	7.2
December	2.84	0.09	0.26	1.77	1.73	0.08	0.16	6.9
Annual Flows (m ³ /s)	1.88	0.06	0.17	1.18	1.16	0.06	0.10	4.6

Location	Bowmanville/ Soper Creek	Westside Creek	Darlington Creek	Oshawa Creek	Black Harmony/ Farewell Creek	Robinson Creek	Tooley Creek	Total
	East of DN	East of DN	East of DN	West of DN	West of DN	West of DN	West of DN	-
Annual (ha m)	5929	202	523	3729	3669	173	329	14554
Annual (mm)(2)	357	353	320	310	342	304	313	337
2-year(3)	55.5	NA(4)	24.5	43.5	59.7	9.2	12.7	-
5-year(3)	95.1	NA(4)	36.4	69.8	94.9	16.7	23.2	-
10-year(3)	126.3	NA(4)	44.5	91.0	121.8	23.4	29.1	-
25 year(3)	169.5	NA(4)	54.9	123.4	155.4	33.2	39.8	-
50-year(3)	203.1	NA(4)	63.8	147.3	181.3	40.8	48.1	-
100-year(3)	240.2	NA(4)	71.9	208.7	212.9	48.3	55.6	-
Regional Storm(3)	972.1	NA(4)	NA(4)	858.6	673.7	64.9	114.5	-

Notes:

- (1) Simulated average monthly flows at the catchment outlets, based on the Precipitation-Runoff-Modelling-System (PRMS) hydrologic modelling carried out as part of the Source Water Protection Program (provided by Central Lake Ontario Conservation Authority (CLOCA))
- (2) Average annual volume of water distributed on the total watershed area
- (3) Watershed areas and design storm peak flows were obtained from CLOCA
- (4) Not Available

Source: Golder (2011a)

2.3.4.5.2 On-Site Drainage

The DN site consists of approximately 480 ha of land bounded by Lake Ontario to the south, Holt Road to the east, Solina Road to the west, and Highway 401 to the north (Golder, 2011a). The surface drainage at the DN site is essentially divided by a railway line which runs east to west across the site. The area south of the railway tracks generally slopes toward Lake Ontario while the area north of the railway tracks and east of Holt Road slopes toward the east.

The ground surface along the lakeshore in the vicinity of the station is slightly elevated (78 masl) compared to the average Lake Ontario water level of 74.7 masl (Golder, 2011a). The ground surface elevation increases to approximately 100 masl at the railway line and approximately 128 masl just south of Highway 401. A soil disposal mound covering approximately 37-ha, located in the northwest corner of the property, is the highest point on the DN site and has an approximate maximum elevation of 133 masl (36 m above the ground surface).

Figure 2-17 shows 30 sub-catchments located within the DN site. Storm runoff generated at the DN site is conveyed off-site to neighbouring land or directly to Lake Ontario via natural channels/swales and constructed outfalls.

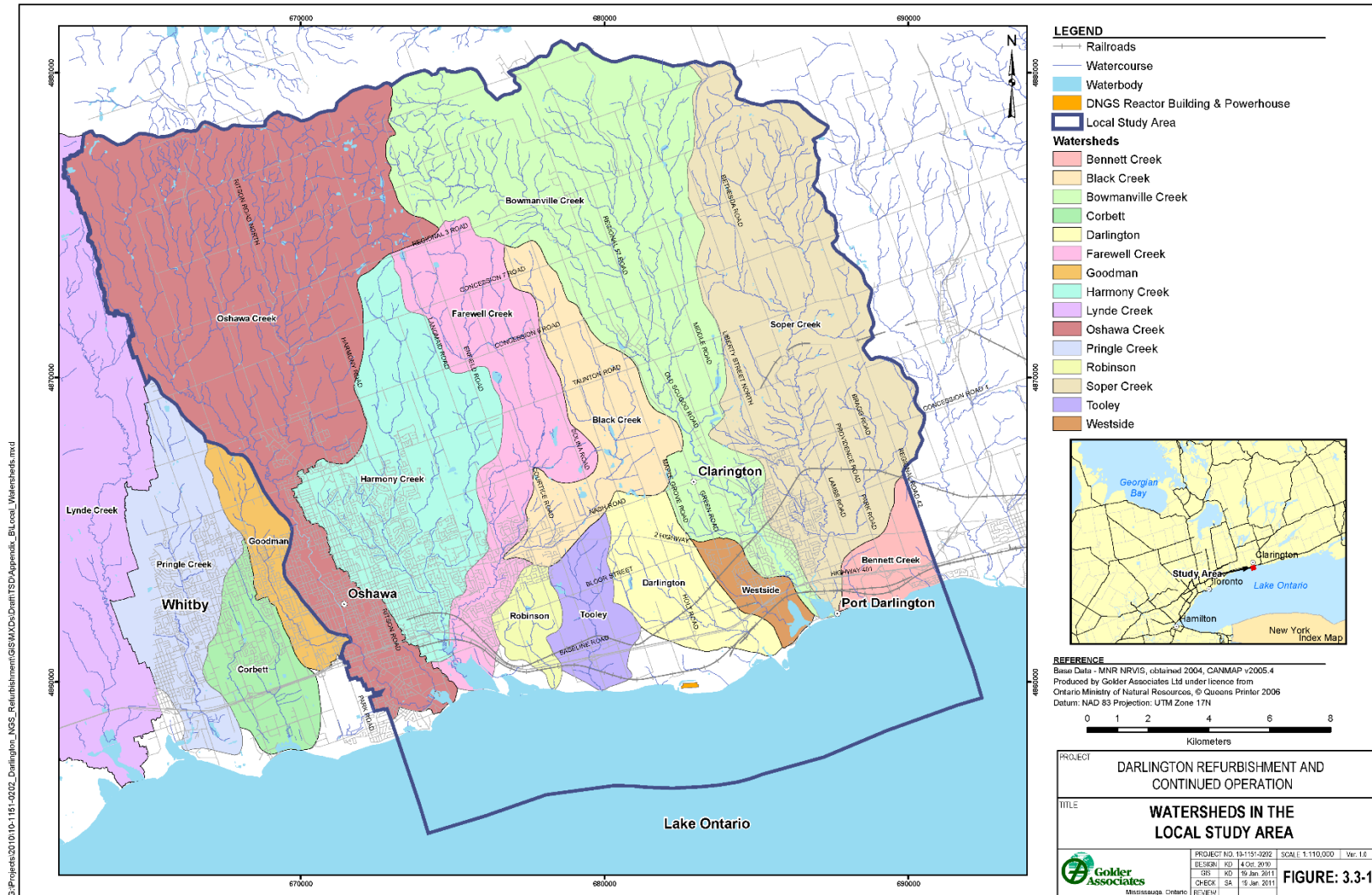


Figure 2-16: Regional Watersheds (Golder, 2011a)

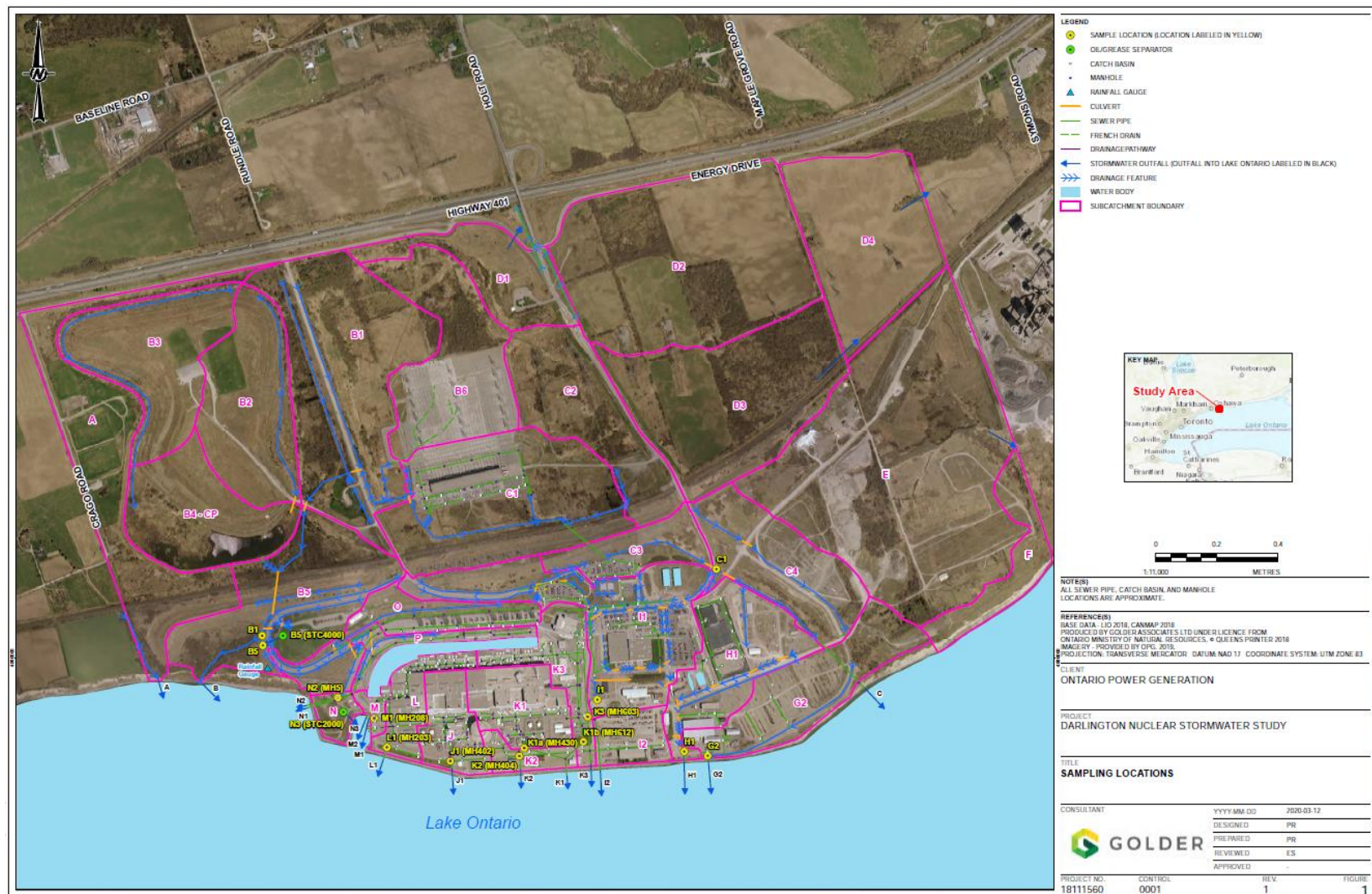


Figure 2-17: Site Surface Water Drainage Catchments (Golder, 2020)

2.3.5 Vegetation Communities

This section provides a brief overview of regional vegetation communities and summarizes existing vegetation communities located in the DN site area. The regional, local and site vegetation communities and other components of the terrestrial environment are described in greater detail in Beacon Environmental (Beacon, 2009a, 2011, 2019a).

Most vegetation communities at the DN site are developing from previous land uses and are not mature. The natural vegetation community classes at the DN site include bluffs, beaches, and forests. However much of the DN site vegetation communities are characterized as cultural communities such as cultural meadows, thickets and woodlands (including plantations) that generally resulted from or are maintained by cultural or anthropogenic disturbances (Beacon, 2009a; Beacon, 2019a). Due to the successional nature of many of the vegetation communities, measurable change can take place over just a few years. Annual reports for the DN Site Biodiversity program (Beacon, 2012, 2013, 2014, 2015, 2016a, 2017, 2018, 2019b, 2019c) and Species at Risk Summaries (Beacon, 2016b) were consulted for this ERA to consider recent changes to the DN site vegetation communities.

2.3.5.1 Terrestrial Vegetation Communities

The DN site is located within the Niagara portion of the Deciduous Forest Region (Rowe, 1972), where the natural forest vegetation is dominated by broadleaved deciduous trees. However, on a regional basis, much of the area has been cultivated over the past century and land use change has resulted in the propagation of numerous anthropogenic vegetation communities. The dominant vegetation cover surrounding the DN site relates to agricultural use, including row crops and pasture land. Some anthropogenic vegetation communities, such as cultural woodland, plantations, thickets and meadow features are in isolated pockets or are located adjacent to natural vegetation communities and are undergoing ecological succession. These areas tend to enhance connectivity and contribute to the natural heritage system (Beacon, 2011).

Natural vegetation features in the region are associated with valley lowlands adjacent to rivers and creeks, and along the Lake Ontario shoreline environment (Beacon, 2011). Oshawa Second Marsh, Westside Marsh, and Harmony-Farewell Iroquois Beach Wetland Complex, three Provincially Significant Wetlands, are located near the DN site.

Coastal wetlands are located between the permanent water of Lake Ontario and adjacent upland areas and provide important habitat for migratory birds during the spring and the fall migrations. The Lake Ontario shoreline supports a variety of features as well as east – west connectivity in the near shore aquatic environment for a variety of waterbirds. The shoreline environment east of Westside Marsh provides extensive areas of relatively undisturbed land that is still well-connected. However, the shoreline connectivity is partially fragmented by St. Marys Cement docks and by the DN site. The northern half of the DN

site represents approximately 200 ha of more or less contiguous wildlife habitat adjacent to the Oshawa Second Marsh-McLaughlin Bay Wildlife Reserve – Darlington Provincial Park complex to the west (Beacon, 2011).

As of 2018, approximately 265 ha, or 57%, of the DN site area is covered by vegetation communities (Beacon, 2019a). Upland vegetation communities and wetland vegetation communities cover approximately 46% and 11% of the DN site area, respectively. Vegetation communities are shown on Figure 2-18 (Beacon, 2019a). These are discussed in more detail in the following sections.

2.3.5.2 Upland Vegetation Communities

Bluffs

Bluff communities are characterized by variable vegetation cover that can range from patchy and barren to herbaceous cover. Generally, bluffs have no more than 10% tree cover because of erosion which results in steep, sometimes near vertical faces that are more than two metres in height. The bluffs are also subject to wave action, and in the case of the DN site, by the lateral movements of water within sand lenses, which are affected by freeze-thaw cycles (Beacon, 2009a). Bluff communities are present west and east of DN and cover a very small portion (<1%) of the DN site (Beacon, 2019a). The bluff community on the west side of DN is dominated by shrubs, mostly willows with Red-Osier Dogwood and Nannyberry. Trees such as Eastern Cottonwood and Balsam Poplar compose a small part of the canopy cover (10%) while more than 60% groundcover is composed of Variegated Horsetail, Canada Goldenrod, Grass of Parnassus, Flat-topped Goldenrod and various sedges, rushes and mosses (Beacon, 2019c). This bluff community on the east side of DN is characterized by open or sparsely vegetated land due to ongoing disturbance. The most abundant vegetation on these bluffs is Colt's Foot (Beacon, 2019c). Bluff communities are identified as BLO 1 on Figure 2-18.

Beaches

The beach community is characterized by patchy vegetation cover that varies from sparse cover to areas with treed cover equal to or less than 60%. Beach areas are subject to active shoreline processes such as wave action, erosion, wind action, and deposition. These areas are located above the seasonal high water mark and are often exposed to extremes in moisture and temperature (Beacon, 2009b). The beach community covers a very small fraction (<1%) of the DN site and much of the area is relatively exposed to the lake (Beacon, 2009b). The area of beach present at the DN site varies annually and seasonally depending on the water level of Lake Ontario. However, beach communities can support a variety of important Great Lakes shoreline plant species. This is more evident in the beach community adjacent to the St. Marys Cement shoreline rather than at the DN site shoreline. Fast-growing, weedy species (e.g., Common Primrose) are the most abundant vegetation on the beaches. Some areas support small colonies of Rough Cockle-

bur, endemic to the Great Lakes (Beacon, 2019c). Beach communities are identified as BBO 1 on Figure 2-18.

Forests

The forest community is characterized by a high level of tree cover (more than 60%) as well as variable substrate types and conditions (Beacon, 2009b) and is classified as a coniferous, deciduous, or mixed forest type. The DN site forest community consists of deciduous and mixed forest classes dominated by such indigenous species as Sugar Maple, White and Green Ash, Manitoba Maple, Trembling Aspen, Balsam Poplar, White Birch, Eastern White Cedar, and Willow species. Forested areas cover about 15.6 ha (about 3%) at the DN site. Deciduous forest communities are identified as FOD 3-1, 4-2, 5-8, 7-2, 7-3 and 8-1, and mixed forest communities are identified as FOM 4-2 and 7-1 on Figure 2-18.

Cultural Woodlands

Cultural woodlands are characterized by a relatively open canopy (less than 60% cover), and arise following anthropogenic disturbance. They cover approximately 5% of the DN site (Beacon, 2019a). They typically consist of a wide variety of indigenous and introduced tree species. At the DN site, groundcover within cultural woodlands consists mainly of grasses and forbs (Beacon, 2019a). Cultural woodlands are identified as CUW 1 on Figure 2-18.

Cultural Meadows

Cultural meadows cover approximately 24% of the DN site (Beacon, 2019a). Dominant vegetation types in field meadows include a variety of grasses and forbs. Field meadows are identified as CUM 1-1 on Figure 2-18.

Cultural Thickets

There are many types of cultural thickets on the DN site; they cover approximately 14% of the DN site (Beacon, 2019a). They are formed during early successional stages following anthropogenic disturbance. Shrubs generally comprise the bulk of the vegetation cover and can include a high proportion of non-native species. Young trees are generally found but usually represent a smaller proportion of cover than shrubs. The composition of ground cover species varies but is generally dominated by a variety of grasses and forbs. The DN site cultural thicket community includes mineral, sumac and chokecherry, identified as CUT 1, 1-1 and 1-3 on Figure 2-18.

Plantations

Plantations have been deliberately planted with trees. Two types of plantations are on the DN site, including White Pine and Scots Pine, identified as CUP 3-2 and 3-3, respectively, on Figure 2-18.

2.3.5.3 Wetland Communities

Marshes

Marsh communities are characterized by dominance by plant species, such as aquatic macrophytes, that are adapted to wet conditions and a small proportion of tree and shrub cover. Marshes typically have variable flooding regimes but the water depth does not exceed 2 m. Marsh areas were found over 17.3 ha on the DN site, or 3.7% of the total area (Beacon, 2019a). Marsh areas include some poorly drained former laydown areas in the eastern portion of the DN site which are now regenerating. The marsh vegetation communities found on the DN site include marshes dominated by horsetail, hanging fen, reed and canary grasses, cattail, phragmites and bur-reed. These are identified by MAM 2-2, 2-7, 2-10, 4-1, and 5, and MAS 2-1, 2 and 2-7, on Figure 2-18.

Open Aquatic

Open aquatic areas at the DN site are identified by a lack of vegetation and a water depth in excess of 2 m. Excluding Lake Ontario, one area within the DN site, the centre of Coot's Pond, is considered open aquatic area. It is less than 0.5 ha in extent.

Submerged Aquatic

Submerged aquatic communities have open water depths up to two metres and are characterized by the presence of submerged or floating-leaved wetland plants. Emergent aquatic plant species may also be present but are not dominant and tree and shrub cover is not present. The submerged aquatic community is very sparse on the DN site (0.4%) and occurs at Dragonfly Pond, shallow areas of Coot's Pond, and Treefrog Pond. The vegetation communities in these areas include species such as Common Bladderwort and stonewort. Ephemeral marsh, dominated by rushes, spike rushes, mint, Water Plantain, and Narrow-leaved Cattail exists along the margins where there is no open water. The submerged aquatic vegetation community is identified by SAS 1-3 on Figure 2-18.

Swamp

Swamps are characterized by the presence of wetland trees and shrubs and a low proportion of tree and shrub cover. Swamps have variable flooding regimes, some standing open water and water depth less than two metres. Swamp areas are the most dominant of the Wetland Community Classes at the DN site, covering approximately 24.8 ha or 5.4% of the total DN site. A number of different swamp community classes were

identified on the DN site. Some had tree species such as willows, green ash and Manitoba maple present, or shrubs such as willows and Red-osier Dogwood. Swamps are identified by SWD 2-2, 3-3, 3-4, 4-1, 4-3 and SWT 2-2 and 2-5 on Figure 2-18.

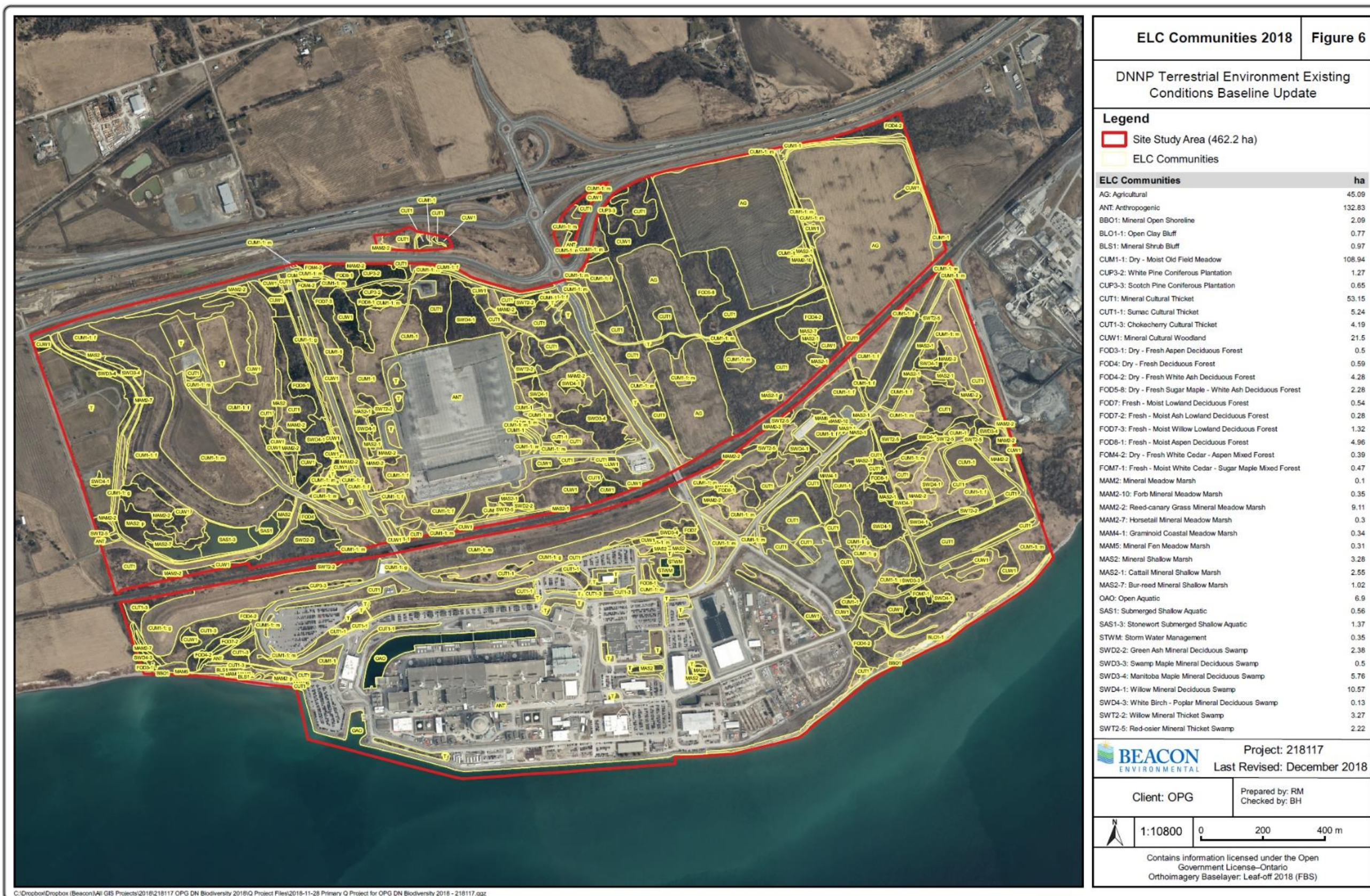


Figure 2-18: Vegetation Ecological Land Classification Communities within the DN Site (Beacon, 2019a)

2.3.5.4 Vegetation Species at Risk

The federal Species at Risk Act [SARA] (2002), the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and the provincial Endangered Species Act (2007) (ESA) protect designated species at risk and their habitat. The provincial act came into effect on June 30, 2008 and it applies to a species once it appears on the official list. The Committee on the Status of Species at Risk in Ontario (COSSARO) is an independent body that classifies native plants or animals in 1 of 4 categories of at risk status under the ESA: endangered, threatened, special concern and extirpated. A list of the plant species that have a species at risk ranking of endangered, threatened or special concern in Ontario, and have been recorded at the DN site, is provided in Table 2-11, along with their regional federal status ranking under Schedule 1 of the federal Species at Risk Act (SARA), and COSEWIC.

The list provided in Table 2-11, includes observations from the 2010 to 2019 inventories. One plant species, Butternut, observed at the DN site during field investigations, is listed as a nationally endangered species provincially and federally (meaning it faces imminent extinction or extirpation). Two individual Butternut trees (an adult and a sapling) have been inventoried at the DN site in the eastern part of the site, last observed in 2019 (Beacon, 2019b). The most serious threat to the Butternut in Canada is a fungal disease known as Butternut Canker. The adult tree has canker but has persisted for more than ten years which suggests that it may benefit from some form of resistance. However, a Butternut Health Assessment (BHA) in 2019 categorized it as non-retainable (Beacon, 2019c). In 2018, a new sapling specimen was found 20 m north of the known tree and was assessed as retainable in 2019. There is potential that additional specimens will be found in the future, although a search in the vicinity of the existing Butternut did not yield more individuals in 2019 (Beacon, 2019b).

Table 2-11: Plant Species at Risk Observed within the DN Site Area

Scientific Name	Common Name	Federal Species at Risk Status ⁽¹⁾	Provincial Ranking ⁽²⁾	Most Recent Year Observed
<i>Juglans cinerea</i>	Butternut Tree	Endangered	Endangered	2019

Notes:

The Provincial Species at Risk in Ontario List and Federal List of Wildlife Species at Risk (Schedule 1 of the Species at Risk Act (SARA)) are frequently revised.

(1) SARA Schedule 1 ranks species at risk as Extirpated, Endangered, Threatened Species and Special Concern. Prohibitions of the Act do not apply to species of Special Concern. COSEWIC is also included.

(2) The provincial Endangered Species Act (2007) came into effect on June 30, 2008 and it applies to these species once they appear on the official list.

Source: adapted from (Beacon, 2019b).

2.3.6 Wildlife Habitat

Wildlife habitat is associated with the vegetation communities, and natural and developed areas found within the DN site. Regionally, over 350 bird species and 50 mammalian species have been inventoried, as well as a number of reptiles and amphibians and insect species of interest.

Within the DN site, most connectivity for wildlife currently exists north of the CN railway line (SENES and MMM, 2009). Ponds or other features on the site either directly on or somewhat removed from the CN corridor enhance this connectivity for some wildlife species. Raby Head Marsh located on the St. Marys Cement property, and the constructed ponds, including Treefrog, Dragonfly, and Polliwog ponds and associated natural features on the DN site, also provide potential local pathways for some species. However, the presence of Highway 401 compromises north – south connectivity between the DN site and other local areas to the north. In 2011, a number of recommendations for indirect and direct enhancement opportunities were identified in the Landscape Connectivity Report (Beacon, 2011) with the objective of maintaining and enhancing corridor function on and within the vicinity of the DN site (Beacon, 2019a). OPG is currently undertaking a study to enhance the DN site wildlife corridor.

Wildlife habitat and species found at the DN site are discussed in the following sections.

2.3.6.1 Wildlife Habitat and Terrestrial Species

Birds

The DN site provides breeding habitat for many bird species as well as habitat for migrant songbirds. A total of 232 different species of birds has been observed at the DN site and almost all have occurred as migrants, even if they breed on the property (Beacon, 2019a; SENES and MMM, 2009). The total annual number of confirmed and probable breeding bird species at the DN site since 1997 has varied between 53 and 69, and was 69 in 2019 (Beacon, 2019a). Bank Swallows have been known to nest at and in the vicinity of the DN site for many years. The DN site also provides waterfowl staging areas and winter habitat at Coot's Pond and along the Lake Ontario shoreline, as well as raptor feeding and roosting areas. The list of confirmed breeding birds for the DN site compiled for 2011 to 2019 is presented in Table 2-12 for areas southwest and southeast of DN as well as within the DN Generating Station area itself.

Table 2-12: Breeding Bird Species Observed during 2011 to 2019 Biodiversity Surveys South of the Rail Line

Common Name	Scientific Name	Southwest	Station	Southeast
Green Heron	<i>Butorides virescens</i>			√
Black-crowned Night Heron	<i>Nycticorax nycticorax</i>	√		
Mute Swan	<i>Cygnus olor</i>	√	√	√
Canada Goose	<i>Branta Canadensis</i>		√	√
Mallard	<i>Anas platyrhynchos</i>	√	√	√
Gadwall	<i>Anas strepera</i>	√	√	√
American Kestrel	<i>Falco sparverius</i>	√	√	√
Red-tailed Hawk	<i>Buteo jamaicensis</i>	√		
Killdeer	<i>Charadrius vociferous</i>	√	√	√
American Woodcock	<i>Scolopax minor</i>	√		
Rock Pigeon	<i>Columbia livia</i>	√	√	√
Mourning Dove	<i>Zenaida macroura</i>	√	√	√
Chimney Swift	<i>Chaetura pelagica</i>	√		
Downy Woodpecker	<i>Picoides pubescens</i>	√		√
Northern Flicker	<i>Colaptes auratus</i>	√	√	√
Willow Flycatcher	<i>Empidonax traillii</i>	√	√	√
Alder Flycatcher	<i>Empidonax alnorum</i>	√	√	√
Great Crested Flycatcher	<i>Myiarchus crinitus</i>	√	√	√
Least Flycatcher	<i>Empidonax minimus</i>	√		√
Eastern Kingbird	<i>Tyrannus tyrannus</i>	√	√	√
N. Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>	√	√	√
Cliff Swallow	<i>Petrochelidon pyrrhonota</i>		√	
Tree Swallow	<i>Tachycineta bicolor</i>	√		√
Barn Swallow	<i>Hirundo rustica</i>	√	√	√
Bank Swallow	<i>Riparia riparia</i>			√
Blue Jay	<i>Cyanocitta cristata</i>	√	√	√
American Crow	<i>Corvus brachyrhynchos</i>	√	√	√
Common Raven	<i>Corvus corax</i>	√		√
Black-capped Chickadee	<i>Poecile atricapillus</i>	√	√	√
Blue-gray Gnatcatcher	<i>Polioptila caerulea</i>	√	√	√
House Wren	<i>Troglodytes aedon</i>	√	√	√
American Robin	<i>Turdus migratorius</i>	√	√	√
Wood Thrush	<i>Hylocichla mustelina</i>			√
Northern Mockingbird	<i>Mimus polyglottus</i>	√	√	√
Gray Catbird	<i>Dumetella carolinensis</i>	√	√	√
Brown Thrasher	<i>Toxostoma rufum</i>	√	√	√
Cedar Waxwing	<i>Bombicilla cedrorum</i>	√	√	√
European Starling	<i>Sturnus vulgaris</i>	√	√	√
Northern Cardinal	<i>Cardinalis cardinalis</i>	√	√	√
Warbling Vireo	<i>Vireo gilvus</i>	√	√	√

Common Name	Scientific Name	Southwest	Station	Southeast
Green Heron	<i>Butorides virescens</i>			√
Black-crowned Night Heron	<i>Nycticorax nycticorax</i>	√		
Mute Swan	<i>Cygnus olor</i>	√	√	√
Canada Goose	<i>Branta Canadensis</i>		√	√
Yellow Warbler	<i>Dendroica petechia</i>	√	√	√
Mourning Warbler	<i>Geothlypis philadelphia</i>			√
American Redstart	<i>Setophaga ruticilla</i>	√		√
Chestnut-sided Warbler	<i>Setophaga pensylvanica</i>			√
Common Yellowthroat	<i>Geothlypis trichas</i>	√	√	√
Chipping Sparrow	<i>Spizella passerina</i>		√	
Field Sparrow	<i>Spizella pusilla</i>	√	√	√
Savannah Sparrow	<i>Passerculus sandwichensis</i>	√	√	√
Song Sparrow	<i>Melospiza melodia</i>	√	√	√
Clay-colored Sparrow	<i>Spizella pallida</i>			√
Swamp Sparrow	<i>Melospiza georgiana</i>		√	√
House Sparrow	<i>Passer domesticus</i>	√	√	√
American Robin	<i>Turdus migratorius</i>	√	√	√
Red-eyed Vireo	<i>Vireo olivaceus</i>	√	√	√
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	√	√	√
Eastern Meadowlark	<i>Sturnella magna</i>	√		√
Common Grackle	<i>Quiscalus quiscula</i>	√	√	√
Brown-headed Cowbird	<i>Molothrus ater</i>	√	√	√
Orchard Oriole	<i>Icterus spurius</i>	√	√	√
Baltimore Oriole	<i>Icterus galbula</i>	√	√	√
House Finch	<i>Haemorhous mexicanus</i>	√	√	√
American Goldfinch	<i>Spinus tristis</i>	√	√	√
Merlin	<i>Falco columbarius</i>			√
Red-tailed Hawk	<i>Buteo jamaicensis</i>			√
Turkey Vulture	<i>Cathartes aura</i>		√	√
Spotted Sandpiper	<i>Actitis macularius</i>	√	√	√
Black-billed Cookoo	<i>Coccyzus erythrophthalmus</i>	√		√
Belted Kingfisher	<i>Megaceryle alcyon</i>	√	√	√
Wild Turkey	<i>Meleagris gallopavo</i>	√		√
Ruby-throated Hummingbird	<i>Archilochus colubris</i>			√
Eastern Wood Peewee	<i>Contopus virens</i>	√		√
Red-breasted Nuthatch	<i>Sitta canadensis</i>	√		√
House Wren	<i>Troglodytes aedon</i>	√		√
Indigo Bunting	<i>Passerina cyanea</i>			√
Bobolink	<i>Dolichonyx oryzivorus</i>	√		√
Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>			√

Source: Beacon (Beacon, 2012, 2013, 2014, 2015, 2016a, 2017, 2018, 2019b, 2019c)

The DN site supports four distinct breeding bird communities: wetland, open country, upland successional, and woodland. The emerging woodland community has only recently been added to biodiversity monitoring.

Wetland

Coot's Pond and other moist or wet thicket areas provide breeding habitats for the wetland bird community (SENES and MMM, 2009). The Yellow Warbler and Red-Ringed Blackbird are the most dominant breeding species in these DN areas, along with Common Yellowthroat, Willow Flycatcher and Song Sparrow (Beacon, 2019a). In 2017 and 2018, threatened Bank Swallows were observed using Phragmites at Coot's Pond as a nocturnal roost (Beacon, 2019a). Wetland breeding species known to use this habitat include Green Heron, Mute Swan, Mallard, Wood Duck, Marsh Wren and Swamp Sparrow. Duck species have declined. Nesting Trumpeter Swans were documented for the first time, which resulted in the non-native Mute Swan pair leaving since both species are territorial and there is insufficient habitat for two pairs of swans (Beacon, 2019a). Coot's Pond also provides waterfowl staging areas and winter habitat. On Lake Ontario, a wide-variety of bird species are associated with the outfall area and with the physical structures (e.g., docks) in the adjacent shoreline at St. Marys Cement (SENES and MMM, 2009).

Open Country

This habitat has been declining in quality and quantity due to succession and land use changes (Beacon, 2019a). Dominating species include Bank Swallow (feeding), Tree Swallow (mainly using nest-boxes), Barn Swallow (feeding), Eastern Kingbird, Song Sparrow, Savannah Sparrow, Red-winged Blackbird, and American Goldfinch. Other species present in small numbers in this community often include: Field Sparrow, Clay-colored Sparrow and Brown-headed Cowbird. Of note, this habitat supports four species protected under SARA: Bank Swallow, Barn Swallow, Eastern Meadowlark and Bobolink (Beacon, 2019a).

Upland Successional

This is the largest and most diverse group of breeding birds present at the DN site. Shrubs and scattered trees characterize this abundant habitat, representing an ecotone between open country and woodland. Dominant species include Mourning Dove, House Wren, Willow Flycatcher, Gray Catbird, American Robin, Cedar Waxwing, Yellow Warbler, Common Yellowthroat, Song Sparrow, Red-winged Blackbird, Common Grackle, and American Goldfinch. Less common species include Northern Flicker, Alder Flycatcher, Brown Thrasher, American Redstart and Orchard Oriole.

Woodland

Woodland species occur in low numbers as well-developed woodland habitat is minimal. Common species include Downy Woodpecker, Eastern Wood-Pewee, Great Crested

Flycatcher, and Black-capped Chickadee, Red-eyed Vireo, American Redstart and Rose-breasted Grosbeak. Eastern Wood-Pewee is designated as special concern both federally and provincially (Beacon, 2019a).

Considered a mix of upland successional and woodland, a woody vegetation area known as Bunting Thicket, in the eastern portion of the site north of the CN railway, provides some of the higher quality migrant bird habitat at the DN site (SENES and MMM, 2009). This area also includes Treefrog, Polliwog and Dragonfly ponds. Bunting Thicket is the largest patch of woody vegetation on the site and the ponds offer additional forage and shelter potential making this thicket attractive to a wider range of bird species.

The bluffs along the Lake Ontario shoreline provide nesting habitat for threatened Bank Swallows. The species typically forages and gathers mud in various parts of the DN site. The lakeshore colonies have been surveyed for over ten years. In 2019 at the DN site, a total of 1,362 burrows were documented with an estimated 817 pairs. All the burrows in 2019 were located in the eastern-most third of the shoreline of the DN site, as is typical. The number of burrows on the DN site has varied during the 2010 to 2019 period from 1,360 burrows in 2017 to 2,617 burrows in 2010 (Beacon, 2019a). Based on the broader evaluation area extending from the site, since 2012 Bank Swallow burrows have decreased, 2019 being the lowest number of burrows recorded (Beacon, 2019a).

Mammals

Thirty-six mammal species have been inventoried at the DN site as a result of incidental observations during field investigations conducted for other purposes since 1997 (Table 2-13) (Beacon, 2019a). Generally, species which frequent the DN site also frequent the St Marys Cement property. Some species are uncommon at the site, such as Black Bear, Pygmy Shrew and Long-tailed Weasel. Wintering habitat for a number of mammals is not well developed but present at the site, especially where some cover was present or slopes provided shelter, such as in the south-eastern area of the property. Mammals that winter at the site include White-tailed Deer, Coyote, Red Fox, Eastern Cottontail and Striped Skunk (SENES and MMM, 2009). In 2013, the Virginia Opossum was recorded as a new mammal species at the DN site. Seven bat species (Big Brown Bat, Silver-haired Bat, Hoary Bat, Eastern Red Bat, Little Brown Myotis, Northern Myotis and Tricoloured Bat) were identified through passive bat surveys in 2018. Bat calls primarily occurred within the southeast area of the DN site (Beacon, 2019c).

Table 2-13: Mammals Species List 1997-2019

Common Name	Scientific Name
MAMMALS	
Virginia Opossum	<i>Didelphis virginiana</i>
Masked Shrew	<i>Sorex cinereus</i>
Smoky Shrew	<i>Sorex fumeus</i>
Pygmy Shrew	<i>Sorex hoyi</i>
Northern Short-tailed Shrew	<i>Blarina brevicauda</i>
Star-nosed Mole	<i>Condylura cristata</i>
Little Brown Myotis	<i>Myotis lucifugus</i>
Northern Myotis	<i>Myotis septentrionalis</i>
Silver-haired Bat	<i>Lasionycteris noctivagans</i>
Tri-coloured Bat	<i>Pipistrellus subflavus</i>
Big Brown Bat	<i>Eptesicus fuscus</i>
Eastern Red Bat	<i>Lasiurus borealis</i>
Hoary Bat	<i>Lasiurus cinereus</i>
Eastern Cottontail	<i>Sylvilagus floridanus</i>
European Hare	<i>Lepus europaeus</i>
Eastern Chipmunk	<i>Tamias striatus</i>
Woodchuck	<i>Marmota monax</i>
Grey Squirrel	<i>Sciurus carolinensis</i>
Red Squirrel	<i>Tamiasciurus hudsonicus</i>
Beaver	<i>Castor canadensis</i>
White-footed Mouse	<i>Peromyscus leucopus</i>
Deer Mouse	<i>Peromyscus maniculatus</i>
Meadow Vole	<i>Microtus pennsylvanicus</i>
Muskrat	<i>Ondatra zibethicus</i>
Norway Rat	<i>Rattus norvegicus</i>
Meadow Jumping Mouse	<i>Zapus hudsonius</i>
Woodland Jumping Mouse	<i>Napaeozapus insignis</i>
Eastern Coyote	<i>Canis latrans</i>
Red Fox	<i>Vulpes vulpes</i>
Black Bear	<i>Ursus americanus</i>
Raccoon	<i>Procyon lotor</i>
Short-tailed Weasel	<i>Mustela erminea</i>
Long-tailed Weasel	<i>Mustela frenata</i>
Mink	<i>Mustela vison</i>
Striped Skunk	<i>Mephitis mephitis</i>
White-tailed Deer	<i>Odocoileus virginianus</i>

Source: (Beacon, 2019a)

Amphibians and Reptiles

Eight species of amphibians and five species of reptiles have been inventoried for the DN site during the breeding season from 2008 to 2019 (Table 2-14) (Beacon, 2019a).

Annual amphibian monitoring surveys (Coot's Pond, Treefrog Pond, Dragonfly Pond, and Polliwog Pond) show that three species occur regularly at the site: Green Frog, American Toad, and Northern Leopard Frog. The Raby Head Marsh on the St. Marys Cement property appears to be a relatively productive area for breeding amphibians and may be the source for the amphibian species that have colonized the DN site. In 2019, breeding Red-backed Salamander was recorded for the first time at DN site, likely an isolated population within the southwest area of the site.

Reptiles are recorded as incidental observations. In 2019, many Eastern Gartersnakes and a DeKay's Brownsnake were found under previously laid snake boards; reports of snakes are generally becoming more frequent (Beacon, 2019a). Two turtle species breed around Coot's Pond and are regularly seen: Midland Painted Turtle (2010-2018) and Common Snapping Turtle (2014-2018). The non-native Red-eared Slider was last observed at Coot's Pond in 2015 (Beacon, 2016a).

Table 2-14: Amphibian and Reptile Species List

Common Name	Scientific Name
REPTILES AND AMPHIBIANS	
American Toad	<i>Bufo americanus</i>
Eastern Gray Treefrog	<i>Hyla versicolor</i>
Western Chorus Frog	<i>Pseudacris triseriata</i>
Northern Leopard Frog	<i>Rana pipiens</i>
Green Frog	<i>Rana clamitans</i>
Wood Frog	<i>Rana sylvatica</i>
Midland Painted Turtle	<i>Chrysemys picta</i>
Common Snapping Turtle	<i>Chelydra serpentina</i>
Red-eared Slider	<i>Trachemys scripta</i>
Eastern Garter Snake	<i>Thamnophis sirtalis</i>
Spring Peeper	<i>Pseudacris crucifer</i>
DeKay's Brownsnake	<i>Storeria dekayi</i>
Red-back Salamander	<i>Plethodon cinereus</i>

Source: (Beacon, 2019a)

Insects and other invertebrates

To date, 299 insect species (butterflies, dragonflies/damselflies, moths, and other insects) have been inventoried for the DN site (Beacon, 2019a). Moths represent the most diverse group (211 species) followed by dragonflies and damselflies (42 species) and butterflies (33

species). Other invertebrate groups that have been identified include tiger beetles (2 species), spiders (2 species) and other insects (9 species). Many of the moths recorded at the site are generalists, commonly associated with regenerating old field habitats, whereas forest and wetland species are rare (SENES and MMM, 2009). The presence of ponds at the DN site add considerably to the level of biodiversity at the DN site and provide habitat for a wide variety of wetland-associated insects such as dragonflies, butterflies, and other aquatic insects (Beacon, 2016a, 2019a). Cultural meadows/open country and thickets provide breeding habitat for Monarch Butterflies which require common milkweed as a caterpillar food and flowering asters and goldenrod which provide sources of nectar for adults migrating south in the fall (SENES and MMM, 2009). Many thousands of monarchs (listed as special concern federally and provincially) pass through the DN site every fall on their southbound migrations, despite the lack of fall roosting sites (large sheltered conifers) (Beacon, 2019a). Since the DN Biodiversity Program was implemented in 1997, migrant butterflies as well as migrant dragonflies which are attracted by the open water, continue to be recorded at the DN site (Beacon, 2019a).

2.3.6.2 Terrestrial Animal Species at Risk

One reptile species, eighteen breeding bird species, three mammals (bats), one insect, and one tree species at risk with a provincial ranking of endangered, threatened or special concern were recorded at the DN site over the period from 2006 to 2019. A list of the animal species that have a species at risk ranking of endangered, threatened or special concern in Ontario and have been recorded at the DN site is provided in Table 2-15, along with their regional federal status ranking under Schedule 1 of SARA and/or COSEWIC.

Table 2-15: Wildlife Species at Risk Observed within the Vicinity of DN

Scientific Name	Common Name	Federal Species at Risk Status ⁽¹⁾	Provincial Ranking ⁽²⁾	Most Recent Year Observed
Amphibians and Reptiles				
<i>Chelydra serpentina</i>	Snapping Turtle	Special Concern	Special Concern	2018
<i>Chrysemys picta marginata</i>	Midland Painted Turtle	Special Concern ³	-	2019
Birds				
<i>Ixobrychus exilis</i>	Least Bittern	Threatened	Threatened	2018
<i>Haliaeetus leucocephalus</i>	Bald Eagle	-	Special Concern	2006
<i>Falco peregrinus</i>	Peregrine Falcon	Special Concern	Special Concern	2019
<i>Chlidonias niger</i>	Black Tern	-	Special Concern	2008
<i>Asio flammeus</i>	Short-eared Owl	Special Concern	Special Concern	2018
<i>Chordeiles minor</i>	Common Nighthawk	Threatened	Special Concern	2018
<i>Chaetura pelagica</i>	Chimney Swift	Threatened	Threatened	2016
<i>Anthus vociferus</i>	Eastern Whip-poor-will	Threatened	Threatened	2018
<i>Contopus cooperi</i>	Olive-sided Flycatcher	Threatened	Special Concern	2019
<i>Contopus virens</i>	Eastern Wood Peewee	Special Concern	Special Concern	2019
<i>Riparia riparia</i>	Bank Swallow	Threatened	Threatened	2019
<i>Hirundo rustica</i>	Barn Swallow	Threatened	Threatened	2019

Scientific Name	Common Name	Federal Species at Risk Status ⁽¹⁾	Provincial Ranking ⁽²⁾	Most Recent Year Observed
<i>Hylocichla mustelina</i>	Wood Thrush	Threatened	Special Concern	2015
<i>Cardellina canadensis</i>	Canada Warbler	Threatened	Special Concern	2011
<i>Icteria virens auricollis</i>	Yellow-breasted Chat	Endangered	Endangered	2009
<i>Dolichonyx oryzivorus</i>	Bobolink	Threatened	Threatened	2019
<i>Sturnella magna</i>	Eastern Meadowlark	Threatened	Threatened	2019
<i>Euphagus carolinus</i>	Rusty Blackbird	Special Concern	Special Concern	2010
Mammals				
<i>Myotis lucifugus</i>	Little Brown Myotis (bat)	Endangered	Endangered	2018
<i>Myotis septentrionalis</i>	Northern Myotis (bat)	Endangered	Endangered	2018
<i>Pipistrellus subflavus</i>	Tri-colored Bat	Endangered	Endangered	2018
Insects				
<i>Danaus plexippus</i>	Monarch (butterfly)	Special Concern	Special Concern	2019
Plants				
<i>Juglans cinerea</i>	Butternut (tree)	Endangered	Endangered	2019

Notes:

The Provincial Species at Risk in Ontario List and Federal List of Wildlife Species at Risk (Schedule 1 of the Species at Risk Act (SARA)) are frequently revised.

(1) SARA Schedule 1 ranks species at risk as Extirpated, Endangered, Threatened Species and Special Concern. Prohibitions of the Act do not apply to species of Special Concern.

(2) The provincial Endangered Species Act (2007) came into effect on June 30, 2008 and it applies to species once they appear on the official list.

(3) Midland Painted Turtle was assessed as Special Concern by COSEWIC in 2018 but currently no Federal status or schedule (Beacon, 2019b).

Source: Beacon (2019a, 2019b)

2.3.7 Aquatic Communities

Aquatic Habitat at the DN site includes tributary watercourses and ponds on the DN site, and the adjacent areas of Lake Ontario. Aquatic habitats support a variety of aquatic plant and animal communities. Depending on the habitat, aquatic biota may include: periphyton, phytoplankton, benthic invertebrates, zooplankton and fishes. Aquatic macrophytes were included as part of vegetation communities discussed in Section 2.3.5.3.

The key aquatic features on the DN site are shown in Figure 2-19 and include:

- The main branch of Darlington Creek and the intermittent upper portions of tributaries to Darlington Creek: Darlington Creek is a Lake Ontario tributary that has been considerably affected by realignment and channelization over much of its length near the DN site to accommodate road and rail corridors and operations at St. Marys Cement;
- The artificially constructed Dragonfly, Treefrog and Polliwog Ponds;

- The intermittent upper portion of a tributary to Lake Ontario at the eastern toe of the Northwest Landfill Area slope; and
- Coot's Pond is a stormwater runoff and settling pond that lies south of the construction waste landfill. Over time, management of the pond according to the DN site biodiversity program has resulted in extensive open water near the eastern end, and emergent vegetation on the margins and dominating the western end of this pond.

The artificially constructed ponds (Dragonfly, Treefrog and Polliwog Ponds) and the intermittent tributaries to Darlington Creek and Lake Ontario do not support fish and are not considered direct fish habitat. Since they are intermittent along most of their reaches aquatic communities in these features are limited. More detail on aquatic habitat in these watercourses and ponds is provided in the following subsections.

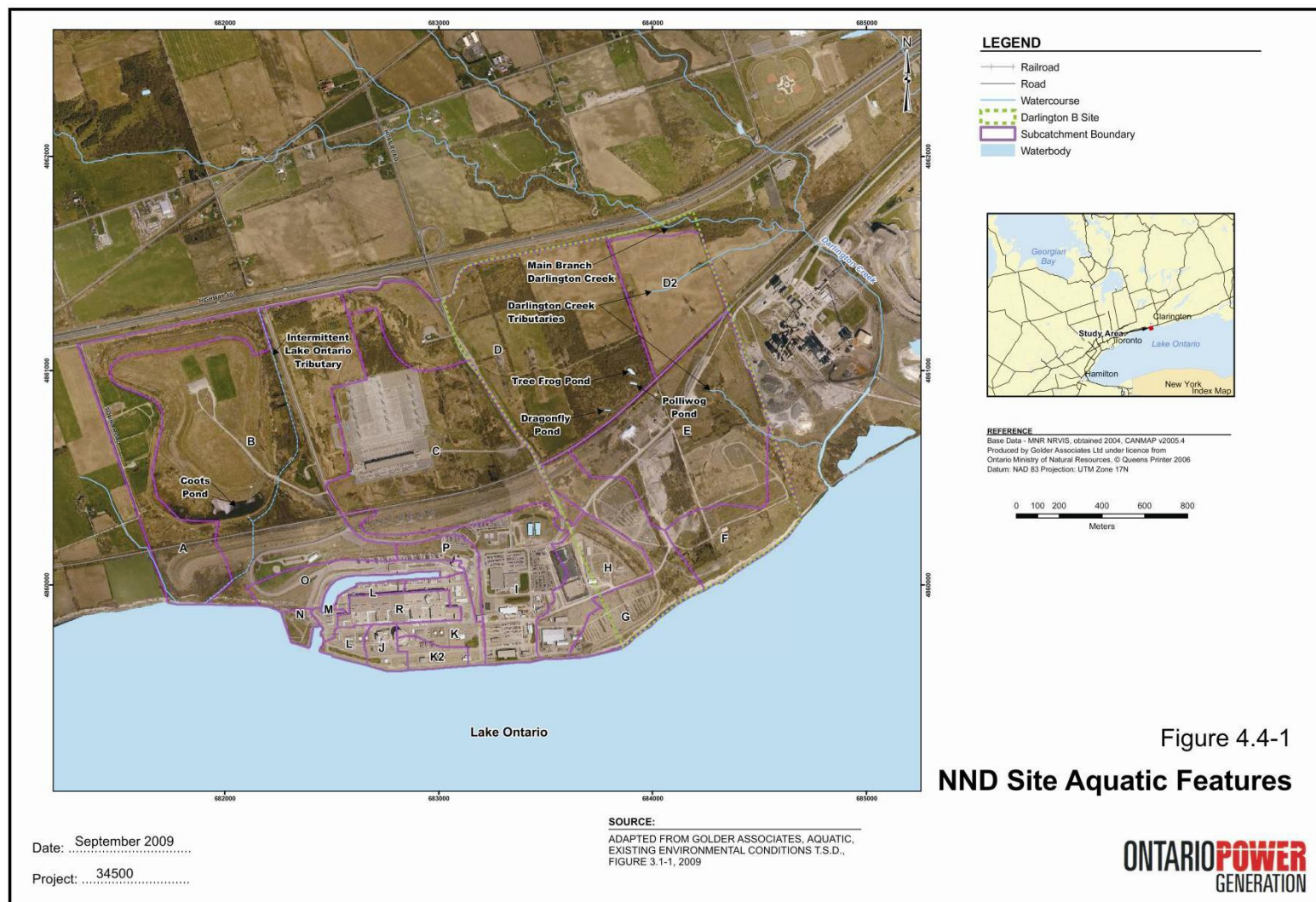


Figure 2-19: Darlington Nuclear Site Aquatic Features (SENES and MMM, 2009)

2.3.7.1 Periphyton, Phytoplankton and Zooplankton Communities

2.3.7.1.1 Lake Ontario

The periphyton community near the DN site is dominated by attached algae (*Cladophora* sp.) (Golder and SENES, 2009). Underwater video habitat monitoring consistently showed abundant attached algae, usually attached to dreissenid mussels but also on pebble-size or larger rocks and bedrock, in the nearshore environment (Ecometrix, 2020; SENES, 2011c, 2011d). Aquatic plants are generally not present in the nearshore area; macrophytes were only noted within the DNGS forebay during a 2010 survey.

Phytoplankton and zooplankton in the nearshore environment occupy the water column and are distributed by ambient current conditions (Golder and SENES, 2009). Seasonal variation in plankton species composition and relative abundances occurs near the DN site.

Macrozooplankton sampling was carried out during spring, summer, and fall periods in 2012-2013 and 2018 at depths ranging from 5 to 30 metres below water surface. The macrozooplankton community is characterized by the following major taxonomic groups: Cladocera, Cyclopoida, Mysidacea, Amphipoda and Ostracoda (Ecometrix, 2020). In 2018, macrozooplankton density and biomass increased from spring to fall, but within each season, varied with depth and substrate. The total number of unique taxa also increased from spring (7) to summer (15) to fall (16). Calanoid Copepods were the most dominant and ubiquitous taxonomic group during the spring, while Cladocera were the most dominant and ubiquitous in the summer and fall (Ecometrix, 2020). Numerical variations in dominant macrozooplankton species, indicating fluctuation in communities throughout the year, is potentially attributed to seasonal variability in the timing of various zooplankton species peaks as well as the influence of lake currents, which are known to affect macrozooplankton distribution.

Native Opossum Shrimp (*Mysis diluviana*) is an important forage species in the Great Lakes and was captured as part of the 2012-2013 (spring, summer and fall) and 2018 (spring) sampling, although in low density in 2018 when water temperatures were warmer than their preferred temperature. Invasive Bloody Red Shrimp (*Hemimysis anomala*) were also captured in low numbers.

2.3.7.1.2 Coot's Pond

Coots Pond has emergent and submerged aquatic vegetation and possesses wetland and open-water pond habitats. An increase in Phragmites around Coot's Pond resulted in a change in the vegetation community designation from Meadow Marsh (MAM2-p) to Mineral Shallow Marsh (MAS2-p) in 2018 to better describe the conditions (Beacon, 2019a). Giant Bur-reed dominates an area on the west side of Coot's Pond (Beacon, 2019c).

2.3.7.2 Benthic Invertebrates

2.3.7.2.1 Lake Ontario

The nearshore environment of Lake Ontario is characterized by hard substrates, and is a high energy environment, supporting a limited density and diversity of benthic invertebrates, mainly in shallow areas (<35 m). Chironomids and amphipods are the major components of the nearshore benthic community. Entrainment studies conducted for DN list the most abundant susceptible invertebrate taxa as copepods/cladocerans, followed by spiny water fleas, rotifers and amphipods (SENES and MMM, 2009). Benthic invertebrates identified during a 2015-2016 entrainment study of the offshore DNGS intake (10 metres depth) included primarily *Echinogammarus* and other amphipods (likely *Gammarus*). Together, these amphipods accounted for approximately 91% (1.4 billion) of the estimated benthic invertebrates entrained annually at DNGS (Ecometrix, 2020).

Invasive zebra mussels (*Dreissena polymorpha*), and now quagga mussels (*Dreissena bugensis*), have colonized the nearshore area of Lake Ontario and influence local benthic habitat and productivity (Golder and SENES, 2009). The presence of these mussels has altered nutrient flow, food webs and productivity in Lake Ontario, which has in turn resulted in a proliferation of attached algae, such as *Cladophora* along the shoreline. Mussels provide a food source for Round Goby, another invasive species, which is now very common in the nearshore environment at DN (SENES and MMM, 2009). Mussels have also been linked to the collapse of *Diporeia*, a native amphipod that previously accounted for more than 80% of total benthic production in Lake Ontario and was a critical component of the diets for most benthic fishes (GLFC, 2007; cited in SENES and MMM, 2009). In 2012-2013, dreissenid mussels (*Dreissena* sp.) were found to be broadly distributed in waters 10 to 30 metres deep, however the highest concentrations were observed within inshore waters at a depth of 12 meters. In 2016 and 2018, all the mussels identified were quagga mussels, which has essentially replaced zebra mussel in the nearshore environment of Lake Ontario (Ecometrix, 2020). The quagga mussels were found in high numbers at locations with hard substrate (cobble and rock).

The benthic invertebrate community was characterized in 2016 and differentiated as epifauna (on-sediment dwellers) or infauna (in-sediment dwellers) components, both at 5, 10, and 15 metre depths. The most abundant and ubiquitous epifauna taxa collected included amphipods, midge larvae (chironomids), oligochaete worms and aquatic sowbugs (isopods). Infauna taxa represented as the most abundant and ubiquitous included the oligochaete worms, water mites (Acari), harpacticoid copepods, seed shrimp (ostracods), and chironomid dipterans. Other taxa such as amphipods, aquatic sowbugs and snails were abundant, but were not as widely distributed. Further benthic community characterization was undertaken in 2018 (5 to 30 metre depths) (Ecometrix, 2020). A total of 64 unique benthic invertebrate taxa from 19 major taxonomic groups were collected with a majority of the unique taxa being dipterans (true flies). Bivalves (exclusively Dreissenid

quagga mussels) and dipterans were most abundant and ubiquitous across the study locations.

2.3.7.2.2 Coot's Pond

Coot's Pond is a stormwater runoff and settling pond. The pond was inhabited by emergent and submergent aquatic vegetation, and habitat quality is sufficient to support a wide array of benthic invertebrates (Golder and SENES, 2009).

2.3.7.3 Fisheries

2.3.7.3.1 Lake Ontario

More than 90 species of fish are known to inhabit Lake Ontario. Almost all of these species make use of nearshore waters of the lake for spawning, rearing, feeding, and migrations. To date, 55 species have been documented within the vicinity of DN through gillnetting, electrofishing, minnow trapping, impingement, entrainment and larval sampling studies (Table 2-16) (Ecometrix, 2020).

The fish community in the vicinity of the DN site is relatively diverse and seasonally dynamic due to the presence of species associated with pelagic, nearshore, tributary, coastal marsh and embayment habitats. Although the community is diverse, fish density tends to be low (Golder and SENES, 2009). The seasonal abundance of many of the fish species may be related to the relatively short periods associated with inshore spawning migrations or may extend throughout seasons when water temperature and weather conditions are favourable for generalized foraging in the nearshore (Golder and SENES, 2009).

Fish community studies conducted near the DN site during the years 2009, 2010, 2011, 2012, 2013, 2018 and 2019 indicated that the fish species commonly present in these years included Alewife (*Alosa pseudoharengus*), Round Goby (*Neogobius melanostomus*), Round Whitefish (*Prosopium cylindraceum*), Lake Trout (*Salvelinus namaycush*), Spottail Shiner (*Notropis hudsonius*), White Sucker (*Catostomus commersonii*), Brown Trout (*Salmo trutta*), Walleye (*Sander vitreus*), Rainbow Smelt (*Osmerus mordax*), and Salmonid species (Ecometrix, 2020). In 2019 specifically, dominant species collected in the spring and summer were Alewife and Round Goby, while dominant species in the fall were Lake Trout and White Sucker (Ecometrix, 2020). Fish impingement sampling conducted from May 2010 to April 2011 identified Round Goby and Alewife to be the dominant fish species (95.8%) affected by impingement at DN (SENES, 2011e). Effects related to impingement and entrainment are discussed in Section 4.4.4.

Studies conducted to date show subtle differences in fish community among years, attributed to natural variation of fish populations (Ecometrix, 2020). Generally, however, the spring and summer fish communities were dominated by small-bodied forage fish (e.g., Alewife), while the fall fish community (with the exception of 2011) was generally dominated

by large-bodied bottom feeding fish, salmonids, and other large-bodied predatory fish (Ecometrix, 2020). Noteworthy is the presence of Atlantic Salmon (*Salmo salar*) in the fall of 2011, summer 2018 and spring of 2019; although listed under SARA Schedule 1 as extinct, their presence may be attributed to re-stocking efforts (e.g., OPG is a sponsor of the Lake Ontario Atlantic Salmon Restoration Program).

Table 2-16: Fish Observed 2009-2019 in DN Studies

Common Name	Species	Most Recent Observation	Year Observed							
		Year	2009	2010	2011	2012	2013	2016	2018	2019
Alewife	<i>Alosa pseudoharengus</i>	2019	•	•	•	•	•	•	•	•
American Eel	<i>Anguilla rostrata</i>	2019			•					•
Atlantic Salmon	<i>Salmo salar</i>	2019			•				•	•
Blacknose Dace	<i>Rhinichthys obtusus*</i>	pre-2007								
Brook Stickleback	<i>Culaea inconstans</i>	pre-2007								
Brook Trout	<i>Salvelinus fontinalis</i>	2012				•				
Brown Bullhead	<i>Ameiurus nebulosus</i>	2019	•	•	•					•
Brown Trout	<i>Salmo trutta</i>	2019	•	•	•	•			•	•
Burbot	<i>Lota lota</i>	2019			•	•		•	•	•
Channel Catfish	<i>Ictalurus punctatus</i>	2019								•
Chinook Salmon	<i>Oncorhynchus tshawytscha</i>	2019				•	•		•	•
Cisco	<i>Coregonus artedii</i>	2018							•	
Coho Salmon	<i>Oncorhynchus kisutch</i>	2018							•	
Common Carp	<i>Cyprinus carpio</i>	2019		•	•				•	•
Creek Chub	<i>Semotilus atromaculatus</i>	pre-2007								
Deepwater Sculpin	<i>Myoxocephalus thompsonii</i>	2018			•			•	•	
Emerald Shiner	<i>Notropis atherinoides</i>	2011		•	•					
Fallfish	<i>Semotilus corporalis</i>	2011			•					
Fathead Minnow	<i>Pimephales promelas</i>	pre-2007								
Freshwater Drum	<i>Aplodinotus grunniens</i>	2018			•				•	
Goldfish	<i>Carassius auratus</i>	pre-2007								
Gizzard Shad	<i>Dorosoma cepedianum</i>	2019	•	•	•				•	•
Johnny Darter	<i>Etheostoma nigrum</i>	pre-2007								
Lake Chub	<i>Couesius plumbeus</i>	2019	•		•					•
Lake Sturgeon	<i>Acipenser fulvescens</i>	pre-2007								
Lake Trout	<i>Salvelinus namaycush</i>	2019	•	•	•	•	•		•	•
Lake Whitefish	<i>Coregonus clupeaformis</i>	2019				•				•
Largemouth Bass	<i>Micropterus salmoides</i>	2019								•
Logperch	<i>Percina caprodes</i>	2009	•		•					
Longnose Dace	<i>Rhinichthys cataractae</i>	2011			•					
Longnose Gar	<i>Lepisosteus osseus</i>	pre-2007								
Longnose Sucker	<i>Catostomus catostomus</i>	2019	•		•					•
Mottled Sculpin	<i>Cottus bairdi</i>	2018						•	•	
Northern Pike	<i>Esox lucius</i>	2011		•	•					•
Northern Redbelly Dace	<i>Chrosomus eos</i>	2008								
Pink Salmon	<i>Oncorhynchus gorbuscha</i>	pre-2007								
Pumpkinseed	<i>Lepomis gibbosus</i>	2010		•						
Rainbow Smelt	<i>Osmerus mordax</i>	2019	•	•	•	•	•	•	•	•
Rainbow Trout	<i>Oncorhynchus mykiss</i>	2019	•		•	•			•	•
Rock Bass	<i>Ambloplites rupestris</i>	2019	•		•				•	•
Round Goby	<i>Neogobius melanostomus</i>	2019	•	•	•	•	•	•	•	•
Round Whitefish	<i>Prosopium cylindraceum</i>	2019	•	•	•	•			•	•
Sea Lamprey	<i>Petromyzon marinus</i>	pre-2007								
Shorthead Redhorse	<i>Moxostoma macrolepidotum</i>	2012				•				
Slimy Sculpin	<i>Cottus cognatus</i>	2018			•		•	•	•	
Smallmouth Bass	<i>Micropterus dolomieu</i>	2019		•						•
Splake	<i>Salvelinus fontinalis</i> x <i>S. namaycush</i>	pre-2007								
Spoonhead Sculpin	<i>Cottus ricei**</i>	2011		•	•					
Spottail Shiner	<i>Notropis hudsonius</i>	2011	•		•					
Threespine Stickleback	<i>Gasterosteus aculeatus</i>	2019			•					•
Trout-Perch	<i>Percopsis omiscomaycus</i>	2009	•							
Walleye	<i>Sander vitreus</i>	2019	•	•	•	•		•	•	•
White Bass	<i>Morone chrysops</i>	2019							•	•
White Perch	<i>Morone americana</i>	2019							•	•
White Sucker	<i>Catostomus commersoni</i>	2019	•	•	•	•			•	•
Yellow Perch	<i>Perca flavescens</i>	2019	•		•	•				•
* - previously recognized as <i>Rhinichthys atratulus</i>										
** - probable misidentified Mottled Sculpin (<i>Cottus bairdi</i>) or Slimy Sculpin (<i>Cottus cognatus</i>)										

2.3.7.3.2 Darlington Creek

Darlington Creek near the DN site supports a warmwater fish community. A habitat assessment of Darlington Creek was conducted in the spring of 2009 and indicated that habitat quality varied considerably along the creek, with higher quality habitat found in the upper reaches and lower quality habitat in the lower reaches in the vicinity of St. Marys Cement near the entrance to Lake Ontario (Golder and SENES, 2009). Historical data compiled for the creek confirmed the presence of ten species between 1998 to 2009 (Common Carp [*Cyprinus carpio*], White Sucker, Brook Stickleback [*Culaea inconstans*], Pumpkinseed [*Lepomis gibbosus*], Bluntnose Minnow [*Pimephales notatus*], Fathead Minnow [*Pimephales promelas*], Blacknose Dace [*Rhinichthys obtusus*], Longnose Dace [*Rhinichthys cataractae*], Creek Chub [*Semotilus atromaculatus*], and Rainbow Trout [*Oncorhynchus mykiss*]).

Fish community surveys were conducted by the Central Lake Ontario Conservation Authority in 2010 and 2015. In 2010, fish collected included Brook Stickleback, White Sucker, Creek Chub, Fathead Minnow, Blacknose Dace, Rainbow Trout, Green Sunfish (*Lepomis cyanellus*) and Northern Redbelly Dace (*Chrosomus eos*) (CLOCA, 2011). The survey in 2015 similarly documented eight species, however in contrast to 2010, Largemouth Bass (*Micropterus salmoides*) was reported and Northern Redbelly Dace was not.

The intermittent tributaries to Darlington Creek on the DN site lack permanent aquatic habitat and do not support fish. They are often dry, based on field visits and review of aerial photographs. Their primary habitat function is the conveyance of water and nutrients to downstream habitats (Ecometrix, 2020; Golder and SENES, 2009). The E tributary had no fish when surveyed during a wet period with water flow. The D2 tributary was dry when surveyed, and overgrown with weeds in the upper swale and corn crops in lower swale. There was no stunting of the crop as would be expected if water was frequently flowing, and no refuge pools were observed. Similar findings were reported for E (no fish) and D2 (dry) tributaries in 2019 (Ecometrix, 2020).

2.3.7.3.3 Artificially Constructed Ponds

Treefrog, Polliwog and Dragonfly ponds are small wetland ponds that are not well-connected to on-site watercourses and have been understood to not support fish (Golder and SENES, 2009), although two Brook Stickleback were seen in Treefrog Pond in 2013 which likely travelled upstream during spring run-off conditions (Beacon, 2019c). Dragonfly and Polliwog Ponds have been observed to dry up completely during summer, while Treefrog Pond remains wet (Beacon, 2019c).

2.3.7.3.4 Tributary to Lake Ontario

The channelized intermittent tributary to Lake Ontario passes between the construction waste landfill and Park Road, skirts south of Coot's Pond and crosses the CN rail line

before reaching Lake Ontario. It receives occasional overflow from the Coot's Pond outfall. Pondered water created by beaver dams constructed along the tributary provide permanent aquatic habitat during periods when there is no flow in the tributary. Fisheries connection to Lake Ontario is limited due to the high gradient and presence of long culvert enclosures (Golder and SENES, 2009). However, the beaver ponds are likely to contain Northern Redbelly Dace, introduced via Coot's Pond outfall.

2.3.7.3.5 Coot's Pond

Habitat quality in Coot's Pond is sufficient to support one small fish species, Northern Redbelly Dace (Golder and SENES, 2009). Coot's Pond was intended to be fish-free to encourage amphibian production. However, Northern Redbelly Dace has become established and has historically been abundant in the pond. Although this minnow species has not been directly observed in biodiversity studies in recent years (Beacon, 2016a), an abundance of fish fry were observed in 2019 (Beacon, 2019b), and in 2018 cormorants and terns were occasionally foraging indicating that fish were present (Beacon, 2019c). The presence of Northern Redbelly Dace is consistent with a habitat of this type, as Northern Redbelly Dace are common inhabitants of wetlands and beaver ponds.

2.3.7.4 Fish Species at Risk

One fish species at risk with a provincial ranking of Endangered has been recorded at the DN site over the period from 2006 to 2019, the American Eel (*Anguilla rostrata*). Provided rankings are shown in Table 2-17, along with regional federal status ranking under Schedule 1 of the federal Species at Risk Act (SARA) and/or COSEWIC.

Table 2-17: Fish Species at Risk Observed in the DN Area

Scientific Name	Common Name	Federal Species at Risk Status (SARA) ⁽¹⁾	Provincial Ranking (SARO) ⁽²⁾	Most Recent Year Observed
<i>Anguilla rostrata</i>	American Eel	No Status ³	Endangered	2019
<i>Acipenser fulvescens</i>	Lake Sturgeon	No Status ³	Endangered	1998 ⁽⁴⁾
<i>Salmo salar</i>	Atlantic Salmon	Extinct (2010)	Not listed	2019
<i>Myoxocephalus thompsonii</i>	Deepwater Sculpin	Special Concern	Not at Risk	2018

Notes:

The Provincial Species at Risk in Ontario List and Federal List of Wildlife Species at Risk (Schedule 1 of the Species at Risk Act (SARA)) are frequently revised.

(1) SARA Schedule 1 ranks species at risk as Extirpated, Endangered, Threatened Species and Special Concern. Prohibitions of the Act do not apply to species of Special Concern.

(2) The provincial Endangered Species Act (2007) came into effect on June 30, 2008 and it applies to species once they appear on the official list.

Source: Ecometrix (2020).

(3) The COSEWIC status of the American Eel and Lake Sturgeon were assessed as Threatened.

(4) Lake sturgeon was observed in 1998 at Bond Head, 13.5 km to the east of the DN Site. This observation suggests that general nearshore nursery/foraging habitat may be present within the region. No Lake Sturgeon was observed at the DN Site.

American Eel

An electrofishing study included observations of 16 adult American Eel in the nearshore in the vicinity of the DN site (Tarandus, 1998). In 2011, one adult American Eel was impinged at DN, and more recently the following number of individuals were impinged: 13 in April 2016 - March 2017, 24 in April 2017 - March 2018, 5 in April 2018 – March 2019, and 0 in April 2019 – March 2020 (Ecometrix, 2020). The most recent observation was during the DN nearshore fish community gillnetting in 2019 where a single American Eel was collected from the Bond Head reference location; the animal was released (Ecometrix, 2020). OPG held permits for American Eel at the Darlington station under the provincial ESA and submitted annual reports to the Ontario Ministry of Natural Resources and Forestry (MNRF) as a condition of those permits. A provincial recovery strategy for the American Eel has been in place since 2013 (MacGregor et al., 2013). OPG has an Ontario ESA Waterpower Agreement for the operation of the Saunders Generating Station on the St. Lawrence River, and as part of that ESA agreement, from 2006 – 2010, OPG stocked 4 million young eels (elvers) in the upper St. Lawrence and Lake Ontario. In addition to the stocking program for the ESA Agreement, OPG participates in the Eel Passage Research Center with Hydro Quebec and New York Power Authority (NYPA) investigating downstream passage for migrating eels on large rivers and OPG runs a trap and transport program to capture large and maturing American Eels; these eels are then transported via truck past the Saunders and Beauharnois (Hydro Quebec) generating stations and released into the St. Lawrence River to reduce turbine mortality.

Lake Sturgeon

Two large juvenile Lake Sturgeon (*Acipenser fulvescens*) were documented at Bond Head, 13.5 km east of the DN site, during a 1998 DN monitoring program thereby suggesting that general nearshore nursery/foraging habitat may be present within the region. Although the DN site nearshore may be considered suitable habitat for large juvenile sturgeon, it is only a small part of widely available similar habitat along the north shore of Lake Ontario (Golder and SENES, 2009). Since this observation from 1998, Lake Sturgeon have not been collected from any fisheries studies near the DN site as shown in Table 2-16 (Ecometrix, 2020).

Atlantic Salmon

Atlantic Salmon were collected during fisheries studies near the DN site in 2011, 2018 and 2019 (Ecometrix, 2020). While the Lake Ontario population of Atlantic Salmon is listed federally as extinct, stocking efforts are ongoing to reintroduce the species back to Lake Ontario. Stocking programs began in 1995, and the Bring Back the Salmon Initiative was implemented in 2006 further increasing efforts to reintroduce this native species back into Lake Ontario (OFAH, 2017). OPG is a sponsor of the Lake Ontario Atlantic Salmon Restoration Program. Atlantic Salmon found in Lake Ontario are likely individuals from the

Atlantic Salmon stocking program and are not considered individuals of the native Lake Ontario Population.

Deepwater Sculpin

During larval tow sampling in 2011, one Deepwater Sculpin (*Myoxocephalus thompsonii*) larva was collected near the DN site (SENES, 2011). An entrainment study at DNGS in 2015-2016 found nine Deepwater Sculpin larvae and estimated 724,746 larvae are entrained annually. One Deepwater Sculpin larva was collected from larval tows in 2018 (Ecometrix, 2020). Data from bottom trawl surveys conducted from 1996 through to 2016 suggest that Deepwater Sculpin populations in Lake Ontario have recovered and current densities and biomass may be similar to those of other Great Lakes (Weidel et al., 2017).

2.3.8 Human Land Use

Land use information includes existing land uses and land use patterns, and any policy framework that guides future growth and development in the Region of Durham.

Information provided in the DN EA (2011) was supplemented with:

- Durham Region Profile Demographic and Socio-economic Data. Planning and Economic Development Department. October 2020. (Durham Region, 2020)
- 2019 Durham Region Business Count. Planning and Economic Development Department. (Durham Region, 2019)
- Durham Region Health Department (DRHD). 2019. Population at a Glance. (DRHD, 2019)
- Review of the Darlington Nuclear Site Specific Survey. Report No. NK38-REP-03443-10004-R000. December. (OPG, 2018e)

2.3.8.1 Regional Land Use: Durham Region and the Municipality of Clarington

DN is located in the Region of Durham, Municipality of Clarington, on the north shore of Lake Ontario. It is approximately 6 km east of the city of Oshawa and approximately 70 km east of downtown Toronto.

Durham Region is characterized by a variety of landscapes and communities including major lakeshore urban communities in the southern portion, and small rural towns, villages, hamlets and farm holdings in the northern portion of the Region. Urban land uses generally parallel the shoreline of Lake Ontario in the communities of Pickering, Ajax, Whitby, Oshawa and Clarington, while rural land uses are found in the communities of Brock, Scugog and Uxbridge in the northern portion of Region. The manufacturing sector within the Region is strong, employing approximately 8.1% of the labour force in 2016, representing the third largest industry after retail trade and health care (Durham Region, 2020). Durham Region hosts ten operating nuclear reactors on the DN site and the Pickering Nuclear site. OPG is the largest employer in the Durham Region, providing 8500

to 9000 jobs (Durham Region, 2019). Agriculture remains an important contributor to the Durham Region's economy and culture.

Urban land uses in the Municipality of Clarington, including residential, commercial and employment, are generally located in Courtice, located approximately 6.4 km northwest of the site, and Bowmanville, located approximately 4 km northeast of the site. Agriculture is a predominant land use in the Municipality of Clarington, and is less predominant in the City of Oshawa west of the site.

2.3.8.2 Agricultural Production

An inventory of Ontario agricultural data was completed for the 2018 DN Site-Specific Survey (OPG, 2018e) using data from the 2016 Census of Agriculture conducted by Statistics Canada. The total area of land used for fruits, vegetables and potatoes in Ontario was estimated at 84,299 ha (843 km²). Of that, 23.8% is used for fruit production, 59.2% is used for vegetable production and 17.0% is used for potato production. Assuming that agricultural production is uniform across Ontario, the total land used for fruit, vegetable and potato production within a semi-circle of 30 km radius centered at DN was estimated to be 336 km², 837 km² and 240 km², respectively. Fruit, vegetable and potato production from within the semi-circle was estimated to be 4.5×10^8 kg, 2.1×10^9 kg and 6.0×10^8 kg, respectively.

2.3.8.3 Water Supply

Three municipal water supply plants are located in the vicinity of DN, which are Oshawa, Bowmanville, and Newcastle Water Supply Plants (WSPs). These plants obtain their water from Lake Ontario. The water supplies for Oshawa and Bowmanville areas are provided primarily from the Oshawa and Bowmanville WSPs, respectively. The more rural areas of Durham are supplied by individual water supply systems from either surface water intakes or ground water wells.

Table 2-18 summarizes the offshore distance and depth of the WSP intakes, capacities, populations served and distance of the intakes from the DN site for each of the DN WSPs ((OPG, 2018e); based on The Oshawa Drinking Water System 2017 Annual Report).

Table 2-18: Water Supply Plant Information (OPG, 2018e)

Water Supply Plant		Distance of Intake from Shore (m)	Intake Depth (m)	Capacity (m ³ /day)	Population Served	Estimated Distance of Intakes from DN (km)
Oshawa WSP	East Intake	924	11	134,000	177,508	7.8 W
	West Intake	831	8			
Bowmanville WSP		1,260	12	36,368	41,858	6.8 ENE
Newcastle WSP		1,070	10	8,173	11,952	13 ENE

2.3.8.4 Recreational Fishing

Recreational fishing and boating are activities undertaken by some residents from the LSA and Durham region. Recreational fishing by local residents is largely on an occasional basis (AECOM, 2011). A number of fishing related activities are organized in the Durham Region, which generally attract tourists and occasional visitors to the region.

A marine prohibited area exists around the intakes and diffusers for the DN site which covers a zone less than 3 km². The objectives of the prohibition are to protect the intake and diffuser structures from damage, and to protect boaters from danger that may arise from the presence of the structures and possibly from turbulence and/or changes in currents in the area. The existing prohibition zone represents a small fraction of the nearshore area that is available for recreational boating and fishing (AECOM, 2011).

2.3.9 Population Distribution

The population for the Durham region is expected to increase from 809,990 in 2021 to 960,000 in 2031 with the population density of urban areas increasing over this time period (Durham Region, 2020). Population growth from 2008 to that estimated for 2018 for the Durham Region was highest among seniors 90 years and older, while populations decreased among adults ages 45 to 49 years and 40 to 44 years (DRHD, 2019). Overall population growth in Durham Region between 2008 and 2018 was highest in Ajax (22%) and Clarington (18%), and decreased growth in Scugog, by 1% (DRHD, 2019). The DN Site is located within the regional municipality of Clarington. Population growth from 2008 to 2018 for Clarington was 18% with a total estimated population of 98,190 in 2018 (DRHD, 2019).

The majority of residents in Durham Region live in urban areas. Over 90% of the population in Pickering, Ajax, Oshawa and Whitby reside in urban areas, whereas, the townships of Brock, Scugog and Uxbridge represent the greatest percentage of the rural population in Durham. Urban/rural population trends for Durham indicate this trend will continue into 2031 (Durham Region, 2020).

Children under the age of 15 comprised 18.0% of Durham's population in 2016, while young persons (aged 15-29), adults (aged 30-64) and older adults (aged 65+) comprised 19.2%, 49.4% and 14.4%, respectively (Durham Region, 2020). Ontario Population Estimates for 2018 (DRHD, 2019) indicate that the 20 to 24 age group is the largest age group for males and 55 to 59 for females in Ontario, while in Durham Region the largest age group was 50 to 59 for males and 50 to 54 for females (DRHD, 2019).

The most recent census data for the region are for 2016. A population of approximately 500,000 resides within a 30 km radius of the DN site, based on 2016 census data shown in Table 2-19 (OPG, 2018e). The bulk of this population (approximately 88% or 478,634 individuals) resides west of the DN site, in the west-south-west to north-north-west sectors, while approximately 12% (64,575 individuals) reside east of the DN site in the north to east-

north-east sectors. Areas south and east of the DN site (south-west to east) are occupied by Lake Ontario. Only 20 residents reside within a 0 to 2 km radius of the DN site and approximately 99,953 individuals reside within 10 kilometers of the DN site.

Table 2-19: Population Distribution Surrounding DN Based on 2016 Census Data

Direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
0-2 km	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
2-4 km	10	3,516	0	0	0	0	0	0	0	0	0	0	0	10	69	50	3,655
4-6 km	1,612	6,803	5,037	315	0	0	0	0	0	0	0	0	0	1,611	1,646	589	17,613
6-8 km	569	14,691	5,809	314	0	0	0	0	0	0	0	0	5	13,936	10,172	247	45,743
8-10 km	751	1,507	196	1,217	0	0	0	0	0	0	0	0	7,389	15,749	5,729	384	32,922
10-12 km	897	221	462	5,004	0	0	0	0	0	0	0	0	15,568	29,781	7,768	251	59,952
12-14 km	390	129	398	3,375	0	0	0	0	0	0	0	0	7,115	27,662	15,599	412	55,080
14-16 km	436	734	943	875	0	0	0	0	0	0	0	0	9,013	21,052	7,294	214	40,561
16-22 km	850	873	691	1,287	0	0	0	0	0	0	0	732	50,773	60,986	4,655	1,394	122,241
22-30 km	1,224	1,562	981	876	0	0	0	0	0	0	0	7,998	141,667	6,853	2,705	1,556	165,422
Total	6,759	30,036	14,517	13,263	0	0	0	0	0	0	0	8,730	231,530	177,640	55,637	5,097	543,209

Source: (OPG, 2018e)

In 2016, the ethnic origin for most Durham Region residents was European (65.2%), North American (28.8%), and Asian (17.7%) descent (Durham Region, 2020). In 2016, 12,535 persons in Durham (2.0% of the population) identified with at least one Aboriginal group, which represents an increase of 3,630 over 2011, when only 8,905 persons (1.5%) identified with one or more Aboriginal groups (Durham Region, 2020). Overall, the ethnicity of the Clarington population was also largely European and North American with very low proportions of ethnic Africans, Asians, Latin/South Americans, Aboriginals and Caribbean individuals (Durham Region, 2020). The nearest First Nations community outside of Durham Region, approximately 35 km from the DN site, is Mississaugas of Scugog Island First Nation (SENES, 2011f).

2.4 Uncertainty in Site Characterization

The DN Site is considered to be well-characterized. No residual uncertainties in the Site Characterization have been identified.

3.0 HUMAN HEALTH RISK ASSESSMENT

The human health risk assessment (HHRA) is a process that evaluates potential health risks to humans exposed to chemical and radiological contaminants. The HHRA accounts for the concentrations and activities of the contaminants in different environmental media; the exposure pathways by which humans may be exposed to these contaminants, and the toxicity of these contaminants to humans through oral, dermal, and inhalation exposure. The HHRA was conducted according to the CSA N288.6-12 standard, with the following supporting documents used where necessary, as documented in this report:

- Health Canada (HC). (2010a). Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0, Prepared by: Contaminated Sites Division, Safe Environments Directorate, September 2010 (Revised 2012).
- Health Canada (HC). (2010b). Federal Contaminated Site Risk Assessment in Canada, Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals (DQRA_{CHEM}), Prepared by: Contaminated Sites Division, Safe Environments Directorate, September 2010.

The HHRA consists of the following steps:

- Problem Formulation;
- Exposure Assessment;
- Toxicity Assessment; and
- Risk Characterization.

3.1 Problem Formulation

The problem formulation provides the objectives, goals, framework and methodology for the risk assessment and consists of identifying the relevant components for the HHRA. These components include the identification of human receptors that may be potentially present in or around the DN Site; the identification of exposure pathways operating on or around the DN Site, based on the fate and transport of chemical and radiological contaminants in the environment; the identification of chemical, radiological, and other stressors; and a conceptual site model that illustrates all of these relationships.

During the problem formulation stage, decisions are made on which COPCs and receptors should be focused on for further assessment in the HHRA. During this planning stage, no conclusions are made regarding effects.

3.1.1 Receptor Selection and Characterization

The receptors for the HHRA were selected to be appropriate for assessment of both chemical and radiological stressors on human health.

3.1.1.1 Receptor Selection

3.1.1.1.1 On-site Non-Nuclear Energy Workers

On-site workers, contractors, and visitors are protected through the Health and Safety Management System Program and the Radiation Protection Program, and are not considered in this HHRA, as discussed below.

OPG's Health and Safety Management System Program is designed to ensure the protection of employees, contractors and visiting members of the public. The program outlines a systems approach used to manage risks associated with activities, products and services of OPG Nuclear operations. Contractors are required to maintain a level of safety equivalent to OPG staff while working at an OPG workplace. Work at DN is subject to safe work planning requirements where safety hazards are identified and mitigating measures are communicated through Pre-Job Briefings. Routine or planned work is governed by approved procedures and operating instructions (OPG, 2018g).

The Radiation Protection Program is designed to ensure that doses for employees, contractors and visiting members of the public are below regulatory limits, and As Low As Reasonably Achievable (ALARA), social and economic factors being taken into account. Employee radiation doses are monitored to ensure they do not exceed exposure control levels that are below regulatory limits. Doses to visitors and contractors are also monitored. Only workers classified as Nuclear Energy Workers (NEWs) may perform radioactive work. Visitors are limited to non-radioactive work and escorted by a qualified NEW. Personal information is collected for the purposes of dose reporting (OPG, 2019b).

Because human exposures on the site are kept within safe levels through the Health and Safety Management System Program and Radiation Protection Program, on-site receptors are not addressed further in the HHRA.

3.1.1.1.2 Members of the Public

Off-site members of the public are defined as "critical groups". Potential critical groups are defined through the site-specific survey and their doses are calculated in the OPG Annual Environmental Monitoring Program (EMP) Reports. Current EMP designs are based on the 2013 site specific survey information; however, site specific surveys were most recently reviewed in 2018 and pathway analyses were updated in 2016. These did not identify any significant changes with the potential to substantially alter the predictions of the ERA or the implementation of the EMP (OPG, 2018e). Any changes to human receptors incorporated in the 2016 update of the DN derived release limits (DRLs) were implemented into the 2019 EMP. The focus of the HHRA is on potential risks to off-site members of the public in the potential critical groups through exposures to chemical and radiological stressors in air and water.

3.1.1.2 Receptor Characterization

The potential critical group receptors used for the risk assessment are considered appropriate for assessment of potential health effects due to chemical and radiological stressors. Their characteristics are described in Appendix E of the 2019 EMP Report (OPG, 2020b) and are presented below.

- The **Oshawa/Courtice** potential critical group consists of urban residents in Oshawa and in the community of Courtice within the Municipality of Clarington located to the W and WNW of the site starting at about 6 km from the site. These residents obtain drinking water from the Oshawa WSP, and grow a small percentage of their annual fruit and vegetable consumption in gardens.
- The **Bowmanville** potential critical group consists of urban residents located to the NE and NNE of the site at distances from 4 to 7 km from DN. These residents obtain drinking water from the Bowmanville WSP, and grow a small percentage of their annual fruit and vegetable consumption in gardens. They also purchase a small percentage of their annual meat, poultry and egg consumption from local farms.
- The **West/East Beach** potential critical group consists of urban residents located to the ENE of the site at distances from 3.5 km to 7 km. These residents obtain their drinking water from both wells and the Bowmanville WSP, and grow a small percentage of their annual fruit and vegetable consumption in gardens. They also purchase a small percentage of their annual poultry and egg consumption from local farms.
- The **Farm** potential critical group consists of agricultural farms (but not dairy farms) located in all landward wind sectors around the DN site at distances from 1.5 km to 10 km. The closest is in the WNW wind sector. Members of this group obtain their water supply mostly from wells and use it for drinking, bathing, irrigation and watering livestock. They also obtain a large fraction of their annual fruit, vegetable and animal product consumption from locally grown products.
- The **Dairy Farm** potential critical group consists of dairy farms located in all landward wind sectors around the DN site at distances from 3 km to over 10 km. The closest is in the N wind sector. Members of this group obtain their water supply from wells and use it for drinking, bathing, irrigation, and livestock watering. They also obtain a large fraction of their annual fruit, vegetable and animal product consumption, including fresh cow's milk, from locally grown products.
- The **Rural Resident** potential critical group consist of residents in rural areas in all landward wind sectors around the site at distances of about 2 km to 5 km. Members of this group obtain about half of their water supply from wells and half from the Bowmanville WSP, and use it for drinking, bathing, and irrigation. They obtain a moderate fraction of their annual fruits, vegetables, poultry and eggs from locally grown products.
- The **Industrial/Commercial** potential critical group consist of adult workers whose work location is close to the nuclear site. The closest location for this group is the

St. Marys cement plant about 1.8 km NE of the site, however, the most affected location due to updated meteorological data is the Courtice Water Pollution Control Plant about 2 km W of DN. Members of this group are typically at this location about 23% of the time. They consume water from the Bowmanville WSP.

- The **Sports Fisher** potential critical group is comprised of non-commercial individuals fishing near the DN site discharge, about 0.5 km S of the DN site. Members of this group were conservatively assumed to obtain their entire amount of fish for consumption from the vicinity of the DN site and spend 1% of their time at the discharge location where atmospheric exposure occurs.
- The **Camper** potential critical group consists of campers at the Darlington Provincial Park, located from 4 to 6 km W of the site at the lakeshore, and includes McLaughlin Bay, a shallow water body where some fishing takes place. The campers are assumed to be in the park no more than six months of the year. They consume drinking water from the Oshawa WSP, and purchase a small fraction of their annual fruits, vegetables, meat, poultry, and eggs from locally grown sources. (OPG, 2020b).

OPG calculates the annual public dose for the three DN potential critical groups which have yielded the highest dose estimates in recent years. Previous to 2019, these were the Dairy Farm, the Farm, and the Rural Resident. In 2019, a change in the Dairy Farm receptor location resulted in a higher relative dose at the West/East Beach Resident location; as such the West/East Beach Resident was identified as one of the three potential critical groups instead of the Dairy Farm (OPG, 2020b). The assessments of the West/East Beach Resident, Farm, and Rural Resident potential critical groups are expected to be protective of the other receptors.

Indigenous peoples were considered in the selection of receptors for the HHRA. Information from engagement with Indigenous communities, councils and organizations gathered during preparation of the DN Refurbishment EA (SENES, 2011f) showed no evidence that indicated use of lands, water or resources for traditional purposes within the Local Study Area. It is possible that a few individuals may carry out these activities in a very limited fashion. However, these activities would be restricted by the urbanization, population density, and preponderance of private land in the area. Based on this, it was concluded that any influence from DN on the health of Indigenous peoples was likely to be bounded by the assessment for potential critical groups located much closer to DN who consume foods local to DN as part of their diet. For example, the farm receptors obtain a large fraction of their fruits, vegetables and animal produce locally, with the nearest location at 1.5 km from DN. While there may be dietary differences, such as more wild game in the Indigenous diet, and more farm produce in the farm diet, both groups will have high local fractions, and overall dietary intakes will be similar. However, the atmospheric dispersion factor from DN to the nearest Indigenous community is orders of magnitude lower than that to the nearest farm receptor. Therefore, it is expected that Indigenous communities would receive doses that are far lower than doses received by the potential critical groups currently assessed in the ERA.

3.1.2 Selection of Chemical, Radiological, and Other Stressors

The DN facility emits chemical and radiological contaminants to air and water in the normal course of operations. Measurements and modelled concentrations of chemical contaminants in air and water, from 2016 to the end of 2019, were screened against available screening benchmarks that are protective of human health to determine if any contaminants of potential concern (COPCs) required further study in the context of human health risk assessment. Where no data were available during the 2016 to 2019 period, older data were used. The selection of COPCs in other environmental media is also discussed in the sections below.

The framework for the chemical COPC screening process used in both the HHRA and EcoRA is illustrated in Figure 3-1. Generally, maximum observed or modelled concentrations were screened against the more conservative of federal or Ontario provincial guidelines. If there was no such guideline, guidelines from other jurisdictions, or the literature were considered and/or derived using federally and/or provincially accepted methods. For COPCs where these criteria were not available, conservative toxicity benchmarks (e.g., no effects levels) or upper limit of background concentrations were used as screening criteria. Maximum measured or modelled concentrations of parameters in air and surface water were compared to the selected screening criteria in order to determine the list of COPCs for further assessment in this HHRA. Subsequent sections for each environmental medium provide hierarchical depictions outlining the specific guidelines considered in the screening process for that medium.

For radionuclides, no formal screening was performed; however, a discussion is provided of radionuclides of interest for DN. Since radionuclides are considered of public interest, relevant radionuclides are carried forward quantitatively in the HHRA without a formal screening assessment.

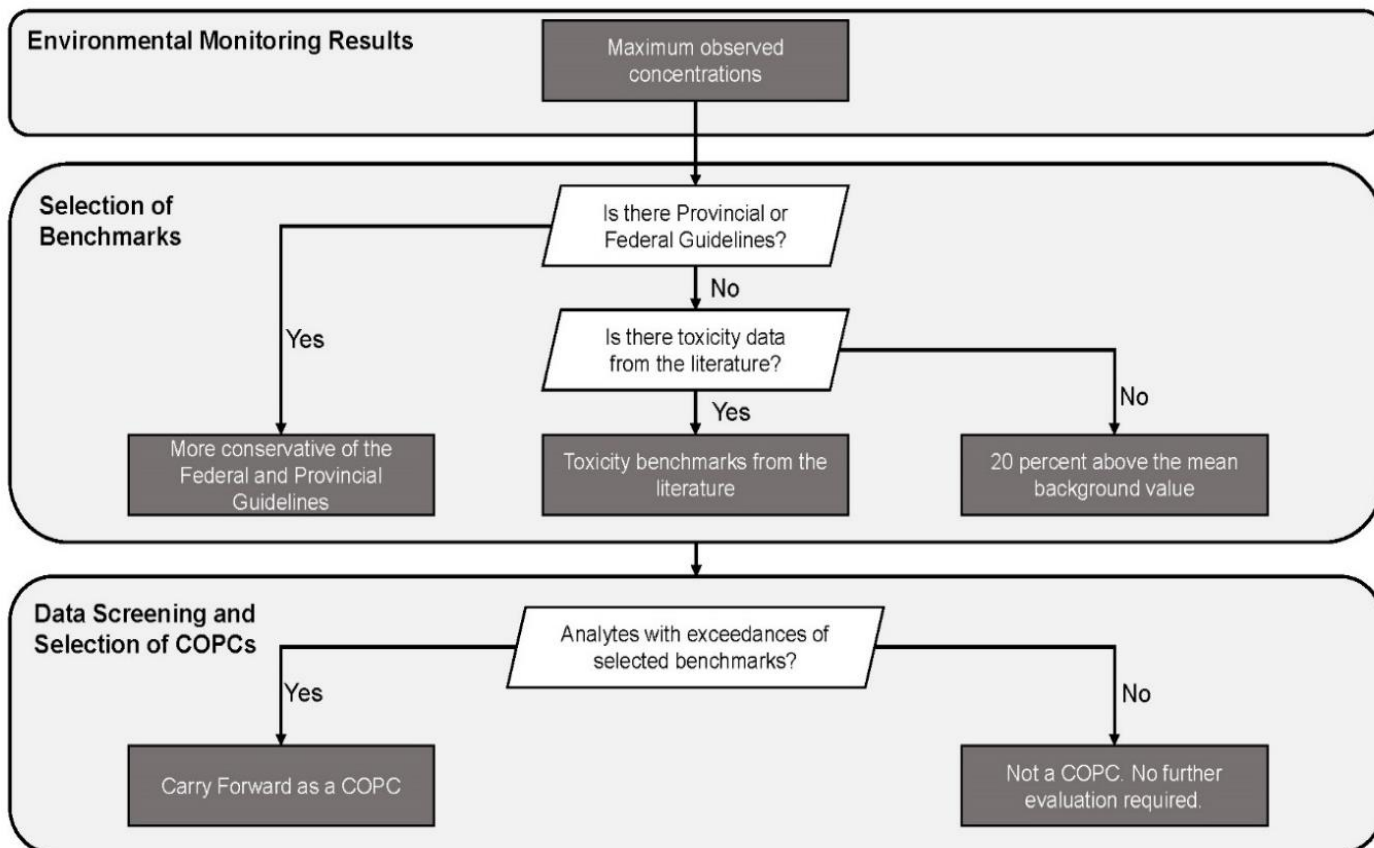


Figure 3-1: Environmental Data Screening Process to Select Chemical COPCs

3.1.2.1 Selection of Chemical COPCs in Air

The main sources of atmospheric emissions result from boiler chemical emissions and fuel combustion. Boiler treatment chemicals including hydrazine, morpholine and degradation products are used within the feedwater system to prevent corrosion in the boilers. These chemicals are released to the atmosphere through controlled boiler venting. Combustion emissions result from the Auxiliary Heating Steam Facility, Standby Generators, Emergency Power Generators, and minor sources. These systems release carbon monoxide, nitrogen oxides, sulphur dioxide, suspended particulate matter, trace volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs).

Emission Summary and Dispersion Modelling (ESDM) Reports

The ESDM Reports from 2016 to 2019 were consulted to aid in chemical COPC selection for air. The main body of each ESDM report presents the estimated atmospheric emissions of COPCs from the DN site (OPG, 2017c, 2018c, 2019d, 2020d). The impact of contaminant emissions was assessed within the ESDM reports by comparing point-of-impingement (POI) concentrations estimated from emission rates to POI exposure benchmarks listed in the MECP publication: *Air Contaminants Benchmarks (ACB) List*:

Standards, guidelines, and screening levels for assessing point of impingement concentrations of air contaminants (the 'ACB list'). The ACB list encompasses the air standards set out in Ontario Regulation (O. Reg.) 419/05, as well as a broader list of additional benchmarks further intended to aid facilities in preparing ESDM reports. Modelled POI concentrations were compared to respective MECP POI benchmarks with corresponding averaging periods, typically ½-hour, 24-hour, or annual averages.

In 2016 and 2017 the O.Reg 346 model was used to provide POI concentrations for ½ hour averaging periods. In 2018, the O.Reg 346 model was no longer used, and modelling transitioned to AERMOD, with POI concentrations provided for 1 hour, 24 hour, and annual averaging periods depending on the MECP POI limits.

The ESDM reports (2016 to 2019) also indicate that OPG conducted a preliminary screening for negligible sources and negligible chemicals using Section 7 criteria in the MECP's Procedure for Preparing an ESDM Report (MOE, 2016, cited in (OPG, 2017c, 2018c, 2019d, 2020d)). Examples of methods used in the ESDM to screen out negligible contaminants include using emission thresholds or de minimus concentrations. Sources and contaminants are identified in the ESDM reports (2016 to 2019) and are the focus of the screening presented in this ERA and discussed below.

Potential additive impacts related to the operation and testing of emergency stand-by power equipment were evaluated as a separate scenario, in accordance with section 20.4 of O. Reg. 419/05 and MECP guidance with respect to assessment of nitrogen oxides emitted from emergency equipment. Specifically, for a generator used for emergency use only, the Environmental Assessment and Approvals Branch approves a screening level of 1,880 µg/m³ - maximum ½-hour average at non-sensitive receptors when certain criteria are met, rather than the Schedule 2 benchmark of 500 µg/m³ - maximum ½-hour average used for non-emergency generator equipment. Note: the application of the screening value was not limited by a sensitive receptor. The air dispersion modelling results for nitrogen oxides from the emergency generator assessments (2017-2019) showed that the maximum predicted concentration remained below the ½-hour POI screening level of 1,880 µg/m³.

In 2016, a higher modelled NO_x POI level was presented than in 2018 to 2019, since during 2016, a standby generator operated for 75 hours, above the 60-hour limit per annum. This was attributed to a reliability issue that has since been addressed. Since the number of hours of operation exceeded the Section 20.4 exemption criteria of 60 hours per annum, NO_x generation through the testing period was modelled and included in the ESDM emission summary table as a source, and therefore included in the air quality screening in 2016 (Appendix A Table A-1). The air quality screening for the HHRA is further discussed below.

HHRA Air Screening

For the purposes of this human health risk assessment, maximum predicted POI concentrations for each of the modelled parameters in Table 1 of the ESDM reports were

compared to selected health-based screening benchmarks. Selection of health-based screening criteria followed the hierarchy depicted in Figure 3-2. Preferred primary guidelines consisted of the most conservative of the MECP Air Contaminants Benchmarks (ACBs), and the more recently available Environment and Climate Change Canada (ECCC) Canadian Ambient Air Quality Standards (CAAQS). CAAQS are only available for four parameters. Secondary guidelines consisted of the MECP ambient air quality criteria (AAQCs, 2016, updated 2019), while tertiary guidelines were the Texas Commission on Environmental Quality Effects Screening Levels (TCEQ, 2016).

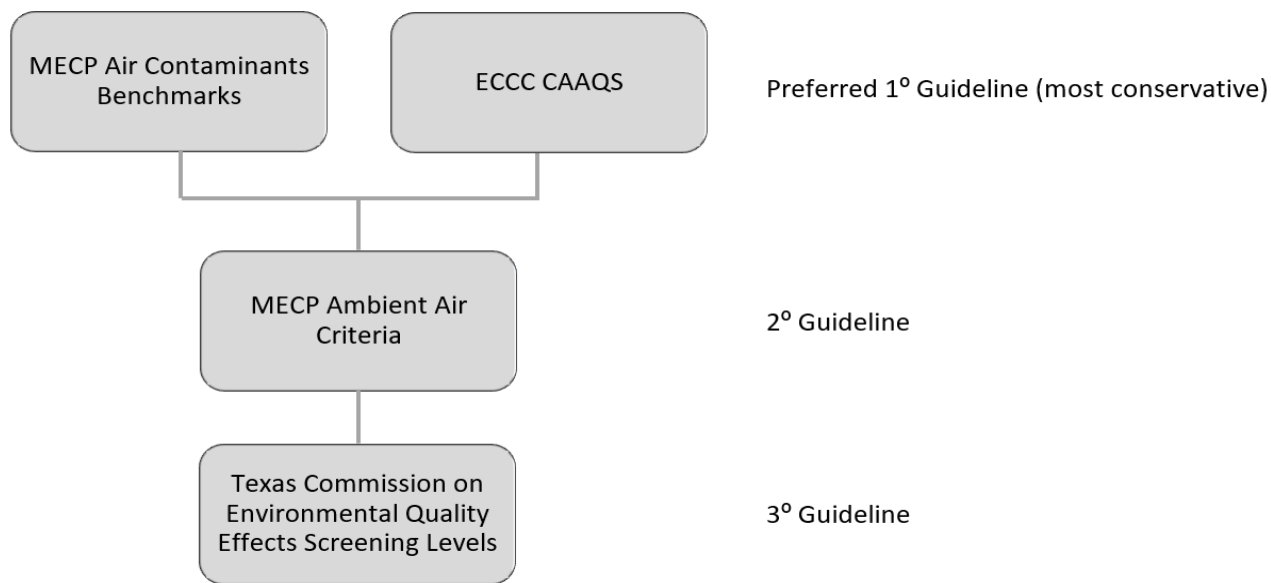


Figure 3-2: Hierarchy of Screening Criteria for HHRA Chemical COPCs in Air

The HHRA screening of chemical COPCs in air is shown in Table A-1 (Appendix A). Modelled POI concentrations were directly compared to guidelines with the same averaging periods (e.g., ½-hour, 24-hour, or annual) or were adjusted to meet the timeframes of the relevant screening criteria. With the exception of nitrogen oxides, no other modelled concentrations exceeded selected screening criteria from 2016 to 2019. Maximum POI concentrations of nitrogen oxides in 2016 exceeded the 1-hour ECCC CAAQS ($526 \mu\text{g}/\text{m}^3 > 113 \mu\text{g}/\text{m}^3$); and the annual ECCC CAAQS ($41 \mu\text{g}/\text{m}^3 > 32 \mu\text{g}/\text{m}^3$). Furthermore, in 2018 and 2019, nitrogen oxides exceeded the 1-hour ECCC CAAQS ($205 \mu\text{g}/\text{m}^3 > 113 \mu\text{g}/\text{m}^3$).

Based on these results, and as shown in Table A-1 in Appendix A, nitrogen oxides were carried forward as a chemical COPC in air for assessment of human health.

3.1.2.2 Selection of Chemical COPCs in Surface Water

The surface water screening is based primarily on measurements of chemical COPCs in lake water. In addition, concentrations of chemical parameters in the CCW discharges from

2016 to 2019, and concentrations of chemical parameters in 2019 stormwater discharges to Lake Ontario, were screened to ensure that the list of chemical COPCs was complete. If a COPC was identified in lake water, effluent or stormwater, it was forwarded for further consideration in the human health risk assessment.

3.1.2.2.1 Lake Water Sampling

Surface water sampling was conducted quarterly (spring, summer, early fall, and early winter) in 2019 (Ecometrix, 2020). This program included nine sampling stations within the offshore, nearshore, and the (future) St. Marys embayment area¹ as well as one reference station (SW2) about 60 km east near the town of Cobourg (Appendix B, Figure B-1). The results of this sampling program were used as the basis for the screening of COPCs in Lake Ontario.

Selection of surface water screening criteria followed the hierarchy depicted in Figure 3-3. Maximum measured concentrations from the 2019 sampling program were compared to the following criteria to determine potential COPCs, in order of preference:

- The more conservative of:
 - Health Canada Canadian Drinking Water Quality Guidelines (HC, 2019); or,
 - Ontario Drinking Water Standards (ODWS) for Potable Ground Water (MOE, 2011) and the related GW1 Component Values in Ontario Regulation 153/04;
- Guidelines available from other jurisdictions (e.g., British Columbia Ministry of Environment (BC MOE) Source Drinking Water Quality Guidelines; United States Environmental Protection Agency (US EPA) Regional Screening Levels (RSLs) for resident tap water - target hazard quotients (THQ) of 0.2);
- Modified toxicity values available from other sources (e.g., World Health Organization (WHO); US EPA Integrated Risk Information System (IRIS); Health Canada (HC)), or background typically found in drinking water (Agency for Toxic Substances and Disease Registry (ATSDR);
- 95th Percentile Background Concentrations (based on 2019 data from sampling station SW2 at Cobourg).

¹ The St. Marys embayment does not refer to an actual embayment, but instead the future embayment that would be created as a result of the proposed DNNP infill area.

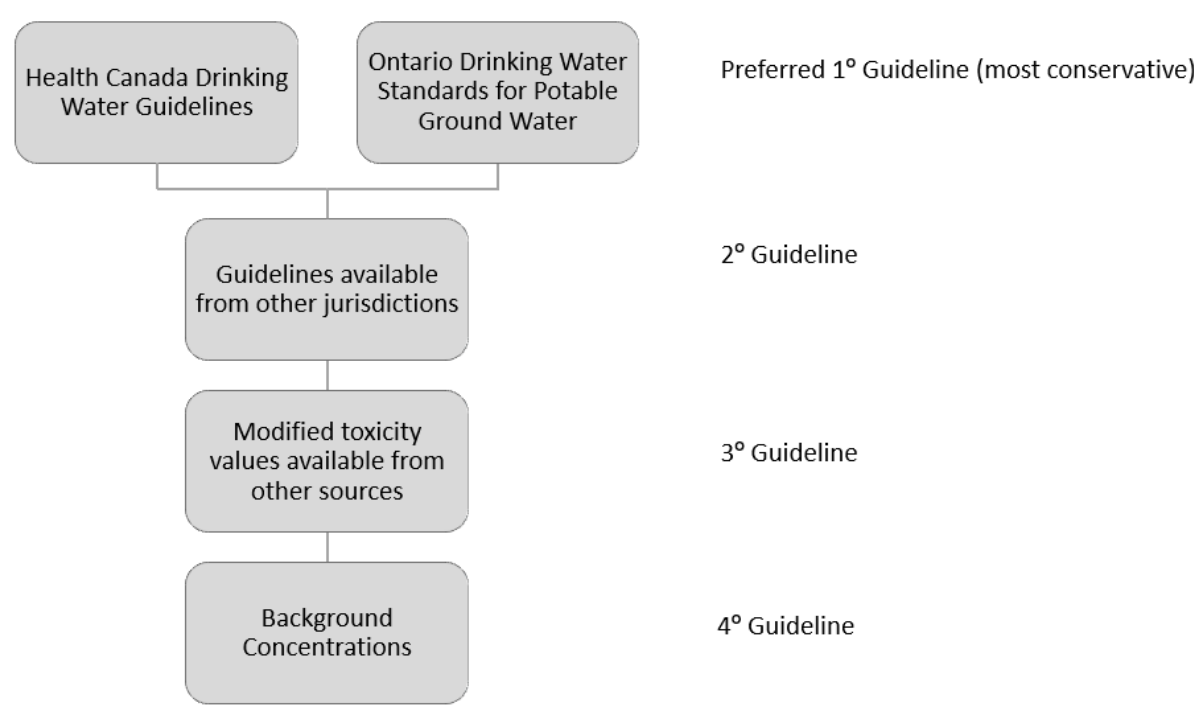


Figure 3-3: Hierarchy of Screening Criteria for HHRA Chemical COPCs in Surface Water

Chemicals with maximum concentrations exceeding the screening criteria were carried forward as chemical COPCs in this assessment. Selections of human health screening criteria are shown in Table A-2 in Appendix A. The results of this screening can be found in Table A-3 in Appendix A.

Hydrazine does not have a Health Canada drinking water guideline, or an ODWS. However, the U.S. EPA estimated that a hydrazine concentration of 0.01 µg/L corresponds to a cancer risk level of one in one million (1×10^{-6}) (EC and HC, 2011; US EPA and IRIS, 1988), based on a drinking water intake rate of 2 L/day and no exposure amortization. This value was used as a human health screening level for hydrazine in water. As shown in Table A-3, the maximum analyzed concentration of hydrazine in Lake Ontario water was 0.11 µg/L, compared to a drinking water cancer risk value of 0.01 µg/L estimated by U.S. EPA (US EPA and IRIS, 1988). As such, hydrazine was carried forward as a COPC for further assessment in the HHRA. Note, the maximum hydrazine concentration in Lake Water of 0.11 µg/L is marginally above the best achievable detection limit of 0.10 µg/L.

Zirconium does not have a Health Canada drinking water guideline or an ODWS. However, the U.S EPA has established a Regional Screening Level (RSL) for tap water of 0.16 µg/L, based on a non-cancer target hazard quotient (THQ) of 0.2 (US EPA, 2020). As shown in Table A-3, the maximum concentration of zirconium in Lake Ontario water was 0.34 µg/L,

compared to the U.S. EPA RSL for tap water of 0.16 µg/L (THQ = 0.2); therefore, zirconium was carried forward as a COPC for further assessment in the HHRA.

Similarly, lithium does not have a Health Canada drinking water guideline or ODWS. The U.S. EPA RSL for tap water of 4 µg/L (THQ = 0.2) was considered, however this was below the 95th percentile background concentration measured near Cobourg in 2019. The selected guideline defaulted to the background concentration of 4.71 µg/L. The maximum concentration in Lake Ontario water of 10.2 µg/L exceeded the 95th percentile background concentration in Lake Ontario near Cobourg of 4.71 µg/L. Therefore, lithium was carried forward as a COPC for further assessment in the HHRA.

In summary, zirconium and lithium were both carried forward as COPCs for further assessment in the HHRA; however, whether their presence in lake water is attributable to OPG operations is not known.

As shown in Table A-3, the total coliforms, fecal coliforms, and *Escherichia coli* exceed the 95th percentile background concentrations (220, 20, and 20 CFU/100mL respectively). However, the maximum concentrations of total coliforms, fecal coliforms, and *Escherichia coli* (2100, 2000, and 2000 CFU/100mL, respectively) were found at one shallow lake sampling station located at the mouth of Darlington Creek. Aside from this location, the highest concentration in the remaining lake water samples was 260 CFU/100mL. These biological parameters are not associated with the DN site and the data suggests Darlington Creek as an input source. Furthermore, these biological parameters are not considered to be hazardous substances, so are not COPCs under CSA N288.6. As such, total coliforms, fecal coliforms, and *Escherichia coli* have not been considered to be COPCs for human health.

Based on the results of the screening shown in Table A-3 in Appendix A, hydrazine, lithium and zirconium were carried forward as chemical COPCs in water for assessment of human health.

3.1.2.2.2 Liquid Effluent Sampling

Clause 0.2.2 and 7.2.5.2 of CSA N288.6 discuss screening of liquid effluents, highlighting the relationship of effluent monitoring programs to environmental risk assessment and the screening process. Information from 2016 to 2019 on the concentration of COPCs discharged in liquid effluents into the environment was available from DN ECA reports and MISA reports. This information was assessed to aid in COPC selection to ensure that the lake water chemical COPC selection was complete. DN liquid effluents originate from the following systems:

- Condenser Cooling Water (CCW) System;
- Service Water Systems;
- Steam and Feedwater System;
- Water Treatment Plant (WTP);

- Radioactive Liquid Waste Management System (RLWMS); and
- Inactive Drainage System.

As shown in Figure 2-4, all liquid effluents from DN are discharged into the CCW (either via the Intake Forebay or directly to the CCW Discharge Duct). Note, screening of stormwater was undertaken separately for the HHRA, with results presented in Section 3.1.2.2.3.

Waterborne effluent from DN discharged to the CCW duct is diluted in Lake Ontario through the diffuser. Concentrations of COPCs measured in the CCW represent concentrations prior to release to Lake Ontario via the diffuser. Effluent quality results were therefore converted to estimated concentrations in the mixing zone using a dilution factor of 7 at the diffuser (OPG, 2016d). The outfall dilution factor of 7 is a recommended site-specific parameter described in the COG DRL Guidance (COG, 2013a). The mixing zone is defined as a one-kilometer square area around the diffuser where the diffuser structure is designed to create turbulent mixing, thereby limiting the surface water temperature rise to a maximum of 2 degrees Celsius above ambient lake temperature at the edge of the one-kilometre square mixing zone (Golder, 2012a).

3.1.2.2.1 Monitoring for ECA Requirements

As part of the ECA requirements, the effluent from the CCW is sampled and analyzed for compliance with effluent limits for unionized ammonia, hydrazine, morpholine, pH, and TRC (OPG, 2017d, 2018h, 2019e, 2020e). For each of these chemicals, the maximum concentration in the mixing zone was estimated based on the maximum measured concentration in the CCW and a dilution factor of 7 at the diffuser (OPG, 2016d). Estimated mixing zone concentrations from 2016 to 2019 were screened against the same screening criteria as the lake water samples.

As previously discussed, (Section 3.1.2.2.1), hydrazine does not have a Health Canada drinking water guideline, or an ODWS. However, the U.S. EPA estimated a drinking water cancer risk value of 0.00001 mg/L based on a cancer risk level 1×10^{-6} (HC, 2019; US EPA and IRIS, 1988). As shown in Table A-4, the estimated maximum effluent concentration of hydrazine exceeds the drinking water value of 0.00001 mg/L. Additionally, the maximum concentration of hydrazine estimated in the mixing zone is 0.0009 mg/L, compared to the drinking water cancer risk value of 0.00001 mg/L. As such, hydrazine was carried forward as a COPC related to CCW effluent in the HHRA. Note, the maximum hydrazine concentration measured in the CCW of 0.006 mg/L is above the detection limit used in the ECA reports of 0.001 mg/L.

Unionized ammonia, pH and TRC are listed in Table A-4, however Health Canada has indicated the guidelines as 'none required' for human health protection. For unionized ammonia, a guideline value is not necessary as ammonia is produced in the body and efficiently metabolized in healthy people; and there are no adverse effects at levels found in drinking water (Health Canada, 2019). There is no evidence of an association between the pH of the diet (food or drinking water) and direct adverse health effects (Health Canada,

2019). Health Canada has classified chlorine as unlikely to be carcinogenic to humans and no adverse health effects have been observed in humans from consuming water with high chlorine levels (up to 50 mg/L) over a short period of time (HC, 2019).

Based on this assessment, and as shown in Table A-4 in Appendix A, hydrazine was identified as a COPC for the HHRA.

3.1.2.2.2 Monitoring for MISA Requirements

Effluent monitoring is required under the MISA program, as described in Section 2.2.2.1.2. As part of the MISA program, COPCs for monitoring are identified for the following Control Points:

- Radioactive liquid waste (RLW) management tanks, Control Point 01 on Figure 3-4, given the MISA Control Point designation 0100;
- Water treatment plant (WTP) neutralization sump, Control Point 04 on Figure 3-4 given the designation 2200; and,
- Building effluent treatment facility lagoon, Control Point 17 on Figure 3-4, given the designation 5000 (note that this is the outlet for the inactive drainage mentioned in Section 3.1.2.2.2) or Control Point 19, given the designation 5100 as the alternate to 5000.

The other MISA Control Points at DN are normally not monitored because their corresponding effluent water streams are directed to another control point within the plant.

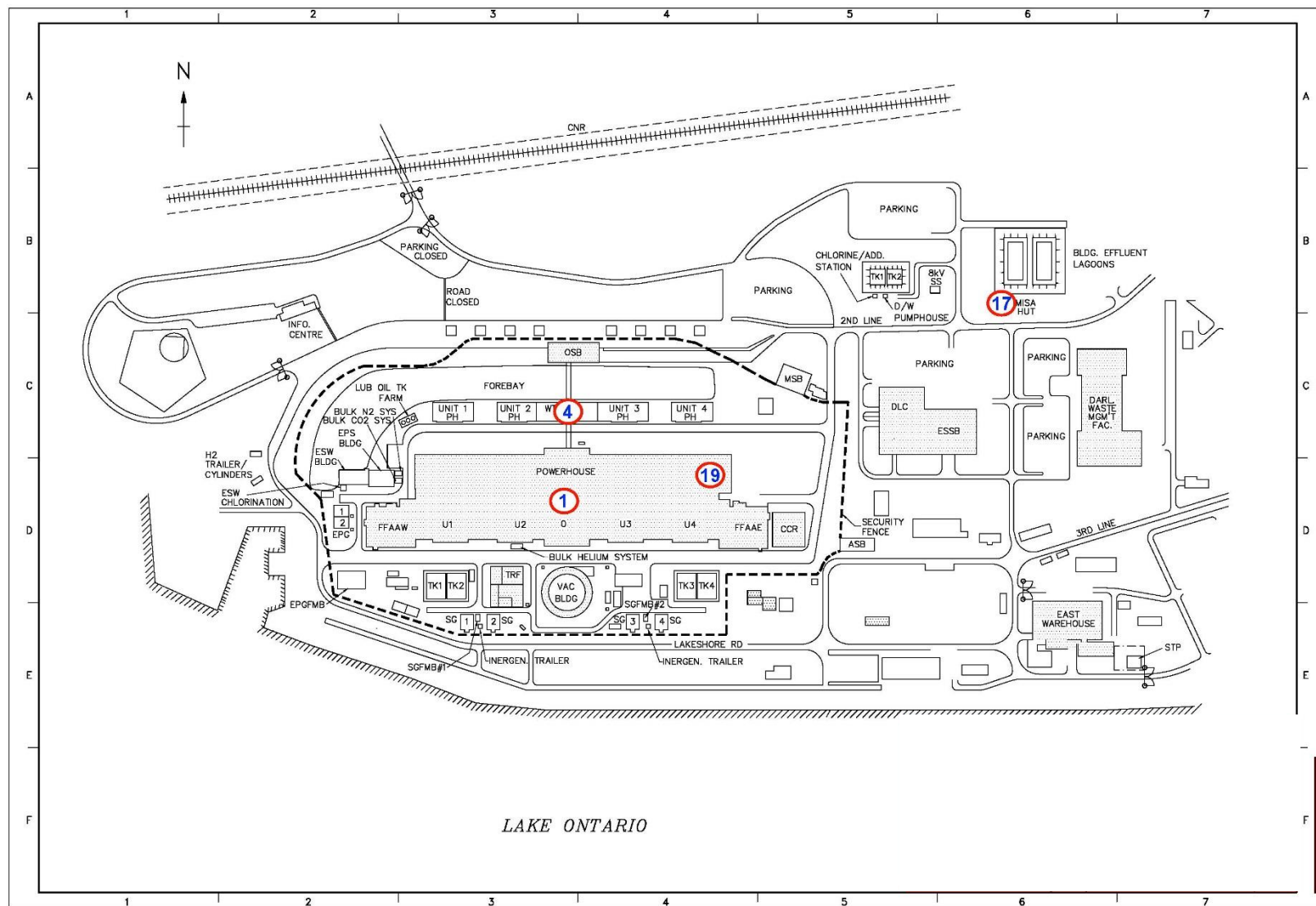


Figure 3-4: Darlington Station General Arrangement Active MISA Control Points

For MISA monitoring parameters measured in the RLW and WTP (phosphorus, Total Suspended Solids (TSS), zinc, iron, oil and grease, and aluminum), Golder (2011a) conducted mixing calculations to obtain expected concentrations of COPCs in the CCW based on effluent discharge to the CCW from the RLW and the WTP. These calculations have been updated for this ERA based on 2016 to 2019 discharge volumes and flowrates as detailed below. Golder based their mixing calculations on a worst-case scenario, assuming effluent was discharged at the MISA limits (Golder, 2011a). A similar approach was adopted for the updated calculations in this HHRA.

Since none of the MISA monitoring parameters (except for pH) for the RLW are measured in the CCW duct after mixing, mixing calculations for the RLW discharge to the CCW duct were based on the maximum concentrations of the RLW discharge allowed under MISA. The calculated CCW concentrations are shown in Table A-5 (Appendix A). Maximum mixing zone concentrations were estimated from calculated CCW concentrations, based on the dilution factor of 7 (OPG, 2016d), and were compared against the human health COPC screening criteria. Both the calculated CCW concentrations and the estimated maximum mixing zone concentrations were found to be well below these limits. The concentration in the CCW was calculated according to the following equation:

$$\text{Conc. in CCW} = \frac{\text{Conc. in RLW} \bullet \text{RLW flow rate} + \text{Intake Conc.} \bullet \text{CCW flow rate}}{\text{CCW flow rate}}$$

The average annual RLW discharge flow rate was calculated based on the annual total discharges, assuming constant flow. To be conservative, the maximum discharge flowrate from 2016 to 2019 was used for the mixing calculation. The maximum flowrate at the RLW was estimated as 0.00112 m³/s. The CCW flow rate was assumed to be 107.1 m³/s, which is equivalent to the average of CCW flows from 2016 through 2019.

For the WTP discharge to the CCW, the concentration in the CCW was calculated according to the following equation:

$$\text{Conc. in CCW} = \frac{\text{Conc. in WTP effluent} \bullet \text{Effl. flow rate} + \text{Intake Conc.} \bullet \text{CCW flow rate}}{\text{CCW flow rate}}$$

The average annual WTP discharge flow rate was calculated based on the annual total discharge, assuming constant flow. To be conservative, the maximum discharge flowrate from 2016 to 2019 was used for the mixing calculation. The maximum flowrate at the WTP from 2016 to 2019 was estimated as 0.00546 m³/s.

The CCW flow rate was assumed to be 107.1 m³/s, which is equivalent to the average of CCW flows from 2016 through 2019. Both the calculated CCW concentrations and estimated maximum mixing zone concentrations were compared against the human health screening criteria and were found to be well below these limits. Based on this information and the estimated maximum mixing zone concentrations, no exceedances of screening criteria in the CCW nor in the initial mixing zone are expected for the MISA parameters, as

shown in Table A-5 in Appendix A. No additional chemical COPCs for lake water were identified through this screening.

3.1.2.2.2.3 2016 Effluent Characterization Study

In support of the review and update of the 2016 DN ERA, liquid effluent sampling and analysis were performed in 2016 to provide data for the characterization of non-radiological parameters. No additional data have been collected since 2016. This program was part of a follow-up monitoring program from the 2011 Refurbishment and Continued Operation (RCO) Environmental Assessment (EA) which includes broad spectrum characterization of DN liquid effluents to confirm EA predictions of no residual adverse effects on surface water. Under the program, five effluent streams were characterized through weekly sampling and chemical analysis for metals, glycols, morpholine, TRC, petroleum hydrocarbons (PHCs), phosphorus and nitrate, alkyl ethoxylates, alkylphenol ethoxylates, and linear alkylbenzene sulphonates. These streams included RLW, inactive drainage (IAD; building effluent treatment facility lagoon, as described in Section 3.1.2.2.2.2), Boiler Blowdown (BB), WTP, and the CCW.

Several parameters, including aluminum, copper, iron, molybdenum, and zinc, did not meet their respective Data Quality Objectives (DQOs) in field blank samples. However, discussions with Maxxam at the time indicated that the results in the field blanks were not abnormal, and that when dealing with trace metals with the low detection limits that are being used for the sampling program, exceedances of the detection limit by two to five times is not uncommon. Maxxam also indicated that the levels of these parameters in the field blanks relative to the levels in the samples should be considered when assessing the data. For example, in general, the measured concentrations of aluminum and zinc in effluent samples are five to ten times higher than in most field blanks and therefore the blanks' contributions are negligible and the data are useable. As such, the data from the 2016 effluent characterization study are considered acceptable for the purposes of conducting a human health risk assessment.

Because waterborne effluent from DN is directed to the CCW (see Figure 2-4), with the exceptions of stormwater drainage from the DN site, the CCW stream was the focus of this screening exercise. Parameter concentrations from CCW samples and the estimated mixing zone concentrations were screened against the same human health screening criteria used for the lake water screening.

Lead has not been carried forward as a chemical COPC in this assessment. While the maximum analyzed concentration of lead in the RLW stream was 19.8 µg/L, which is above the selected human health screening criterion of 5 µg/L, the maximum measured concentration of lead in the CCW stream was 0.335 µg/L, which is almost two orders of magnitude less than the screening criterion. Furthermore, the estimated maximum mixing zone concentration was 0.05 µg/L, well below the screening criterion for lead. As such, lead in the RLW stream is not expected to result in an exceedance of lead in the CCW nor in the initial mixing zone.

Ethylene glycol has not been considered a COPC for human health. As shown in Table A-6a, the maximum concentration of ethylene glycol in the CCW stream is non-detectable (<5 µg/L). This detection level exceeds the ethylene glycol screening criterion of 2 µg/L, based on the U.S. EPA RSL for tap water (US EPA, 2020). However, if the concentration were conservatively assumed to be 5 µg/L at the CCW, the estimated maximum concentration within the initial mixing zone would be 0.71 µg/L, which is below the screening criterion.

Similarly, propylene glycol has not been carried forward as a chemical COPC in this assessment. The non-detectable concentration of <20 µg/L for propylene glycol in the RLW stream exceeds the propylene glycol screening criterion of 10 µg/L, based on the U.S. EPA RSL for tap water (US EPA, 2020). However, the maximum non-detect level in the CCW stream was found to be <5 µg/L, and the estimated concentration in initial mixing zone was 0.71 µg/L, which are both below the screening criterion.

A screening of alcohol ethoxylates (AEOs), nonylphenol ethoxyacetic acid (nonylphenol ethoxycarboxylate, or NP1EC), and linear alkylbenzene sulphonates (LASs) in surface water samples taken from the CCW is summarized in Table A-6b. Human health screening benchmarks were not available from regulatory sources for these substances, so a literature search was conducted for appropriate toxicity information.

For AEOs, following HERA (2009), the lowest available No Observed Adverse Effect Level (NOAEL) of 50 mg/kg/day for an individual AEO, namely C₁₂₋₁₃ AE_{6.5}, was assumed to apply to all AEOs, and a drinking water screening criteria of 512,500 µg/L for the most sensitive human life stage (an infant) was derived from this NOAEL assuming, also following HERA (2009), 75% bioavailability of AEOs in the human gastrointestinal tract. The maximum analyzed total AEO concentration from the study was 121 µg/L, which is over three orders of magnitude less than the derived screening value. Further, the estimated maximum mixing zone concentration would have been 17.3 µg/L, adding a fourth order of magnitude below the derived screening criteria. As such, none of the individual AEO parameters, nor total AEOs, were carried forward as human health COPCs.

Similarly, a NOAEL of 85 mg/kg/day, as presented by HERA (2013), was assumed for LAS toxicity. With an assumed bioavailability of 80% (HERA, 2013), a drinking water screening criterion of 929,333 µg/L for the most sensitive life stage (an infant) was derived. The maximum analyzed total LAS concentration from the study was 15.3 µg/L, which is over four orders of magnitude less than the derived screening value. Further, the estimated maximum mixing zone concentration of 2.2 µg/L would be five orders of magnitude below the derived LAS screening criteria. As such, none of the individual LAS parameters, nor total LASs, were carried forward as human health COPCs.

Lastly, NP1EC was not detected in any of the CCW samples from the study, so NP1EC has not been carried forward as a human health COPC.

Based on the discussions above pertaining to effluent stream concentrations and estimated maximum mixing zone concentrations from the CCW, no exceedances of screening criteria

in the initial mixing zone are expected for the 2016 CCW effluent parameters, as shown in Table A-6a and A-6b in Appendix A. No additional chemical COPCs for lake water were identified through this screening.

3.1.2.2.3 Stormwater Sampling

The Stormwater Management System, or Yard Drainage System, collects storm runoff from the entire DN site and discharges to Lake Ontario either directly through the storm sewer drainage system or through drainage swales/creeks via culverts which eventually discharge to the Lake. Surface drainage around the DN site is comprised of 30 sub-catchments, as shown in Figure 2-17. A brief discussion of the drainage pattern is presented below:

- Sub-catchments A and B1, B2, B3, B4, B5, and B6 discharge to Lake Ontario via natural streams;
- Sub-catchments C1, C2, C3, and C4 discharges through a culvert and a storm sewer at the southeast quadrant of the property and ultimately into Lake Ontario;
- Sub-catchment D1 discharges to a Highway 401 roadside ditch;
- Sub-catchments D2, D3, and D4 flow offsite to the east;
- Sub-catchment E flows into a marshy area and ultimately to the eastern property limit, after which it discharges to Lake Ontario;
- Sub-catchment F discharges to Lake Ontario;
- Sub-catchment H1 discharges through a culvert into Lake Ontario;
- Sub-catchments G2, I2, J, K1, K2, K3, I1, L, M, and N discharge through storm sewers into Lake Ontario; and,
- Sub-catchments O and P connect via culverts and storm sewers to discharge out of Catchment N.

The quality of the storm runoff generated at the DN site has been reported in the following studies:

- DNGS Storm Water Control Study (Sharma, 1997);
- DNGS Storm Water Remediation Report (Dunstall and Kinectrics, 2000);
- DNGS Storm Water Remediation Report 2001 (Dunstall and Kinectrics, 2001);
- Follow-Up Storm Water Control Study of Four Drainage Outfalls (Dunstall, 2002);
- Follow-Up Stormwater Control Study for SW Outfalls - Phase I, Fall 2010 (Golder, 2011b);
- Follow-Up Stormwater Control Study: Phase II Monitoring Program, Spring 2011 (Golder, 2011c); and
- Results of Stormwater Sampling at DN Site, 2019 (Golder, 2020)

Storm Water Control Study (Sharma 1997)

As reported by SENES and MMM (2009), in 1995 and 1996, OPG (then Ontario Hydro) commissioned a Storm Water Control Study (Sharma 1997, cited in SENES and MMM, 2009) at the DN site under Ontario's MISA program. As part of this study, the DN site

stormwater drainage areas and flow pathways were identified and documented. Estimates of flow rates for each drainage area were derived and sources of potential environmental contaminants were identified.

Storm Water Remediation Reports and Follow-Up Storm Water Control Study of Four Drainage Outfalls (Dunstall, 2002; Dunstall and Kinectrics, 2000, 2001)

Based on the results of the 1997 study, a two-phase Storm Water Control Plan (Dunstall and Kinectrics, 2000) was developed. Phase I of the plan recommended stormwater management measures to improve the quality of stormwater discharges and reduce TSS loadings to Lake Ontario. Phase II included a verification study to investigate the effectiveness of the management measures to reduce TSS concentrations in the stormwater discharges and eliminate toxicity to aquatic organisms.

The 2000 Phase I Storm Water Remediation Program was then implemented for the potentially contaminated drainage areas. The remediation efforts consisted of regrading, slope stabilization, landscaping, plantation and placement of erosion control blankets at areas susceptible to erosion. The remediation work was reported in detail by Dunstall and Kinectrics (2000, 2001). The 2001 Phase 2 toxicity and TSS reduction evaluation study was documented in detail by Dunstall (2002). In this study, four locations corresponding to failed toxicity tests in 1996 were monitored for toxicity, water quality parameters including TSS, phosphorus, metals, oil and grease, and PCBs. One *Daphnia magna* acute lethality test failure was observed at outfall G-2 in May 2001 as compared to a total of six toxicity test failures in 1996; however, there was no detectable change in the TSS and iron concentrations measured at these locations.

Storm Water Control Study 2010-2011 (Golder, 2011b, 2011c)

Stormwater studies were conducted in support of the DNGS Refurbishment and Continued Operations Project Environmental Assessment. The overall objective was to verify and/or update existing information for the stormwater drainage system serving the DN site and, where applicable, increase the robustness of the database. In 2010, data on stormwater drainage on the DN site and surrounding areas was updated through the DN Storm Water Study (Golder, 2011b, 2011c), which was conducted in two phases. There are no directly applicable criteria regulating allowable concentrations for the water quality parameters measured in stormwater discharges from the DN site (with the exception of the DN ECA which limits the allowable oil and grease concentrations in storm/groundwater collected in the Emergency Power Generator Buildings, the Emergency Power Generator Fuel Management Building, the Standby Generator Buildings, the Standby Generator Fuel Management Buildings and the Standby Generator Fuel Oil Storage Tank Dykes and discharged to the Yard Drainage System). The water quality data collected during the Phase I and Phase II Program storm events were reviewed as part of the 2010 DN Storm Water Study and, where possible, compared to observed/typical urban runoff water quality (as cited in the U.S. EPA Results of the Nationwide Urban Runoff Program (NURP) –Final Report Volume I (US EPA, 1983) and in the MECF Storm Water Management Planning and

Design Manual (SWMP) (MOEE, 2003). The DN site consists mainly of buildings, parking lots, landscaped areas and ponds and was, therefore, considered comparable to a typical urban site as opposed to a rural site which consists of mostly agricultural fields. The data were also compared to other guidelines, i.e., PWQOs and the Durham Region Sewer Use By-law (Regional Municipality of Durham, 2009). The available stormwater chemical analyses from 2010 and 2011 were screened in the 2016 DN ERA (Ecometrix, 2017), and no COPCs were identified.

Stormwater Sampling at DN Site, 2019 (Golder, 2020)

Stormwater sampling at the DN Site (Golder, 2020) was conducted in 2019 to characterize the quality of stormwater runoff from the DN site and to provide updated baseline data to (a) update this ERA and (b) provide follow-up monitoring data for the DNGS Refurbishment and Continued Operation EA Integrated Implementation Plan (IPP) commitment number IPP EA-011. Fifteen locations were sampled (Figure 2-17). Results from the chemical analyses in the 2019 study were compiled and converted to equivalent loadings to Lake Ontario using the maximum measured peak flow rates at the time of sampling (Golder 2020a). On a few occasions, the maximum peak flowrate was not available, due to backwater, sediment accumulation or instrument error. In this case, a linear relationship was developed between the 24-hr total rainfall and peak flowrate using both the 2011 and 2019 stormwater monitoring report (Golder, 2011c, 2020). This relationship was used to estimate a flowrate for the missing data point. Flowrate estimation was conducted for four monitoring stations shown on Figure 2-17: Culvert H1 (106.7 L/s), MH208 (0.200 L/s and 0.124 L/s), MH430 (59.9 L/s) and MH404 (105.1 L/s and 97.7 L/s). There was no flow monitoring data, in 2019, at station MH612 (Figure 2-17) due to high standing water. The flow at MH612 has been negligible during the 2011 storm sampling events, and the high standing water implies backwater at the outfall. Therefore, it is not likely that stormwater discharged at MH612 contributes significant chemical loading in Lake Ontario.

HHRA Stormwater Screening

For the purposes of this HHRA, results of stormwater loadings to Lake Ontario from the 2019 sampling program (Golder, 2020) were used in chemical COPC screening for stormwater. The maximum equivalent stormwater loading for each analyte was converted to an estimated Lake Ontario concentration using the OPG observation that Lake Ontario current speeds at Port Darlington were on average 0.081 m/s in both easterly and westerly directions between 2012 and 2016 (OPG, 2018e). The wave zone in Lake Ontario extends to about 2 m depth, and this depth is achieved approximately 120 m from the shoreline. The stormwater loading was assumed to be diluted in an alongshore flow, calculated as the current speed times the cross-sectional area of the wave zone. The calculation resulted in an estimated average Lake Ontario shoreline flow rate of 9720 L/s.

The estimated Lake Ontario concentrations were then screened against the same human health screening criteria used in the lake water screening, as shown in Table A-7 in Appendix A. Measured parameters in stormwater which are not considered a human health

risk are not displayed for human health screening in Table A-7. Individual polychlorinated biphenyl (PCB) congeners as well as total oil and grease are displayed in Table A-7, but without benchmarks since these parameters are encompassed by screenings of other parameters. Specifically, total oil and grease is covered by other petroleum hydrocarbon screenings, including benzene, toluene, ethylbenzene, and xylene (BTEX) and fractions F1 through F4 of petroleum hydrocarbons; individual xylene isomers are covered by the total xylenes screening; and individual PCB congeners are covered by the total PCB screening.

As shown in Table A-7, the estimated fecal coliform concentration in Lake Ontario of 28.25 CFU/100mL exceeded the 95th percentile of background of 20 CFU/100 mL. However, coliforms are not considered to be a hazardous substance and are not associated with DN (see section 3.1.2.2.1). As such, fecal coliform has not been considered as a COPC for human health.

None of the remaining stormwater constituents had estimated Lake Ontario concentrations exceeding the selected human health screening criteria. As such, none of the analytes in stormwater were assessed as chemical COPCs in the HHRA.

3.1.2.3 Selection of Chemical COPCs in Soil

For the human health risk assessment, potential risks from soil were determined to be of little concern. On-site workers, contractors, and visitors are potentially exposed to on-site soil; however, these exposures are considered and controlled through the Health and Safety Management System Program described in Section 3.1.1.1.1. For example, minimal soil exposure would be incurred by on-site workers using appropriate Personal Protective Equipment (PPE) and following safe work practices. Human exposure to contaminants in off-site soil is unlikely, since the results of the air screening presented in Section 3.1.2.1 show acceptable concentrations for contaminants that could deposit on soil. The DN site is not a source of dust. Any releases from DN and subsequent off-site deposition of non-radiological particulates (metals) will be lost against the background soil levels.

Soil has been considered in the ecological risk assessment; an EcoRA screening for non-radiological COPCs in soil is presented in Section 4.1.5.3.

3.1.2.4 Selection of Chemical COPCs in Groundwater

OPG executes an annual groundwater monitoring program to understand the groundwater quality beneath the DN site. Based on the results of this program, groundwater on the DN site was found to generally flow toward Lake Ontario or the Forebay. In 2016 to 2019, the groundwater monitoring program included sampling groundwater monitoring wells for tritium, and certain locations for selected hazardous substances, such as petroleum hydrocarbons (PHCs), benzene, toluene, ethylbenzene and xylenes (BTEX).

Specifically, the DN groundwater monitoring program is designed to meet the following objectives:

- Confirm predominant on-site groundwater flow characteristics of the DN;
- Monitor changes to groundwater quality to ensure timely detection of non-routine releases of nuclear and hazardous substances to groundwater; and;
- Demonstrate no adverse impacts from COPCs in groundwater to the receiving environment through tracking movement of existing elevated concentrations and monitoring of groundwater leaving the site.

The known source areas for chemical COPCs with potential for groundwater contact can be summarized as follows:

- Switchyard – Zinc and boron in soils south of the switchyard, identified prior to 2005, are believed to originate from galvanized steel structures in the yard (Ecometrix, 2012). Zinc and boron concentrations in groundwater in the area were below MECP Table 3 values in 2008-2012 monitoring (Ecometrix, 2012).
- Main Output Transformers (MOTs) – Past spill of insulating oil near the Unit 2 MOT, identified prior to 2010, resulted in soil contamination, which could not be completely remediated, due to the presence of underground utilities and structures. It is believed that the small quantity of residual petroleum hydrocarbon is sorbed to soil and is not likely to migrate.
- Pumphouses – A hydrocarbon odour was noticed while drilling a monitoring well east of Pumphouse 1 in 2009. Investigations in 2010 found elevated concentrations of petroleum hydrocarbons in shallow bedrock in adjacent wells that have no connection to site infrastructure. The bedrock in the area is known to be naturally petroliferous.
- Locations within the DNNP Site - The 2009 Geological and Hydrogeological Environment Existing Environmental Conditions TSD discussed visual observations of potentially impacted soils in the spoils disposal area, concrete plant area, and asphalt storage area (CH2M Hill and Kinectrics, 2009). These areas are on the north portion of the DNNP site and are designated as zone F1 in the midterm report (OPG, 2018a). In 2017, OPG completed remediation of this area including: removal and remediation of soil, remediation of the former concrete plant area to meet MECP standards, removal of waste sandblast grit piles, and demolition of the Emergency Vehicle Garage (OPG, 2018a) and back filled with clean fill. Other areas of the DNNP site are being characterized. Based on the 2019 soil sampling program to support DNNP licence renewal, results showed that soils within the yard waste and building materials storage area (specifically location DN6 and DN6A in Figure B-4, Appendix B, and zone F15 in (OPG, 2018a) have elevated concentrations of metals PHCs, and cyanide (Ecometrix, 2020).

Overall, groundwater on the DN site was found to generally flow toward Lake Ontario, while groundwater in the Protected Area is flowing toward the Forebay and into the cooling water system (Ecometrix, 2012; OPG, 2018d, 2019c). In general, groundwater monitoring results

in 2016 to 2019 were not significantly different from past results. Results from over this time period show no impact on groundwater as a result of DN station operations.

There are no groundwater supply wells downgradient of potential source areas on-site. As water on the DN site is not used for human consumption, the only on-site pathway for human exposure to groundwater would be from ingestion of water from Lake Ontario after dilution of the groundwater in the Lake. Concentrations of potential chemical stressors in off-site drinking water wells are not influenced by DN.

There is potential for site groundwater to migrate to surface water (Lake Ontario); however, groundwater flux from the site into Lake Ontario is likely to be small based on the estimated groundwater velocity and influence of site infrastructure (CH2M Hill, 2011); therefore, any COPCs in groundwater that reach the lake are subject to considerable dilution before they can migrate with surface water to a point of water intake for human consumption. The nearest water intakes are at Bowmanville, 7 km ENE of DN, and at Oshawa, 8 km west. The surface water near DN is monitored and screened for classes of contaminants such as polycyclic aromatic hydrocarbons (PAHs), PHCs, and BTEX, so any groundwater migration to surface water would be observed through this monitoring.

Maximum diluted concentrations in Lake Ontario were estimated based on maximum concentrations observed in recent annual groundwater monitoring conducted in 2016 to 2019, in conjunction with a dilution factor (DF). The DF was calculated based on groundwater flow to the lake divided by alongshore flow within the wave zone. Specifically, the following equation was used to calculate the DF:

$$\begin{aligned} DF &= \frac{\text{Groundwater flow}}{\text{Alongshore Flow}} \\ &= \frac{\text{Darcy velocity} \times \text{seepage area}}{\text{current speed} \times \text{wave zone cross sectional area}} \\ \text{Therefore, DF} &= \frac{3.17 \times 10^{-8} \text{ m/s} \times 120 \text{ m} \times 1000 \text{ m}}{0.081 \text{ m/s} \times 120 \text{ m} \times 2 \text{ m} / 2} \end{aligned}$$

where,

Darcy velocity = 3.17×10^{-8} m/s (CSA N288.1-14)

Seepage area = 120 m offshore x 1000 m alongshore

Lake Ontario current speed = 0.081 m/s (OPG, 2018e)

Wave zone cross sectional area = 120 m offshore x 2 m water depth / 2

The calculation of groundwater flow uses the Darcy velocity described in CSA N288.1-14. The seepage area is approximately 1000 m alongshore and extends approximately 120 m offshore.

The calculation of alongshore flow uses the OPG observation that Lake Ontario current speeds at Port Darlington were on average 0.081 m/s in both easterly and westerly directions between 2012 and 2016 (OPG, 2018e). The wave zone in Lake Ontario extends to about 2 m depth, and this depth is achieved approximately 120 m from the shoreline. The groundwater seepage was assumed to be diluted in an alongshore flow, calculated as the current speed times the cross-sectional area of the wave zone. The calculation resulted in an estimated average Lake Ontario shoreline flow rate of 9720 L/s.

Maximum estimated concentrations in the wave zone are screened in Table A-8 of Appendix A against the selected human health screening criteria shown in Table A-2. The MECP (MOE, 2011) groundwater GW1 criteria for protection of drinking water are also conservatively displayed in Table A-8 for reference. Screening calculations of potential groundwater impact on surface water quality adjacent to the site shows that no chemicals in groundwater have potential for human health impact and therefore none are considered as COPCs in surface water.

3.1.2.5 Selection of Chemical COPCs in Sediment

Sediment in Lake Ontario was characterized as part of the baseline data collection exercise for the ecological risk assessment in the New Nuclear Darlington EA (SENES, 2009a). Except in embayments (St. Marys boat slip) the substrate is predominantly gravel and cobble on top of glacial till or bedrock. Any finer material, mostly sand, is patchy, thin and transient.

Additional sediment sampling programs were carried out in 2018 and 2019. The 2018 program consisted of sediment characterization (two sampling events) of the Darlington Harbour area and near-shore locations immediately west of Darlington Harbour (Ecometrix, 2018, 2019).

The 2019 program included sediment sampling within Lake Ontario in order to support the DNNP site preparation licence renewal project. Lake Ontario samples were collected from the St. Marys (future) embayment, proposed DNNP infill area, and at one offshore location (Ecometrix, 2020). Findings from particle size analysis of finer substrate that could be sampled (i.e., avoidance of boulder and cobble substrates) found that sediments are primarily composed of sand in the St. Marys (future) embayment, in the proposed infill area, and at the offshore location (Ecometrix, 2020). Furthermore, visual observations made during the sediment sampling and 2018 and 2019 gillnetting studies confirmed previous video studies that the nearshore area is dominated by hard substrates (e.g., cobble, rocky glacial till, dreissenid mussels) with intermittent patches of sand.

No direct human health exposure pathways exist between potential chemical COPCs in sediments and the selected human receptors, so no screening of chemicals in sediment for potential human health effects is required. Bioaccumulation of chemicals in fish is likely to be primarily driven by water exposures for the fish, since sediments in areas where human receptors catch fish, such as Lake Ontario, are transient. As such, the Lake water

screening is considered sufficient to identify COPCs for human health due to potential fish ingestion.

Chemical COPCs relevant to ecological health, in both lake and pond sediments, are evaluated in Section 4.1.4.2.

3.1.2.6 Selection of Radiological COPCs Released to Air and Surface Water

Radiological emissions from DN from the four-year period 2016 to 2019 were a small fraction of the DRL ranging from <0.01 to 0.41% of the DRL (as summarized in Table 3-1). Figure 3-5 presents the past 10 years of tritium and C-14 emissions to air, and tritium and gross beta-gamma emissions to water. Given that the reported noble gas stack emissions and results from noble gas monitors are typically below detection at DN, no trend graph is presented for noble gas. Iodine and particulate in airborne emissions and C-14 waterborne emissions are not graphed because their contribution to the overall public dose is minimal.

Table 3-1: Radioactive Emissions from DN (Bq)

Medium	Parameter	Year				Average (2016-2019)
		2016	2017	2018	2019	
Air	Tritium Oxide	1.8E+14	2.4E+14	2.1E+14	2.0E+14	2.1E+14
	Elemental Tritium	1.7E+13	1.4E+14	4.7E+13	2.5E+13	5.7E+13
	Noble Gas	1.6E+13	1.5E+13	4.7E+13	5.0E+13	3.2E+13
	Iodine	1.4E+08	1.5E+08	1.4E+08	1.4E+08	1.4E+08
	Particulate	3.2E+07	2.6E+07	2.5E+07	2.6E+07	2.7E+07
	Carbon 14	1.6E+12	1.4E+12	8.4E+11	9.7E+11	1.2E+12
Water	Tritium Oxide	3.5E+14	5.6E+14	2.2E+14	1.0E+14	3.1E+14
	Gross Beta/Gamma	4.9E+10	2.6E+10	2.6E+10	2.3E+10	3.37E+10
	Carbon 14	2.2E+09	1.7E+09	1.2E+09	3.8E+09	2.2E+09

Sources: (OPG, 2017b, 2018b, 2019a, 2020b).

Airborne Emissions

As indicated in Figure 3-5, elemental tritium (HT) emissions have remained at low levels. However, the increase in elemental tritium emissions observed in 2017 (1.3×10^{14} Bq) is primarily attributed to a valve that was inadvertently opened and vented to the TRF stack. Corrective actions were immediately taken to redirect residual elemental tritium to the Air Clean up System and a procedure update was subsequently initiated to rectify the deficiencies. In 2019, the HT emissions were 2.5×10^{13} becquerels (Bq), which is less than 0.01% of the DRL.

In 2014, a small increase was observed in DN tritium oxide (HTO) airborne emissions (Figure 3-5) to 2.7×10^{14} Bq, which was attributed to both dryer performance and TRF

restart activities. During 2015 and 2016, work plans were executed to refurbish dryers throughout the station resulting in a decrease in emissions. Airborne HTO emissions in 2019 were 2.0×10^{14} Bq, which is 0.34% of the DRL.

Airborne emissions of C-14 remain stable (Figure 3-5). The 2019 C-14 airborne emissions were 9.7×10^{11} Bq, which is 0.28% of the DRL.

Waterborne Emissions

A vacuum building outage is scheduled to occur every 7 to 10 years to meet licensing requirements. The 2015 vacuum building outage required system drainage in 2014 and 2015, which resulted in slightly elevated DN HTO to water emissions during these years (Figure 3-5), although emissions have remained well below the HTO DRL. The increases in emissions observed in 2016 and 2017 are primarily attributed to the processing and discharge of condensate from reactor building air conditioning units through the radioactive liquid waste system. The majority of ACU coils were replaced during unit outages in 2018. The DN tritium to water emission has been steadily decreasing from 5.6×10^{14} Bq in 2017 to 1.0×10^{14} Bq in 2019 (less than 0.01% of the DRL).

The DN gross beta-gamma emissions to water remain low and well below the DRL (Figure 3-5). The slightly elevated emission values in 2015 and 2016 (4.9×10^{10} Bq in 2016) do not reflect a true increase in emissions, but rather the use of an alternate counter with a higher detection limit than the main counter. The main counter was returned to service in November 2016 and as a result, emissions have decreased in the subsequent years. The 2019 gross beta-gamma water emission was 2.3×10^{10} Bq, which is 0.032% of the DRL.

The Radiation and Radioactivity TSD (SENES, 2011e) indicated that although residual adverse effects on members of the public or workers are not anticipated, radiation doses should be carried forward for further consideration since radiation dose is of great public and regulatory interest. This approach is consistent with CSA N288.6 guidance (CSA, 2012) and is applied for the purposes of this HHRA.

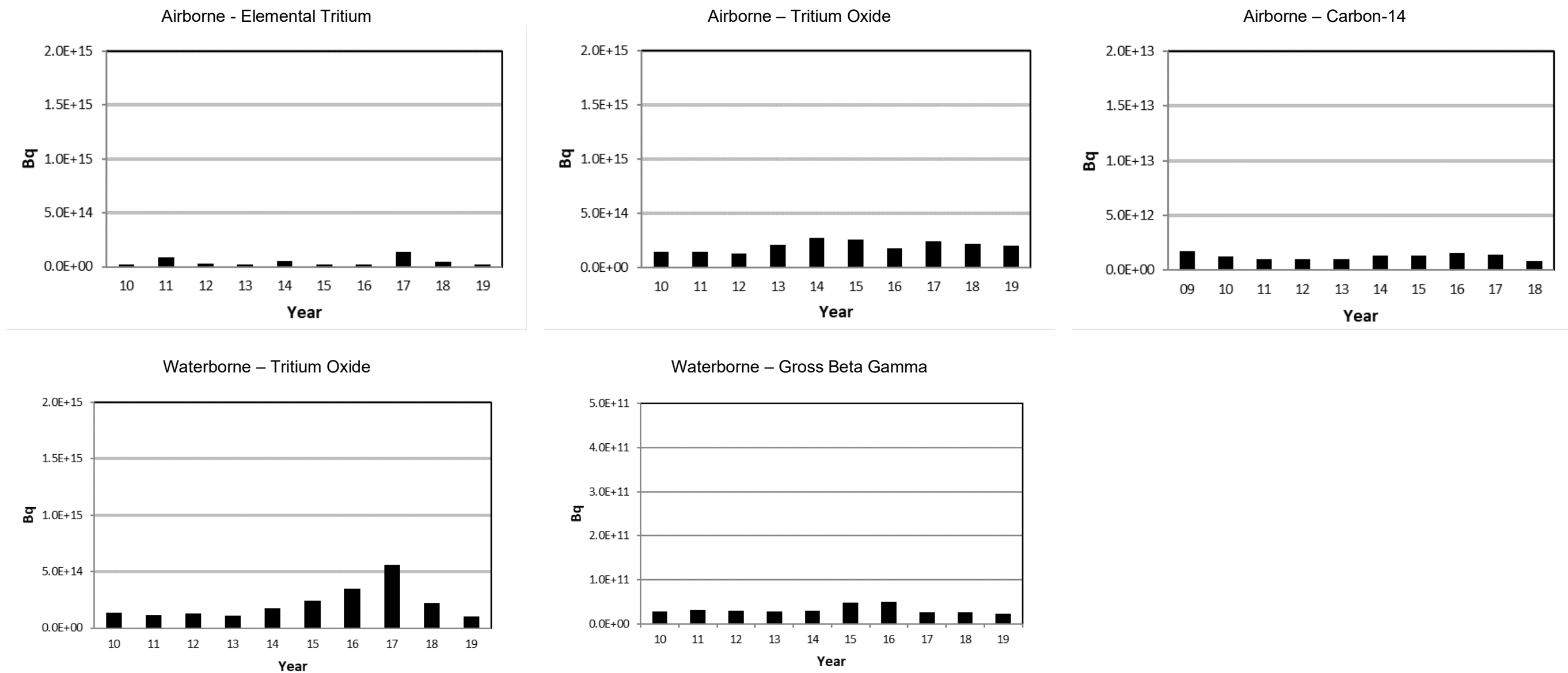


Figure 3-5: Airborne and Waterborne Radiological Emissions at Darlington Nuclear (2010 to 2019)

OPG calculated Derived Release Limits (DRLs) for DN (OPG, 2016d) based on CSA N288.1-14. A DRL is the release rate for a radionuclide or a group of radionuclides that would result in the average member of the critical group (most exposed group of members of the public) receiving an annual dose of 1 mSv (regulatory limit, CNSC 2000). The list of parameters, for which DRLs were derived is shown in Table 3-2:

Table 3-2: Radionuclides Considered for Derivation of DRLs (OPG, 2016d)

³ H	⁹⁹ Tc	¹⁴¹ Ce
¹⁴ C	¹⁰³ Ru (^{103m} Rh)	¹⁴⁴ Ce (^{144m} Pr, ¹⁴⁴ Pr)
²⁴ Na	¹⁰⁶ Ru (¹⁰⁶ Rh)	¹⁴⁷ Pm
³² P	^{110m} Ag (¹¹⁰ Ag)	¹⁵² Eu
³⁵ S	¹¹³ Sn (^{113m} In)	¹⁵⁴ Eu
⁴¹ Ar	¹²² Sb	¹⁵⁵ Eu
⁴⁶ Sc	¹²⁴ Sb	¹⁵³ Gd
⁵¹ Cr	¹²⁵ Sb (^{125m} Te)	¹⁵⁹ Gd
⁵⁴ Mn	¹³² Te (¹³² I)	¹⁶⁰ Tb
⁵⁵ Fe	¹²⁹ I	¹⁸¹ Hf
⁵⁹ Fe	¹³¹ I (^{131m} Xe)	²⁰³ Hg
⁵⁸ Co	¹³² I	²³⁴ Th (^{234m} Pa, ²³⁴ Pa)
⁶⁰ Co	¹³³ I (^{133m} Xe, ¹³³ Xe)	²³⁴ U (²³⁰ Th, ²²⁶ Ra)
⁶⁵ Zn	¹³⁴ I	²³⁵ U (²³¹ Th, ²³¹ Pa)
⁷⁶ As	¹³⁵ I (^{135m} Xe, ¹³³ Xe)	²³⁶ U (²³² Th, ²²⁸ Ra)
^{83m} Kr	^{131m} Xe	²³⁸ U (²³⁴ Th, ^{234m} Pa)
⁸⁵ Kr	¹³³ Xe	²³⁷ Np (²³³ Pa, ²³³ U)
^{85m} Kr	^{133m} Xe (¹³³ Xe)	²³⁹ Np (²³⁹ Pu, ²³⁵ U)
⁸⁷ Kr	¹³⁵ Xe	²³⁸ Pu (²³⁴ U, ²³⁰ Th)
⁸⁸ Kr (⁸⁸ Rb)	^{135m} Xe (¹³⁵ Xe)	²³⁹ Pu (²³⁵ U, ²³¹ Th)
⁸⁹ Sr	¹³⁸ Xe (¹³⁸ Cs)	²⁴⁰ Pu (²³⁶ U, ²³² Th)
⁹⁰ Sr (⁹⁰ Y)	¹³⁴ Cs	²⁴¹ Pu (²⁴¹ Am, ²³⁷ U)
⁹¹ Y	¹³⁵ Cs	²⁴² Pu (²³⁸ U, ²³⁴ Th)
⁹⁴ Nb	¹³⁶ Cs	²⁴¹ Am (²³⁷ Np, ²³³ Pa)
⁹⁵ Zr (⁹⁵ Nb)	¹³⁷ Cs (^{137m} Ba)	²⁴³ Am (²³⁹ Np, ²³⁹ Pu)
⁹⁵ Nb	¹⁴⁰ Ba (¹⁴⁰ La)	²⁴² Cm (²³⁸ Pu, ²³⁴ U)
⁹⁹ Mo (^{99m} Tc, ⁹⁹ Tc)	¹⁴⁰ La	²⁴⁴ Cm (²⁴⁰ Pu, ²³⁶ U)

Separate medium-specific DRLs were calculated for each radionuclide released to air and to water, but some of these radionuclides were grouped to allow easier screening. The airborne effluent groups that were used for DN are as follows:

- Elemental tritium (HT),
- Tritium oxide as water vapour (HTO),
- Noble gas mixtures (Noble Gases),
- Radioiodine mixed fission products (Imfp),

- Carbon-14 as $^{14}\text{CO}_2$ (^{14}C),
- Mixed beta-gamma emitting radionuclides (Particulate), and
- Mixed alpha emitting radionuclides (Gross alpha).

The liquid effluent release groups that were used for DN are:

- Tritium oxide as water (HTO),
- Mixed beta-gamma emitting radionuclides (Gross beta-gamma),
- Carbon-14 as dissolved carbonate/bicarbonate (^{14}C), and
- Mixed alpha emitting radionuclides (Gross alpha).

The DRLs for the mixed radionuclide release groups were calculated based on selection of the radionuclide in each group with the most restrictive DRL, according to the process outlined in the CANDU Owners Group (COG) DRL Guidance document (COG, 2013a). Radionuclides were selected to represent mixed beta-gamma based on meeting both of the following criteria for inclusion:

- Radionuclides are regularly present in the effluent; and
- Radionuclides represent no less than 1% of the total radioactivity present.

The very conservative criteria for “regularly present” is that radionuclides must be found more than once in the effluent. Additionally, radionuclides must make up more than 1% of the total radioactivity in the effluent based on long term analyses of representative samples.

The radionuclides selected to represent gross beta-gamma in effluent in DRL calculations are the beta-gamma emitters that result in the highest dose per unit release. These have also been used to represent gross beta-gamma in effluent in OPG’s annual public dose assessments. These multi-media dose assessments form the basis of the radiological dose assessment in the HHRA. The 2016 DRL report (OPG, 2016d) indicated that Co-60 is the limiting radionuclide for gross beta/gamma in air, and Cs-134 is the limiting radionuclide for gross beta/gamma in water.

All alpha emitters from the COG DRL Guidance document were considered as surrogates for gross alpha in air and gross alpha in water.

The 2016 gross alpha DRL for air emissions is 5.61×10^{-2} Ci/week (equivalent to 1.08×10^{11} Bq/year) based on Pu-239, and the 2016 gross alpha DRL for water emissions is 9.89×10^{-2} Ci/month (4.39×10^{11} Bq/year) based on Pu-239. The total annual gross alpha emissions to air and water and their respective fractions of these DRLs are presented in Table 3-3.

Table 3-3: Total Annual Gross Alpha Emissions to Air and Water

Year	Medium	Total Annual Emission	Unit	% of DRL
2016	Air	4.70E+06	Bq	5.00E-03
	Water	<1.21E+06	Bq	<3.87E-07
2017	Air	2.50E+06	Bq	2.40E-05
	Water	<1.06E+06	Bq	<3.39E-07
2018	Air	1.00E+06	Bq	1.00E-03
	Water	<3.30E+05	Bq	<1.06E-07
2019	Air	1.30E+06	Bq	1.00E-03
	Water	5.30E+05	Bq	1.21E-04

Notes:

% of DRL was calculated by dividing the total annual emission by the annual gross alpha DRL for airborne and waterborne emissions and multiplying by 100.

Since water emissions of gross alpha over this period are on the order of five to six orders of magnitude smaller than the applicable water DRL, and air emissions over this period are four orders of magnitude smaller than the applicable air DRL, gross alpha and its constituent radionuclides were not considered to be COPCs for the HHRA.

As such, in accordance with the above, the following airborne and waterborne radiological stressors were selected for the assessment of human health:

- Carbon-14 (C-14), which is released to both air and surface water by reactor operations at DN;
- Cobalt-60 (Co-60), which represents gross beta-gamma released to the atmosphere by DN;
- Cesium-134 (Cs-134), which represents gross beta-gamma emissions released to surface water in liquid effluent from DN;
- Elemental tritium (HT), which is released to the atmosphere by the Tritium Removal Facility (TRF) and, to a lesser degree, from the powerhouse at DN;
- Tritium oxide, also known as tritiated water (HTO), which is released to both air and water by the reactor operations at DN;
- Argon-41, xenon-133, and xenon-135 (collectively referred to as noble gases), which are released to the atmosphere by DN;
- Mixed fission product radioiodines, including iodine-131 (I-131), iodine-132, iodine-133, iodine-134, and iodine-135 (collectively referred to as I(mfp)), which are released to the atmosphere by DN; I-131 is the only iodine radioisotope released to the atmosphere with a long enough half-life to be present in other media.
-

Those COPCs released to air were considered to be COPCs in air, and those released to surface water were considered to be COPCs in surface water. Some may be COPCs in other media as well, according to their partitioning properties, as noted in the subsections below.

Organically Bound Tritium (OBT) may be created in living organisms as HTO produced by DN moves through the food chain, so the HHRA also assessed potential risks due to OBT, but this evaluation was considered part of the overall HTO risk.

3.1.2.6.1 Darlington Waste Management Facility

Waste management operations at DN are undertaken in three locations within the DN site, including in two Fueling Facilities Auxiliary Areas (FFAAs; East and West) and the DWMF. The DWMF is located within its own fenced protected area. The DWMF is currently made up of two buildings, each able to hold up to 500 DSCs, and a RWSB with the capacity of 490 retube waste containers with intermediate level waste. OPG monitored air kerma measurements from the two DSC storage buildings in the period of 2016 to 2019, and from the RWSB from the end of 2017 onward. The results were reported quarterly in OPG's DWMF quarterly reports (OPG, 2016e, 2016f, 2016g, 2017e, 2017f, 2017g, 2017h, 2018b, 2018i, 2018j, 2018k, 2018l, 2019f, 2019g, 2019h, 2019i, 2020f). The average DWMF fence perimeter air kerma rate from 2016 to 2019 was 0.08 $\mu\text{Gy/h}$. In 2017, OPG started to transfer retube waste containers loaded with Darlington Storage Overpack from the DNGS to the RWSB as part of the Darlington Refurbishment Project. The perimeter dose rate at the RWSB was monitored from 2017 to 2019, with an average air kerma rate at 0.06 $\mu\text{Gy/h}$. All dose rates are below the dose target rate of 0.5 $\mu\text{Gy/h}$, based on a public dose limit of 1 mSv/a and a maximum of 2,000 hours exposure per year.

Radiological waterborne emissions from the DWMF include yard drainage (runoff) and facility drainage. Weekly average values from yard drainage have been below the minimum detectable activity (OPG, 2012a). Tritium and gross gamma were also measured weekly at the DWMF from 2016 to 2019, and all measured values were below the administrative level of 1850 Bq/L (tritium) and 37 Bq/L (gross gamma). Facility drainage remains below approved limits.

The DWMF Safety Report (OPG, 2016a) estimated that the dose rate at the DN site boundary (1,025 m from the DWMF) due to gamma radiation and skyshine from the DWMF is $2.94 \times 10^{-6} \mu\text{Sv/h} \pm 8.1\%$, equivalent to $2.58 \times 10^{-2} \mu\text{Sv/a}$ assuming full capacity.

OPG calculated dose rates for these facilities in 2012 and in 2015 as part of their As Low As Reasonably Achievable (ALARA) update reporting. The 2015 ALARA update noted that all results from stack particulate samples from the DWMF for this period were below the minimum detectable activity. In all 2016 to 2019 quarterly reports, all results from stack particulate samples from the DWMF for this period were at least 5 orders of magnitude lower than the action level of $1.21 \times 10^9 \text{ Bq}$ (modified in 2019; previous action level was $1.3 \times 10^9 \text{ Bq}$).

In 2017, air kerma (i.e., kinetic energy released in matter) rates from the Pickering Waste Management Facility (PWMF) were measured at various locations over Lake Ontario (OPG, 2018b). At a distance of 400 m from the PWMF, the measured air kerma rate was below the detection limit of 0.33 nGy/h. Based on the 2017 assessment, it was determined that

air kerma rates from the PWMF are not significant for potential critical groups farther than 1 km from the source. For the DWMF, air kerma is not significant since all potential critical groups are farther than 1 km from the DWMF (OPG, 2018b).

As such, the contribution of the DWMF to dose for human receptors identified would be negligible. The dose contribution from the DWMF is not discussed further in the HHRA.

Based on the discussion above the relevant radiological COPCs in air include: C-14, Co-60, HT, HTO, noble gases, I(mfp) and the relevant radiological COPCs in water include: C-14, Cs-134, and HTO (see Table 3-7).

3.1.2.7 Selection of Radiological COPCs in Soil

The primary transport pathway of radiological COPCs to soil on-site and off-site is through deposition from air. However, two COPCs, HT and noble gases, are not expected to partition to soil. In addition, most of the radioiodines have short half-lives and would disappear quickly from soil, with the exception of I-131, which has a half-life of 8.03 days (CNSC, 2017b). The beta-gamma released to air, represented conservatively by Co-60, will deposit to soil, and is considered to be a COPC in soil. In addition, gross beta-gamma released to surface water, represented conservatively by Cs-134, can be transferred to soil by irrigation of gardens, and is considered as a COPC in soil for rural residents with gardens.

The final list of COPCs for soil was therefore as follows: C-14, Co-60, Cs-134, HTO, and I-131.

3.1.2.8 Selection of Radiological COPCs in Groundwater

Previous groundwater studies at DN have demonstrated that at many locations, tritium concentrations in groundwater have remained relatively constant or have decreased over time. However, tritium concentrations have fluctuated at some locations in recent years due to the incremental amounts of tritium emitted through a 2009 Injection Water Storage Tank D20 spill, located south of Unit 0. Tritium from the spill is migrating towards the westerly end of the Forebay; however, groundwater discharged into the Forebay channel is significantly diluted by the Forebay water. Overall, there is no adverse impact on human health resulting from the 2009 event. This was also confirmed by the measurement of low tritium concentrations in groundwater in both the Controlled Area (See Figure 3-6) and the Site Perimeter.

Although the atmospheric release of tritium from DN influences tritium concentrations in groundwater on-site, the on-site groundwater is not considered potable. There are no groundwater supply wells downgradient of potential source areas on-site. Off-site drinking water wells are influenced by atmospheric tritium, but this makes a negligible contribution to dose. In order to be consistent with the EMP, however, tritium has been identified as a radiological COPC in offsite groundwater for assessment as part of the HHRA. In addition,

I-131 partitions to shallow groundwater, and is a COPC for farm and rural residents with shallow wells. I-131 cannot migrate to deep well screens.

The final list of COPCs for groundwater was therefore as follows: HTO, and I-131.

3.1.2.9 Selection of Radiological COPCs in Sediment

Since the primary pathway for radionuclides to be transported to sediment is through partitioning from liquid effluents, the same COPCs were selected for sediment as were selected for surface water. The final list of radionuclides for Lake Ontario was therefore as follows: C-14, Cs-134, and HTO.

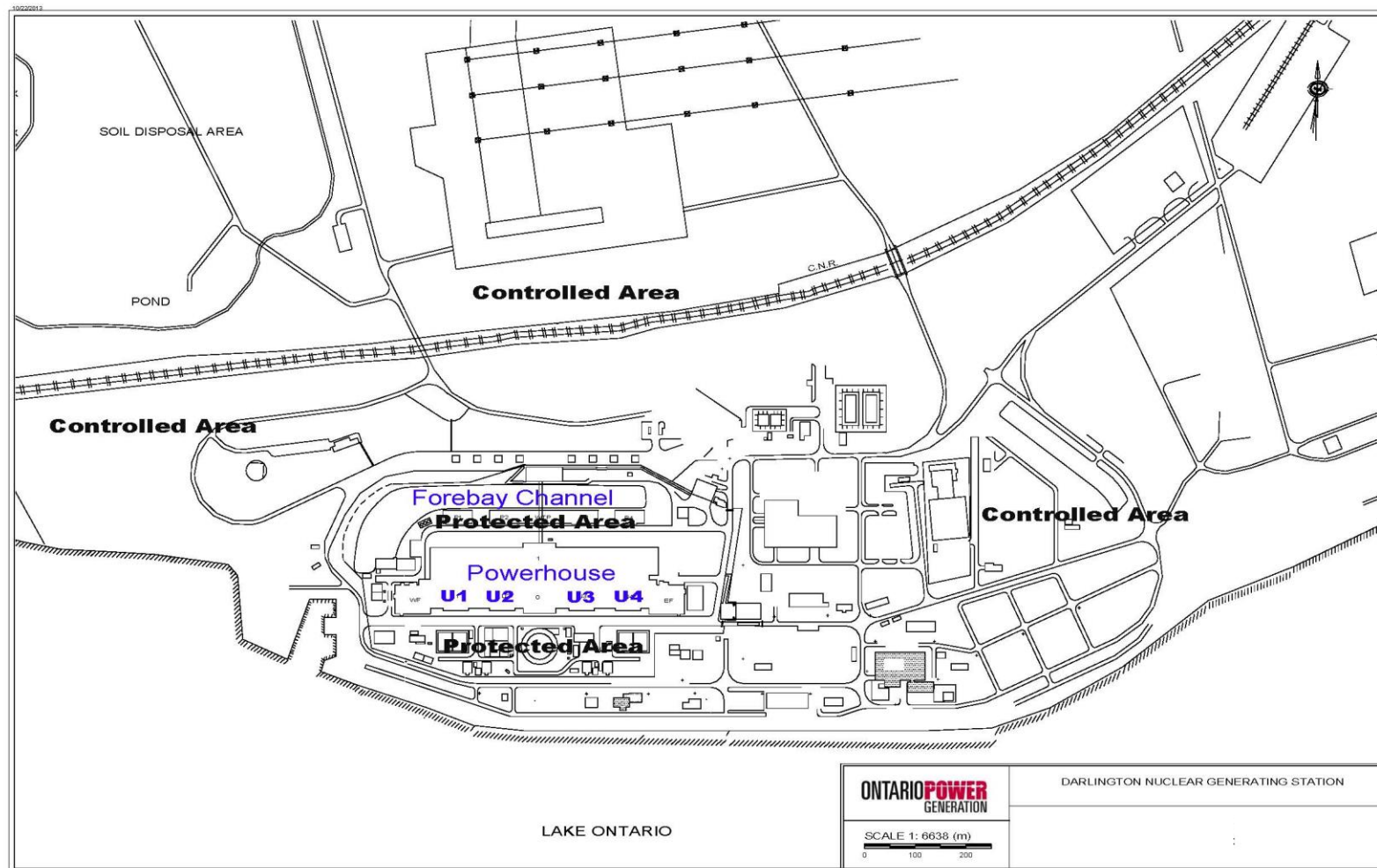


Figure 3-6: DN Site Plan Showing Controlled Areas

3.1.2.10 Selection of Other Stressors

Noise is the only physical stressor mentioned in N288.6 as a potential human stressor, and is the only physical stressor associated with DN that is of potential concern to humans.

3.1.2.10.1 Noise

The noise environment in the vicinity of DN site is typical of an urban setting and is influenced by several noise sources including DN Generating Station, traffic on Highway 401 and local roads, the CN rail line and local industry (e.g., St. Marys Cement plant and Durham York Energy Centre (DYEC)).

The noise monitoring locations for humans, also known as Point(s) of Reception, located in the vicinity of OPG DN are in an area best described as Class 1 as per MECP publication NPC 300 *“Environmental Noise Guideline, Stationary and Transportation Sources – Approval and Planning”* (NPC 300) (MOE, 2011). This designation is based on the presence of Highway 401 and its consistent contribution to background sound levels in the area. The energy equivalent sound levels for stationary sources in Class 1 areas (L_{eq}) are summarized in Table 3-4 and used to assess compliance of a facility in accordance with NPC 300.

Table 3-4: Sound Level Limits for Class 1 Areas (SENES, 2009c)

Time Period	Class 1 MECP Energy Equivalent Sound Level Limit (dBA)
Daytime (07:00 – 19:00)	50
Evening (19:00 – 23:00)	47
Night-time (23:00 – 07:00)	45

Acoustic assessments from the following two reports are summarized below:

- Atmospheric Environment Existing Environmental Conditions Technical Support Document New Nuclear – Darlington Environmental Assessment (SENES, 2009c); and,
- Acoustic Assessment Report: For New Nuclear Darlington Acoustic Conditions Update (OPG, 2020a).

Atmospheric Environment Existing Environmental Conditions Technical Support Document New Nuclear – Darlington Environmental Assessment (SENES, 2009c)

Continuous noise monitoring was conducted at two of the closest residential receptors to the DN, R15 and R23 (see Figure 3-7), in order to establish background noise levels for the NND EA (SENES, 2009c). Both receptors were located approximately 1 km north and west of the DN Site. The results of this measuring campaign are presented in Table 3-5.

Table 3-5: Measured Noise Levels at Residential Receptors (SENES, 2009c)

Location	Minimum Measured Background Energy Equivalent Sound Level Limit (dBA)	Maximum Measured Background Energy Equivalent Sound Level Limit (dBA)
R15	44.7	63.4
R23	46.2	62.3

SENES also carried out noise modelling with Cadna-A software to determine the sources of noise to these residential receptors. This model considered local terrain data, assumed perfectly reflective ground, and did not consider meteorology or railway sources of noise. Sources of noise in the modelling included DN, St. Marys Cement, and road traffic on Highway 401, as well as other local roads. Overall, based on this modelling, SENES concluded that sound levels in the DN area were influenced by traffic, as well as DN and St. Marys Cement operations. In particular, SENES noted that at location R15, the Solina Road location, the monitored day and night sound levels were roughly 3-5 dB higher than the modelled results, which suggested an influence of additional local sources of sound at this location, possibly including the nearby rail line, nature sounds, and Lake Ontario wave noise. SENES also noted that at location R23, at 2185 Baseline Road, which is closer to Highway 401, the monitored day and night sound levels were similar to the modelled sound levels. SENES concluded that overall, road traffic noise dominated other sources of noise at these locations.

The sound environment at both locations was dominated primarily by road traffic from Highway 401 and to a lesser degree from local roads. Noise from DN was not distinctly audible during the monitoring period which occurred between June 20 and June 23, 2008. Continuous noise monitoring results from the NND EA (SENES, 2009c) for the two monitoring locations are shown in Figure 3-8 and Figure 3-9, respectively. Monitoring results show noise levels consistently above Sound Level Limits for Class 1 Areas, which are provided in Table 3-4.

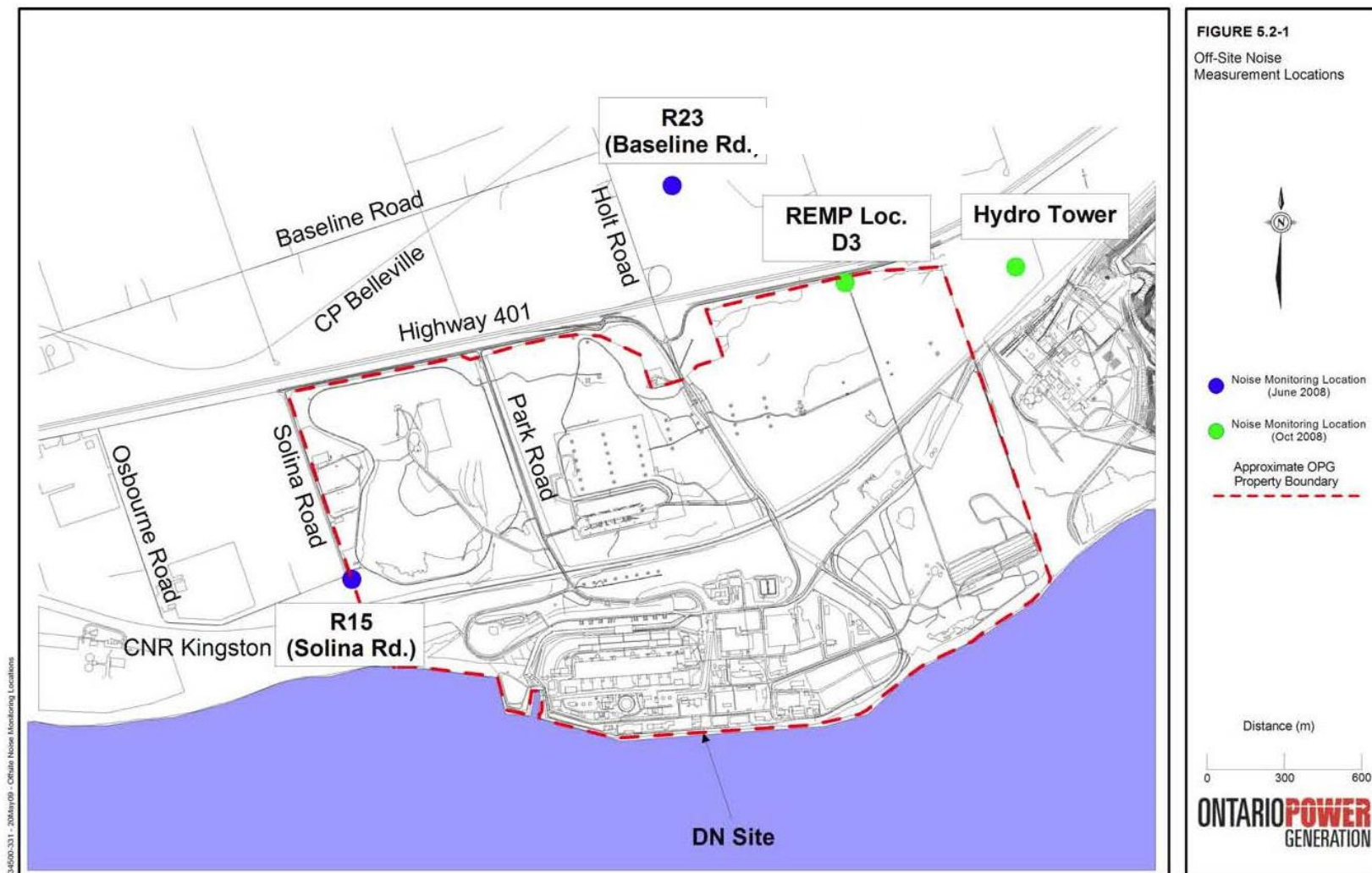


Figure 3-7: Offsite Noise Measurement Locations (SENEC, 2009c)

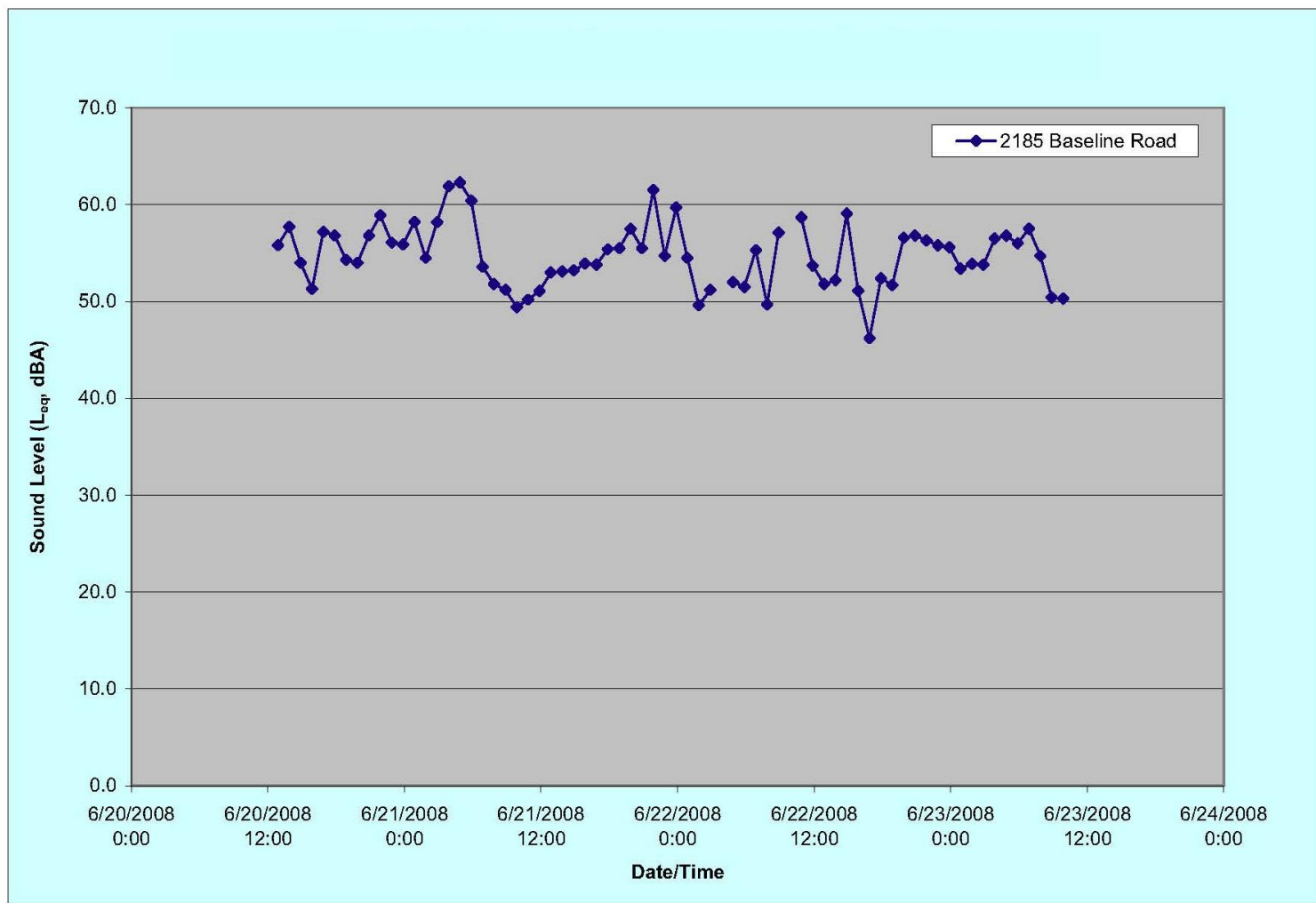


Figure 3-8: Measured Sound Levels at 2185 Baseline Road (SENES, 2009c)

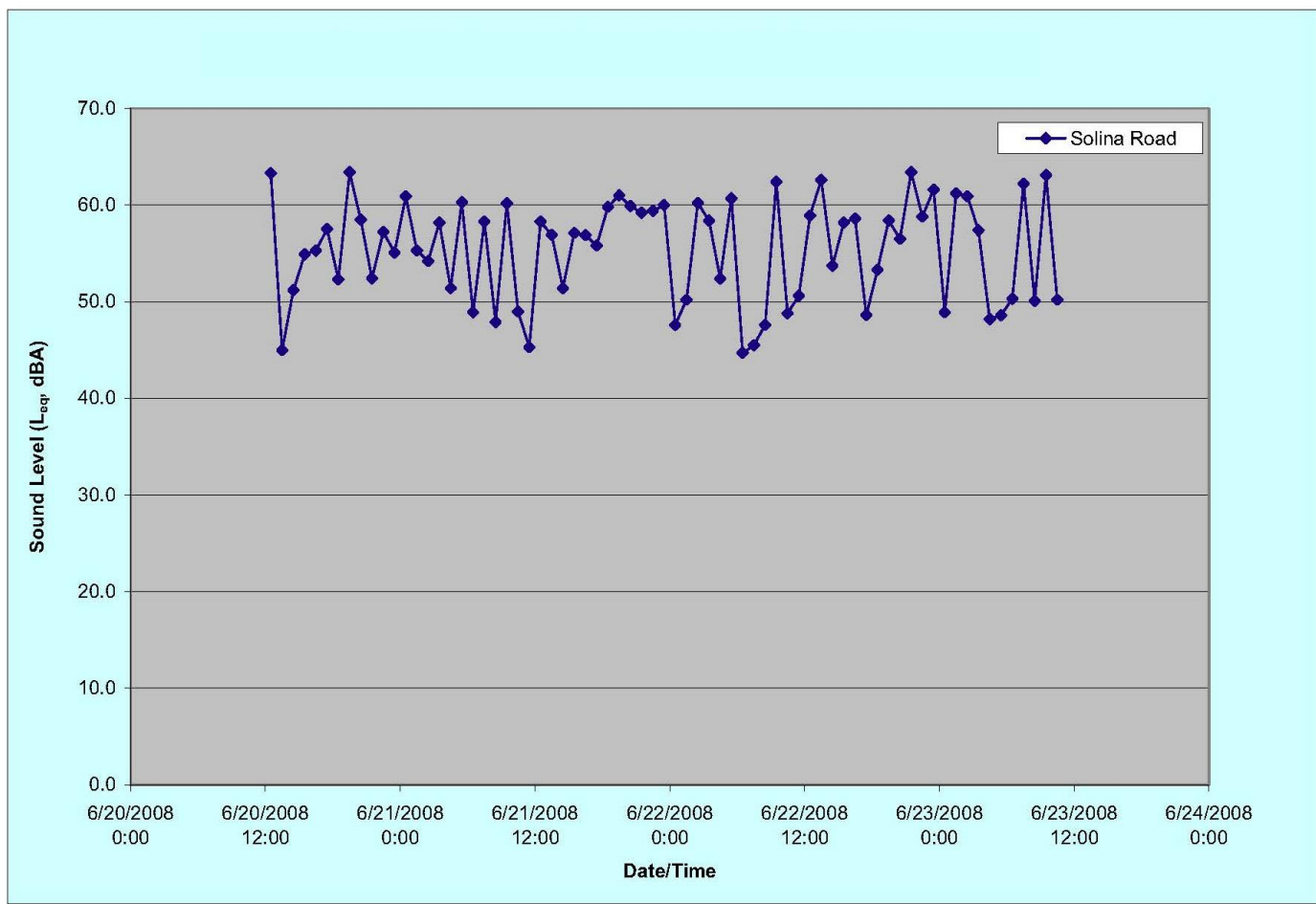


Figure 3-9: Measured Sound Levels at Solina Road Location (SENES, 2009c)

Acoustic Assessment Report: For New Nuclear Darlington Acoustic Conditions Update (OPG, 2020a)

Background monitoring conducted in 2018 included a third additional offsite residential receptor location (R19) (Figure 3-10). Locations R15 and R19 are considered to be the nearest Point of Reception (POR) to the NND site, but R23 was also considered for consistency with previous monitoring. The results of this measuring campaign are presented in Table 3-6. The sound levels generated from these monitoring stations were consistent with a Class 1 Area as defined in NPC-300.

Table 3-6: Measured Noise Levels at Residential Receptors in 2018 (OPG, 2020a)

Location	Minimum Measured Background Energy Equivalent Sound Level Limit (dBA)	Maximum Measured Background Energy Equivalent Sound Level Limit (dBA)
R15	46.6	62.2
R19	51.6	69.9
R23	46.2	62.3

To characterize noise from St. Marys Cement, noise was monitored at offsite locations 'REMP Location D3' and at a hydro tower location near St. Marys Cement in 2019 (Figure 3-10) as well as at the DYEC to the west.

On-site noise was characterized by monitoring at 42 locations across the DN site in 2018 and 2019 and compared to 2008. Generally, sound levels collected in 2008 were lower than those in 2018/2019, particularly for local traffic locations.

Acoustic modelling characterized the impact of DNGS, traffic and other noise sources at the PORs. Results of monitoring determined that DNGS is not audible above other noise sources at the receptor locations. Noise impacts both at the POR locations and baseline close to NND are mainly attributed to traffic from highway 401. Partial influence was also noted from local traffic volume and operation of DNGS, St. Marys Cement and DYEC. These findings are consistent with those determined by SENES in the 2008 acoustic monitoring.



Figure 3-10: Nearest Residential Noise Receptors

Given that noise from DN was not distinguishable at offsite receptor monitoring locations in both the 2008 and 2018/2019 acoustic assessments, and given the large contribution of noise at these receptors from roads in the area, in particular from Highway 401, noise was not carried forward as a COPC in the HHRA.

3.1.2.11 Summary of COPC Selection

Table 3-7 summarizes the radiological and non-radiological COPCs that are carried forward to the exposure assessment in the HHRA.

Table 3-7: Summary of COPCs Selected for the HHRA

Category	Radiological COPC	Chemical COPC
Air	C-14, Co-60, HT, HTO, noble gases, I(mfp)	nitrogen oxides
Surface water	C-14, Cs-134, HTO	hydrazine, lithium, zirconium
Soil	C-14, Co-60, Cs-134, HTO, I-131	None
Groundwater	HTO, I-131	None
Sediment (beach sand)	C-14, Cs-134, HTO	None
Other Stressors	None	

3.1.3 Selection of Exposure Pathways

For exposure of human receptors to radiological COPCs, the relevant exposure pathways include:

- Air inhalation and external exposure to air;
- Ingestion of water (WSP, wells) and external exposure to water (lakes, WSPs, wells)
- Soil and beach sand incidental ingestion
- Soil and beach sand external exposure;
- Ingestion of food.

The complete exposure pathways, as defined in OPG's EMP, for exposure of relevant receptors to radiological COPCs are summarized in Table 3-8. The exposure pathways for chemical COPCs were selected to be consistent with the radiological exposure pathways, but environmental media that were not expected to be affected by chemical COPCs (soil, ground water, terrestrial plants, and terrestrial animals) were not considered to have complete exposure pathways for human health. In addition, whereas immersion in water was considered to be a complete pathway for radiological COPCs, dermal absorption of chemical COPCs was considered to be minimal in comparison to drinking water ingestion, and was therefore not considered a complete exposure pathway for chemical COPCs. The final list of exposure pathways for chemical COPCs is presented in Table 3-9.

Table 3-8: Complete Exposure Pathways for Receptors for Exposure to Radiological COPCs

Receptor	Exposure Pathway	Environmental Media
Oshawa/Courtice Urban Resident	Inhalation	Air
	Ingestion	Water (Oshawa WSP) Soil and beach sand Aquatic animals (Lake Ontario) Terrestrial plants (homegrown)
	External	Air Water Soil and beach sand
Bowmanville Urban Resident	Inhalation	Air
	Ingestion	Water (Bowmanville WSP) Soil and beach sand Aquatic animals (Lake Ontario) Terrestrial plants (homegrown) Terrestrial animals (local)
	External	Air Water Soil and beach sand
West/East Beach Urban Resident	Inhalation	Air
	Ingestion	Water (ground water wells, Bowmanville WSP) Soil and beach sand Aquatic animals (Lake Ontario) Terrestrial plants (homegrown) Terrestrial animals (local)
	External	Air Water Soil and beach sand

Receptor	Exposure Pathway	Environmental Media
Farm	Inhalation	Air
	Ingestion	Water (ground water wells) Soil and beach sand Aquatic animals (Lake Ontario) Terrestrial plants (homegrown) Terrestrial animals (home raised)
	External	Air Water Soil and beach sand
Dairy Farm	Inhalation	Air
	Ingestion	Water (ground water wells) Soil and beach sand Aquatic animals (Lake Ontario) Terrestrial plants (homegrown) Terrestrial animals (home raised incl. milk)
	External	Air Water Soil and beach sand
Rural Resident	Inhalation	Air
	Ingestion	Water (ground water wells, Bowmanville WSP) Soil and beach sand Aquatic animals (Lake Ontario) Terrestrial plants (local) Terrestrial animals (local)
	External	Air Water Soil and beach sand
Industrial/ Commercial Worker	Inhalation	Air
	Ingestion	Water (Bowmanville WSP)
	External	Air Water Soil
Sport Fisher	Inhalation	Air
	Ingestion	Aquatic animals (Lake Ontario)
	External	Air Water
Camper	Inhalation	Air
	Ingestion	Water (Oshawa WSP) Soil and beach sand Aquatic animals (Lake Ontario) Terrestrial plants (local) Terrestrial animals (local)
	External	Air Water Soil and beach sand

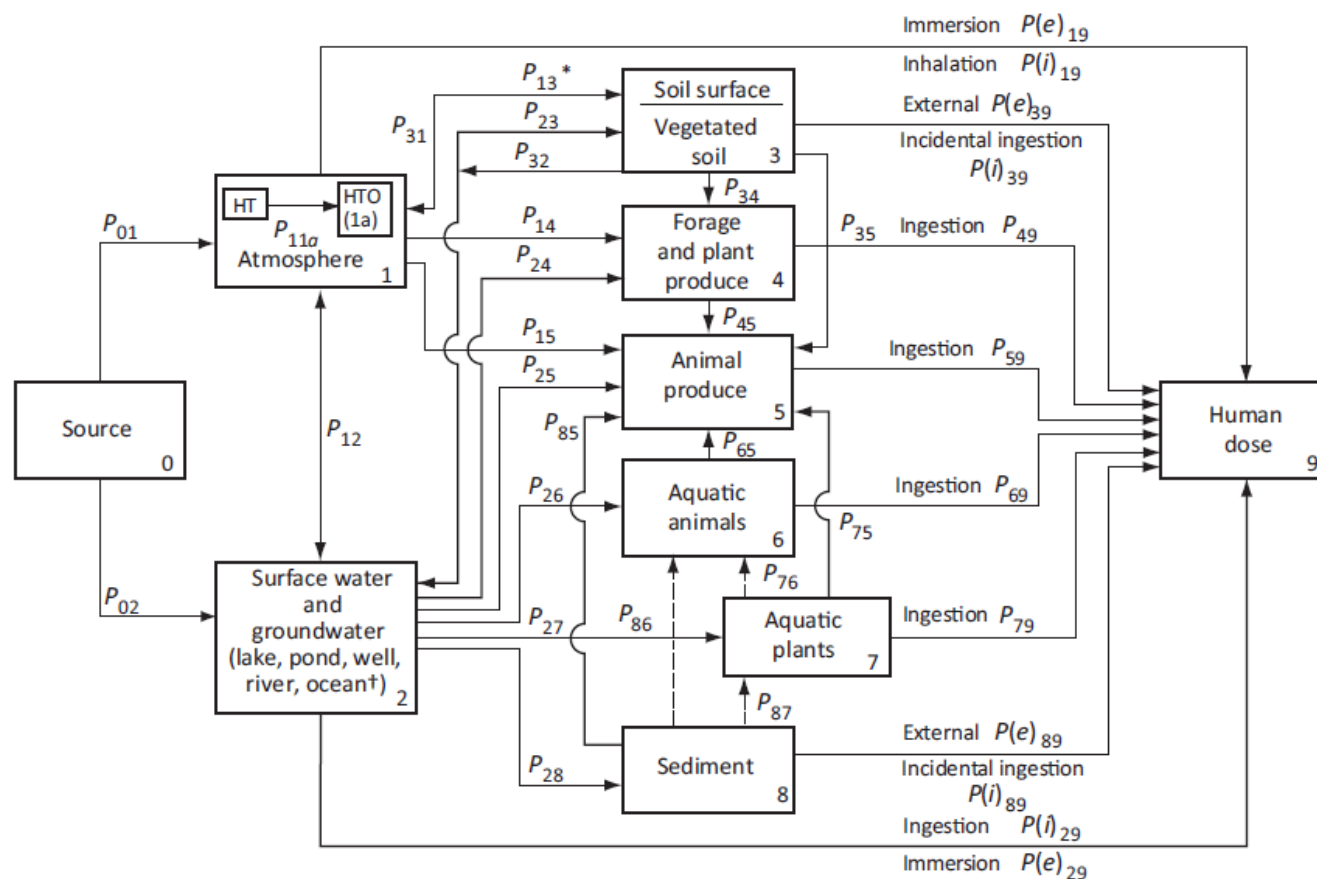
Table 3-9: Complete Exposure Pathways for Receptors for Exposure to Chemical COPCs

Receptor	Exposure Pathway	Environmental Media
Oshawa/Courtice Urban Resident	Inhalation	Air
	Ingestion	Water (Oshawa WSP) Aquatic animals (Lake Ontario)
Bowmanville Urban Resident	Inhalation	Air
	Ingestion	Water (Bowmanville WSP) Aquatic animals (Lake Ontario)
West/East Beach Urban Resident	Inhalation	Air
	Ingestion	Water (Bowmanville WSP) Aquatic animals (Lake Ontario)
Farm	Inhalation	Air
	Ingestion	Aquatic animals (Lake Ontario)
Dairy Farm	Inhalation	Air
	Ingestion	Aquatic animals (Lake Ontario)
Rural Resident	Inhalation	Air
	Ingestion	Water (Bowmanville WSP) Aquatic animals (Lake Ontario)
Industrial/ Commercial Worker	Inhalation	Air
	Ingestion	Water (Bowmanville WSP)
Sport Fisher	Inhalation	Air
	Ingestion	Aquatic animals (Lake Ontario)
Camper	Inhalation	Air
	Ingestion	Water (Oshawa WSP) Aquatic animals (Lake Ontario)

3.1.4 Human Health Conceptual Model

The conceptual model illustrates how receptors are exposed to COPCs. It represents the relationship between the source and receptors by identifying the source of contaminants, receptor locations and the exposure pathways to be considered in the assessment for each receptor. Exposure pathways represent the various routes by which radionuclides and/or chemicals may enter the body of the receptor, or (for radionuclides) how they may exert effects from outside the body.

A generic conceptual model, taken from CSA N288.1 (2014) is shown in Figure 3-11, and is applied to human receptors around DN. This represents the exposure pathways from source to receptor. It is appropriate for radiological and non-radiological COPCs, except that, for non-radionuclides, external and immersion pathways represent dermal exposure, and ingestion of homegrown terrestrial plants (forage and plant produce) and animal produce are not considered complete pathways.



*Includes transfer factors P_{13area} , P_{13mass} , and P_{13spw}

†For ocean water, pathways P_{23} , P_{24} , P_{25} , and $P(i)_{29}$ are not used.

Notes:

- (1) The broken lines represent pathways that are not explicitly considered in the model or are considered only in special circumstances.
- (2) Factors include multiple transfers where appropriate.

Figure 3-11: Generic Conceptual Model for Human Receptors (CSA, 2014)

3.1.5 Problem Formulation Checklist

The information required in Health Canada's (HC, 2010a) Problem Formulation Checklist has been provided in Sections 3.1.3 and 3.1.4, above.

3.1.6 Uncertainty in Problem Formulation

The data used in the HHRA problem formulation were concluded to be of adequate quality and quantity to support the objectives of the HHRA. Maximum measured concentrations were selected for COPC screening; this is considered conservative and is not reflective of typical human exposures. The human health screening benchmarks for water were generally the lower of applicable provincial and federal drinking water standards and guidelines, which is a conservative approach, ensuring that the list of COPCs would be as comprehensive as possible. The COPC screening also considered several media as sources of potential exposure, such as air, surface water (including Lake Ontario water, effluent, and stormwater), soil, ground water, and sediment. As such, the COPC screening has resulted in a conservative list of COPCs.

More generally, the HHRA problem formulation has been conservative in its assumptions to accommodate uncertainties and meet the objective of protecting human health. The conceptual model for human health is considered to be complete for the majority of general public exposures in the vicinity of the DN site. The selected receptors are expected to lead to conservative estimates of health risks, and are expected to be protective of any shorter-term exposures to environmental media in the vicinity of the DN site. The selected exposure pathways are consistent with available guidance (for example, N288.1-14), and are expected to account for all significant exposure pathways for human receptors in the area.

There are uncertainties and conservative assumptions made in the emission estimates and operating conditions for the ESDM (OPG, 2020d):

- The highest emission rate that each source is capable of (i.e., maximum usage rates or throughputs) was used to characterize the emissions.
- All sources are assumed to be operating simultaneously at the corresponding maximum emission rate for the averaging period.
- All fuel-fired combustion equipment (i.e., comfort heating and emergency power) emission rates were determined using the highest emission factor, combined with the maximum thermal heat input or engine rating for each piece of equipment.
- Other conservative assumptions (e.g., virtual source, 100% volatilization) were incorporated.

Based on the conservative assumptions summarized above the emission rates used for the ESDM are not likely to be an underestimate of the actual emission rates.

3.2 Exposure Assessment

The exposure assessment describes the exposure scenarios (locations, receptors), the methods used in estimating exposure concentrations and doses at the receptor locations, and the results of the exposure and dose calculations for each human receptor.

3.2.1 Exposure Locations

An exposure location is the place where the receptor comes into contact with a COPC. For both the radiological and chemical exposure assessments, the relevant human receptors are the potential critical groups defined by the EMP, as discussed in Section 3.1.1.1. Figure 3-12 presents the locations of these receptors used for the 2019 EMP report (OPG, 2020b). The exposure assessment considered all nine receptors, as reported in the EMP, where appropriate. For the non-radiological exposure assessment, the farm and dairy farm potential critical groups were not assessed for water ingestion since they obtain the majority of their water intake from water wells, and not from a WSP.



3.2.2 Exposure Duration and Frequency

The assumptions made for exposure duration and frequency are presented in Section 3.2.4.

3.2.3 Exposure and Dose Calculations

3.2.3.1 Radiological Dose Calculations

Radiological dose calculations follow the equations presented in CSA N288.1-14 (2014), which are not reproduced in this report.

3.2.3.2 Chemical Dose Calculations

Air

In calculating the inhalation exposures for nitrogen oxides, only the air concentration is necessary since the hazard quotient is determined by comparing to a toxicity reference value which in the case of NO_x is a Reference Air Concentration (RfC). Therefore, dose is not calculated, and inhalation rates and body weights for receptors are not used.

The assessment of inhalation exposure to COPCs in air is assessed at the location of all potential critical groups. The estimated POI concentrations from the ESDM reports are predicted for the DN property boundary; however, a dispersion factor from the source to all potential critical groups is not available through the ESDM reports. Therefore, to estimate the concentration of NO_x in air at the potential critical group locations, the dispersion factors from IMPACT™ are used, as shown in Table 3-10. The dispersion factors in IMPACT™ are appropriate for an annual averaging period. The release rate for NO_x from the 2019 ESDM report is 2.43 g/s (OPG, 2020d). Multiplication by the dispersion factor provides an estimate of annual average NO_x at each location.

Table 3-10: Dispersion Factor from Source to Potential Critical Group

Potential Critical Group	Approximate Distance From DN	Wind Sector (Direction TO)	Transfer Parameter From Source to Air, from DRL
			P ₀₁ (s/m ³)
Farm	1.45 km	WNW	6.85E-07
Dairy Farm	6.1 km	NW	6.39E-08
Rural Resident	2.17 km	NNE	2.70E-07
Oshawa	5.66 km	NW	8.29E-08
Bowmanville	3.2 km	NNE	1.56E-07
West East Beach	3.6 km	ENE	2.26E-07
Industrial/Commercial	2.0 km	W	4.43E-07
Sport Fisher	500 m	S	4.44E-06
Camper	3.8 km	W	1.83E-07

Surface Water

The ingestion dose from exposure to hydrazine, lithium and zirconium in drinking water was calculated according to the following equation, consistent with CSA N288.6 (CSA, 2012):

$$\text{Dose (mg/kg-d)} = C \cdot IR \cdot \text{RAF}_{\text{GIT}} \cdot D_2 \cdot D_3 \cdot D_4 / (\text{BW} \cdot \text{LE})$$

where,

- C = concentration of contaminant in drinking water (mg/L)
- IR = receptor intake rate (L/d)
- RAF_{GIT} = absorption factor from the gastrointestinal tract (unitless)
- D_2 = days per week exposed $\cdot (7 \text{ days})^{-1}$ (d/d)
- D_3 = weeks per year exposed $\cdot (52 \text{ weeks})^{-1}$ (wk/wk)
- D_4 = total years exposed to site (years) (for carcinogens only)
- BW = body weight (kg)
- LE = life expectancy (years) (for carcinogens only).

The ingestion dose from exposure to hydrazine, lithium and zirconium in fish was calculated according to the following equation, consistent with CSA N288.6 (CSA, 2012):

$$\text{Dose (mg/kg-d)} = [\sum (C_{\text{food } i} \cdot IR_{\text{food } i} \cdot \text{RAF}_{\text{GIT } i} \cdot D_i)] \cdot D_4 / (\text{BW} \cdot 365 \cdot \text{LE})$$

where,

- $C_{\text{food } i}$ = concentration of contaminant in food i (mg/kg)
- $IR_{\text{food } i}$ = receptor ingestion rate for food i (kg/d)
- $\text{RAF}_{\text{GIT } i}$ = relative absorption factor from the gastrointestinal tract for contaminant i (unitless)
- D_i = days per year during which consumption of food i will occur (d/a)
- D_4 = total years exposed to site (years) (for carcinogens only)
- BW = body weight (kg)
- 365 = total days per year (constant) (d/a)
- LE = life expectancy (years) (for carcinogens only)

3.2.4 Exposure Factors

3.2.4.1 Radiological Exposure Factors

For the radiological dose calculations, the exposure factors (e.g., intake rates, occupancy and shielding factors, etc.) are generally those used in CSA N288.1-14. The intake rates for ingestion and inhalation are the central or mean intake rates provided in CSA N288.1-14 (2014) and COG (2013a) with the exception of the drinking water intake rate for a 1-year

old infant. The drinking water intake rate for the 1-year old infant was adjusted from the default value in CSA N288.1-14 based on guidance in Clause 6.15.3.2, since the DN infant is assumed to drink only cow's milk (not water and infant formula) (OPG, 2016d). Table 3-11 summarizes the exposure factors used in the 2016-2019 radiological dose calculations that were updated for the 2019 EMP report (OPG, 2020b).

Table 3-11: Human Exposure Factors for Radiological Dose Calculations

Exposure Factor	Units ⁽⁴⁾	Infant 1 year	Child 10 year	Adult
Inhalation rate	m ³ /a	1830	5660	5950
Inhalation occupancy factor	unitless	1.0	1.0	1.0
Incidental soil ingestion rates	g dw/d	0.061	0.055	0.004
Incidental ingestion of sediment	g dw/d	0.061	0.055	0.004
Drinking water intake rate ⁽¹⁾	L/a	0	151.1	379.6
Aquatic animal intake rate ⁽²⁾	kg/a	1.68	4.82	6.86
Terrestrial animal intake rates	kg/a	262.3	286.3	255.5
Terrestrial plant intake rates	kg/a	144.5	331.1	440
Outdoor occupancy factor	unitless	0.2	0.2	0.2
Indoor plume shielding factor (skin dose and pure beta emitters)	unitless	1.0	1.0	1.0
Indoor groundshine shielding factor (gamma emitters) ⁽³⁾	unitless	0.5	0.5	0.5
Groundshine shielding factor (uneven surface shielding)	unitless	0.2	0.2	0.2
Beach swim occupancy factor	unitless	0	0.014	0.014
Bathing occupancy factor	unitless	0.014	0.014	0.014
Pool swim occupancy factor (WSP fill)	unitless	0	0.028	0.028
Pool swim occupancy factor (Well water fill)	unitless	0	0.014	0.014
Skin area	m ²	0.72	1.46	2.19
Dilution factor for shoreline sediments (DF)s	unitless	1.0	1.0	1.0
Shore Width factor (lake)	unitless	0.3	0.3	0.3
Shoreline occupancy factor	unitless	0.02	0.02	0.02
No. days/a soil ingested	d/a	135	135	135
No. days/a sediment ingested	d/a	45	45	45

Notes:

(1) The infant is conservatively assessed as consuming only cow's milk.

(2) Excludes shellfish due to fresh water environment at DN. Shellfish are a marine environment food product.

(3) For effective and skin dose. For essentially pure beta emitters, this shielding factor is zero.

(4) dw used in specification of units indicates dry weight.

Sources: (COG, 2013a; CSA, 2014)

3.2.4.2 Non-Radiological Exposure Factors

Based on the results of the screening, the human exposure assessment was performed for the inhalation pathway for NO_x, and the drinking water and fish ingestion pathways for hydrazine, lithium and zirconium.

Air

As discussed in Section 3.2.3.2, inhalation rates and body weights for receptors are not necessary since a dose is not needed; assessment of risk from NO_x is based on the comparison of air exposure concentrations to a reference concentration.

Surface Water

For non-radiological dose calculations, exposure factors are generally those from Health Canada Preliminary Quantitative Risk Assessment guidance (2004, 2010a), as recommended by Clause 6.3.5 of CSA N288.6-12 (CSA, 2012). Table 3-12 summarizes the exposure factors used in the non-radiological dose calculations.

For surface water, each receptor was assumed to obtain only a portion of their drinking water or fish from the exposed media. The fractions of the total drinking water and total fish obtained from local WSPs and at the site, respectively, were based on the results of the site-specific survey (OPG, 2018e). These fractions are tabulated in Table 3-13.

3.2.5 Dispersion Models

OPG uses IMPACT™ version 5.5.2 (IMPACT) to calculate its annual public radiological doses using a mixture of environmental monitoring data and emissions data. IMPACT represents the method of dose calculation presented in CSA N288.1-14 (2014). Where environmental monitoring data were lacking, the concentration of radionuclides in air was determined from the sector-averaged Gaussian plume atmospheric dispersion model in IMPACT, based on the release rates from DN. Table 3-14 shows a summary of which radionuclides and pathways were modelled and where measured data were used.

The dispersion factors from IMPACT™ were also used to estimate the NO_x concentration in air at potential critical group locations.

Table 3-12: Human Exposure Factors for Non-Radiological Dose Calculations

Parameter	Units	Urban Resident		Farm		Rural Resident		Industrial/ Commercial Worker	Sport Fisher		Camper		Reference
		Toddler	Adult	Toddler	Adult	Toddler	Adult	Adult	Toddler	Adult	Toddler	Adult	
Drinking Water Intake Rate	L/d	0.6	1.5	0.6	1.5	0.6	1.5	1.5	N/A	N/A	0.6	1.5	(HC, 2010a)
Fish Ingestion Rate	kg/d	0.056	0.111	0.056	0.111	0.056	0.111	N/A	0.056	0.111	0.056	0.111	(HC, 2004)
Days per Week/7 (D2)	d/d	1	1	1	1	1	1	1	N/A	N/A	1	1	(OPG, 2020b)
Weeks per Year/52 (D3)	wk/wk	1	1	1	1	1	1	0.23	N/A	N/A	0.5	0.5	(OPG, 2020b)
Years Exposed (D4)	years	N/A	30	N/A	30	N/A	30	30	N/A	30	N/A	30	(HC, 2004)
D _{fish}	d/a	365	365	365	365	365	365	N/A	365	365	365	365	(OPG, 2020b)
Body Weight	kg	16.5	70.7	16.5	70.7	16.5	70.7	70.7	16.5	70.7	16.5	70.7	(HC, 2010a)
Life Expectancy	years	N/A	70	N/A	70	N/A	70	70	N/A	70	N/A	70	(HC, 2010a)
RAF _{GI} Thallium	unitless	1	1	1	1	1	1	1	1	1	1	1	conservative assumption
RAF _{GI} Zirconium	unitless	1	1	1	1	1	1	1	1	1	1	1	conservative assumption
RAF _{GI} Thydrazine	unitless	1	1	1	1	1	1	1	1	1	1	1	conservative assumption

Table 3-13: Assumed Fractions of Drinking Water from WSPs and Fish from DN Outfall (OPG, 2020b)

Media	Urban Resident Oshawa/Courtice	Urban Resident Bowmanville	Urban Resident West/East Beach	Farm	Dairy Farm	Rural Resident	Industrial/ Commercial Worker	Sport Fisher	Camper
Water	0.834	0.785	0.142	0.05	0	0.158	1	0	1
Fish	0.1136	0.0061	0.1183	0.0518	0.0103	0.035	0	1	0.5

Table 3-14: Darlington Nuclear Potential Critical Groups Data Use (OPG, 2020b)

Pathway	Radionuclide	Modelled (a)	Measured
Air Inhalation	HTO	√ (Fisher)	√(c)
	HT	√ (b)	
	C-14	√ (b)	√
	I(mfp)	√ (b)	
	Co-60	√ (b)	
Air External Exposure	Noble Gas		√ (c)
	C-14	√ (b)	√
	I(mfp)	√ (b)	
	Co-60	√ (b)	
Soil External Exposure	C-14	√	
	I-131	√	
	Cs-134, Co-60	√	
Sand External Exposure	C-14	√	
	Cs-134		√
Water External Exposure (Lakes, WSPs, Wells)	HTO	√ (wells)	√
	C-14	√	
	I-131	√	
	Cs-134	√	
Terrestrial Animals Ingestion	HTO	√	√ (milk, eggs, poultry)
	C-14	√	√ (milk, eggs, poultry)
	I-131	√	
	Cs-134, Co-60	√	
	OBT	√ (d)	
Terrestrial Plants Ingestion	HTO		√
	C-14		√
	I-131	√	
	Cs-134, Co-60	√	
	OBT	√ (d)	
Aquatic Animals Ingestion	HTO		√
	C-14		√
	I-131	√	
	Cs-134		√
	OBT	√ (d)	
Sand and Soil Incidental Ingestion	HTO	√	
	C-14	√	
	I-131	√	
	Cs-134, Co-60	√	√ (sand)
Water Ingestion (WSPs, Wells)	HTO		√
	C-14	√	
	I-131	√	
	Cs-134	√	

Notes:

(a) Modelling is based on emissions or from local air measurements where they are available.

(b) Concentrations are modelled from emissions and adjusted using empirical Ka determined for each potential critical group location.

(c) Doses are measured directly at the site boundary and adjusted to potential critical group locations using the ratio of modelled air dispersion factors for the boundary monitor and potential critical group.

(d) OBT dose is modelled from HTO concentration in terrestrial plants, terrestrial animals, or fish respectively.

3.2.6 Exposure Point Concentrations and Doses

3.2.6.1 Exposure Point Concentrations and Doses for Radiological COPCs

Since 2013, the annual Radiological Environmental Monitoring Program report was changed to the annual EMP report entitled “Results of Environmental Monitoring Programs”. During this time, the EMP was redesigned to meet the requirements of CSA N288.4-10 (CSA, 2010) and expanded to include conventional contaminants, physical stressors and non-human biota in addition to the radiological contaminants and human exposure. The radiological dose calculations were updated to the latest CSA N288.1-14 standard which is reflected in the dose results presented in the 2019 EMP Report (OPG, 2020b).

For the radiological exposure assessment, exposure point concentrations are either based on measured data from the annual EMP or modelled from emissions data, as described in Table 3-14 and in the 2019 EMP Report (OPG, 2020b). Additionally, when measurement averages or other calculations are performed, they are calculated using actual results obtained even if they are below the critical level (OPG, 2020b). As mentioned above, OPG uses IMPACT™ version 5.5.2 (IMPACT) to calculate its annual public doses using a mixture of environmental monitoring data and emissions data. Table 3-15 presents a summary of the annual doses to the three most exposed critical groups from 2016 to 2019. These doses were calculated using annual average measured and modelled concentrations in environmental media.

The annual average dose to the three most exposed critical groups during the four-year period of interest (2016 to 2019) ranged from 0.1 to 0.8 μSv . From 2016 to 2018, the most exposed critical groups were the dairy farm, farm and rural residents. In 2019, the most exposed critical groups were the West/East Beach Resident, farm and rural residents. The dominant pathways and radionuclides that contribute significantly to the total dose are inhalation and ingestion of HTO in air and in water, plants, and animal products; external exposure to noble gases; and ingestion of C-14 in plants and animal products.

The dose to the most exposed critical groups over the 2016 to 2019 time period remained relatively constant, and the doses have remained largely unchanged for the past ten years (OPG, 2020b).

Table 3-15: Summary of Doses to Most Exposed Critical Groups from 2016 to 2019

Year	Age Class	Radiological Dose (µSv/a)		
		Dairy Farm	Farm	Rural Resident
2016	Adult	0.4	0.4	0.2
	Child	0.4	0.4	0.2
	Infant	0.6	0.3	0.1
2017	Adult	0.4	0.6	0.2
	Child	0.4	0.5	0.3
	Infant	0.7	0.3	0.2
2018	Adult	0.5	0.8	0.4
	Child	0.5	0.7	0.3
	Infant	0.5	0.5	0.2
		West/East Beach Resident	Farm	Rural Resident
2019	Adult	0.2	0.4	0.3
	Child	0.2	0.4	0.3
	Infant	0.1	0.3	0.2

Sources: OPG (OPG, 2017b, 2018b, 2019a, 2020b)

3.2.6.2 Exposure Point Concentrations and Doses for Chemical COPCs

The exposure point concentrations are based on the screening conducted during problem formulation. For the waterborne non-radiological COPCs, data were screened based on a number of data sources: CCW data from the ECA from 2016 to 2019 (hydrazine), and Lake Ontario water samples collected at DN in 2019 (hydrazine, lithium and zirconium). The overall maximum and UCLM concentration from all of these sources was used for the exposure assessment. The dose to receptors due to ingestion of fish exposed to hydrazine assumes a continuous release.

3.2.6.2.1 Exposure Point Concentrations in Air

Annual exposure at the potential critical group locations is based on NO_x release rates reported in the 2016 to 2019 ESDM reports and dispersion factors from IMPACT™. The emission rate from the 2019 ESDM report is 2.43 g/s (OPG, 2020d). Applying this emission rate to the annual average dispersion factors from IMPACT™ (Table 3-10), results in estimated concentrations of NO_x at potential critical group locations, as shown in Table 3-16. Note that these concentrations represent annual NO_x concentrations for a steady release at 2.43 g/s.

There is uncertainty as to what the short-term air concentrations would be beyond the property boundary, as the IMPACT™ dispersion factors represent annual average meteorological conditions. The Sport Fisher is the closest receptor to the property boundary since he is fishing at the DN outfall. Therefore, the short-term air concentration at the property boundary would be considered appropriate for the Sport Fisher, with a maximum

short-term exposure point concentration of 526 $\mu\text{g}/\text{m}^3$ in 2016 and 205 $\mu\text{g}/\text{m}^3$ in 2018/2019 based on a 1-hr averaging period (OPG, 2017c, 2018c, 2019d, 2020d).

Table 3-16: Annual Average Exposure Point Concentrations of NO_x in Air

Potential Critical Group	Approximate Distance From DN	Annual Average NO_x Concentration ($\mu\text{g}/\text{m}^3$)
Farm	1.45 km	1.66
Dairy Farm	6.1 km	0.16
Rural Resident	2.17 km	0.66
Oshawa	5.66 km	0.20
Bowmanville	3.2 km	0.38
West East Beach	3.6 km	0.55
Industrial/Commercial	2.0 km	1.08
Fisher	500 m	10.79
Camper	3.8 km	0.44

3.2.6.2.2 Exposure Point Concentrations in and Doses from Surface Water

Maximum and UCLM measured concentrations in Lake water and maximum and mean measured concentrations in CCW effluent were diluted using the estimated dilution factors from OPG (2016d) in order to estimate exposure point concentrations for the COPCs, as follows:

- A dilution factor of 7 was applied to measured CCW effluent to estimate a concentration in Lake Ontario at the Outfall;
- A dilution factor of 34.7 was applied to the CCW effluent to estimate a concentration at the Bowmanville WSP; and,
- A dilution factor of 35.6 was applied to the CCW effluent to estimate a concentration at the Oshawa WSP.

The WSP dilution factors were calculated using the CSA N288.1-14 aquatic dispersion model (CSA 2014), which is an approved method of estimating dilution factors. The outfall dilution factor of 7 is a recommended site-specific parameter described in the COG DRL Guidance (COG, 2013a). Additional model parameter values used in the calculations are listed in Table 3-17.

Table 3-17: Parameter Values for CSA Model and Resulting Dilution Factors (OPG, 2016d)

Parameter	Units	Description	Outfall	Camper (Beach)	Bowmanville WSP	Oshawa WSP
X	m	distance from DN	0	1,688	6,770	7,800
β	na	recirculation factor	1.15	1.15	1.15	1.15
Q_v	L/s	discharge flow	1.231E+05	1.231E+05	1.231E+05	1.231E+05
κ	na	proportionality factor	7.1E-06	7.1E-06	7.1E-06	7.1E-06
D_0	na	initial dilution factor	7	7	7	7
U_c	m/s	current speed to the right (W)	0.085	0.085	0.085	0.085
U_c	m/s	current speed to the left (E)	0.082	0.082	0.082	0.082
α	na	fraction of year current flows toward receptor	1.0	1.0	1.0	1.0
d	m	average plume depth	12	7	12	10.6
D_F	na	calculated overall dilution factor	7.0	10.9	34.7	35.6

Dilution factors (D_F) are calculated based on release from the CCW. Therefore, in order to estimate COPC concentrations in surface water at the WSPs, the maximum and the UCLM surface water COPC concentrations measured in Lake Ontario were first concentrated by a factor of 7 (D_0) to estimate an equivalent concentration in the CCW, as if the surface water COPCs originated from the CCW. The dilution factor of 34.7 or 35.6 was then applied to this equivalent concentration to estimate the surface water COPC concentrations at Bowmanville and Oshawa WSPs, respectively.

At a pH of 8 (representative of the typical pH observed in Lake Ontario near DN), the chemical half-life of hydrazine ranges from 0.6 to 1.31 days (EC and HC, 2011). Considering dilution along the flowpath from DN to the WSPs, and the range in half-life for hydrazine, calculations of exposure point concentrations are carried out accounting for dilution and decay, starting from both lake water and CCW concentrations of hydrazine (Table 3-18). Starting with the CCW concentrations, the hydrazine concentration estimated at the WSPs would range from 0.06 to 0.1 $\mu\text{g/L}$ at both the Bowmanville and Oshawa WSPs, depending on the half-life. Both are greater than the drinking water benchmark of 0.01 $\mu\text{g/L}$. However, starting with the lake water concentrations, the hydrazine concentration estimated at the WSPs would range from 0.007 to 0.01 $\mu\text{g/L}$. Based on a half-life of 1.3 days, the hydrazine concentration at the WSPs (0.01 $\mu\text{g/L}$) is equivalent to the benchmark for drinking water of 0.01 $\mu\text{g/L}$. Based on a half-life of 0.6 days, the hydrazine concentration at the WSPs (0.007 $\mu\text{g/L}$) is below the benchmark for drinking water of 0.01 $\mu\text{g/L}$. The maximum and UCLM exposure point concentrations for hydrazine are presented in Table 3-18 using CCW and lake water data. The UCLM exposure point concentrations are more representative of concentrations at WSPs than the maximum

concentrations because UCLM concentrations reflect expected exposure over the long-term.

The resulting exposure point concentrations in surface water are presented in Table 3-18 for hydrazine, lithium and zirconium. Based on these exposure point concentrations, and using the equations presented in Section 3.2.3.2 and the receptor characteristics presented in Section 3.2.4.2, surface water doses were estimated for each receptor. These doses are presented in Table 3-19 for COPCs considered to have non-carcinogenic health effects (lithium and zirconium) and carcinogenic health effects (hydrazine). Dose calculations are provided based on maximum and UCLM concentrations of hydrazine, lithium and zirconium measured in lake water.

Table 3-18: Summary of Exposure Point Concentrations of Non-Radiological COPCs in Surface Water

COPC	Lake Water (mg/L)		Effluent (ECA) (mg/L)		Dilution Factors ^b			
	Maximum Concentration	UCLM Concentration	Maximum Concentration	Mean ^a Concentration	Outfall	Beach	Bowmanville WSP	Oshawa WSP
Hydrazine (CCW)	-	-	0.006	0.001	7	10.9	34.7	35.6
Hydrazine (Lake Water)	0.00011	0.00010	-	-	7	10.9	34.7	35.6
Lithium (Lake Water)	0.0102	0.0026	-	-	7	10.9	34.7	35.6
Zirconium (Lake Water)	0.00034	0.00002	-	-	7	10.9	34.7	35.6

Notes:

^a Hydrazine concentrations from the CCW are based on mean concentrations, since raw data to calculate UCLM concentrations were not available.

^b See Table 3-17 for parameters used in the derivation of these dilution factors.

COPC	Estimated Point of Exposure Concentrations (mg/L)							
	Outfall		Beach		Bowmanville WSP		Oshawa WSP	
	Maximum	UCLM ^a	Maximum	UCLM ^a	Maximum	UCLM ^a	Maximum	UCLM ^a
Hydrazine (CCW)	8.57E-04	1.61E-04	5.50E-04	1.03E-04	1.73E-04	3.24E-05	1.69E-04	3.16E-05
Hydrazine (CCW) decayed $t_{1/2} = 0.6$ days	8.57E-04	1.61E-04	4.22E-04	7.91E-05	5.80E-05	1.09E-05	4.94E-05	9.26E-06
Hydrazine (CCW) decayed $t_{1/2} = 1.3$ days	8.57E-04	1.61E-04	4.87E-04	9.13E-05	1.04E-04	1.96E-05	9.57E-05	1.79E-05
Hydrazine (Lake Water)	1.10E-04	1.00E-04	7.06E-05	6.45E-05	2.22E-05	2.03E-05	2.16E-05	1.98E-05
Hydrazine (Lake Water) decayed $t_{1/2} = 0.6$ days	1.10E-04	1.00E-04	5.42E-05	5.42E-05	7.44E-06	7.44E-06	6.34E-06	6.34E-06
Hydrazine (Lake Water) decayed $t_{1/2} = 1.3$ days	1.10E-04	1.00E-04	6.25E-05	6.25E-05	1.34E-05	1.34E-05	1.23E-05	1.23E-05
Lithium (Lake Water)	1.02E-02	2.58E-03	6.55E-03	1.66E-03	2.06E-03	5.21E-04	2.01E-03	5.07E-04
Zirconium (Lake Water)	3.40E-04	2.26E-05	2.18E-04	1.45E-05	6.86E-05	4.56E-06	6.69E-05	4.44E-06

Notes:

^a Hydrazine concentrations from the CCW are based on mean concentrations, since raw data to calculate UCLM concentrations were not available.

Table 3-19: Summary of Estimated Doses Due to Ingestion of Maximum and UCLM COPC Concentrations in Surface Water

Receptor Group		Dose (mg/kg/d) - Non-Carcinogenic				Dose (mg/kg/d) - Carcinogenic											
		Lithium		Zirconium		Hydrazine (CCW)		Hydrazine (CCW) decayed $t_{1/2} = 0.6$ days		Hydrazine (CCW) decayed $t_{1/2} = 1.3$ days		Hydrazine (Lake Water)		Hydrazine (Lake Water) decayed $t_{1/2} = 0.6$ days		Hydrazine (Lake Water) decayed $t_{1/2} = 1.3$ days	
		Max	UCLM	Max	UCLM	Max	Mean ^a	Max	Mean ^a	Max	Mean ^a	Max	UCLM	Max	UCLM	Max	UCLM
Urban Resident Oshawa/Courtice	Toddler	6.08E-05	1.54E-05	2.03E-06	1.35E-07	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	3.55E-05	8.98E-06	1.18E-06	7.86E-08	1.28E-06	2.40E-07	3.75E-07	7.03E-08	7.25E-07	1.36E-07	1.64E-07	1.50E-07	4.81E-08	4.81E-08	9.31E-08	9.31E-08
Urban Resident Bowmanville	Toddler	5.87E-05	1.49E-05	1.96E-06	1.30E-07	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	3.43E-05	8.67E-06	1.14E-06	7.59E-08	1.23E-06	2.31E-07	4.14E-07	7.76E-08	7.45E-07	1.40E-07	1.58E-07	1.45E-07	5.31E-08	5.31E-08	9.57E-08	9.57E-08
Urban Resident West/East Beach	Toddler	1.06E-05	2.69E-06	3.54E-07	2.35E-08	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	6.20E-06	1.57E-06	2.07E-07	1.37E-08	2.23E-07	4.19E-08	7.49E-08	1.40E-08	1.35E-07	2.53E-08	2.87E-08	2.62E-08	9.61E-09	9.61E-09	1.73E-08	1.73E-08
Farm	Toddler	3.74E-06	9.47E-07	1.25E-07	8.29E-09	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	2.18E-06	5.52E-07	7.28E-08	4.84E-09	7.86E-08	1.47E-08	2.64E-08	4.94E-09	4.75E-08	8.90E-09	1.01E-08	9.22E-09	3.38E-09	3.38E-09	6.09E-09	6.09E-09
Dairy Farm	Toddler	Does Not Drink Lake Water				Does Not Drink Lake Water											
	Adult																
Rural Resident	Toddler	1.18E-05	2.99E-06	3.94E-07	2.62E-08	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	6.90E-06	1.75E-06	2.30E-07	1.53E-08	2.48E-07	4.66E-08	8.33E-08	1.56E-08	1.50E-07	2.81E-08	3.19E-08	2.91E-08	1.07E-08	1.07E-08	1.93E-08	1.93E-08
Industrial / Commercial Worker	Adult	1.00E-05	2.54E-06	3.35E-07	2.23E-08	3.62E-07	6.78E-08	1.21E-07	2.27E-08	2.18E-07	4.10E-08	4.64E-08	4.24E-08	1.56E-08	1.56E-08	2.80E-08	2.80E-08
Sport Fisher	Toddler	Does Not Drink Lake Water				Does Not Drink Lake Water											
	Adult																
Camper	Toddler	3.65E-05	9.23E-06	1.22E-06	8.08E-08	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	2.13E-05	5.38E-06	7.09E-07	4.72E-08	7.66E-07	1.44E-07	2.25E-07	4.21E-08	4.35E-07	8.16E-08	9.83E-08	8.98E-08	2.88E-08	2.88E-08	5.58E-08	5.58E-08

Notes:

^a Dose calculations for hydrazine from the CCW are based on mean concentrations, since raw data to calculate UCLM concentrations were not available.

3.2.6.2.3 Exposure Point Concentrations in and Doses from Fish

Hydrazine is released into the atmosphere through boiler steam releases and venting. Hydrazine is discharged into the aquatic environment through boiler blowdown and flushing to the intake forebay. Hydrazine is added to the feedwater for oxygen removal. For this assessment, it was conservatively assumed that hydrazine is released to the aquatic environment on an on-going basis.

Since several human receptors are potentially exposed to chemical COPCs through fish ingestion, the fish tissue concentrations for hydrazine, lithium and zirconium were estimated using bioaccumulation factors (BAFs), as discussed below.

Hydrazine BCF

Limited data exist on the bioaccumulation of hydrazine in aquatic organisms. Slonim and Gisclard (1976) derived a bioconcentration factor (BCF) of 288 L/kg based on a hydrazine concentration (144 mg/kg) estimated in guppies after four days exposure to hard water at a hydrazine concentration of 0.5 mg/L. According to Environment Canada and Health Canada (EC and HC, 2011) there are limitations and uncertainties associated with this study. Hydrazine was not measured in the fish, but was estimated from measurements in water, assuming that the slightly greater loss from water over 4 days, when fish were in the water, was due to uptake into the fish. Hydrazine bioaccumulation in fish was not directly measured. Since the same study showed higher rates of hydrazine degradation due to fish excreta in water, it is not clear that any hydrazine uptake into fish actually occurred. As well, a hydrazine concentration of 0.5 mg/L can generate ecotoxicity; therefore, there is uncertainty around the BCF of 288 L/kg. According to the *Persistence and Bioaccumulation Regulations* under the *Canadian Environmental Protection Act*, hydrazine would not be considered a substance that bioaccumulates since its BAF (or BCF) is less than 5000 and its $\log K_{ow}$ is less than 5 ($\log K_{ow}$ of -2.07) (EC and HC, 2011).

Considering the large uncertainty surrounding the Slonim and Gisclard (1976) study, the published BCF from that study was not used for the quantitative evaluation of hydrazine. Quantitative Structure-Activity Relationship (QSAR) models are available to estimate bioconcentration factors for chemicals using correlations between BCFs and hydrophobicity ($\log K_{ow}$), where experimental data on bioaccumulation are lacking (European Commission, 2006). Meylan et al. 1999 (as cited in European Commission, 2006) recommends an improved model that suggests using a $\log BCF$ of 0.5 for all non-ionic compounds with $\log K_{ow} < 1$. Therefore, a $\log BCF$ of 0.5 was used to represent bioaccumulation of hydrazine in fish.

Lithium and Zirconium BCFs

Lithium has a low potential for bioaccumulation in aquatic organisms. The European Chemicals Agency (ECHA) cites a BCF of 8.0 L/kg in freshwater fish. The BCF of 8 L/kg was reported by Barber *et al.* for the liver of Tilapia, collected in wastewater wetlands

(Barber et al., 2006). As a liver value, it may be conservative for fish flesh. The ECHA identified that there were limitations in design and/or reporting of the study, but the study follows sound scientific principles and is considered reliable and relevant for use for this endpoint.

Zirconium also has a low potential for bioaccumulation in aquatic organisms. N288.1-14 (Table A-25a) cites a BAF of 7.0 L/kg in freshwater fish. This value represents the geometric mean of pooled data from *Chant et al.* for Lake Ontario, Lake Huron, Ottawa River, and St. Lawrence River (Chant et al., 2000).

The resulting estimated exposure point concentrations for fish are presented in Table 3-20. Based on these exposure point concentrations, and using the equations presented in Section 3.2.3.2 and the receptor characteristics presented in Section 3.2.4.2, fish ingestion doses were estimated for each receptor. These doses are presented in Table 3-21. Dose calculations are provided based on maximum and UCLM concentrations of hydrazine, lithium and zirconium measured in lake water. Dose calculations are provided based on maximum and mean concentrations of hydrazine measured in the CCW.

Table 3-20: Summary of Exposure Point Concentrations of Non-Radiological COPCs in Fish

COPC	Estimated Water Concentrations		Bioconcentration Factor (BCF) (L/kg)	Estimated Fish Concentrations	
	Estimated at Outfall (mg/L)			Estimated at Outfall (mg/kg)	
	Maximum Concentration	UCLM ^a Concentration		Maximum Concentration	UCLM ^a Concentration
Hydrazine (CCW)	8.57E-04	1.61E-04	3.2	2.7E-03	5.1E-04
Hydrazine (CCW) decayed t½ = 0.6 days	8.57E-04	1.61E-04	3.2	2.7E-03	5.1E-04
Hydrazine (CCW) decayed t½ = 1.3 days	8.57E-04	1.61E-04	3.2	2.7E-03	5.1E-04
Hydrazine (lake water)	1.10E-04	1.00E-04	3.2	3.5E-04	3.2E-04
Hydrazine (lake water) decayed t½ = 0.6 days	1.10E-04	1.00E-04	3.2	3.5E-04	3.2E-04
Hydrazine (lake water) decayed t½ = 1.3 days	1.10E-04	1.00E-04	3.2	3.5E-04	3.2E-04
Lithium	1.02E-02	2.58E-03	8	8.2E-02	2.1E-02
Zirconium	3.40E-04	2.26E-05	7	2.4E-03	1.6E-04

Notes:

^a Hydrazine concentrations from the CCW are based on mean water concentrations, since raw data to calculate UCLM concentrations were not available.

COPC	Estimated Water Concentrations		Bioconcentration Factor (BCF) (L/kg)	Estimated Fish Concentrations	
	Estimated at Beach (mg/L)			Estimated at Beach (mg/kg)	
	Maximum Concentration	UCLM ^a Concentration		Maximum Concentration	UCLM ^a Concentration
Hydrazine (CCW)	5.50E-04	1.03E-04	3.2	1.74E-03	3.26E-04
Hydrazine (CCW) decayed t½ = 0.6 days	4.22E-04	7.91E-05	3.2	1.33E-03	2.50E-04
Hydrazine (CCW) decayed t½ = 1.3 days	4.87E-04	9.13E-05	3.2	1.54E-03	2.89E-04
Hydrazine (lake water)	7.06E-05	6.45E-05	3.2	2.23E-04	2.04E-04
Hydrazine (lake water) decayed t½ = 0.6 days	5.42E-05	5.42E-05	3.2	1.71E-04	1.71E-04
Hydrazine (lake water) decayed t½ = 1.3 days	6.25E-05	6.25E-05	3.2	1.98E-04	1.98E-04
Lithium	6.55E-03	1.66E-03	8	5.24E-02	1.33E-02
Zirconium	2.18E-04	1.45E-05	7	1.53E-03	1.02E-04

Notes:

^a Hydrazine concentrations from the CCW are based on mean water concentrations, since raw data to calculate UCLM concentrations were not available.

Table 3-21: Summary of Estimated Doses Due to Ingestion of Maximum and UCLM COPC Concentrations in Fish

Receptor Group		Dose (mg/kg/d) - Non-Carcinogenic				Dose (mg/kg/d) -Carcinogenic											
		Lithium		Zirconium		Hydrazine (CCW)		Hydrazine (CCW) decayed t _{1/2} = 0.6 days		Hydrazine (CCW) decayed t _{1/2} = 1.3 days		Hydrazine (Lake Water)		Hydrazine (Lake Water) decayed t _{1/2} = 0.6 days		Hydrazine (Lake Water) decayed t _{1/2} = 1.3 days	
		Max	UCLM	Max	UCLM	Max	Mean ^a	Max	Mean ^a	Max	Mean ^a	Max	UCLM	Max	UCLM	Max	UCLM
Urban Resident Oshawa/Courtice	Toddler	3.15E-05	7.96E-06	9.18E-07	6.10E-08	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	1.46E-05	3.68E-06	4.24E-07	2.82E-08	2.07E-07	3.88E-08	2.07E-07	3.88E-08	2.07E-07	3.88E-08	2.66E-08	2.43E-08	2.66E-08	2.43E-08	2.66E-08	2.43E-08
Urban Resident Bowmanville	Toddler	1.69E-06	4.27E-07	4.93E-08	3.28E-09	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	7.81E-07	1.98E-07	2.28E-08	1.52E-09	1.11E-08	2.09E-09	1.11E-08	2.09E-09	1.11E-08	2.09E-09	1.43E-09	1.30E-09	1.43E-09	1.30E-09	1.43E-09	1.30E-09
Urban Resident West/East Beach	Toddler	3.28E-05	8.29E-06	9.56E-07	6.35E-08	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	1.52E-05	3.83E-06	4.42E-07	2.94E-08	2.16E-07	4.05E-08	2.16E-07	4.05E-08	2.16E-07	4.05E-08	2.77E-08	2.53E-08	2.77E-08	2.53E-08	2.77E-08	2.53E-08
Farm	Toddler	1.43E-05	3.63E-06	4.18E-07	2.78E-08	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	6.64E-06	1.68E-06	1.94E-07	1.29E-08	9.45E-08	1.77E-08	9.45E-08	1.77E-08	9.45E-08	1.77E-08	1.21E-08	1.11E-08	1.21E-08	1.11E-08	1.21E-08	1.11E-08
Dairy Farm	Toddler	2.85E-06	7.22E-07	8.32E-08	5.53E-09	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	1.32E-06	3.34E-07	3.85E-08	2.56E-09	1.88E-08	3.52E-09	1.88E-08	3.52E-09	1.88E-08	3.52E-09	2.41E-09	2.20E-09	2.41E-09	2.20E-09	2.41E-09	2.20E-09
Rural Resident	Toddler	9.69E-06	2.45E-06	2.83E-07	1.88E-08	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	4.48E-06	1.13E-06	1.31E-07	8.69E-09	6.38E-08	1.20E-08	6.38E-08	1.20E-08	6.38E-08	1.20E-08	8.19E-09	7.48E-09	8.19E-09	7.48E-09	8.19E-09	7.48E-09
Industrial / Commercial Worker	Adult	Does Not Eat Local Fish				Does Not Eat Local Fish											
Sport Fisher	Toddler	2.77E-04	7.01E-05	8.08E-06	5.37E-07	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	1.28E-04	3.24E-05	3.74E-06	2.48E-07	1.82E-06	3.42E-07	1.82E-06	3.42E-07	1.82E-06	3.42E-07	2.34E-07	2.14E-07	2.34E-07	2.14E-07	2.34E-07	2.14E-07
Camper	Toddler	8.89E-05	2.25E-05	2.59E-06	1.72E-07	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	4.11E-05	1.04E-05	1.20E-06	7.98E-08	5.86E-07	1.10E-07	4.49E-07	8.42E-08	5.18E-07	9.71E-08	7.52E-08	6.87E-08	5.76E-08	5.76E-08	6.65E-08	6.65E-08

Notes:

^a Dose calculations for hydrazine from the CCW are based on mean concentrations, since raw data to calculate UCLM concentrations were not available.

3.2.7 Uncertainties in the Exposure Assessment

Table 3-22 summarizes the major uncertainties in the exposure assessment.

Table 3-22: Summary of Major Uncertainties in the Exposure Assessment

Risk Assessment Assumption	Justification	Over/Under Estimate Risk?
Air exposure calculations for nitrogen oxides were estimated at potential critical group locations using dispersion factors from IMPACT™ for the annual averaging period, and assuming steady release.	Available data from the ESDM is limited to maximum modelled POI concentrations for the DN property boundary, and release rates for operating equipment. Actual operation is occasional.	Overestimate
Water concentration for hydrazine, lithium and zirconium at Bowmanville and Oshawa WSPs is pre-treatment, and is modelled from liquid releases, with no degradation.	Hydrazine degrades by oxidation in water, with rates depending on hardness and organic matter; it degrades rapidly under chlorinated conditions typically used for treatment/distribution of drinking water (EC/HC, 2011). No information on degradation of other COPCs post WSP treatment or from DN to WSPs.	Overestimate
Dilution factors based on CSA aquatic dispersion model, as specified in CSA N288.1-14 (2014), were used to estimate water concentrations at the WSPs from CCW releases	These dilution factors form the basis for the DRL calculation, which are consistent with N288.1-14. They are expected to be conservative estimates of true dilution factors.	Overestimate
BAF for hydrazine is based on QSAR model and not measured bioaccumulation data.	Limited information exists on bioaccumulation of hydrazine, although it is expected to be low. Only one study (Slonim and Gisclard, 1976) exists on hydrazine bioaccumulation (EC and HC, 2011), and there is large uncertainty surrounding the methods and results.	Neither (value is best estimate)
Water concentration of hydrazine at WSPs estimated from lake water measurements at DN.	Hydrazine is periodically released in batches from the CCW to Lake Ontario through the DN diffuser. Lake water monitoring events may not occur during the effluent release when the maximum concentrations of hydrazine would be expected. To reduce uncertainty, another line of evidence is used (see uncertainty on application of conservative dilution factors above).	Underestimate

3.3 Toxicity Assessment

3.3.1 Toxicological Reference Values (TRVs)

A toxicity reference value (TRV) is a toxicological index, associating specific health effects with a level of exposure to a chemical. TRVs may include slope factors and unit risks for carcinogens, and reference doses, tolerable daily intakes, or acceptable daily intakes for non-carcinogens. TRVs are used in the risk characterization to determine Incremental Lifetime Cancer Risks (ILCRs) and Hazard Quotients (HQs), as discussed in Section 3.4.1.2.

Air

A summary of the TRVs selected for the COPC in air – nitrogen oxides – is presented in Table 3-23 and discussed below.

The ECCC (2017) 1-hour and annual CAAQS for nitrogen dioxide (NO₂) were selected as Reference Air Concentrations (RfCs) for nitrogen oxides (NO_x). Note that nitrogen oxides (NO_x) are defined as the sum of nitrogen dioxide (NO₂) and nitric oxide (NO). Emissions of NO_x consist mainly of NO, with some NO₂. In ambient air, NO converts rapidly to NO₂. NO₂ has adverse health effects at much lower concentrations than NO. Therefore, air quality guidelines are typically based on the health effects of NO₂.

Health Canada conducted a review to support the development of a CAAQS for NO₂ (HC, 2016). Based on evidence from epidemiological and animal toxicology studies, linking ambient concentrations of NO₂ pollution to a wide range of health effects Health Canada (2016) concluded the following:

- there is strong evidence that ambient NO₂ causes both short-term and long-term respiratory effects (e.g., asthma), and short-term mortality; as well as suggestive evidence linking it to a wide range of other adverse health outcomes;
- these effects have been observed in epidemiological studies at NO₂ concentrations that commonly occur in Canada;
- in studies examining the shape of the concentration–response curve, there is an approximately linear relationship between ambient NO₂ concentrations and health effects, with no clear evidence of a threshold; hence, based on the balance of the evidence it should be assumed that any increment in levels of ambient NO₂ presents an increased risk for health effects, up to and including mortality;
- the health evidence supports the establishment of both short-term and long-term standards to protect against the full suite of health effects associated with ambient NO₂.

As a result of these findings, (ECCC, 2017) selected a CAAQS for 1-hour exposure based on an upper bound value of ambient 1-hour average NO₂ concentrations in Canada, and a CAAQS for annual average exposure based on the annual average of 1-hour average NO₂ concentrations (Table 3-23).

Table 3-23: Selected Human Toxicity Reference Values for Chemical COPCs in Air

COPC	Averaging Period	TRV Type	Value	Reference
Nitrogen oxides	1-hour	2020 CAAQS (Nitrogen Dioxide)	113 µg/m ³ (60 ppb)	ECCC, 2017
	Annual	2020 CAAQS (Nitrogen Dioxide)	32 µg/m ³ (17 ppb)	ECCC, 2017

Surface Water

A summary of the TRVs selected for COPCs in water - hydrazine, lithium and zirconium - is presented in Table 3-24 and discussed below.

Hydrazine is classified by the International Agency for Research on Cancer (IARC) as a Group 1A carcinogen and the US EPA as a Group B2 carcinogen – probable human carcinogen; and by the European Commission as Category 2 for carcinogenicity – should be regarded as if it is carcinogenic to man. Studies showed tumor induction in mice, rats and hamsters following administration of hydrazine via inhalation (1.3 and/or 6.5 mg/m³) and in mice treated orally (1.87 mg/kg bw/day) (EC and HC, 2011). The US EPA (1991) has derived an oral slope factor of 3.0 (mg/kg-day)⁻¹ for human ingestion of hydrazine based on a 1970 study by Biancifiori on liver cancer in mice exposed to hydrazine sulphate orally.

Lithium is not known to be carcinogenic. The US EPA (2008) derived a chronic reference dose (RfD) for oral exposure of 0.002 mg/kg/d for lithium, which was established by a Provisional Peer Reviewed Toxicity Values (PPRTV). The RfD is based on a Lowest-Observed-Adverse-Effect Level (LOAEL) of 2.1 mg/kg/d for adverse effects produced by lithium therapy in several human organs and systems. The most common adverse effect known from human lithium therapy is impaired renal function. Additional adverse effects include neurological, endocrine, gastrointestinal, hematological and developmental effects (US EPA, 2008). An uncertainty factor (UF) of 1,000 was applied to the 2.1 mg/kg/d, resulting in an RfD of 0.002 mg/kg/d.

Zirconium is not known to be carcinogenic. The US EPA derived a chronic reference dose (RfD) for oral exposure of 0.00008 mg/kg/d for zirconium, which was established as a provisional PPRTV (US EPA, 2012). The RfD is based on a LOAEL of 0.79 mg/kg/d corresponding to higher cholesterol levels in male rats in Schroeder *et al.* (1970); female rats displayed significantly increased glycosuria in the urine and higher glucose levels (LOAEL 0.89 mg/kg/d). An earlier study on mice conducted by Schroeder *et al.* (1968)

determined a LOAEL in male mice of 1.71 mg/kg-day for reduced mean body weight, strengthening the use of the male rat LOAEL of 0.79 mg/kg/d which is also protective of the female (US EPA, 2012). An UF of 10,000 was applied to the 0.79 mg/kg/d LOAEL resulting in an RfD of 0.00008 mg/kg/d.

Table 3-24: Selected Human Toxicity Reference Values for Chemical COPCs in Water

COPC	TRV Type	Value	Units	Reference
Hydrazine	Oral Slope Factor	3	(mg/kg/d) ⁻¹	IRIS US EPA, 2001 (as cited in US EPA, 2009)
Lithium	Reference Dose	0.002	mg/kg/d	US EPA, 2008
Zirconium	Reference Dose	0.00008	mg/kg/d	US EPA, 2012 (provisional)

3.3.2 Radiation Dose Limits and Targets

The public dose limit for radiation protection is 1 mSv/a, as described in the Radiation Protection Regulations under the *Nuclear Safety and Control Act*. This limit is defined as an incremental dose to background. It is set at a fraction of natural background exposure to radiation. Public doses arising from licensed facilities are compared to the public dose limit and higher doses are considered unacceptable.

3.3.3 Uncertainties in the Toxicity Assessment

Oral slope factors, such as that for hydrazine, are developed as conservative upper-bound estimates of the increase in carcinogenic risks due to lifetime exposure to the COPC. Slope factors are used to estimate an upper bound probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen. The slope factor is based on the assumption of a linear low-dose response. This is considered conservative.

The reference dose values for lithium and zirconium incorporate several UFs. Specifically, the composite UF of 1,000 for lithium includes a factor of 10 to extrapolate from a LOAEL to a NOAEL, a factor of 10 to protect susceptible individuals and a factor of 10 to account for database insufficiencies. The composite UF of 10,000 for zirconium encompasses a factor of 10 for interspecies extrapolation from rats to humans, a factor of 10 due to the lack of acceptable two-generation reproductive or developmental toxicity studies, a factor of 10 for intraspecies differences in response among humans, and a factor of 10 since a LOAEL was used. These factors are intended to provide a conservative toxicity reference value.

3.4 Risk Characterization

3.4.1 Risk Estimation

3.4.1.1 Risk Estimation for Radiological COPCs

For radionuclides, the total doses presented in Table 3-15 are compared to the public dose limit of 1 mSv/a, as discussed in Section 3.3.2 above.

3.4.1.2 Risk Estimation for Chemical COPCs

In order to characterize potential risks due to chemical COPCs quantitatively, the results of the exposure and toxicity assessments were used to estimate HQs and ILCRs for each receptor. HQs were estimated for non-carcinogenic substances using a threshold TRV as follows:

$$\text{Hazard Quotient} = \text{Estimated Exposure} / \text{Toxicity Reference Value}$$

These HQs were compared to a target value of 0.2, as recommended by Clause 6.5.2.6 in CSA N288.6-12.

For carcinogenic substances, the estimated oral exposure was multiplied by a slope factor, to derive a conservative estimate of the potential ILCR, as follows:

$$\text{ILCR} = \text{Estimated Oral Exposure} \times \text{Cancer Slope Factor}$$

The estimated ILCRs were compared to a target cancer risk of 1 in 1,000,000 or 10^{-6} , as recommended by Clause 6.5.2.4 in CSA N288.6-12. This level is consistent with the acceptable risk level used by the Ontario MECP (MOE, 2011) and the US EPA (2005). At this risk level, health impacts are considered to be negligible. Other agencies, such as Health Canada use a target cancer risk of 1 in 100,000 or 10^{-5} . However, a range of cancer risk levels between 1 in 10,000 and 1 in 1,000,000 may be considered acceptable (HC, 2010a).

Air

A summary of the HQs for NO_x inhalation is presented in Table 3-25. The HQs are only calculated for the potential critical groups based on annual average air concentrations. The estimated exposures are discussed in the exposure assessment in Section 3.2. The TRVs used are those from Table 3-23 in the toxicity assessment in Section 3.3.

There is also a TRV available for 1-hr NO_x of 113 µg/m³; however, the 1-hr NO_x concentrations could only be calculated for the Sport Fisher as short-term concentrations or dispersion factors for all potential critical groups are not available in the ESDM reports. Since the Sport Fisher is located at the outfall, the property boundary concentration is appropriate as a conservative assumption for the Sport Fisher. Conservatively assuming

that the Sport Fisher would be exposed to the maximum 1-hr concentration at the DN property boundary of 526 $\mu\text{g}/\text{m}^3$ (based on 2016 data), the short-term HQ for the Sport Fisher would be 4.65. Based on the 1-hr NO_x concentration at the DN property boundary in 2018/2019 of 205 $\mu\text{g}/\text{m}^3$, the short-term HQ for the Sport Fisher would be 1.8. An HQ based on short-term exposure, cannot be calculated for the other potential critical groups.

Table 3-25: Summary of Estimated Risk Due to Inhalation of Annual Average Modelled NO_x Concentrations in Air

Potential Critical Group	Non-Cancer Hazard Quotients (HQ) NO_x (annual)*
Farm	0.052
Dairy Farm	0.005
Rural Resident	0.021
Oshawa	0.006
Bowmanville	0.012
West East Beach	0.017
Industrial/Commercial	0.008
Sport Fisher	0.003
Camper	0.014

Notes:

Grey shading and bold font indicates when the risk exceeds $\text{HQ} > 0.2$.

The Sport Fisher, Camper, and Industrial/Commercial potential critical groups are assumed to only spend 1%, 50%, and 23% of their time at their locations. This has been factored into the HQ calculation.

* The air concentration used in the HQ calculation is based on the 2019 ESDM report emission rate of 2.43 g/s and IMPACT dispersion factors as presented in Table 3-16.

Surface Water

Summaries of the HQs and ILCRs for surface water ingestion are presented in Table 3-26, and those for fish ingestion are presented in Table 3-27. The HQs and ILCRs are calculated according to the equations described above. The estimated exposures are from Table 3-19 in the exposure assessment in Section 3.2. The TRVs used are those from Table 3-24 in the toxicity assessment in Section 3.3.

Table 3-26: Summary of Estimated Risk Due to Ingestion of Maximum and UCLM COPC Concentrations in Surface Water

Receptor Group		Non-Cancer Hazard Quotients (HQ) (unitless)				Incremental Lifetime Cancer Risks (ILCR) (unitless)											
		Lithium		Zirconium		Hydrazine (CCW)		Hydrazine (CCW) decayed t _{1/2} = 0.6 days		Hydrazine (CCW) decayed t _{1/2} = 1.3 days		Hydrazine (Lake Water)		Hydrazine (Lake Water) decayed t _{1/2} = 0.6 days		Hydrazine (Lake Water) decayed t _{1/2} = 1.3 days	
		Max	UCLM	Max	UCLM	Max	Mean	Max	Mean	Max	Mean	Max	UCLM	Max	UCLM	Max	UCLM
Urban Resident	Toddler	3E-02	8E-03	3E-02	2E-03	-	-	-	-	-	-	-	-	-	-	-	-
Oshawa/Courtice	Adult	2E-02	4E-03	1E-02	1E-03	4E-06	7E-07	1E-06	2E-07	2E-06	4E-07	5E-07	4E-07	1E-07	1E-07	3E-07	3E-07
Urban Resident	Toddler	3E-02	7E-03	2E-02	2E-03	-	-	-	-	-	-	-	-	-	-	-	-
Bowmanville	Adult	2E-02	4E-03	1E-02	9E-04	4E-06	7E-07	1E-06	2E-07	2E-06	4E-07	5E-07	4E-07	2E-07	2E-07	3E-07	3E-07
Urban Resident	Toddler	5E-03	1E-03	4E-03	3E-04	-	-	-	-	-	-	-	-	-	-	-	-
West/East Beach	Adult	3E-03	8E-04	3E-03	2E-04	7E-07	1E-07	2E-07	4E-08	4E-07	8E-08	9E-08	8E-08	3E-08	3E-08	5E-08	5E-08
Farm	Toddler	2E-03	5E-04	2E-03	1E-04	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	1E-03	3E-04	9E-04	6E-05	2E-07	4E-08	8E-08	1E-08	1E-07	3E-08	3E-08	3E-08	1E-08	1E-08	2E-08	2E-08
Dairy Farm	Toddler	Does Not Drink Lake Water				Does Not Drink Lake Water											
	Adult																
Rural Resident	Toddler	6E-03	1E-03	5E-03	3E-04	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	3E-03	9E-04	3E-03	2E-04	7E-07	1E-07	2E-07	5E-08	5E-07	8E-08	1E-07	9E-08	3E-08	3E-08	6E-08	6E-08
Industrial / Commercial Worker	Adult	5E-03	1E-03	4E-03	3E-04	1E-06	2E-07	4E-07	7E-08	7E-07	1E-07	1E-07	1E-07	1E-07	5E-08	8E-08	8E-08
Sport Fisher	Toddler	Does Not Drink Lake Water				Does Not Drink Lake Water											
	Adult																
Camper	Toddler	2E-02	5E-03	2E-02	1E-03	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	1E-02	3E-03	9E-03	6E-04	2E-06	4E-07	6.7E-07	1E-07	1E-06	2E-07	3E-07	3E-07	9E-08	9E-08	2E-07	2E-07

Notes:

Grey shading and bold font indicates when the risk exceeds the associated target value. Cancer Risk > 1E-06, HQ > 0.2.

^a Risk calculations for hydrazine from the CCW are based on mean concentrations, since raw data to calculate UCLM concentrations were not available.

Table 3-27: Summary of Estimated Risk Due to Ingestion of Maximum and UCLM COPC Concentrations in Fish

Receptor Group		Non-Cancer Hazard Quotients (HQ)				Incremental Lifetime Cancer Risks (ILCR)											
		Lithium		Zirconium		Hydrazine (CCW)		Hydrazine (CCW) decayed t½ = 0.6 days		Hydrazine (CCW) decayed t½ = 1.3 days		Hydrazine (Lake Water)		Hydrazine (Lake Water) decayed t½ = 0.6 days		Hydrazine (Lake Water) decayed t½ = 1.3 days	
		Max	UCLM	Max	UCLM	Max	Mean	Max	Mean	Max	Mean	Max	UCLM	Max	UCLM	Max	UCLM
Urban Resident Oshawa/Courtice	Toddler	2E-02	4E-03	1E-02	8E-04	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	7E-03	2E-03	5E-03	4E-04	6E-07	1E-07	6E-07	1E-07	6E-07	1E-07	8E-08	7E-08	8E-08	7E-08	8E-08	7E-08
Urban Resident Bowmanville	Toddler	8E-04	2E-04	6E-04	4E-05	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	4E-04	1E-04	3E-04	2E-05	3E-08	6E-09	3E-08	6E-09	3E-08	6E-09	4E-09	4E-09	4E-09	4E-09	4E-09	4E-09
Urban Resident West/East Beach	Toddler	2E-02	4E-03	1E-02	8E-04	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	8E-03	2E-03	6E-03	4E-04	6E-07	1E-07	6E-07	1E-07	6E-07	1E-07	8E-08	8E-08	8E-08	8E-08	8E-08	8E-08
Farm	Toddler	7E-03	2E-03	5E-03	3E-04	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	3E-03	8E-04	2E-03	2E-04	3E-07	5E-08	3E-07	5E-08	3E-07	5E-08	4E-08	3E-08	4E-08	3E-08	4E-08	3E-08
Dairy Farm	Toddler	1E-03	4E-04	1E-03	7E-05	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	7E-04	2E-04	5E-04	3E-05	6E-08	1E-08	6E-08	1E-08	6E-08	1E-08	7E-09	7E-09	7E-09	7E-09	7E-09	7E-09
Rural Resident	Toddler	5E-03	1E-03	4E-03	2E-04	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	2E-03	6E-04	2E-03	1E-04	2E-07	4E-08	2E-07	4E-08	2E-07	4E-08	2E-08	2E-08	2E-08	2E-08	2E-08	2E-08
Industrial / Commercial Worker	Adult	Does Not Eat Local Fish				Does Not Eat Local Fish											
Sport Fisher	Toddler	1E-01	4E-02	1E-01	7E-03	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	6E-02	2E-02	5E-02	3E-03	5E-06	1E-06	5E-06	1E-06	5E-06	1E-06	7E-07	6E-07	7E-07	6E-07	7E-07	6E-07
Camper	Toddler	4E-02	1E-02	3E-02	2E-03	-	-	-	-	-	-	-	-	-	-	-	-
	Adult	2E-02	5E-03	1E-02	1E-03	2E-06	3E-07	1E-06	3E-07	2E-06	3E-07	2E-07	2E-07	2E-07	2E-07	2E-07	2E-07

Notes:
 Grey shading and bold font indicates when the risk exceeds the associated target value. Cancer Risk > 1E-06, HQ > 0.2.
^a Risk calculations for hydrazine from the CCW are based on mean concentrations, since raw data to calculate UCLM concentrations were not available.

3.4.2 Discussion of Chemical and Radiation Effects

3.4.2.1 Effects Monitoring Evidence

Two studies of health indicators in Durham Region (DRHD, 2007) compared the incidence of cancer deaths and birth defects for Durham Region, and for municipalities within Durham Region including Ajax-Pickering, Oshawa-Whitby, Clarington, and North Durham against the same statistics for the Province of Ontario. In the 1996 study, Halton Region and Northumberland were used for comparison purposes and in the 2007 study Halton Region and Simcoe County were used for comparison against Durham Region. Both studies found no evidence that any emissions from the CANDU stations at DN and at Pickering Nuclear Generating Station had any adverse health effects on nearby residents. In an additional study in 2013, cancer risk in Pickering residents due to tritium exposure from PN was studied (Wanigaratne et al., 2013). In order to determine whether tritium was associated with cancers that can be caused by radiation exposure, the tritium concentration in air was estimated based on an atmospheric dispersion model. It was found that tritium estimates were not associated with increased risk of radiation -sensitive cancers in Pickering.

3.4.2.2 Likelihood of Effects

3.4.2.2.1 Likelihood of Effects from Radiological COPCs

The 2016-2019 public dose estimates for the critical groups are at most approximately 0.08% of the regulatory public dose limit of 1 mSv/a, and at most approximately 0.06% of the dose from background radiation (1.4 mSv/a) in the vicinity of DN. Demonstration that these critical groups are protected implies that other receptor groups near DN with anticipated lower exposure are also protected.

Facility releases are considered to be adequately controlled, and further optimization of DN operations is not required. Nevertheless, the ALARA principle is applied at DN to keep emissions as low as reasonably possible.

Since the dose estimates are a small fraction of the public dose limit and natural background exposure, no discernable health effects are anticipated due to exposure of potential groups to radiological effluent from DN.

3.4.2.2.2 Likelihood of Effects from Chemical COPCs

Air - Inhalation

For air inhalation exposures, potential non-carcinogenic effects attributed to nitrogen oxides were evaluated for all potential critical groups, as shown in Table 3-25. Estimated hazard quotients for the potential critical groups based on modelled annual average concentrations, were below 0.2.

The estimated hazard quotient for the Sport Fisher, based on a modelled 1-hr NO_x concentration, ranged from 1.8 to 4.65, which is above 0.2. However, there is uncertainty around the short-term (1-hr) air concentrations at the potential critical group locations. Based on available data in the ESDM report, a hazard quotient for short-term exposure was calculated for the Sport Fisher. However, since other potential critical groups are farther away, it is anticipated that the hazard quotient for the other receptors will be lower than that for the Sport Fisher. To provide a more realistic interpretation of risk, NO₂ data from air quality monitoring planned to be initiated at the DN site in 2021, as part of a separate study proposed for DNNP, should be used to refine the risk estimates.

Surface Water – Drinking Water Ingestion

Estimated maximum and UCLM hazard quotients for lithium and zirconium were below 0.2 for all human receptors for surface water ingestion exposures. No human health risks are expected due to ingestion of surface water for lithium and zirconium. The estimated hazard quotients for lithium and zirconium are shown in Table 3-26.

The estimated ILCRs for hydrazine based on UCLM hydrazine concentrations in the CCW lake water were below the one in one million cancer risk level for all human receptors; therefore, adverse effects due to hydrazine originating from DN through surface water ingestion are not expected. The ILCRs assessed due to exposure to hydrazine, both estimated maximum and UCLM concentrations from the CCW and measured in lake water, through surface water ingestion, are shown in Table 3-26.

The ILCRs for hydrazine based on the maximum hydrazine concentrations in the CCW exceeded one in one million for the Oshawa/Courtice and Bowmanville urban residents, and Camper receptors. When accounting for decay based on a half-life of 0.6 days, resulting estimated ILCRs did not exceed the one in one million level for any of the receptors. Additionally, since people tend to average their exposure by spending time in various locations, the maximum is not considered representative of long-term exposure and results should be interpreted based on the UCLM.

Given that ILCRs for any of the receptors, based on UCLM hydrazine concentrations, either measured in the CCW or in lake water, are all below one in a million, adverse effects to humans due to hydrazine originating from DN through surface water ingestion are not expected.

Surface Water – Fish Ingestion

For fish ingestion exposures, adverse effects to humans due to ingestion of lithium and zirconium in fish from the DN area are not expected. Estimated maximum and UCLM hazard quotients for lithium and zirconium were below 0.2 for all receptors. The hazard quotients evaluated for lithium and zirconium are shown in Table 3-27.

The resulting estimated ILCRs did not exceed one in one million for any human receptor due to exposure to UCLM concentrations of hydrazine in fish. The ILCRs for all receptors due to exposure to hydrazine, both estimated from the CCW and measured in lake water, through fish ingestion, are shown in Table 3-27.

While exposure to maximum concentrations of hydrazine in fish resulted in ILCRs greater than one in one million for the Sport Fisher and the Camper, the maximum is not considered representative of long-term exposure, and results should be interpreted based on the UCLM. The Camper was assumed to eat half of the fish portion of their diet from Lake Ontario fish caught at DN. The Sport Fisher was assumed to eat all of the fish portion of their diet from Lake Ontario fish caught at DN, which is considered to be an unlikely scenario because a person would not be expected to catch all of their fish in one specific place, but the approach is consistent with OPG's DRL calculations and EMP calculations for radionuclides. As such, adverse effects on humans due to hydrazine originating from DN through fish ingestion are not expected.

Overall, health risks are not expected for human receptors due to lithium, zirconium and hydrazine in water and in fish.

3.4.3 Uncertainties in the Risk Characterization

The uncertainties in the characterization of risk consist of those in the exposure and toxicity assessments (Sections 3.2 and 3.3), since the function of this section in a risk assessment is to combine the results of these two sections. In the exposure assessment, uncertainties included the conservative use of estimated pre-treatment concentrations at Oshawa and Bowmanville WSPs that do not account for water treatment before distribution to residents, the use of QSAR models to develop BCFs for hydrazine, modelling of hydrazine at WSPs based on lake water measurements that may not capture periodic batch releases from the CCW in addition to modelling from CCW which may overestimate concentrations at the WSPs, and the use of Gaussian plume models to derive dilution factors for transport of the COPCs in Lake Ontario. Those from the toxicity assessment include conservatism built into the selected TRVs. Taken together, these approaches have ensured that the risk characterization has been undertaken in a manner that has not underestimated risk; the resulting hazard quotients are either overestimates or realistic estimates of risk, both of which are considered acceptable.

A probabilistic risk assessment to quantify uncertainty in the risk estimate has not been performed and is not considered necessary, since it is not likely to provide a better basis for risk management/decision making. According to CSA N288.6 (CSA, 2012), a qualitative or semi-quantitative evaluation of uncertainty is considered sufficient for evaluation of uncertainty.

4.0 ECOLOGICAL RISK ASSESSMENT

4.1 Problem Formulation

The Problem Formulation defines the problem to be addressed in the EcoRA and the framework and general methodology by which the EcoRA will address the defined problem (FCSAP, 2012). Consistent with the FCSAP (2012), the problem formulation typically includes the following elements:

- A description of the EcoRA objectives or management goals;
- A description of the regulatory context of the EcoRA;
- A review of existing Study Area information;
- The selection of COPCs;
- The selection of Valued Ecosystem Components (VECs) that may be present in the Study Area;
- A description of the exposure pathways by which COPCs in the Study Area may come into contact with the VECs,
- An ecological conceptual model (CSM) that illustrates the connections between the sources of contaminants, the exposure pathways and VECs;
- An explanation of protection goals;
- Identification of assessment endpoints and measurement endpoints;
- The development of lines of evidences for each assessment endpoint and how the measurement endpoints will be used to evaluate risk to VECs;
- How risks will be characterized; and
- The description of any uncertainties associated with the Problem Formulation.

These elements are discussed in the following sections. During the problem formulation stage, decisions are made on which COPCs and receptors should be further evaluated in the EcoRA. During this planning stage, no conclusions are made regarding effects.

The EcoRA focuses on the DN site and surrounding area, as shown in Figure 4-1. The assessment has been divided into polygons, generally consistent with past EcoRAs, with modifications to Polygon E to assess the Darlington New Nuclear Project lands separately from the existing DNGS. The assessment also looks at nearshore Lake Ontario, generally in the area surrounding the outfall from the DN diffuser.



Figure 4-1: Area of Assessment for Ecological Risk Assessment

4.1.1 EcoRA Objectives and Management Goals

The objectives of the EcoRA are to:

- Characterize and evaluate potential health risks to current and future VECs exposed to affected air, surface water, sediment, and soil in the receiving environments surrounding DN, and
- Assess the potential for effects on VEC populations or communities in order to inform the environmental management system.

The management goal of the EcoRA is to provide information about the potential for DN effects on VEC populations or communities in order to inform the environmental management system.

4.1.2 Receptor Selection and Characterization

4.1.2.1 Receptor (VEC) Selection

It is generally an impractical task to assess the effect of radiological and non-radiological emissions on all the species of biota within a natural ecosystem, and specifically within the ecosystem around the DN site. Therefore, a representative group of organisms are chosen for dose and risk analysis. These organisms are selected because they are known to exist on the site, and are representative of major taxonomic groups or exposure pathways, or have a special importance or value. These organisms are known as valued ecosystem components (VECs).

VECs were selected in previous ecological assessments for the DN site in 2017 (Ecometrix, 2017), 2011 (SENES, 2011b) and 2009 (SENES, 2009a). For the 2009 EcoRA, a number of VECs were selected that were representative of the various feeding habits and characteristics of the species present at the site. In 2019, environmental studies investigated the terrestrial and aquatic communities at the DN site focusing on the study period of 2011 to 2019 (Beacon, 2019a; Ecometrix, 2020). These studies present the most up to date site condition. New species observed during the 2016 to 2019 have also been considered during VEC selection in the current updated ERA.

The selection process was described in SENES (2009a) Appendix C and included a staged approach to VEC selection. This process was adapted for the current EcoRA:

- Preliminary selection: a list of ecological receptors for the DN site was compiled from previous DN assessment reports;
- Secondary selection: The list of ecological receptors was expanded to include other species identified in the terrestrial and aquatic environment TSDs for the 2009 NND EA (Beacon, 2009a; Golder and SENES, 2009), the 2011 Refurbishment and Continued Operation EA (Beacon, 2011; SENES, 2011e), and the 2019 DNNP

supporting environment studies report (Ecometrix, 2020) that were found to frequent the DN site;

- Final selection: The list of ecological receptors was refined. In some instances, individual species with similar exposure pathways were grouped together and analyzed as one generic type of ecological receptor. For example, all terrestrial trees and grasses were analyzed as “terrestrial plants” and various benthic invertebrate species were analyzed as “benthic invertebrates.” In other cases, particular species were selected as representatives of different feeding habits. For example, American Robin, Bank Swallow, Yellow Warbler, and Song Sparrow were analyzed with species-specific feeding habits.

Stakeholder input into VEC selection was also considered, as documented in the Communications and Consultation TSDs from both EAs (SENES, 2011b, 2011b). The ecological receptors from the two EcoRAs, along with their rationale for selection, were reviewed and assessed based on the criteria listed in Table 7.1 of CSA N288.6. The 2009 and 2011 lists of ecological receptors known to frequent the Site were reviewed, with data provided in DN Biodiversity reports for the most recent 9-year period (2011 to 2019). Common nesting bird species, bats, as well as amphibians and reptiles identified in the 2011 to 2019 biodiversity reports were added to the list. Fish species commonly observed in the Lake Ontario near-shore area were also presented based on fish and larval fish community assessments in the most recent 9-year period (2011-2019, (Ecometrix, 2020)). Table 4-1 presents the selection of ecological receptors for the DN site based on the CSA N288.6 criteria.

VECs were selected as receptors for the conceptual model based on the criteria in Table 4-1. This table summarizes the key information used in the selection process. Receptors in bold are selected as VECs for further assessment.

Table 4-1: Criteria for the Selection of Ecological Receptors

Organism Category	Species Considered	Selection Criteria				Outcome of Selection
		1	2	3	4	
		Major Plant or Animal Group	Facility, Stakeholder or Indigenous Importance	Socio-economic/ Ecological Significance	Exposed to and/or Sensitive to Stressor	
Bottom-Feeding Fish	Northern Redbelly Dace	Benthopelagic forage fish	Present on Site – Coot’s Pond	Food source for other receptors (fish/birds)	Exposed to aquatic release through water, sediment and consumption of food (planktonic crustaceans, benthic invertebrates, fish eggs).	Selected as VEC
	Round Whitefish	Benthic forage fish	Present near Site - VEC for previous EAs	Nearshore spawning shoals in the area	Exposed to aquatic release through water, sediment and consumption of food (planktonic crustaceans, benthic invertebrates, fish eggs). Sensitive to thermal stressor.	Selected as VEC
	White Sucker	Common nearshore benthic forage fish	Present near Site - VEC for previous EAs	Dominant member of sparse nearshore fish community	Exposed to aquatic release through water, sediment and consumption of food (planktonic crustaceans, benthic invertebrates, fish eggs). Exposed to thermal stressor.	Selected as VEC
	American Eel	Benthic predator fish	Present near Site - Highly valued by Indigenous peoples	Listed as Endangered in Ontario. Listed as Threatened by COSEWIC	Exposed to aquatic release through surface water and consumption of prey. Occasionally impinged species.	Selected as VEC
	Burbot	Benthic predator fish	Present near Site. Entrained species in the 2015/16 entrainment study	-	Exposed to aquatic release through water, sediment and consumption of prey (planktonic crustaceans, benthic invertebrates, other fish species and fish eggs). Commonly entrained fish.	Not selected as VEC: Assessment of other bottom-feeding fish will be protective of Burbot
	Deepwater Sculpin	Benthic forage fish	Present near Site. Entrained species in the 2015/2016 entrainment study.	Listed as special concern federally (SARA and COSEWIC).	Exposed to aquatic release through water, sediment and consumption of food (planktonic crustaceans, benthic invertebrates, fish eggs).	Not selected as VEC: Assessment of other bottom-feeding fish will be protective of Deepwater Sculpin
	Lake Sturgeon	Benthic fish	Present near Site - VEC for previous EAs - found in Lake Ontario and adjacent tributary mouths	Conservation concern in Great Lakes (Threatened provincially)- Subject to recovery efforts in Lake Ontario - Historical commercial species	Exposed to aquatic release through water, sediment and consumption of food (planktonic crustaceans, benthic invertebrates, fish eggs).	Not selected as VEC: Assessment of other bottom-feeding fish will be protective of Lake Sturgeon
	Longnose Sucker	Benthic forage fish	Present near Site	-	Exposed to aquatic release through water, sediment and consumption of food (planktonic crustaceans, benthic invertebrates, fish eggs)	Not selected as VEC: Assessment of other bottom-feeding fish will be protective of Longnose Sucker
	Mottled Sculpin	Benthic forage fish	Present near Site. Entrained species in the 2015/16 entrainment study	-	Exposed to aquatic release through water, sediment and consumption of food (planktonic crustaceans, benthic invertebrates, fish eggs).	Not selected as VEC: Assessment of other bottom-feeding fish will be protective of Mottled Sculpin
	Rainbow Trout	Benthopelagic predator fish	Common fish near site.	Species of fishery interest	Exposed to aquatic release through water, sediment and consumption of food (planktonic crustaceans, benthic invertebrates, other fish species and fish eggs)	Not selected as VEC: Assessment for other pelagic fish expected to be protective of Rainbow Trout
	Brown Trout	Benthopelagic predator fish	Present near Site.	Species of fishery interest	Exposed to aquatic release through water, sediment and consumption of food (planktonic crustaceans, benthic invertebrates, other fish species and fish eggs)	Not selected as VEC: Assessment for other pelagic fish expected to be protective of Brown Trout

Organism Category	Species Considered	Selection Criteria				Outcome of Selection
		1	2	3	4	
		Major Plant or Animal Group	Facility, Stakeholder or Indigenous Importance	Socio-economic/ Ecological Significance	Exposed to and/or Sensitive to Stressor	
	Walleye	Benthopelagic predator fish	Present near Site. Entrained in the 2015/16 entrainment study	Species of fishery interest	Exposed to waterborne effluent through water, sediment and consumption of food (planktonic crustaceans, benthic invertebrates, other fish species and fish eggs). Commonly entrained fish.	Not selected as VEC: Assessment for other pelagic fish expected to be protective of Walleye
	Round Goby	Benthic forage fish	Present near Site - VEC for previous EAs - found in Lake Ontario	Invasive species in Lake Ontario	Exposed to waterborne effluent through water, sediment and consumption of food. Commonly impinged/entrained species.	Not selected as VEC: Invasive species; assessment for other pelagic fish expected to be protective of Round Goby
Pelagic Fish	Alewife	Common schooling pelagic forage fish	Present on Site - VEC for previous EAs	Dominant member of sparse nearshore fish community	Exposed to waterborne effluent through surface water and consumption of food. Exposed to thermal stressor. Commonly impinged/entrained species.	Selected as VEC
	Lake Trout	Common pelagic predator fish	Present near Site - VEC for previous EAs	Potentially spawns in the area - Commercial and sport fish	Exposed to waterborne effluent through surface water and consumption of prey. Exposed to thermal stressor.	Selected as VEC
	Chinook Salmon	Pelagic predator fish	Present near Site	Species of fishery interest	Exposed to waterborne effluent through surface water and consumption of prey	Not selected as VEC: Assessment for other pelagic fish expected to be protective of Chinook Salmon
	Emerald Shiner	Nearshore schooling pelagic forage fish	Present on Site - VEC for previous EAs - found in Forebay and Lake Ontario	Numerically important in nearshore fish community	Exposed to waterborne effluent through surface water and consumption of food. Exposed to thermal stressor.	Not selected as VEC: Assessment for other pelagic fish expected to be protective of Emerald Shiner
	Rainbow Smelt	Pelagic forage fish	Common fish near site	-	Exposed to waterborne effluent through surface water and consumption of prey. Commonly impinged/entrained species.	Not selected as VEC: Assessment for other pelagic fish expected to be protective of Rainbow Smelt
	Spottail Shiner	Pelagic forage fish	Present near Site - found in forebay and Lake Ontario	-	Exposed to waterborne effluent through surface water and consumption of food	Not selected as VEC: Assessment for other pelagic fish expected to be protective of Spottail Shiner
Reptiles and Amphibians	American Toad	Toad	Present on Site	On-Site breeder	Exposed to waterborne effluent through surface water, sediment, and prey.	Not selected as VEC: Insufficient information for assessment
	Midland Painted Turtle	Turtle	Present and breed on Site - VEC for previous EAs	On-Site breeder. COSEWIC Special Concern Status	Exposed to waterborne effluent through surface water, sediment, and prey.	Selected as VEC
	Snapping Turtle	Turtle	Present and breed on Site	On-Site breeder. Listed as species of Special Concern Federally (Both SARA and COSEWIC)	Exposed to waterborne effluent through surface water, sediment, and prey.	Selected as VEC
	Green Frog	Frog	Present on Site - VEC for previous EAs	On-Site breeder	Exposed to waterborne effluent through surface water, sediment, and prey.	Selected as VEC
	Northern Leopard Frog	Frog	Present on Site	On-Site breeder	Exposed to waterborne effluent through surface water, sediment, and prey.	Selected as VEC

Organism Category	Species Considered	Selection Criteria				Outcome of Selection
		1	2	3	4	
		Major Plant or Animal Group	Facility, Stakeholder or Indigenous Importance	Socio-economic/ Ecological Significance	Exposed to and/or Sensitive to Stressor	
	Red-backed Salamander	Salamander	Present near site	Rare species in the region	Exposed to airborne emissions through soil	Not Selected as VEC. Insufficient information for assessment
	Eastern Gartersnake	Snake	Present on site	-	Exposed to airborne emissions through soil	Not Selected as VEC. Insufficient information for assessment
Aquatic Plants	Burreed	Aquatic plant	VEC for previous EAs	Heavily used by wildlife - represents permanent shallow water marshland areas	Exposed to waterborne effluent through surface water and sediment	Selected as VEC
Aquatic Invertebrates	Amphipods	Benthic invertebrates	VEC for previous EAs	Food source for fish and riparian birds	Exposed to waterborne effluent through sediment	Selected as VEC
	Oligochaetes/ chironomids					
	Molluscs					
	Crayfish					
	Zebra mussel					
Riparian Birds	Bufflehead	Diving bird - omnivore	Present on Site -VEC for previous EAs - Inshore and Coot's Pond	Nesting near Site	Exposed to waterborne effluent through water, food (aquatic plants and invertebrates) and sediment	Selected as VEC
	Mallard	Dabbling bird - omnivore	Present on Site -VEC for previous EAs - Inshore and Coot's Pond	Nesting near Site	Exposed to waterborne effluent through water, food (aquatic plants and invertebrates) and sediment	Selected as VEC
	Green Heron	Wetland breeder - piscivore	Present on Site	Breeding on Site	Exposed to waterborne effluent through water and food (fish)	Selected as VEC
	Wood Duck	Dabbling bird - herbivore	Present on Site	Breeding on Site	Exposed to waterborne effluent through water, food (aquatic plants) and sediment	Not selected as VEC: Assessment of Mallard and Bufflehead is expected to be protective of Wood Duck
	Trumpeter Swan	Dabbling bird - herbivore	Present on Site	Nesting on Site	Exposed to waterborne effluent through water, food (aquatic plants) and sediment	Not selected as VEC: Assessment of Mallard and Bufflehead is expected to be protective of Trumpeter Swan
	Pied-billed Grebe	Diving bird - invertebrates	Present on Site - VEC for previous EAs - Inshore and Coot's Pond	Breeding on Site	Exposed to waterborne effluent through water, food (aquatic plants and invertebrates) and sediment	Not selected as VEC: Assessment of Mallard and Bufflehead is expected to be protective of Pied-billed Grebe
	Least Bittern	Wetland breeder - piscivore	Occasionally observed on Site	Listed as Threatened federally (SARA and COSEWIC) and provincially	Exposed to waterborne effluent through water and food (fish)	Not selected as VEC: Assessment of Green Heron is expected to be protective of Least Bittern

Organism Category	Species Considered	Selection Criteria				Outcome of Selection
		1	2	3	4	
		Major Plant or Animal Group	Facility, Stakeholder or Indigenous Importance	Socio-economic/ Ecological Significance	Exposed to and/or Sensitive to Stressor	
Riparian Mammals	Muskrat	Mammalian herbivore	Present on Site -VEC for previous EAs	On-site breeder – year-round presence	Exposed to waterborne effluent through water, food (aquatic vegetation) and sediment	Selected as VEC
Terrestrial Invertebrates	Butterflies (Caterpillars)	Long-distant migrant	Present on Site	Conservation concern for winter habitat stress (Mexico)	Exposed to airborne emissions through soil	Not selected as VEC: Assessment for Earthworm is expected to be protective of butterflies
	Dragonflies	Aquatic early life stage - Insectivore	Present on Site	-	Exposed to airborne emissions through soil	Not selected as VEC: Assessment for Earthworm is expected to be protective of dragonflies
	Earthworms	Soil dwelling - Detritivore	Present on Site - VEC for previous EAs	Food source for other ecological receptors	Exposed to airborne emissions through soil	Selected as VEC
Terrestrial Plants	Canada Blue Joint	Grasses	Present on Site	Food source for terrestrial mammals	Exposed to airborne emissions through soil and atmospheric deposition	Selected as VEC
	Sugar Maple	Deciduous tree	Present on Site - VEC for previous EAs	Important element in woodland community	Exposed to airborne emissions through soil and atmospheric deposition	Selected as VEC
	Butternut Tree	Deciduous tree	Present on Site	Endangered species on both federal and provincial level	Exposed to airborne emissions through soil and atmospheric deposition	Not selected as VEC: Assessment of sugar Maple is expected to be protective of Butternut Tree
Terrestrial Birds	American Robin	Ground feeding insectivore	Present on Site - VEC for previous EAs	On-Site breeder - Common to the upland community	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Selected as VEC
	Bank Swallow	Aerial insectivore	Present on Site - VEC for previous EAs	Breeds along Lake Ontario shoreline. Threatened species on both the federal and provincial level	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Selected as VEC
	Song Sparrow	Tree/shrub feeding omnivore	Present on Site - VEC for previous EAs	On-Site breeder - Common to upland successional habitat	Exposed to airborne emissions through food (terrestrial invertebrates and plants) and soil	Selected as VEC
	Yellow Warbler	Tree/shrub feeding insectivore	Present on Site - VEC for previous EAs	On-Site breeder - Common to Coot's pond, upland successional habitat	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Selected as VEC
	Marsh Wren	Marsh-dwelling insectivore	Present on Site	On-site breeder	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Marsh Wren
	Swamp Swallow	Marsh-dwelling insectivore	Present on Site	On-site breeder	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Swamp Swallow

Organism Category	Species Considered	Selection Criteria				Outcome of Selection
		1	2	3	4	
		Major Plant or Animal Group	Facility, Stakeholder or Indigenous Importance	Socio-economic/ Ecological Significance	Exposed to and/or Sensitive to Stressor	
	House Wren	Tree/shrub feeding insectivore	Present on Site	On-site breeder	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of House Wren
	Barn Swallow	Aerial insectivore	Present on Site	On-Site breeder. Threatened species on both the federal and provincial level	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of –Barn Swallow
	Tree Swallow	Aerial insectivore	Present on Site	On-Site breeder	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Tree Swallow
	Mourning Dove	Ground feeding herbivore	Present on Site	On-Site breeder	Exposed to airborne emissions through food (plants) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Mourning Dove
	Downy Woodpecker	Tree feeding insectivore	Present on Site	On-Site breeder - common to woodland habitat	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Downy Woodpecker
	Eastern Wood-Pewee	Aerial insectivore	Present on Site	On-Site breeder - common to woodland habitat. Listed as species of special concern provincially and federally (SARA and COSEWIC)	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Eastern Wood-Pewee
	Willow Flycatcher	Aerial insectivore	Present on Site	On-Site breeder - Common to Coot's pond, upland successional habitat	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Willow Flycatcher
	Great Crested Flycatcher	Aerial insectivore	Present on Site	On-Site breeder	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Great Crested Flycatcher
	Eastern Kingbird	Aerial insectivore	Present on Site	On-Site breeder - Common to Coot's pond	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Eastern Kingbird
	Black-capped chickadee	Tree feeding insectivore	Present on Site	On-Site breeder - common to woodland habitat	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Black-capped Chickadee
	Grey Catbird	Ground feeding insectivore	Present on Site	On-Site breeder - Common to upland successional habitat	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Grey Catbird

Organism Category	Species Considered	Selection Criteria				Outcome of Selection
		1	2	3	4	
		Major Plant or Animal Group	Facility, Stakeholder or Indigenous Importance	Socio-economic/ Ecological Significance	Exposed to and/or Sensitive to Stressor	
	Cedar Waxwing	Tree feeding herbivore (berries and fruit)	Present on Site	On-Site breeder - Common to upland successional habitat	Exposed to airborne emissions through food (plants) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Cedar Waxwing
	American Redstart	Aerial insectivore	Present on Site	On-Site breeder - common to woodland habitat	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of American Redstart
	Common Yellowthroat	Shrub/ ground feeding insectivore	Present on Site	On-Site breeder - Common to upland successional habitat	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Common Yellowthroat
	Savannah Sparrow	Ground feeding insectivore	Present on Site	On-Site breeder	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Savannah Sparrow
	Red-winged Blackbird	Shrub/ ground feeding omnivore	Present on Site	On-Site breeder - Common to Coot's pond, upland successional habitat	Exposed to airborne emissions through food (plants and terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Red-winged Blackbird
	Common Grackle	Shrub/ ground feeding omnivore	Present on Site	On-Site breeder	Exposed to airborne emissions through food (plants and terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Common Grackle
	American Goldfinch	Tree/shrub feeding herbivore (seeds)	Present on Site	On-Site breeder	Exposed to airborne emissions through food (plants) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of American Goldfinch
	American Crow	Omnivore	Present on Site -VEC for previous EAs	Common to the Site	Exposed to airborne emissions through food (plants and terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of American Crow
	Red-eyed Vireo	Tree/ shrub feeding insectivore	Present on Site -VEC for previous EAs	Infrequent on-Site breeder - woodland habitat	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Red-eyed Vireo
	Olive-sided flycatcher	Aerial insectivore	Present on Site	Listed as Threatened federally (SARA) and Special Concern provincially	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Olive-sided flycatcher

Organism Category	Species Considered	Selection Criteria				Outcome of Selection
		1	2	3	4	
		Major Plant or Animal Group	Facility, Stakeholder or Indigenous Importance	Socio-economic/ Ecological Significance	Exposed to and/or Sensitive to Stressor	
	Bobolink	Ground feeding omnivore	Present on Site	Breeding on Site. Listed as Threatened federally (SARA and COSEWIC) and provincially	Exposed to airborne emissions through food (plants, terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Bobolink
	Eastern Meadowlark	Ground feeding omnivore	Present on Site	Breeding on Site. Listed as Threatened federally (SARA and COSEWIC) and provincially	Exposed to airborne emissions through food (plants, terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Eastern Meadowlark
	Wood Thrush	Ground feeding insectivore	Present on Site	Listed as Threatened federally (SARA and COSEWIC) and provincially	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Wood Thrush
	Canada Warbler	Tree/shrub feeding insectivore	Present on Site	Listed as Threatened federally (SARA and COSEWIC), and Special Concern provincially	Exposed to airborne emissions through food (terrestrial invertebrates) and soil	Not selected as VEC: Assessment of other terrestrial birds is expected to be protective of Canada Warbler
Mammals	Eastern Cottontail	Mammalian herbivore	Present on Site - VEC for previous EAs	Common to upland habitat	Exposed to airborne emissions through food (plants) and soil	Selected as VEC
	Meadow Vole	Mammalian herbivore	Present on Site - VEC for previous EAs	On-site breeder – year-round presence - Common to upland habitat - common prey item	Exposed to airborne emissions through food and soil	Selected as VEC
	White-tailed Deer	Mammalian herbivore	Present on Site - VEC for previous EAs	Common to upland habitat	Exposed to airborne emissions through food (plants) and soil	Selected as VEC
	Common Shrew	Mammalian insectivore	-	Common in similar habitats to the Site	Exposed to airborne emissions through food (insects) and soil	Selected as VEC
	Raccoon	Mammalian omnivore	Present on Site - VEC for previous EAs	Common to upland habitat	Exposed to airborne emissions through food and soil	Selected as VEC
	Red Fox	Mammalian carnivore	Present on Site - VEC for previous EAs	Common to upland habitat	Exposed to airborne emissions through food (small mammals) and soil	Selected as VEC
	Short Tailed Weasel	Mammalian carnivore	Present on Site - VEC for previous EAs	Common to upland habitat	Exposed to airborne emissions through food (small mammals) and soil	Selected as VEC
	Deer Mouse	Mammalian omnivore	Present on Site - VEC for previous EAs	Common to upland habitat	Exposed to airborne emissions through food and soil	Not selected as VEC: Assessment of other terrestrial mammals is expected to be protective of Deer Mouse

Organism Category	Species Considered	Selection Criteria				Outcome of Selection
		1	2	3	4	
		Major Plant or Animal Group	Facility, Stakeholder or Indigenous Importance	Socio-economic/ Ecological Significance	Exposed to and/or Sensitive to Stressor	
	Little Brown Myotis (Bat)	Mammalian insectivore	Present on Site	Listed as Endangered both federally and provincially	Exposed to airborne emissions through food (insects) and soil	Not selected as VEC: Assessment of other terrestrial mammals is expected to be protective of Little Brown Myotis
	Northern Myotis (Bat)	Mammalian insectivore	Foraging on Site	Listed as Endangered both federally and provincially	Exposed to airborne emissions through food (insects) and soil	Not selected as VEC: Assessment of other terrestrial mammals is expected to be protective of Northern Myotis

Note:
Species selected as VEC was bolded in the “Species Considered” column.

The VECs were selected to represent each major plant and animal group, reflecting the main ecological exposure pathways, feeding habits and habitats at or around the site. In making the selection, species that were ecologically similar to other species and could be represented by another species, were not selected, in order to reduce redundancy in the exposure calculations. For example, the Alewife and emerald shiner are similar across all criteria, and could be assessed interchangeably. However, according to impingement reports, of these two species, the Alewife is the dominant species impinged at DN, so it was chosen to be a receptor. Other effects on the Alewife are considered to be representative of effects on the emerald shiner. Further descriptions regarding the selected VECs, such as habitat and feeding habits, are provided in Appendix C.

Table 4-2 shows the VECs chosen for assessment and the assessment models used in estimating their COPC exposure, dose and risk. Six species of fish were chosen as VECs to represent the fish likely to be influenced by the operation of DN. However, due to the limited species-specific exposure factor and toxicity data available, risks to fish are estimated by assessing the fish in two categories (bottom-feeding fish and pelagic fish) for the radiological assessment and as one category of fish for the non-radiological assessment. The radiological dose assessment considers the fish exposure to water and sediment as part of the external dose calculation, and therefore, the bottom-feeding and pelagic fish are exposed to contaminants via different pathways. For non-radiological dose assessment, only uptake from water is considered and therefore there is only one exposure pathway for all fish species. Similarly, for terrestrial plants, all species were assessed in one category (terrestrial plants) using generic bioaccumulation factors and toxicity reference values.

A fish model is used for assessment of frogs because the sensitive life stages for frogs (i.e., egg and tadpole) are aquatic and similar to the sensitive life stages for fish. For example, during the tadpole stage, tadpoles and fish have similar exposure pathways (e.g., absorption through skin and gills). In addition, exposure factor and toxicity data for amphibians are limited. Therefore, the fish assessment model is considered to be appropriate for frogs during their sensitive life stages.

A fish model is also used for assessment of turtles, since there is a lack of exposure factor and toxicity data for turtles. Both organisms reside in water, and they share similar exposure pathways.

Several of the buildings on the DN site may provide a suitable habitat for birds. Geese and gulls typically nest on most of the building roofs in the protected area. The assessment of other riparian birds as VECs, such as the Bufflehead and the Mallard, is expected to be protective of geese and gulls.

Table 4-2: Summary of VECs and their Assessment Models used in the EcoRA

VEC Category	Assessment Model	VEC
Fish	Bottom Feeding Fish	Northern Redbelly Dace
		Round Whitefish
		White Sucker
		American Eel
	Pelagic Fish	Alewife
		Lake Trout
Reptiles and Amphibians	Bottom Feeding Fish	Turtles
		Frogs
Aquatic Plants	Aquatic Plant	Aquatic Plants
Aquatic Invertebrates	Benthic Invertebrate	Benthic Invertebrates
Riparian Birds	Bufflehead	Bufflehead
	Mallard	Mallard
	Green Heron	Green Heron
Riparian Mammals	Muskrat	Muskrat
Terrestrial Invertebrates	Soil Invertebrate	Earthworm
Terrestrial Birds	American Robin	American Robin
	Bank Swallow	Bank Swallow
	Song Sparrow	Song Sparrow
	Yellow Warbler	Yellow Warbler
Terrestrial Plants	Terrestrial Plant	Grass
	Terrestrial Plant	Sugar Maple
Terrestrial Mammals	Eastern Cottontail	Eastern Cottontail
	Meadow Vole	Meadow Vole
	White-tailed Deer	White-tailed Deer
	Common Shrew	Common Shrew
	Raccoon	Raccoon
	Red Fox	Red Fox
	Short-tailed Weasel	Short-tailed Weasel

4.1.2.2 Consideration of Species at Risk

A review of all flora and fauna identified in the DN Species at Risk and Biodiversity reports from 2011 to 2019 was performed against the Species at Risk in Ontario (SARO) list, Schedule 1 of the federal Species at Risk Act, and the COSEWIC list. A number of threatened and endangered species have been identified within the DN Site Study Area during the 2011 to 2019 time period, as shown in Table 4-3. To be conservative, if a species is listed as threatened or endangered by either COSEWIC, SARA, or SARO, this species is included in Table 4-3. As the general prohibitions under Species at Risk Act (SARA) do not apply to species of Special Concern, and CSA N288.6 does not specify

species of Special Concern as ecologically significant, the status of “Special Concern” is not listed in Table 4-3.

Exposure models for specific assessment of these species are typically lacking. Most of these species can be assessed by reference to surrogate species already selected as VECs for the EcoRA. Detailed justifications for selections of each of the surrogate species, based on habitat, diet, and ecological niche considerations, are presented below.

Table 4-3: Surrogate Species for Identified Species at Risk (Threatened or Endangered Status Only)

Species at Risk (Common and Scientific Name)	SARA (Federal- official list)	COSEWIC (Federal)	SARO (Provincial)	Surrogate Species	Last Observed
Terrestrial Invertebrates					
Monarch (<i>Danaus plexippus</i>)	-	Endangered	-	Earthworm (<i>Lumbricus</i>)	2019
Plants					
Butternut Tree (<i>Juglans cinerea</i>)	Endangered	Endangered	Endangered	Sugar Maple (<i>Acer saccharum</i>)	2019
Birds					
Bank Swallow (<i>Riparia riparia</i>)	Threatened	Threatened	Threatened	Bank Swallow (<i>Riparia riparia</i>)	2019
Barn Swallow (<i>Hirundo rustica</i>)	Threatened	Threatened	Threatened	Bank Swallow (<i>Riparia riparia</i>)	2019
Bobolink (<i>Dolichonyx oryzivorus</i>)	Threatened	Threatened	Threatened	American Robin (<i>Turdus migratorius</i>)	2019
Canada Warbler (<i>Cardellina canadensis</i>)	Threatened	Threatened	-	Bank Swallow (<i>Riparia riparia</i>)	2011
Eastern Meadowlark (<i>Strunella magna</i>)	Threatened	Threatened	Threatened	American Robin (<i>Turdus migratorius</i>)	2019
Wood Thrush (<i>Hylocichla mustelina</i>)	Threatened	Threatened	-	American Robin (<i>Turdus migratorius</i>)	2015
Mammals					
Little Brown Myotis (Bat) (<i>Myotis lucifugus</i>)	Endangered	Endangered	Endangered	Common Shrew (<i>Sorex cinereus</i>)	2018
Northern Myotis (<i>Myotis septentrionalis</i>)	Endangered	Endangered	Endangered	Common Shrew (<i>Sorex cinereus</i>)	2018
Fish					
American Eel (<i>Anguilla rostrata</i>)	-	Threatened	Endangered	American Eel (<i>Anguilla rostrata</i>)	2018

Notes:

1. These species were identified at the DN Site during the 2011 to 2019 period.
2. For birds, only species possibly breeding on-Site are included. Least Bittern and Olive-Sided Flycatcher are not identified as species that are breeding on-site (Beacon, 2019a), therefore are not included in this table.
3. For bat species, only species roosting on-site are included.
4. Federal and Provincial status may change. The status of these species was last verified August 20, 2020 from: Federal: COSEWIC (October, 2019), SARA (Species at Risk Act), Schedule 1 Status (modified December 12, 2019, (Government of Canada, 2020)). The habitat of listed species (Schedule 1) is protected under SARA. Provincial: Species at Risk in Ontario (SARO) status ((MECP, 2020) Updated August 1, 2018).
5. Species with Special Concern Status is not included in this table, as the general prohibitions under SARA do not apply to species of Special Concern, and CSA N288.6 does not specify this status as ecologically significant.

Six bird species, two mammals, one plant, one terrestrial invertebrate and one fish, were identified as threatened or endangered species at the Site over the 2011 to 2019 period. Species designations change over time; therefore, the most recent designation guided the selection of Species at Risk for the 2011 to 2019 period. Since the 2016 DN ERA (Ecometrix, 2017), a number of changes have occurred. Monarch was newly designated endangered (COSEWIC, previously Special Concern) in 2016, and Bank Swallow was newly listed as Threatened (SARO) in 2014. Therefore, these two species are included in the list of species at risk. Peregrine Falcon was downgraded from Threatened to Special Concern (SARO) at the end of 2012 and therefore does not appear on the list.

Monarch is a milkweed butterfly. It is a migrating butterfly species that covers long distances between Ontario and Florida or central Mexico annually through four generations. In Ontario, Monarch caterpillars feed on milkweed plants and are confined to meadows and open areas with food sources. Adult butterflies are found in more diverse habitats. Monarch is a breeding species and migrates through the DN site in large numbers. It was observed annually between 2011 and 2019. Potential risk to Monarch is expected to be adequately assessed by Earthworm, as they are both terrestrial invertebrates. Both Earthworm and Monarch caterpillar are exposed to airborne emissions via soil. Earthworms dwell underground and receive more soil exposure. Therefore, using Earthworm to represent monarch caterpillar is conservative.

Butternut is a medium-sized tree, belonging to the walnut family, which can reach up to 30 m in height. In Ontario, Butternut usually grows alone or in small groups in deciduous forests, in sunny openings and near forest edges. It prefers moist, well-drained soil and is often found along streams, or on well-drained gravel sites. Two Butternut trees are located in the southeast area of the DN site, on DNNP lands. In 2019, a Butternut Health Assessment was conducted and one of the Butternut trees was assessed as non-retainable (Beacon, 2019a). Potential risk to this species is expected to be adequately assessed by reference to other terrestrial plant species such as the Sugar Maple, as they receive similar exposure to airborne emissions via soil.

Least Bitterns are aquatic carnivores. Their diet consists mainly of fish, frogs, crustaceans and insects, which they capture directly from the water while climbing through or perching on marsh plants. They are visual predators and prefer dense marshes with some open water areas to forage for prey. Least Bitterns generally nest in marshes with dense vegetation. Least Bittern is considered to be an occasional user of the Site. It was identified at the Site in 2012 at Coot's Pond and was considered unlikely to be breeding there. In 2018, one Least Bittern was found dead in the east end of the Protected Area, likely due to a collision with the overhead transmission line. It was the subject of annual species-specific searches in suitable habitat. Because it is only an occasional user of the Site and is not expected to breed on-Site, this species is not included in Table 4-3 or assessed in the ERA.

Bank Swallow and Barn Swallow are aerial insectivores and feed over open areas such as fields, meadows, watercourses and waterbodies. Bank swallows nest colonially in small to

large colonies where there are natural or artificial soft soil banks, such as natural river and lake bluffs, in which they create nesting burrows. The lakeshore Bank Swallow colonies at the DN site during the 2011 to 2019 period were estimated to be between 1,360 and 2,617 burrows, the majority of which are found along the eastern-most third of the shoreline of the DN site. Bank Swallow was considered as a VEC in the ERA.

Barn Swallow, in Ontario, typically nests in small openings in man-made buildings, such as barns. Barn Swallows are annual breeders at the Site, all around the existing station. Over the 2011 to 2019 period 20 to 86 active nests were observed in any one year in and around the buildings on the site, including an artificial nesting site created by OPG. Barn Swallows are typically observed foraging over lawns, open field areas, wetlands and along the lakeshore at the DN Site. Several of the buildings on the DN site may provide a suitable habitat for birds: in 2015, Barn Swallows nested on various buildings within the protected area such as the TRF, Vacuum Building, Emergency Power Generator Fuel Maintenance Building, Drawing storage Facility, Standby Generator (SG) Building 1-4, Compressed gas Storage Building, D₂O Management Building, Reactor Building 1 & 2, Turbine Building at U4 end, and Emergency Power Supply Building (M. Crouch, personal communication, September 7, 2016). The population of Barn Swallow has increased over the years, and is the most numerous breeding species at the DN site (Beacon, 2019a). The Bank Swallow is considered a suitable surrogate species for the Barn Swallow, and the assessment of ecological risks for the Bank Swallow in this ERA is expected to be adequate for protection of the Barn Swallow, considering their similar diet and other characteristics.

The Bank Swallow is also considered a suitable surrogate species for the Canada Warbler considering the similar diet and physical characteristics. The Canada Warbler eats insects such as spiders that have been gleaned off of foliage (COSEWIC, 2008). The Canada Warbler is a regular migrant species. The last observation of this species at the DN site was 2011.

Olive-sided Flycatcher is also an aerial insectivore. They are most often found along natural forest edges and openings where they typically hunt from foraging perches such as trees. Olive-sided Flycatchers' breeding habitat usually consists of coniferous or mixed forest adjacent to rivers or wetlands. It is not considered to breed onsite. During the 2011 to 2019 period, a single bird was observed on migration in 2012, and another incidental observation was documented in 2019. As Olive-Sided Flycatcher is only a scarce migrant and is not breeding on site, it is not included in Table 4-3 or assessed in the EcoRA.

Bobolink and Eastern Meadowlark are omnivores which typically forage on or near the ground for insects, seeds and berries. The Bobolink typically breeds in large agricultural grasslands or fields such as hayfields and other fields with tall lush forb vegetation. It is an annual breeder at the DN Site mostly at the Bobolink Hill area. Eastern Meadowlark also breeds in grasslands and prairie, as well as pastures and hay fields. The Eastern Meadowlark builds its nest on the ground, covered with a roof woven from grasses. The species is an annual breeder at the DN site mostly at the Bobolink Hill area. Potential risk to these species is expected to be adequately assessed by reference to other avian

omnivores such as the American Robin, as they are all ground feeding birds and receive similar atmospheric exposure through food and soil.

Wood Thrush are omnivores which typically forage on invertebrates and fruits. They prefer woodlands and are not typically found at DN. However, in 2014, a singing male was heard near the east end of Coot's Pond and another was recorded in the New Build area in 2015 (Beacon, 2016b). American Robin is also considered a suitable surrogate for Wood Thrush, as they are both ground feeding insectivores, and are exposed to similar atmospheric exposure through food and soil.

Little Brown Myotis and Northern Myotis are aerial insectivores. Like other bats, they forage during the night and roost in trees or buildings during the day. Little Brown Myotis will often select attics, abandoned buildings and barns for summer colonies to raise their young. It was recorded near the DN site in 2013, 2017 and 2018, and likely has roosting habitat on site. Northern Myotis is typically associated with boreal forests, and often roosts under loose bark and in the cavities of trees. It was recorded for the first time in 2018 at the DN site. It may not be roosting on site, but using treed communities for foraging. Potential risk to Little Brown Myotis and Northern Myotis is expected to be adequately assessed by reference to other mammalian insectivores such as the Common Shrew considering their similar diet. Common Shrew has more soil exposure compared to Little Brown Myotis and Northern Myotis, and therefore it is a conservative surrogate.

The American Eel is carnivorous, feeding on a variety of fishes and invertebrates. The American Eel is catadromous, utilizing a variety of marine and freshwater habitats over the course of its life history. It spawns in the Sargasso Sea, and during its migrations to and from spawning areas, it occurs in continental and oceanic habitats. In fresh water, its preferred habitat is in lakes and rivers including all waters to a depth of least a 10 m. The American Eel has been assessed as a VEC in this ERA.

4.1.2.3 Receptor Characterization

Receptor profiles in Appendix C describe the habitat and the feeding habits of the selected receptor species. The receptor species were assigned to assessment locations on the site based on habitat features at each location and species habitat preferences. Receptor locations for assessment purposes are discussed in Section 4.1.5.

For mammals and birds, dietary assumptions were made based on the described feeding habits. Diets were simplified to represent the main food chain pathways without trying to capture their full taxonomic complexity. For example, Muskrats are assumed to eat aquatic plants. Additionally, although some species may primarily eat insects (i.e., red-winged blackbird), Earthworm is used as a representative for all terrestrial insects and soil invertebrates, since limited bioaccumulation data are available for insects and other invertebrates. The dietary assumptions for bird and mammal receptors are detailed in Table 4-9.

Species-specific exposure parameters, including bioaccumulation factors, food and water ingestion rates, transfer factors and body weights, are described Section 4.2.4.

4.1.3 Assessment and Measurement Endpoints

Assessment endpoints are explicit expressions of the environmental values that are to be protected (FCSAP, 2012). Assessment endpoints should include the VEC and the attribute of the VEC that is to be protected (e.g. abundance and viability) (FCSAP, 2012). The assessment endpoints to be evaluated in this EcoRA are presented in Table 4-4.

Measurement endpoints are conceptually related to assessment endpoints and are defined as the tools that are used to measure exposure of or effects on each VEC. Based on these measures, a potential for effect on the attribute of an assessment endpoint can be inferred. Measurement endpoints are the foundation for the lines of evidence that are used to estimate risks to VECs (FCSAP, 2012).

Measurement endpoints for COPCs are often linked to low-effect threshold concentrations or doses, also known as toxicological reference values (TRVs). The TRV represents the level of COPC exposure that is associated with a minimal and acceptable level of effect to the VEC. The TRVs typically used in EcoRA are based on growth, survival and reproduction measurement endpoints. They represent effects on individuals that are relevant to the viability of VEC populations.

For benthic invertebrates, TRVs are often chosen from the low end of a species sensitivity distribution, but do not necessarily represent the most sensitive species of their group, recognizing that the ecological function of benthic invertebrates as a food source does not depend on protecting all species.

For this EcoRA, sediment concentration-based TRVs (mg/kg dry weight) were selected for the benthic community, water concentration-based TRVs (mg/L or µg/L) were selected for aquatic plants, plankton and forage fish, and dose-based TRVs (mg/kg body weight/day) were selected for mammalian and avian wildlife. These TRVs were based on the lowest low-effect threshold concentrations or doses for survival, growth or reproduction.

For most VECs, the assessment endpoint is the viability of the population. This implies that very localized areas of effect on individuals may be tolerated, based on minimal expected effect at the population level. For species at risk (SAR), the assessment endpoint is individual health, recognizing that each individual is important to the population, thus any TRV exceedance is considered unacceptable.

Table 4-4: Assessment Endpoints, Measurement Endpoints, and Lines of Evidence

Valued Ecosystem Components	Level of Protection	Protection Goal	Assessment Endpoint	Lines of Evidence	
				Line of Evidence	Use of Measurement Endpoints for Specific LOEs
Bottom Feeding Fish (Northern Redbelly Dace, Round Whitefish, White Sucker, American Eel*)	Population	Maintenance of bottom feeding fish populations in Lake Ontario as source of food for piscivorous fish and wildlife.	Viability of bottom-feeding fish populations	Water Chemistry	Comparison of COPC concentrations to growth, survival and reproduction toxicological reference values (low-effect threshold concentrations).
				Radiological Dose	Comparison of estimated doses of COPCs to growth, survival and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Pelagic Fish (Alewife, Lake Trout)	Population	Maintenance of pelagic fish populations in Lake Ontario as source of food for piscivorous fish and wildlife.	Viability of pelagic fish populations.	Water Chemistry	Comparison of COPC concentrations to growth, survival and reproduction toxicological reference values (low-effect threshold concentrations).
				Radiological Dose	Comparison of estimated doses of COPCs to growth, survival and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Reptiles and Amphibians (Turtles, Frogs)	Population	Maintenance of turtle and frog populations in Coot's Pond and Treefrog Pond as sources of food for fish and wildlife.	Viability of turtle and frog populations.	Water Chemistry	Comparison of COPC concentrations to growth, survival and reproduction toxicological reference values (low-effect threshold concentrations).

Valued Ecosystem Components	Level of Protection	Protection Goal	Assessment Endpoint	Lines of Evidence	
				Line of Evidence	Use of Measurement Endpoints for Specific LOEs
				Radiological Dose	Comparison of estimated doses of COPCs to growth, survival and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Aquatic Plants	Population	Maintenance of aquatic plant populations in Coot's Pond and Treefrog Pond as a source of food and cover for wildlife.	Viability of aquatic plant populations.	Water Chemistry	Comparison of COPC concentrations to growth, survival and reproduction toxicological reference values (low-effect threshold concentrations) for aquatic plants.
				Radiological Dose	Comparison of estimated doses of COPCs to growth, survival and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Benthic Invertebrates	Community	Maintenance of a diverse aquatic and benthic invertebrate community in Lake Ontario, Coot's Pond, and Treefrog Pond as source of food for fish and wildlife.	Richness, diversity, abundance of benthic invertebrates.	Water Chemistry	Comparison of COPC concentrations to water quality guidelines.
				Sediment Chemistry	Comparison of COPC concentrations to sediment quality guidelines.
				Radiological Dose	Comparison of estimated doses of COPCs to growth, survival and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.

Valued Ecosystem Components	Level of Protection	Protection Goal	Assessment Endpoint	Lines of Evidence	
				Line of Evidence	Use of Measurement Endpoints for Specific LOEs
Riparian Birds (Bufflehead, Mallard, Green Heron)	Population	Maintenance of riparian bird populations along Lake Ontario shoreline and Coot's Pond as source of food for predatory wildlife.	Viability of aquatic riparian bird populations	Radiological and Toxicological Doses	Comparison of estimated doses of COPCs to growth, survival and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Riparian Mammals (Muskrat)	Population	Maintenance of riparian mammal population along Coot's Pond as source of food for predatory wildlife.	Viability of aquatic riparian mammal populations		
Terrestrial Invertebrates (Earthworm)	Population	Maintenance of terrestrial invertebrate population at the DN site as a source of food for wildlife.	Viability of terrestrial invertebrate populations	Soil Chemistry	Comparison of COPC concentrations to soil quality guidelines.
				Radiological Dose	Comparison of estimated doses to growth, survival and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Terrestrial Plants (Grasses, Sugar Maple)	Population	Maintenance of the terrestrial plant population at the DN site.	Viability of terrestrial plant populations	Soil Chemistry	Comparison of COPC concentrations to soil quality guidelines.
				Radiological Dose	Comparison of estimated doses to growth, survival and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.

Valued Ecosystem Components	Level of Protection	Protection Goal	Assessment Endpoint	Lines of Evidence	
				Line of Evidence	Use of Measurement Endpoints for Specific LOEs
Terrestrial Birds (American Robin, Bank Swallow*, Song Sparrow, Yellow Warbler)	Population	Maintenance of the terrestrial bird population at the DN site.	Viability of terrestrial bird populations	Radiological and Toxicological Doses	Comparison of estimated doses of COPCs to growth, survival and reproduction benchmark values (low-effect threshold doses) relevant to the assessment endpoint.
Terrestrial Mammals (Eastern Cottontail, Meadow Vole, White-Tailed Deer, Common Shrew, Raccoon, Red Fox, Short-Tailed Weasel)	Population	Maintenance of terrestrial mammal population at the DN site.	Viability of terrestrial mammal populations		

Notes:

LOE: Line of evidence

* For Species at Risk (SAR), the goal is protection of individuals, recognizing that each individual's health is important to the population, thus any toxicological reference value exceedance is considered unacceptable.

4.1.4 Selection of Chemical, Radiological, and Other Stressors

The same monitoring data sources previously screened for the HHRA (Section 3.1.2) were screened for the EcoRA using the more conservative of available federal and provincial guidelines and objectives as screening criteria. If there was no such guideline or objective, screening criteria were obtained from the literature, and/or derived using federally and/or provincially accepted methods. For COPCs where these criteria were not available, conservative toxicity benchmarks (e.g., no effects levels) or upper limit of background concentrations were used as screening criteria. Maximum measured concentrations of parameters in air, surface water, soil, and sediment were compared to the selected screening criteria in order to determine the list of COPCs for further assessment in this EcoRA. The screening process is illustrated in Figure 4-2.

For radionuclides, no formal screening was performed; however, a discussion is provided of radionuclides of interest for DN. Since radionuclides are considered of public interest, relevant radionuclides are carried forward quantitatively in the EcoRA without a formal screening assessment.

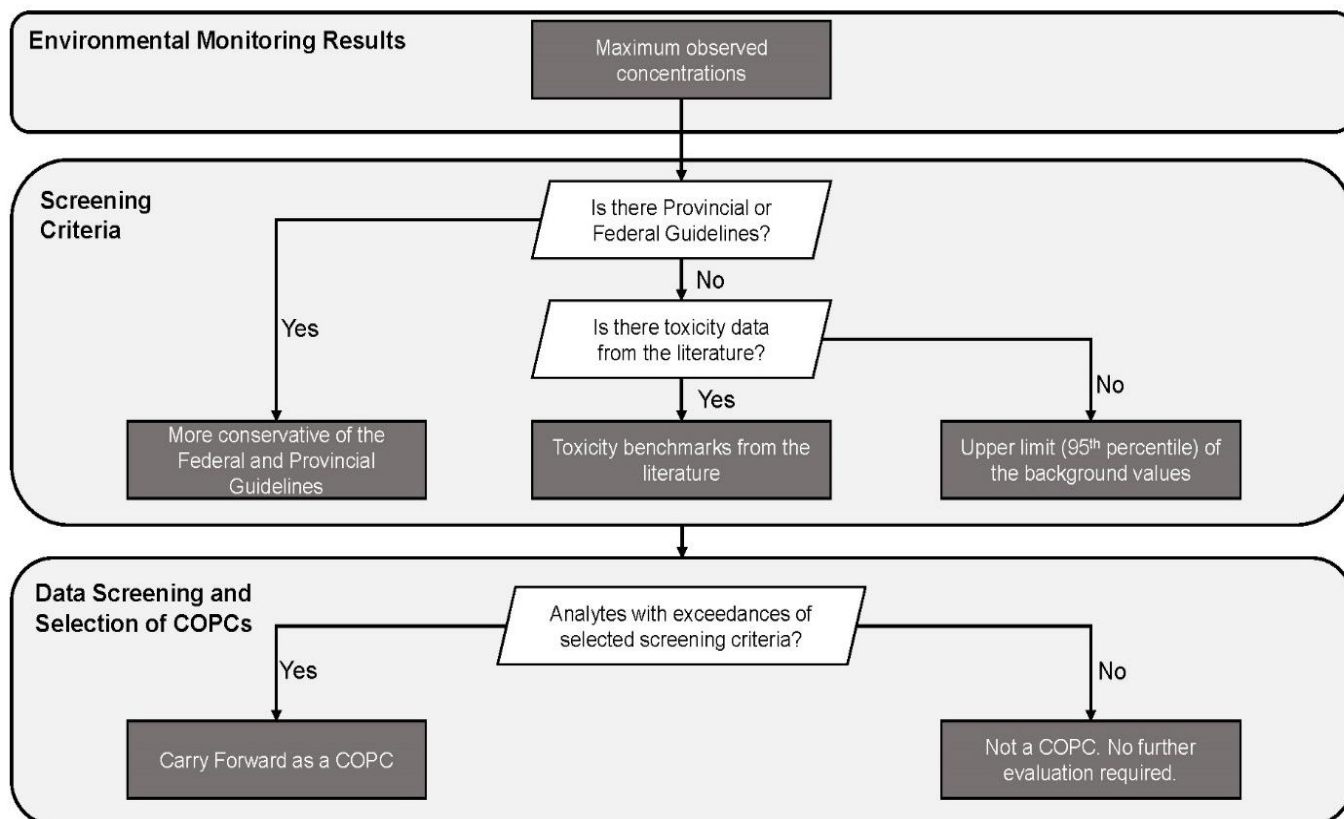


Figure 4-2: Environmental Data Screening Process to Select Chemical COPCs

4.1.4.1 Selection of Chemical COPCs in Air

Section 3.1.2.1 describes the airborne emissions due to the operations at the DN site. As per clause 7.3.4.2.5 in N288.6-12, inhalation exposures to biota are usually minor compared to the soil and food ingestion pathways, and can be ignored for most substances, except for substances that do not partition to soil (CSA, 2012). These substances may include gases such as nitrogen oxides (NO_x), sulphur dioxide, hydrazine, and morpholine, of which air concentrations dominate the exposure pathway to terrestrial biota. For completeness, all chemicals modelled in the 2016-2019 ESDM reports (OPG, 2017c, 2018c, 2019d, 2020d) were screened against relevant ecological screening criteria (Figure 4-3, Appendix A, Table A-9). However, only chemicals that do not partition to soil were considered for COPC selection for air.

Different from the 2017-2019 ESDM report, the only modelled and reported chemical in 2016 was NO_x. This is because, for other chemicals, the air emissions in 2016 at the DN site were the same as in the 2014 and 2015 ESDM report, and therefore, other chemicals were not reported for 2016 (OPG, 2017c). Higher NO_x emissions were expected in 2016 compared to 2015, and hence NO_x was modelled and reported. In 2016, a standby generator operated for 75 hours, above the 60-hour limit per annum. Since the number of hours of operation exceeded the Section 20.4 exemption criteria of 60 hours per annum, NO_x generation through the testing period was modelled and included in the ESDM emission summary table as a source (OPG, 2017c). In 2014, the standby generator was run for less than 60 hours and was not modelled as a source (OPG, 2015a). The modelled maximum POI concentration was used to screen air COPCs. As the 2014 ESDM results were screened in the 2016 ERA, and no COPCs were identified, only the modelled NO_x POI concentrations in 2016 was screened for inclusion in the updated EcoRA.

The modelled POI concentrations provided in the ESDM report were typically ½-hour, 24-hour, or annual averages. These modelled POI concentrations were directly compared to selected screening criteria, as described below, with the same averaging periods (e.g., ½-hour, 24-hour, or annual), or were adjusted to meet the timeframes of the relevant screening criteria using the suggested conversion method provided by MECP (MOECC, 2017). It should be noted that POI conversion is minimized in this screening process to avoid uncertainty introduced by converting POI concentrations to different averaging periods.

The MECP AAQC was used as the preferred screening level as AAQCs are developed to be protective of health and the environment (MOE, 2009). Where AAQCs were not available, the Effects Screening Levels (ESLs) from the Texas Commission on Environmental Quality (TCEQ, 2016) were used. Effects Screening Levels are based on data for health effects, odour and effects on vegetation and can therefore be applied as ecological screening levels. There are no MECP AAQC or TCEQ ESL values for hydrazine and morpholine. For these two COPCs, toxicity benchmarks from literature were modified and applied as the screening criteria, as detailed below.

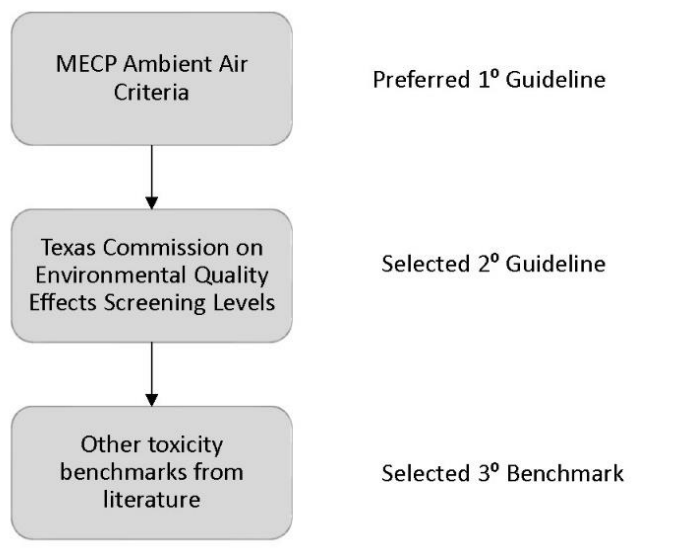


Figure 4-3: Hierarchy of Screening Criteria for Chemical COPCs in Air

For NO_x, air concentrations dominate the exposure pathway to terrestrial biota. As discussed in Section 3.1.2.1, the main source of NO_x includes combustion emissions from the Auxiliary Heating Steam Facility, Standby Generators, Emergency Power Generators, and minor sources. The maximum concentrations at the DN property line POI for NO_x were predicted using estimated atmospheric emissions and a dispersion factor. The ½ hour POI concentrations were converted to concentrations with averaging periods comparable to the relevant MECP AAQC. The AAQCs are developed to be protective of health and the environment. The estimated maximum 1-hr NO_x concentration at the property line was 526 µg/m³, exceeding the 1-hr AAQC of 400 µg/m³. This exceedance occurred in 2016, when a standby generator operated for up to 75 hours during testing, which was a rare incident. In most years and at present, the standby generators typically operate within the 60 hour per annum limit, and in all years other than 2016, the modelled maximum POI values for NO_x are all below the AAQC. Therefore, it is unlikely that NO_x concentrations exceed the selected criteria during typical normal operations. However, since there was an occurrence where NO_x exceeded the screening criteria, NO_x was carried forward as an air COPC for further assessment.

Sulphur dioxide is released through fuel oil combustion. It was deemed a substantial contaminant in 2017 and a negligible contaminant in 2018 and 2019 in the ESDM report because of its lower emission rate (OPG, 2018c, 2019d, 2020d). The maximum POI concentration at the DN property line for sulphur dioxide was 11.37 µg/m³ on a 24 hour averaging period, well below the MECP AAQC of 275 µg/m³. Therefore, sulphur dioxide was not carried forward for further assessment.

Hydrazine and morpholine are released to the air through atmospheric boiler emissions, as described in Section 3.1.2.1, and also do not partition well to soil. The releases due to boiler venting were compared against chronic or sub-chronic toxicity benchmarks.

The screening criterion considered for hydrazine was a Lowest Observable Adverse Effect Level (LOAEL) at $60 \mu\text{g}/\text{m}^3$ (EC and HC, 2011) converted to a No Observable Adverse Effect Level (NOAEL) by applying a safety factor of 10, resulting in a screening criteria of $6 \mu\text{g}/\text{m}^3$. This conversion factor has been used to derive the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 1999), and is the most conservative factor cited in Suter *et al.* (1993). The maximum annual POI for hydrazine was $0.00039 \mu\text{g}/\text{m}^3$, well below the screening criterion (Appendix A, Table A-9). Therefore, hydrazine was not carried forward for further assessment.

The screening criterion selected for morpholine was the NOAEL for rats in a 13-week study (WHO, 1996) of $90,000 \mu\text{g}/\text{m}^3$. The $\frac{1}{2}$ -hour and 24-hour POI concentrations of morpholine were converted to the 13-week average POI concentration using an equation provided by the MECP (MOECC, 2017), and this concentration was compared to the screening criterion. The maximum 13-week POI for morpholine was $1.47 \mu\text{g}/\text{m}^3$ (Appendix A, Table A-9), well below the screening criterion. Therefore, morpholine was not carried forward for further assessment.

Based on the screening presented in Appendix A, Table A-9, for chemicals released to air, NO_x was carried forward as a COPC for further consideration.

4.1.4.2 Selection of Chemical COPCs in Surface Water

The surface water screening is based primarily on measurements of chemical COPCs in Lake Ontario water (Section 4.1.4.2.1), as well as Coot's Pond and Treefrog Pond water (Section 4.1.4.2.4). In addition, concentrations of chemical parameters in the CCW discharges from 2016 to 2019 (Section 4.1.4.2.2), and concentrations of chemical parameters in stormwater discharges to Lake Ontario in 2019 (Section 4.1.4.2.3) were screened to ensure that the list of chemical COPCs was complete. Clause 0.2.2 and 7.2.5.2 of N288.6 discusses screening of liquid effluents as part of the screening process for identifying COPCs in receiving waters. Therefore, if a COPC was identified in lake water, pond water, effluent, or stormwater, it was considered further in the EcoRA.

For each COPC, its maximum concentration in surface water was screened against its screening criterion, which was selected following the process illustrated in Figure 4-4, and detailed below.

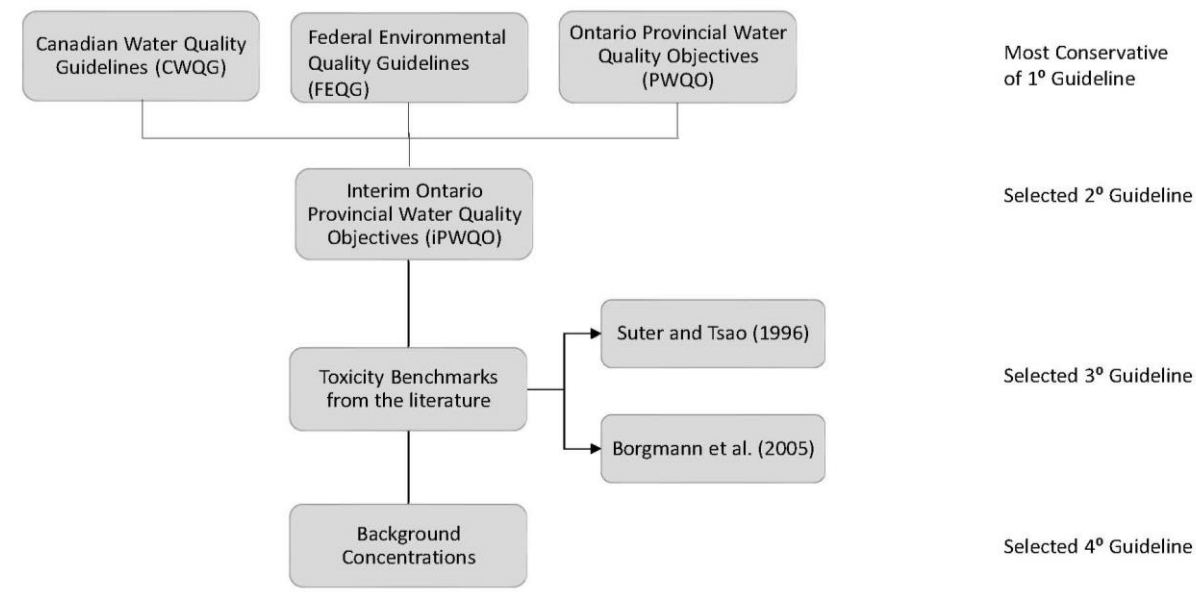


Figure 4-4: Selection of Screening Criteria for Chemical COPCs in Surface Water.

The most restrictive federal or provincial guideline for surface water quality, including the Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of freshwater aquatic life (CWQG), the federal environmental quality guidelines (FEQG), the provincial water quality objective (PWQO), or the interim PWQO (iPWQO) were selected as the screening criteria for most surface water COPCs. For ethylene glycol, propylene glycol, benzene, boron, thallium and uranium, in the absence of a primary guideline, the iPWQO was used as the secondary guideline; the iPWQO values were developed for emergency purposes based on readily available information and were not peer-reviewed. Toxicity based water quality benchmark values were selected from the literature for COPCs which do not have a value from the federal or provincial guidelines. The toxicity benchmark values selected for screening are chronic low-effect threshold concentrations for sensitive test species, modified by a safety factor for conversion to a no effect level (Appendix A, Table A-10). Toxicity benchmark values were selected for barium, calcium, cesium, lithium, magnesium, potassium, sodium, thorium, tin, and titanium. Chemicals with maximum concentrations exceeding the selected screening criteria were carried forward as chemical COPCs in the EcoRA. In cases where no toxicity benchmarks were available from selected literature, the maximum concentrations were compared to the 95th percentile of background concentrations in Lake Ontario.

4.1.4.2.1 Lake Water Sampling

Results from Lake water sampling prior to 2016 were discussed in the 2016 ERA (Ecometrix, 2017). This current ERA focuses on data collected since 2015 – lake water samples were collected in 2019 to support DNNP site preparation licence renewal (Ecometrix, 2020). The dataset used in this screening was the same as that used in the

human health screening in Section 3.1.2.2.1. Sampling locations are presented in Appendix B, Figure B-1.

As shown in Table A-11, the maximum measured concentration for total aluminum in Lake Ontario water was 142 µg/L, as compared to a Canadian Drinking Water Quality Guideline of 100 µg/L. However, the maximum measured concentration for dissolved aluminum (in a filtered sample) was 21 µg/L, which was below the screening criteria (PWQO value) at 75 µg/L. The relatively high concentration of aluminum in the unfiltered samples is therefore considered to be indicative of the presence of suspended solids in the samples. The dissolved phase of aluminum is expected to be more bioavailable and toxic than any aluminum in a suspended phase. There is very limited toxicological study on total aluminum in water with pH >6.5 (which was the case for Lake Ontario). The CCME CWQG for total aluminum is a value that was tentatively recommended by US EPA in 1973 (US EPA, 1973), while acknowledging that further data is required (CCREM, 1987). The PWQO value for dissolved aluminum, on the other hand, is more recent and is derived from a LOEC value. Therefore, whenever data for dissolved aluminum are available, screening of this parameter using the PWQO value is more defensible as compared to the CWQG for total aluminum. As the dissolved aluminum did not exceed its screening criteria, aluminum was not carried forward as a chemical COPC for ecological health.

The maximum concentrations of a few biological parameters, including total coliforms, fecal coliforms, and *Escherichia coli* exceeded their selected screening criteria (lake water background concentrations). Available screening criteria include PWQO values, which were developed for the protection of recreational water uses, rather than ecological health (MOEE, 1994). There are no established regulatory or toxicity benchmarks for coliforms for the protection of ecological health because coliforms are not relevant to ecological health. Therefore, although these biological parameters have higher concentrations than the lake water background values, these biological parameters were not carried forward as COPCs.

The maximum concentrations of a few major ions (calcium, magnesium, potassium) exceeded the selected screening criteria (the Lake Ontario background concentrations). There is no evidence of adverse health effects from these major ions in drinking water (HC, 2012), and they were considered to be essentially non-toxic for environmental biota. These major ions are effectively regulated on the cellular level, and have not been associated with adverse effects in environmental biota at environmental concentrations. Therefore, calcium, magnesium, and potassium were not carried forward as COPCs for further assessment in the EcoRA.

In addition, the maximum field pH value observed in Lake Ontario was 9.21, beyond the range of selected screening criteria. Similarly, the maximum concentrations of total suspended solids, total ammonia, un-ionized ammonia, barium, and zinc exceeded the selected screening criteria, and therefore were carried forward as COPCs for further assessment in the EcoRA.

As presented in Appendix A, Table A-11, the maximum measured concentration of phosphorus exceeded its ecological screening criteria. Phosphorus presents in the aquatic environment as phosphate, where it acts as a nutrient rather than a toxicant. The interim PWQO guideline was set to avoid nuisance concentrations of algae in lakes, and is not relevant to ecological health. As such, phosphorus is not considered a COPC for ecological health.

4.1.4.2.2 Liquid Effluent Sampling

As in the HHRA, information from 2016 to 2019 on the concentrations of COPCs in liquid effluents was available and was assessed to aid in COPC selection to ensure that the lake water chemical COPC selection was complete. As in the HHRA, the final discharge released from the CCW duct was assessed for this screening. In addition, effluent released from the CCW duct is diluted in Lake Ontario through the diffuser. Thus, the initial mixing zone in Lake Ontario represents a maximum potential exposure for ecological receptors. Effluent quality results were converted to estimated concentrations in the mixing zone using a dilution factor of 7 at the diffuser (OPG, 2016d).

4.1.4.2.2.1 Monitoring for ECA Requirements

As part of the ECA requirements, the effluent from the CCW is sampled and analyzed for compliance with effluent limits for unionized ammonia, hydrazine, morpholine, pH, and total residual chlorine (TRC) (OPG, 2017d, 2018h, 2019e, 2020e). For each of these chemicals, the maximum concentration in the mixing zone was estimated based on the maximum measured concentration in the CCW and a dilution factor of 7 at the diffuser. Estimated mixing zone concentrations from 2016 to 2019 were screened against the same screening criteria as the lake water samples.

Environment and Climate Change Canada (ECCC) has developed a Federal Environmental Quality Guideline (FEQG) for hydrazine of 2.6 µg/L for fresh water (EC, 2013a). This value represents a chronic no-effect concentration based on an acute toxicity threshold with a safety factor (EC and HC, 2011). The maximum observed hydrazine concentration (6 µg/L) at the CCW duct was above the screening level of 2.6 µg/L, while the detection limit of hydrazine was 1 µg/L. Similarly, the maximum measured morpholine and TRC concentrations in the CCW were greater than their respective screening criteria. However, the estimated maximum mixing zone concentrations for hydrazine, morpholine, and TRC were all below their selected screening criteria, and therefore, these parameters were not carried forward for further assessment in the EcoRA.

The MECP water quality objective for pH in freshwater is within the range from 6.5 to 8.5 (MOE, 1979). The MECP considers the PWQO for pH to be the range within which waters are the most productive (MOE, 1979). Surface water with pH above the upper limit of the PWQO may be less productive. The Canadian water quality objective for pH for freshwater biota is a range from 6.5 to 9.0 (CCME, 2010a). This same pH range has been recommended by the International Joint Commission (1977) and the U.S. EPA (1986). The

range from 6.5 to 9.0 is considered to be harmless to fish and benthic invertebrates, although the toxicity of other contaminants, such as ammonia, may be affected by pH changes within this range. Since the pH in effluent was within the range of the CCME guideline, pH was not carried forward as a COPC from the effluent screening.

Based on the above discussion, and as shown in Table A-12 in Appendix A, there were no COPCs carried forward for further assessment in the EcoRA from the ECA effluent screening.

4.1.4.2.2.2 Monitoring for MISA Requirements

Effluent monitoring is required under the MISA program, as described in Section 2.2.2.1.6. As outlined in Section 3.1.2.2.2.2, for MISA monitoring parameters measured in the RLW and WTP effluents (phosphorus, TSS, zinc, iron, oil and grease, and aluminum), Golder (2011a) conducted mixing calculations to obtain expected concentrations of COPCs in the CCW based on effluent discharge to the CCW from the RLW and the WTP. The results of these calculations have been included in this ERA report (Appendix A, Table A-13). Mixing calculations were based on a worst-case scenario, assuming effluent was discharged at the MISA limits. The calculated CCW concentrations, as well as the estimated mixing zone concentrations were compared against the ecological health screening criteria, and were found to be well below these limits.

Based on MISA reports from 2016 to 2019 (OPG, 2017i, 2020g, 2020h, 2020i), only one exceedance of MISA limits has been observed. The November 2019 acute toxicity sample failed for rainbow trout with 100% mortality in a 96-hr single concentration test (the *Daphnia magna* result was 0%). This incident occurred at an inactive control point, which is only used for emergency discharges. The toxicity failure is likely due to an abnormal configuration at the inactive drainage system. After this incident, a corrective action plan was initiated and completed at the facility to prevent recurrence.

Based on this information, no exceedances of screening criteria in the CCW were expected for the MISA parameters, as shown in Table A-13 in Appendix A, and no additional chemical COPCs are carried forward for further assessment in the EcoRA.

4.1.4.2.2.3 2016 Effluent Characterization Study

No COPCs from the 2016 effluent characterization study are carried forward for further assessment in the EcoRA, as the estimated maximum concentrations of all measured parameters in the initial mixing zone in Lake Ontario are below the screening criteria.

In support of the review and update of the 2016 DN ERA, liquid effluent sampling and analysis were performed in 2016 to provide data for the characterization of non-radiological parameters. No additional data have been collected since 2016. As in the HHRA, screening of the CCW results, as well as the estimated mixing zone concentrations from this study, against ecological health screening criteria was the focus of this screening

exercise. Parameter concentrations from CCW samples and the estimated mixing zone concentrations were screened against the same ecological health screening criteria used for the lake water screening.

Morpholine exceeded its screening benchmark in the RLW, as shown in Table A-14a, and it was not measured in the CCW in the 2016 Effluent Characterization sampling program. Since, at the time of the study, the RLW stream flowed at 0.0126 m³/s, and the average daily CCW flow rate between 2011 and 2015 was equivalent to 114.56 m³/s, a multiplicative dilution factor of roughly 1×10^{-4} (equivalent to division by a factor of about 9,000) is expected to apply, and morpholine from the RLW stream was not expected to lead to an exceedance for morpholine in the CCW. As the morpholine concentration from the CCW will be further diluted through the DN diffuser, the elevated morpholine concentration will not exceed the screening criteria in the mixing zone in the lake. Morpholine is therefore not considered a COPC based on the effluent characterization study results.

Similarly, TRC exceeded its screening criterion in the WTP stream, as shown in Table A-14a, and it was not measured in the CCW stream during the 2016 Effluent Characterization Program. TRC in the CCW stream was reported weekly in the 2016 ECA, and was below its detection limit in all data points. Therefore, the elevated TRC in the WTP stream does not result in exceedances in the CCW, and does not result in exceedances in the initial mixing zone in lake water. TRC is therefore not considered a COPC based on the 2016 effluent characterization study results.

The maximum analyzed concentration of total aluminum in the CCW exceeded its selected ecological screening criterion; however, the aluminum concentration in the initial mixing zone is below the screening criterion after dilution in the DN diffuser. Therefore, aluminum was not carried forward as a chemical COPC for ecological health.

The detection limit of mercury in the RLW and CCW streams ranged between 0.01 to 0.1 µg/L, with the higher range exceeding its ecological screening criterion of 0.026 µg/L. As the majority of analyzed mercury concentrations were below the lower detection limit in the effluent characterization study, and as there were no detected concentrations exceeding the selected screening criterion, the lake water mixing zone mercury concentration will not be exceeding the screening criteria because of the CCW release. Therefore, mercury was not carried forward as a chemical COPC for ecological health.

Concentrations of cadmium, chromium, copper, lead, molybdenum, nickel, and selenium exceeded their respective ecological health screening criteria in one or more of the RLW, IAD, or WTP streams. Maximum concentrations of all of these contaminants in the CCW, however, did not exceed their screening benchmarks. Since the CCW is the stream discharged to Lake Ontario, and the concentrations of these chemicals will be further diluted through the DN diffuser, these contaminants in DN effluent do not exceed the screening criteria in the lake, and were not carried forward as chemical COPCs for the EcoRA.

In 2018, the CCME published an updated water quality guideline for zinc based on dissolved zinc (7 µg/L). The maximum analyzed concentration of total zinc in the CCW exceeds this updated guideline, and no dissolved zinc was measured in the CCW. The estimated total zinc concentration in the initial mixing zone in lake water from the CCW through the DN diffuser was 1.26 µg/L, lower than the screening criteria. The concentration of the dissolved zinc is expected to be lower than the total zinc. Therefore, zinc was not carried forward as a COPC from the effluent screening. Dissolved zinc was measured in 2019 in Lake Ontario and exceeds the CCME value (See Section 4.1.4.2.1). Therefore, dissolved zinc is carried forward as a COPC in lake water for the EcoRA.

As shown in Table A-14a, the maximum measured concentration of phosphorus in the CCW exceeded its ecological screening benchmark. Phosphorus exists in the environment as phosphate, where it acts as a nutrient rather than a toxicant. As such, phosphorus was not considered a COPC for ecological health.

PHC F2 was not detected in any analyzed samples in the 2016 Effluent Characterization Study, but its detection limit of 100 µg/L exceeded its ecological health screening benchmark of 42 µg/L. No PHC fractions have been detected in any samples from this study. In addition, the estimated maximum mixing zone concentrations of PHC F2 in Lake Ontario after being diluted through the DN diffuser was below 14.29 µg/L, lower than the screening criteria. Therefore, PHC F2 was not considered a COPC for ecological health.

Similarly, a screening of alcohol ethoxylates (AEOs), nonylphenol ethoxycetic acid (nonylphenol ethoxycarboxylate, or NP1EC), and linear alkylbenzene sulphonates (LASs) in surface water samples taken from the CCW is summarized in Table A-14b. Ecological health benchmarks were available from Environment Canada (EC, 2013b), CCME (2002), and the Human and Environmental Risk Assessment (HERA) on Ingredients of Household Cleaning Products (HERA, 2013). For a given contaminant, the most conservative available benchmark was selected as the screening criterion.

Concentrations of the total C12-C13 and C14-C15 AEOs in the CCW exceeded their respective ecological screening criteria, so a detailed screening of individual homologues within each grouping was performed; the results are presented in Table A-14c. None of the individual analyzed homologues exceeded their respective EC Fresh Water Quality Guidelines (FWQGs) in either CCW or the initial mixing zone in lake water, so none of the AEOs in these groupings were carried forward as COPCs for ecological health. In addition, neither of the C12-C13 nor C14-C15 groupings, nor total AEOs were carried forward as ecological health COPCs, since none of their individual homologue components exceeded their respective guidelines.

NP1EC and individual LAS fractions did not exceed their respective ecological screening benchmarks in either CCW or the initial mixing zone in lake water, and these chemicals, as well as total LAS, were therefore not carried forward as chemical COPCs for ecological health.

Based on the discussion above, the estimated maximum concentrations of all measured parameters in the initial mixing zone in Lake Ontario are all below the screening criteria. No COPCs were carried forward from this screening of the 2016 effluent characterization study results; however, dissolved zinc is assessed further in the context of the lake water measurements.

4.1.4.2.3 Stormwater Sampling

The Stormwater Management System, or Yard Drainage System, collects storm runoff from the entire DN site and discharges to Lake Ontario, either directly through the storm sewer drainage system, or through drainage swales/creeks via culverts which eventually discharge to the Lake.

As described in the HHRA (see Section 3.1.2.2.3, the available stormwater chemical analyses from 2019 were compiled and maximum concentrations from this dataset were converted to equivalent loadings to Lake Ontario using the maximum measured peak flow rates at the time of sampling (Golder, 2020), except for temperature, conductivity and pH, for which the maximum values measured in stormwater were directly used for screening.

These equivalent loadings were then converted to estimated Lake Ontario concentrations in a nearshore mixing zone. The flow in this zone was defined by an average alongshore current speed of 0.081 m/s (OPG, 2018e) and the cross-sectional area of the wave zone. The wave zone in Lake Ontario extends to about 2 m depth, which is typically about 120 m from the shoreline. These assumptions resulted in an estimated average shoreline flow rate of 9,720 L/s. The estimated Lake Ontario concentrations were then screened against the same ecological screening benchmarks used in the lake water screening. The results are presented in Table A-15 in Appendix A.

While the minimum pH value was within the regulated range, the greatest pH value observed in the stormwater was 8.97, beyond the MECP pH range (MOE, 1979) of 6.5 to 8.5. The MECP considers the PWQO for pH to be the range within which waters are the most productive (MOE, 1979). Surface water with pH above the upper limit of the PWQO may be less productive. The Canadian water quality objective for pH for freshwater biota is a range of 6.5 to 9.0 (CCME, 2010a). This same pH range has been recommended by the International Joint Commission (1977) and the U.S. EPA (1986). The range from 6.5 to 9.0 is considered to be harmless to fish and benthic invertebrates, although the toxicity of other contaminants, such as ammonia, may be affected by pH changes within this range. Since the maximum measured pH was less than the CCME upper bound, and the stormwater would be diluted in Lake Ontario, pH was not carried forward for assessment in the EcoRA.

The maximum estimated concentration of both total and dissolved barium in the lake water exceeded the selected screening criteria. Therefore, barium was carried forward for further assessment as a chemical COPC for lake water in the EcoRA.

There were no regulatory or toxicity benchmarks for PCBs in surface water. PCBs do not partition to water due to their low solubility. In addition, none of the PCB compounds were detected in the stormwater samples. Therefore, it was considered that screening of PCBs was not necessary and they were not considered chemical COPCs for further assessment in the EcoRA.

The concentration of oil and grease was also analyzed in the 2019 stormwater sampling event. The oil and grease test has been largely replaced by testing for petroleum hydrocarbons (PHCs), as analyzing each PHC fraction allows recognition of compositional shifts associated with weathering, and assessment of PHC fractions with different toxicities (CCME, 2008). As the maximum estimated concentrations of the PHC compounds and fractions in lake water were well below their screening criteria, no screening of oil and grease was necessary and this parameter was not carried forward as a COPC for further assessment in the EcoRA.

In summary, based on the screening of estimated concentrations of chemicals from stormwater in near shore lake water, barium was carried forward as a chemical COPC for further assessment in the EcoRA. The maximum estimated barium concentration in lake water due to stormwater was 4.3 µg/L, lower than the maximum observed barium concentration in Lake Ontario during the 2019 sampling events, which was 32.3 µg/L. As ecological receptors may reside in the wave zone in Lake Ontario and therefore may be exposed to diluted stormwater in Lake Ontario, exposure to barium should be considered. However, since measured barium concentrations in lake water are higher than those estimated from stormwater in Lake Ontario, the exposure assessment will focus on measured barium concentrations in lake water as a conservative approach.

4.1.4.2.4 Pond Water Sampling

Golder collected surface water samples from Coot's Pond in Polygon AB and Treefrog Pond in Polygon D in the course of the preparation of the NND EA (Golder, 2009), and the data were assessed in the 2009 EcoRA (SENES, 2009a). These ponds are not exposed to liquid effluent from DN, but Coot's Pond is exposed to stormwater runoff from the construction landfill. The ponds are also expected to be exposed to chemical contaminants in air, which could be deposited in surface water after release to the atmosphere from DN. A screening of the available data from the 2009 EcoRA (SENES, 2009a) was conducted in the 2016 ERA (Ecometrix, 2017).

In 2019, Ecometrix performed environmental studies to support DNNP site preparation licence renewal. Quarterly surface water samples were collected from both Coot's Pond and Treefrog Pond (Ecometrix, 2020). Sampling locations are presented in Appendix B, Figure B-2. Parameters analyzed in this study included most chemicals that partition to water of those modelled by OPG in air (See Table A-9 in Appendix A). Anions modelled in air, such as chloride and fluoride, were not analyzed in pond water samples. However, none of these chemicals were modelled to be present in air at concentrations of concern (See Section 4.1.4.1), so potential deposition of these chemicals to the ponds is not

expected to lead to environmental risks. A screening of available data from the 2019 environmental study was conducted to determine if any COPCs could be present in surface water in either of these ponds. This screening used the same criteria as the other surface water screenings for ecological health. Results of this screening are presented in Table A-16 in Appendix A.

The maximum concentration of a few major ions, including calcium, magnesium, and potassium exceeded the screening criteria in both Coot's Pond and Treefrog Pond. As discussed in Section 4.1.4.2.1, these major ions are not considered as toxicants for environmental receptors. Therefore, they were not carried forward as COPCs for pond water.

For Coot's Pond, pH, total and unionized ammonia, barium and iron exceeded the screening criteria and were identified as COPCs. For Treefrog Pond, total ammonia, barium, and iron exceeded their selected screening criteria, and were identified as chemical COPCs.

The maximum concentrations of a few biological parameters, including total coliforms, fecal coliforms, and *Escherichia coli* exceeded their selected screening criteria in both Coot's Pond and Treefrog Pond. Available screening criteria include PWQO values, which were developed for the protection of recreational water uses, rather than ecological health (MOEE, 1994). There are no established regulatory or toxicity benchmarks for coliforms for the protection of ecological health, and these parameters are not relevant to ecological health. Therefore, these biological parameters were not carried forward as COPCs for this EcoRA.

As shown in Table A-16, the maximum concentration for total aluminum in Coot's Pond water was 369 µg/L, which exceeded its CWQG screening criterion. The maximum analyzed concentration for dissolved aluminum (in a filtered sample) was 25 µg/L, which was below the selected criterion (PWQO value) of 75 µg/L. The relatively high concentration of aluminum in the unfiltered samples is therefore considered to be indicative of the presence of suspended solids in the samples. The aluminum associated with suspended particles is typically in the oxide form, which is less bioavailable and toxic than its dissolved species to ecological receptors. There is very limited toxicological study on total aluminum at water with pH >6.5 (which was the case for Lake Ontario). The CCME CWQG for total aluminum is a value that was tentatively recommended by US EPA in 1973, while acknowledging that further data is required (CCREM, 1987). The PWQO value for dissolved aluminum, on the other hand, is more recent and is derived from a LOEC value. Therefore, whenever data for dissolved aluminum are available, screening of dissolved aluminum using the PWQO value was considered more defensible as compared to the CWQG for total aluminum. As the dissolved aluminum was analyzed and did not exceed its screening criteria, aluminum was not carried forward as a chemical COPC for ecological health.

The maximum measured concentration of phosphorus in both ponds exceeds their ecological screening benchmark. Phosphorus exists in the environment as phosphate, where it acts as a nutrient rather than a toxicant. As such, phosphorus was not considered a COPC for ecological health.

4.1.4.3 Selection of Chemical COPCs in Sediment

Sediment in Lake Ontario was characterized as part of the baseline data collection for the ecological risk assessment in the New Nuclear Darlington EA (SENES, 2009a). From 2016 to 2019, two additional sampling studies were carried out. In 2018, a sediment characterization study consisted of two sampling events at the Darlington Harbour area and near-shore locations immediately west of the Darlington Harbour. In 2019, sediment samples were collected at the Lake Ontario near-shore (including the St. Marys (future) embayment and proposed infill area) and off-shore to support DNNP site preparation licence renewal. Sampling locations in Lake Ontario during the 2018-2019 sediment studies are presented in Appendix B, Figure B-3. The updated 2018 to 2019 sediment data were screened against relevant screening criteria to select chemical COPCs for the EcoRA. The screening criteria were selected following the hierarchy illustrated in Figure 4-5. All regulatory and toxicity benchmarks consulted were listed in Appendix A, Table A-17.

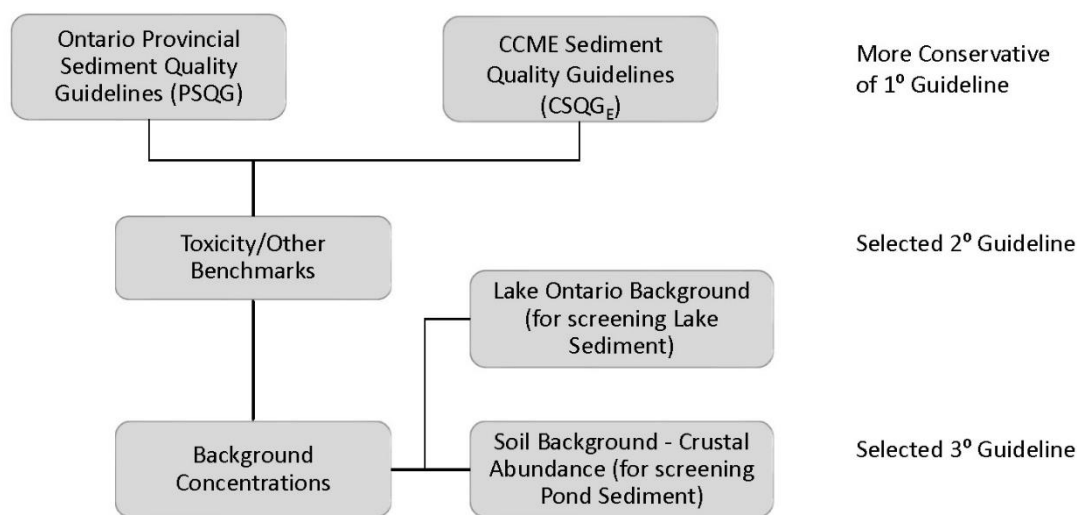


Figure 4-5: Selection of Screening Criteria for COPCs in Sediment

In particular, maximum measured concentrations of sediment parameters were compared against the more conservative values of Ontario Provincial Sediment Quality Guidelines (PSQG, (MOE, 2008)), and the CCME Sediment Quality Guidelines for the Protection of Aquatic Life (CSQG, (CCME, 2001)). If regulatory criteria were not available, values from toxicity studies and other literature were used, as detailed in Appendix A, Table A-17. If there were no reported toxicity values for a certain parameter analyzed in Lake Ontario, the

95th percentile of background concentrations in Lake Ontario sediment (SENES, 2009a) were used as the screening criteria for this parameter. These background values were not used to screen sediment chemicals in Coot's Pond and Treefrog Pond as the background values are not representative of pond background concentrations. The upper end of the ranges of crustal abundance for the United States from Dragun and Chiasson (1991) were consulted to screen the pond sediment COPCs, if no toxicity-based benchmark was available.

4.1.4.3.1 Lake Ontario Sediment Sampling

Within the study area in Lake Ontario, the substrate is predominantly gravel and cobble on top of glacial till or bedrock, except in (future) embayments (St. Marys boat slip). Any finer material, mostly sand, is patchy, thin and transient. Lake Ontario in the vicinity of DN is not a depositional environment, as characterized in COG (2013b). As such, any chemical parameters in sediments in Lake Ontario due to DN's influence are likely to be due to liquid effluents, and screening of Lake Ontario water and liquid effluents for COPCs are expected to be protective of aquatic life. However, to be complete, the sediment monitoring data were screened as an additional line of evidence for the selection of COPCs.

The screening results for Lake Ontario sediment are presented in Appendix A, Table A-18. Some nutrients, metals, and PHCs exceeded their selected criteria; these were: total Kjeldahl nitrogen (TKN), phosphorus, cesium, strontium, and PHC F3 fraction. Several PAHs also exceeded their CSQG guidelines: benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, phenanthrene, and pyrene. Among parameters that exceeded the screening criteria, the elevated TKN and phosphorus is likely due to agricultural inputs into Lake Ontario, and not due to DNGS operations. All of the above-mentioned nutrient, metal, PHC, and PAH parameters with exceedances were carried forward as chemical COPCs for further assessment in the EcoRA.

The maximum concentration of calcium in lake sediment also exceeded the selected screening criterion, which was derived from the background calcium concentration in Lake Ontario sediment. Calcium is a natural component of sediment and not a toxicant to ecological life. Therefore, it was not carried forward as a chemical COPC for further assessment in the EcoRA.

The detection limits of a few PCBs and pesticides, including heptachlor, aroclor 1016, aroclor 1248, aroclor 1260, and total PCBs, exceeded their selected screening criteria. All PCB concentrations in the 2018 to 2019 sampling events were below detection. There is no known source of PCBs at the Darlington site since PCBs were banned in the late 1970s, well before DNGS was constructed. Therefore, these parameters were not carried forward as chemical COPCs in sediment.

4.1.4.3.2 Pond Sediment Sampling

The on-site ponds, including Coot's Pond and Treefrog Pond, are depositional environments. However, other than stormwater runoff, these ponds do not receive liquid effluents from DN, so the only potential transport pathway for COPCs from DN to these ponds is through airborne deposition of air emissions from DN. Among the contaminants that OPG modelled in air, NO_x were defined as chemical COPCs in air. NO_x is unlikely to deposit on surface water and partition to sediments. None of the other modelled contaminants in air were at concentrations of concern (See Section 4.1.4.1), so potential deposition of these chemicals to the ponds was not expected to lead to environmental risks.

During the 2019 environmental studies to support DNNP site preparation licence renewal, sediment samples were collected at Coot's Pond and Treefrog Pond (Appendix B, Figure B-2). The monitoring results were screened against selected screening criteria protective of ecological health, as discussed in 4.1.4.5. As Lake Ontario background concentrations were not appropriate to represent the background in the ponds, parameters without regulatory and toxicological benchmarks were screened against the upper range of crustal abundance in the United States (Dragun and Chiasson, 1991).

The results of this screening are presented in Table A-19 in Appendix A. For Coot's Pond, TKN, total organic carbon (TOC), phosphorus, cadmium, chromium, copper, iron, manganese, nickel, vanadium, and zinc were carried forward as chemical COPCs in sediment. For Treefrog Pond, TKN, TOC, phosphorus, cadmium, copper, selenium, and vanadium were carried forward as chemical COPCs for ecological health in sediment.

It is evident that both Coot's Pond and Treefrog Pond are nutrient enriched, as there were elevated concentrations of ammonia and phosphorus in pond water. Therefore, exceedances of TKN, TOC and phosphorus are likely due to agricultural runoff rather than operations at the DN site.

4.1.4.4 Selection of Chemical COPCs in Soil

In order to determine whether any COPCs may pose a risk to ecological receptors, available soil concentrations measured by SENES (SENES, 2009a, 2011b) were screened against ecological screening benchmarks protective of plants, soil organisms, birds, and mammals in the 2016 ERA (Ecometrix, 2017). Since then, Ecometrix collected soil samples at the DN site as part of conducting environmental studies to support DNNP site preparation licence renewal in 2019 (Ecometrix, 2020). The sampling locations are presented in Appendix B, Figure B-4. The maximum concentrations observed in 2019 were compared to screening criteria, selected following the process illustrated in Figure 4-6, to re-evaluate the updated site condition.

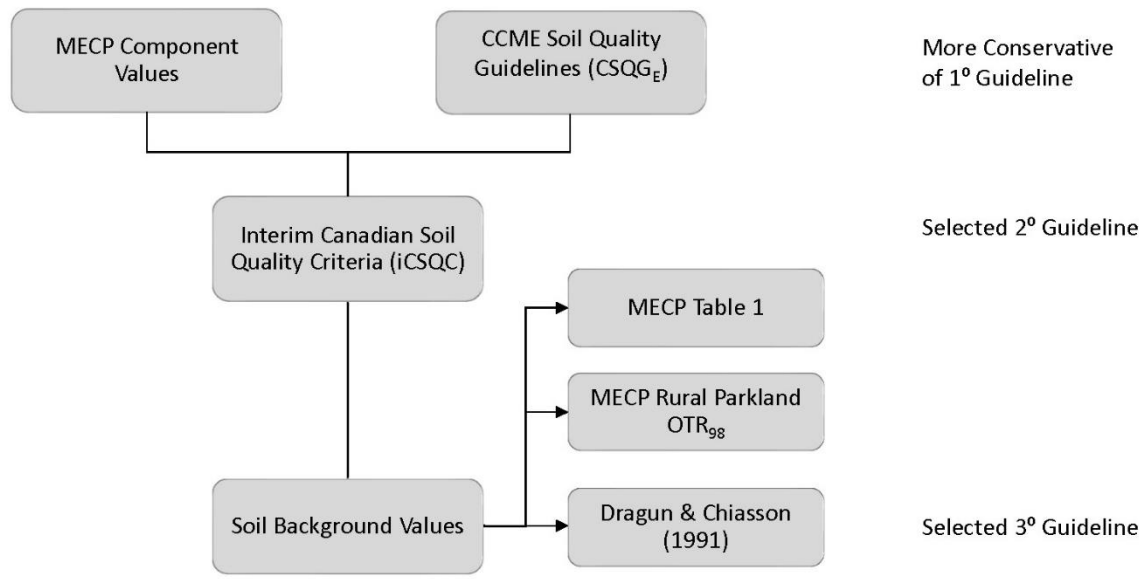


Figure 4-6: Selection of Screening Criteria for Chemical COPCs in Soil

In particular, maximum measured concentrations of soil COPCs were compared against two MECP (MOE, 2011) component values, one based on protection of Plants and Soil Organisms (PSO), and the other based on protection of Birds and Mammals (BM). The residential/parkland component values were selected considering these benchmarks are protective of ecological receptors observed at the site. From a federal perspective, CCME Soil Quality Guidelines for Environmental Health (SQG_E) were consulted, as were Interim Canadian Soil Quality Criteria (ICSQC; (CCME, 1991)), if an SQG_E was not available. Agricultural SQG_E values were used because these guidelines account for bird and mammal ingestion of plants. The more conservative of these provincial and federal screening criteria were selected for the protection of plants, soil organisms, mammals, and birds. The only exception was that for selected PAHs, including benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, fluorene, indeno[1,2,3-c,d]pyrene, phenanthrene, and pyrene, there were insufficient soil contact data, and the CCME SQG_E was based on the 1991 interim soil quality criteria (CCME, 2010b). For these parameters, the Ontario provincial component values were adopted, if available, prior to the CCME SQG_E, as the Ontario provincial values are considered more recent.

If none of the provincial or federal criteria, guidelines, or component values were available, background concentrations of analyzed chemicals in soil were used. The MECP Table 1 Site Condition Standards under Ontario Regulation 153/04 are derived from the Ontario Typical Range (OTR₉₈) values for the land use and are considered representative of upper limits of typical province-wide background concentrations in soils that are not contaminated by point sources (MOE, 2011). If MECP Table 1 values were not available, MECP's Ontario Typical Range (OTR₉₈) concentrations (for rural parkland) were used instead. If

background values from Ontario were not available, the upper end of the ranges of crustal abundance for the United States from Dragun and Chiasson (1991) were used to represent the background soil concentrations.

Of the screening criteria derived in this way, the benchmark for vanadium was given more detailed scrutiny because of its use by MECP in deriving a Site Condition Standard under O.Reg. 153/04. MECP derived a vanadium soil protection value for mammals and birds of 18 mg/kg, with the American Woodcock as the most sensitive receptor (MOE, 2011). This concentration is less than the OTR₉₈ concentration for vanadium of 86 mg/kg in rural parkland. In setting their Site Condition Standard, MECP chose the Ontario background concentration for vanadium over the mammal and bird soil protection value. A similar approach was used here, in that the Ontario background concentration for vanadium was selected as a more appropriate screening benchmark for birds and mammals. This approach is also consistent with the guidance in N288.6-12 (CSA, 2012) that screening benchmarks should not be set below an upper limit of background.

Similarly, the CCME Soil Quality Guideline (SQG) values, for benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene and pyrene, which were based on the 1991 interim soil quality criteria, were lower than the Ontario background soil concentrations (MECP Table 1). For these three compounds, the soil background values were selected as the screening criteria instead of the CCME values. The selected screening criteria are presented in Appendix A, Table A-20.

As shown in Table A-21 in Appendix A, the measured maximum soil concentrations in polygons AB, C, D, and E exceeded selected screening criteria protective of both PSO and BM for strontium. Strontium was therefore carried forward as a soil COPC for all receptors in all polygons.

The maximum observed concentration for calcium also exceeded the selected screening criterion, which is based on the Ontario soil background concentration, in all polygons. Calcium is an essential nutrient for life, and does not pose ecological risk. Therefore, it is not carried forward as a soil COPC.

In polygon E, the maximum analyzed concentrations of arsenic, cadmium, chromium, cobalt, copper, iron, lead, molybdenum, nickel, selenium, sodium, strontium, tin, zinc exceeded their selected screening criteria protective of both PSO and BM. These parameters have been carried forward as soil COPCs for all receptors in polygon E. The maximum analyzed concentration of free cyanide in Polygon E also exceeded the BM component value, and therefore, free cyanide was carried forward as a soil COPC for birds and mammals in polygon E. The maximum cyanide concentration was lower than the selected criterion protective of the plants and soil organisms, suggesting that free cyanide should not cause any risks to plants and soil organisms.

In addition, the gravimetric heavy hydrocarbons, PHC-F4(sg), exceeded the selected screening criteria protective of both PSO and BM. Both PHC-F4 and PHC F4(sg) represent

the heavy fraction of petroleum hydrocarbons. Although PHC-F4 did not exceed its selected criteria, it is required by CCME that the greater result between PHC-F4 and PHC-F4(sg) is reported to represent PHC-F4 in comparing to criteria. Therefore, PHC-F4 was carried forward as a soil COPC for all receptors in Polygon E.

All observed exceedances occurred at monitoring locations DN6 and DN6A (Appendix B, Figure B-4), which is the yard waste and building materials storage area. As wildlife has access to this area, all parameters exceeding the screening criteria are carried forward for further assessment.

In summary, the chemical COPCs carried forward in soil are as follows:

- Strontium for plants, soil organisms, birds and mammals in polygons AB, C, D, and E;
- Arsenic, cadmium, chromium, cobalt, copper, iron, lead, molybdenum, nickel, selenium, sodium, tin, zinc, and PHC F4 for plants, soil organisms, birds and mammals in polygon E;
- Free cyanide for birds and mammals in polygon E.

4.1.4.5 Selection of Chemical COPCs in Groundwater

OPG executes an annual groundwater monitoring program to understand the groundwater flow and quality beneath the DN site. Based on the results of this program, groundwater on the DN site was found to generally flow toward Lake Ontario or the Forebay. In 2016 to 2019, the groundwater monitoring program included sampling groundwater monitoring wells for tritium, and certain locations for select hazardous substances, such as petroleum hydrocarbons (PHCs), benzene, toluene, ethylbenzene and xylenes (BTEX).

As there is no on-site exposure of ecological receptors to groundwater, the only pathway for ecological receptors to be exposed to groundwater would be at the shoreline of Lake Ontario after dilution of the groundwater in the near shore lake. The maximum concentrations of groundwater COPCs were estimated to determine the resulting concentration in Lake Ontario, as detailed in Section 3.1.2.4 and tabulated in Appendix A, Table A-22. The estimated concentrations were then screened against selected surface water criteria (Appendix A, Table A-10). None of the parameters exceeded their screening criteria. In addition, groundwater monitoring results were not significantly different from 2016 to 2019 based on the assessment in EcoMetrix (2020). Results over this time period do not show evidence of any significant leaks occurring from the DN systems; the PHC and benzene concentrations are naturally elevated in the bedrock groundwater because of the naturally occurring hydrocarbons in the petroliferous rock formation. After dilution in near shore lake water, the additional loadings of PHCs from groundwater are insignificant. As such, no COPCs in groundwater were identified for the EcoRA.

4.1.4.6 Selection of Radiological COPCs in Air and Water

A summary of radiological emissions from DN is presented in Section 3.1.2.6. Also presented in that Section is information concerning the Derived Release Limits for DN, which are developed to be protective of human health. As noted in that Section, the airborne effluent release groups that are used for DRL calculation and public dose calculation at DN are as follows:

- Elemental tritium (HT),
- Tritium oxide as water vapour (HTO),
- Noble gas mixtures (Noble Gases),
- Radioiodine mixed fission products (Imfp),
- Carbon-14 as $^{14}\text{CO}_2$ (^{14}C),
- Mixed beta-gamma emitting radionuclides (Particulate), and
- Mixed alpha emitting radionuclides (Gross alpha).

The liquid effluent release groups that are used for DRL calculation and public dose calculation at DN are:

- Tritium oxide as water (HTO),
- Mixed beta-gamma emitting radionuclides (Gross beta-gamma),
- Carbon-14 as dissolved carbonate/bicarbonate (^{14}C), and
- Mixed alpha emitting radionuclides (Gross alpha).

These release groups were identified as being important for estimating potential impacts on human health partly because they are present in, and measured in, air and water effluents at DN. Because of their presence and importance in DN effluents, these same release groups were considered for estimating potential impacts on ecological health.

Air immersion and inhalation pathways for ecological receptors are considered to be minor compared to the ingestion pathway, and were ignored for radionuclides, with the exception of noble gases, which are non-reactive and do not enter the food chain (CSA, 2012). Therefore, noble gases were considered further. Based on air kerma results presented in OPG's annual EMP reports, the average dose rates for noble gases (Ar-41, Xe-133, Xe-135, and Ir-192) at the DN boundary are typically below the detection limits; therefore, the contribution of noble gases to the total radiation dose for an ecological receptor located at the site boundary would be negligible. As such, exposure from noble gases is not included in the exposure assessment for ecological receptors.

As discussed in Section 3.1.2.6, the beta-gamma emitters that give the highest human dose per unit release are Co-60 for beta-gamma release to air, and Cs-134 for beta-gamma release to water. In addition, Cs-137 was considered as the radionuclide representing beta-gamma release to water prior to 2016 (OPG, 2011b), and it is often detected in environmental samples (Ecometrix, 2020). For the ecological assessment, on-site

measurements for all of these important radionuclides were included in the dose calculation.

As discussed in Section 3.1.2.6, since water emissions of gross alpha over this period are about six to seven orders of magnitude smaller than the applicable water DRL, gross alpha and its constituent radionuclides were not considered to be COPCs for the HHRA. In addition, over the period from 2016 to 2019, gross alpha activities in water were at least two orders of magnitude less than all other radionuclides or release groups. As such, the contribution of gross alpha to total radioactive emissions is considered to be minimal. Gross alpha was therefore not considered to be a COPC for the EcoRA.

As such, the following radiological stressors measured in the aquatic environment were used in the assessment of ecological health, for Lake Ontario and for the on-Site ponds:

- Carbon-14 (C-14), which is released to both air and surface water by reactor operations at DN;
- Cobalt-60 (Co-60), which represents gross beta-gamma released to the atmosphere by DN;
- Cesium-134 (Cs-134), which represent gross beta-gamma emissions released to surface water in liquid effluent from DN (surface water monitoring data are available for Cs-134, Cs-137, and Co-60 and will be included in the exposure calculations);
- Elemental tritium (HT), which is released to the atmosphere by the (TRF) and in very small amounts from the powerhouse at DN;
- Tritium oxide, also known as tritiated water (HTO), which is released to both air and water by the reactor operations at DN; and
- Iodine-131 (I-131), which was included for consistency with other EcoRAs conducted for DN (SENES 2009a) and is not expected to be a primary contributor to radiological dose for ecological VECs.

SENES (2009a, 2011b) also identified strontium-90 as a COPC in water. SENES (2009a) noted that this radionuclide is not reported separately, but is captured in the measurement of gross beta-gamma emissions to water. Since the 2016 DRL report indicates that Sr-90 is not a limiting beta-gamma radionuclide, beta-gamma emissions are represented by Co-60 and Cs-134 instead of Sr-90 in this report.

4.1.4.6.1 Darlington Waste Management Facility

As outlined in Section 3.1.2.6.1, waste management operations at DN are undertaken in three locations within the DN site: two Fueling Facilities Auxiliary Areas (FFAAs; East and West) and the DWMF. The DWMF is currently made up of two buildings, each able to hold up to 500 DSCs, and a retube waste storage building (RWSB) with the capacity of 490 retube waste containers with intermediate level waste. OPG monitored air kerma measurements from the two DSC storage buildings in the period of 2016 to 2019, and from the RWSB from the end of 2017 onward. The results were reported quarterly in OPG's DWMF quarterly reports (OPG, 2016e, 2016f, 2017e, 2017f, 2017g, 2017h, 2018b, 2018i,

2018j, 2018k, 2018l, 2019f, 2019g, 2019h, 2019i, 2020f). The average DWMF of perimeter air kerma rates from 2016 to 2019 was 0.08 $\mu\text{Gy/h}$. In 2017, OPG started to transfer retube waste containers loaded with Darlington Storage Overpack from the DNGS to the RWSB as part of the Darlington Refurbishment Project. The perimeter dose rate at the RWSB was monitored from 2017 to 2019, with an average air kerma rate at 0.06 $\mu\text{Gy/h}$.

For the EcoRA, it has been assumed that the dose to any ecological VEC located at the DWMF perimeter fence is 0.08 $\mu\text{Gy/h}$. This dose rate is orders of magnitude less than the terrestrial dose benchmark of 100 $\mu\text{Gy/h}$. In addition, none of the annual average air kerma rates at individual locations exceeded this dose rate limit.

In all 2016 to 2019 quarterly reports, all results from stack particulate samples from the DWMF for this period were at least 5 orders of magnitude lower than the action level of 1.21×10^9 Bq (modified in 2019; previous action level was 1.3×10^9 Bq). As such, the contribution of the DWMF to dose for ecological receptors at the DWMF perimeter fence would be negligible. Radiological waterborne emissions from the DWMF include yard drainage (runoff) and facility drainage. As discussed in Section 3.1.2.6.1, waterborne emissions have generally been negligible. Tritium and gross gamma were also measured weekly at the DWMF from 2016 to 2019, and all measured values were below the administrative level of 1850 Bq/L (tritium) and 37 Bq/L (gross gamma).

For ecological receptors residing on the DN site, in the immediate vicinity of the DWMF (within 5 m distance of the DWMF wall), the expected dose rate could be up to 1 $\mu\text{Gy/h}$ (Figure B-9 in (OPG, 2016a)). This assumes the wildlife whole body absorbed dose is comparable to the human effective dose. Assuming that this is a whole body effective dose, the tissue absorbed dose at body surface may be slightly higher, but the whole body tissue absorbed dose for wildlife may be lower. It is difficult to translate the human effective dose to a whole body absorbed dose for various wildlife species with different geometries.

The combined dose from the DWMF and other activities at DN to ecological receptors is discussed in the exposure assessment.

4.1.4.7 Selection of Radiological COPCs in Soil

The primary transport pathway of radiological COPCs to soil on-site and off-site is through deposition from air. Certain airborne effluent release groups, such as HT and noble gases, are not expected to partition to soil. The beta-gamma release to air, represented conservatively by Co-60, will deposit to soil, and is considered to be a COPC in soil. The radioiodines have short half-lives and would disappear quickly from soil, with the exception of I-131, which has a half-life of 8.03 days (CNCS, 2017b).

In addition, gross beta-gamma release to surface water, represented conservatively by Cs-134, can be transferred to soil by irrigation of gardens, and is considered as a COPC in soil for rural residents with gardens. While gross-beta gamma released to surface water is represented by Cs-134. In addition, Cs-137 was considered as the radionuclide

representing beta-gamma release to water prior to 2016, and Cs-137 was more frequently detected in the environment than Cs-134. Therefore, both have been included as COPCs and are evaluated in the exposure assessment. The final list of COPCs for soil was as follows: C-14, Co-60, Cs-134, Cs-137+, HTO, and I-131.

4.1.4.8 Selection of Radiological COPCs in Groundwater

Of all of the radionuclides under consideration, only tritium has consistently been observed in Site groundwater. Previous groundwater studies at DN have demonstrated that at many locations, tritium concentrations in groundwater have remained relatively constant or have decreased over time (OPG, 2017j, 2018d, 2019j, 2020j). However, tritium concentrations have fluctuated at some locations due to the incremental amounts of tritium emitted through a 2009 Injection Water Storage Tank D20 spill, located south of Unit 0. Tritium from the spill is migrating towards the westerly end of the Forebay; however, groundwater discharged into the Forebay is significantly diluted by the Forebay water. Overall, there is no adverse impact on ecological health resulting from the 2009 event.

In general, the tritium in groundwater on the Site is expected to originate from atmospheric emissions from DN, since no significant leaks appear to have occurred over the period since 2009, as described in the annual groundwater monitoring reports (OPG, 2017j, 2018d, 2019j, 2020j). The tritium concentrations in pore water at the soil surface are expected to exceed those in groundwater at the Site, and since tritium has already been designated a soil COPC, and its presence in pore water has directly formed part of the soil assessment, no additional selection of groundwater COPCs is considered necessary.

4.1.4.9 Selection of Radiological COPCs in Sediment

Sediment in Lake Ontario, Coot's Pond and Treefrog Pond was characterized as part of the baseline data collection for the ecological risk assessment in the New Nuclear Darlington EA (SENES, 2009a). Since the primary pathway for radionuclides to be transported to Lake Ontario sediment is through partitioning from liquid effluents, the same radionuclides were selected for sediment as were selected for surface water. This is conservative, since Lake Ontario in the vicinity of DN is not a depositional environment, and COPCs are unlikely to accumulate in sediment. Coot's Pond and Treefrog Pond are depositional environments; however, as these ponds do not receive liquid discharge from DNGS, the main input of radiological contaminants is from airborne deposition from DN emissions and subsequent partitioning to sediment. While gross-beta gamma released to surface water is represented by Cs-134, sediment data are available for Cs-137 and Co-60 as well; therefore, they have been included as COPCs and are evaluated in the exposure assessment.

The final list of radionuclides for both Lake Ontario and pond sediment was therefore as follows: C-14, Cs-134, Cs-137+, Co-60, HTO, and I-131.

4.1.4.10 Selection of Other Stressors

Physical stressors are not subject to a formal screening process; however, CSA N288.6 recommends that thermal stressors and entrainment and impingement should be carried forward for assessment in the EcoRA since they are widely recognized as being of primary concern at nuclear power plants. As such, thermal stressors and entrainment and impingement have been selected as stressors in the EcoRA.

4.1.4.10.1 Noise

As discussed in Section 3.1.5.10, the noise environment in the vicinity of DN site is typical of an urban setting and is influenced by several noise sources including the DN Generating Station, traffic on Highway 401 and local roads, the CN rail line and the St. Marys Cement plant. Beacon Environmental noted that bird and wildlife communities at DN would likely be adjusted to the high level of baseline noise in the vicinity of the Station (Beacon, 2009a, 2011), and observed that none of the planned activities, for which the respective EAs were being conducted, were likely to increase noise to beyond levels tolerable by breeding birds from the literature. In 2018, the baseline noise at the DN vicinity was monitored again, and the results were similar to previous studies (OPG, 2020a). As such, noise has not been considered a stressor in the EcoRA.

4.1.4.10.2 Bird Strikes and Wildlife Collisions

SENES (2009a) carried out thirteen bird strike surveys at DN between May 7, 2007, and May 28, 2008 as part of the NND EA. These surveys resulted in a total count of 31 dead, injured, or dazed birds, and one labeled as “uninjured,” over the course of the year. Several of these birds appeared to have been raptor kills, so were not caused by building strikes. Further details concerning the intensity of the surveys and the complete list of species killed are presented in SENES (2009a). In their conclusions, SENES noted that “the very low number of birds killed or injured that were attributable to structures indicates that further study may not be warranted” (SENES, 2009a).

OPG tracks wildlife fatalities and injuries through an informal reporting process. For the period from 2016 to 2019, the fatalities and injuries reported through this method, not including predation deaths, are summarized in Table 4-5. The 2011 to 2015 list was reported in the 2016 ERA (Ecometrix, 2017). The 2016 to 2019 wildlife list documented a similar number of incidents compared to the 2011 to 2015 list, and contains fewer fatalities and injuries than the number in the SENES 2007 to 2008 list. The only incident involving a mammal (deer) occurred in 2018, but did not result in any fatality. Due to the small number of affected wildlife, bird strikes and other types of physical wildlife incidents are not expected to affect populations of birds and mammals at the DN Site. Wildlife fatalities and injuries are not discussed further in the EcoRA.

Table 4-5: Summary of Reported Wildlife Fatalities at DN (2016 to 2019)

Year	Type	Number	Species	Cause
2016	Fatality	Several (~3)	Bird	Unknown
	Fatality	1	Seagull	Unknown
	Likely Fatality	more than 1	Bird	Removal of nest on equipment
2017	Likely Fatality	likely 1	Unknown (likely a bird)	Trapped in Equipment
	Injury	1	Goose	Unknown
	Fatality	1	Seagull	Unknown
	Fatality	3	Cormorants	Powerline
	Fatality	6	Cormorants	Likely Avian Virus
	Fatality	1	Cormorant	Fence
2018	Fatality	2	Bird	Trapped
	Fatality	1	Bird	Unknown
	Fatality	more than 1	Seagull	Unknown
	Injury (or covered in oily water), taken to vet	1	Bird	Covered in oil water
	Fatality	at least 10	Seagull	Fence
	Injury (taken to vet)	1	Gull	Unknown
	Fatality	1	Least Bittern	Unknown
2019	Injury (ran away)	1	Deer	Vehicle Hit
	Fatality	1	Seagull	Trapped in Equipment

4.1.4.11 Summary of COPC Selection

Table 4-6 summarizes the radiological and non-radiological COPCs that are carried forward to the exposure assessment in the EcoRA.

Table 4-6: Summary of COPCs Selected for the EcoRA

Environmental Medium	Radiological COPC	Chemical COPC
Air	C-14, Co-60, HT, HTO, I(mfp)	Nitrogen Oxides
Surface water	C-14, Cs-134, Cs-137+, Co-60, HTO, I-131	pH, Total suspended solids, Ammonia, Barium, Zinc (Lake Ontario, including COPCs from effluents and Stormwater) pH, Ammonia, Barium, Iron, (Polygon AB – Coot's Pond) Ammonia, Barium, Iron (Polygon D – Treefrog Pond)
Soil	C-14, Co-60, Cs-134, Cs-137+, HTO, I-131	Strontium for all ecological receptors in polygons AB, C, D, and E; Arsenic, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Molybdenum, Nickel, Selenium, Sodium, Tin, Zinc, PHC-F4 for all ecological receptors in polygon E; Free cyanide for birds and mammals in polygon E.
Groundwater	None	None

Environmental Medium	Radiological COPC	Chemical COPC
Sediment	C-14, Cs-134, Cs-137+, Co-60, HTO, I-131	Total Kjeldahl Nitrogen, Phosphorus, Cesium, Strontium, PHC F3, Benzo(a)pyrene, Chrysene, Dibenzo(a,h)anthracene, Phenanthrene, Pyrene (Lake Ontario); Total Kjeldahl Nitrogen, Total organic carbon, Cadmium, Chromium, Copper, Iron, Manganese, Nickel, Phosphorus, Vanadium, Zinc (Polygon AB) Total Kjeldahl Nitrogen, Total organic carbon, Cadmium, Copper, Phosphorus, Selenium, Vanadium (Polygon D)
Other		
Other Stressors	Thermal effects, entrainment, and impingement	

4.1.5 Selection of Exposure Pathways

Exposure pathways include the routes of contaminant dispersion from the source to the receptor location, and the routes of contaminant transport through the food chain or other media to the receptor organism. Both are considered, as appropriate to the species and location, using measured concentrations of COPCs wherever such data exist, and estimating concentrations where measured values are not available.

For fish, frog and aquatic plants, contact with water and contaminant uptake from water via bioaccumulation represents the main exposure pathway. For soil invertebrates and terrestrial plants, the main exposure pathway is through contact with soil and contaminant uptake from soil via bioaccumulation. The dominant exposure pathways for birds, mammals and turtles are through the uptake of contaminants via the ingestion of water, incidental ingestion of soil or sediment, and ingestion of food.

Airborne COPCs partition to soil and plants, and ingestion pathways dominate over inhalation and air immersion for most COPCs. The latter pathways will be omitted for ecological receptors in this assessment. Noble gases can be important COPCs in air; however, they are not considered significant for this assessment as described in Section 4.1.4.6.

4.1.6 Ecological Health Conceptual Model

The conceptual model illustrates how receptors are exposed to COPCs. It identifies the source of contaminants, receptor locations and the exposure pathways to be considered in

the assessment for each receptor. Exposure pathways represent the various routes by which radionuclides and/or chemicals may enter the body of the receptor, or (for radionuclides) how they may exert effects from outside the body. Table 4-7 summarizes the relevant exposure pathways for each type of ecological receptor. The conceptual model for the EcoRA is illustrated in Figure 4-7. The air exposure pathway can usually be ignored since it is usually minor compared to the soil or sediment ingestion exposure (CSA, 2012). Exposures to noble gases in air can be important, since air is the dominant pathway for noble gases; however, they are not considered significant for this assessment as described in Section 4.1.4.6.

All of the avian receptors to be assessed are migratory, and are likely to reside at the DN site for approximately half of the year.

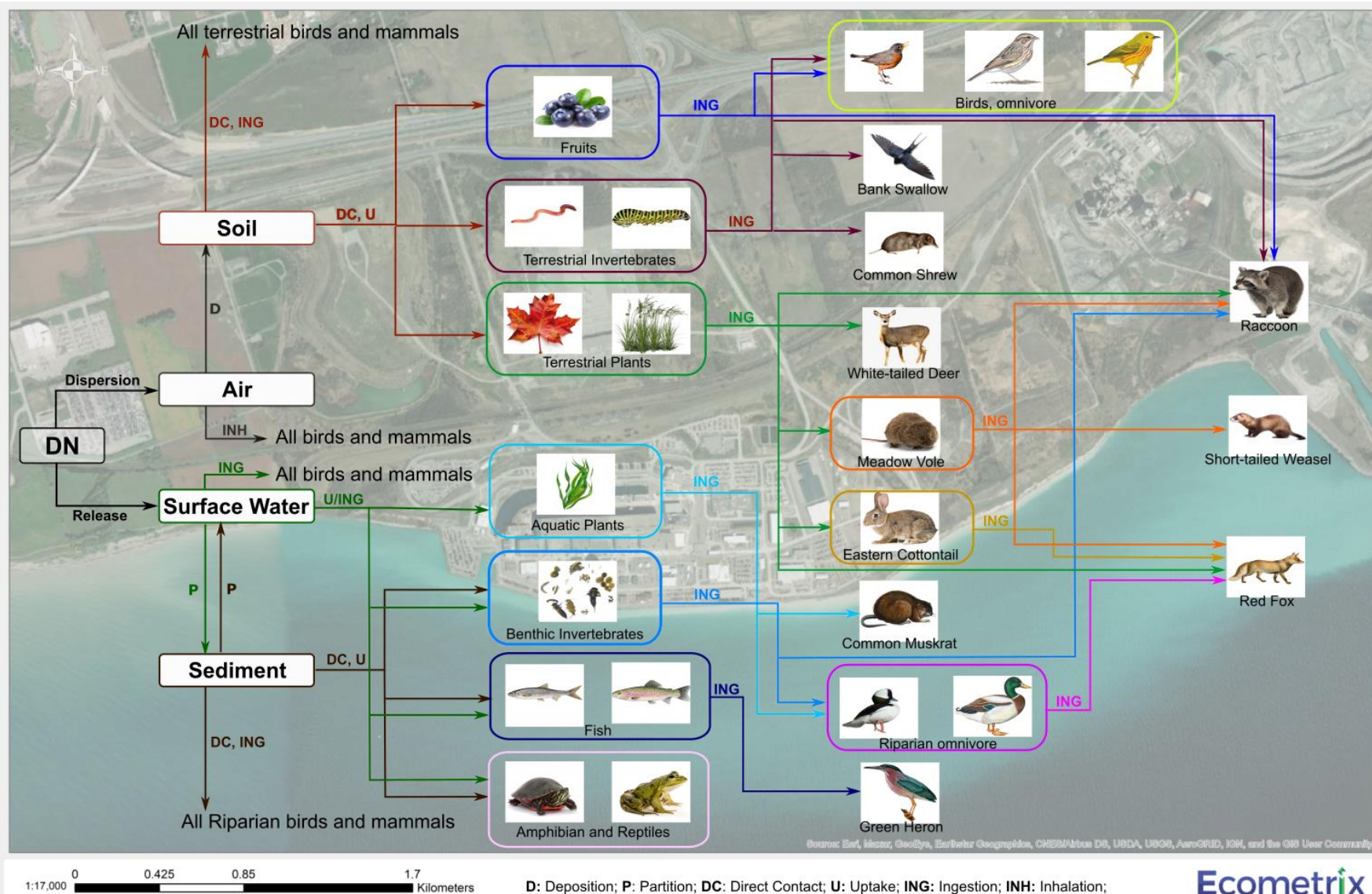


Figure 4-7: Conceptual Model for the Ecological Receptors

Table 4-7: Complete Exposure Pathways for All Selected VEC Species

VEC Category	VEC	Location	Exposure Pathways	Environmental Media
Bottom Feeding Fish	Northern Redbelly Dace	Coot's Pond (AB)	Direct Contact	In Water On Sediment
	Round Whitefish	Lake Ontario	Direct Contact	In Water On Sediment
	White Sucker		Direct Contact	In Water On Sediment
	American Eel		Direct Contact	In Water On Sediment
Pelagic Fish	Alewife	Lake Ontario	Direct Contact	In Water
	Lake Trout		Direct Contact	In Water
Reptiles and Amphibians	Turtle	Coot's Pond (AB), Treefrog/Dragonfly/ Polliwog Pond (D)	Direct Contact	In Water On Sediment
	Frog		Direct Contact	In Water On Sediment
Aquatic Plants	Aquatic Plant	Coot's Pond (AB), Treefrog/ Dragonfly/ Polliwog Pond (D)	Direct Contact	In Water
Benthic Invertebrates	Benthic Invertebrate	Lake Ontario, Coot's Pond (AB)	Direct Contact	In Water In Sediment
Riparian Birds	Bufflehead	Lake Ontario	Direct Contact	On Sediment
			Ingestion	Water Sediment Benthic Invertebrates
		Coot's Pond (AB)	Direct Contact	On Sediment
			Ingestion	Water Sediment Aquatic Plants Benthic Invertebrates
	Mallard	Lake Ontario	Direct Contact	On Sediment
			Ingestion	Water Sediment Benthic Invertebrates
		Coot's Pond (AB)	Direct Contact	On Sediment
			Ingestion	Water Sediment Aquatic Plants Benthic Invertebrates
	Green Heron	Coot's Pond (AB)	Direct Contact	On Sediment
			Ingestion	Water Sediment Bottom-Feeding Fish (Northern Redbelly Dace)
Riparian Mammals	Muskrat	Coot's Pond (AB)	Direct Contact	On Sediment
			Ingestion	Water Sediment Aquatic Plants
Terrestrial Invertebrates	Earthworm	AB, C, D, E	Direct Contact	In Soil
Terrestrial Birds	American Robin	AB, C, D, E	Direct Contact	On Soil
			Ingestion	Water Soil

VEC Category	VEC	Location	Exposure Pathways	Environmental Media
				Earthworms Fruit
			Direct Contact	On Soil
	Bank Swallow	AB, E	Ingestion	Water Soil Caterpillars
			Direct Contact	On Soil
	Song Sparrow	AB, C, D, E	Ingestion	Water Soil Fruit Caterpillars
			Direct Contact	On Soil
	Yellow Warbler	AB, C, D, E	Ingestion	Water Soil Fruit Caterpillars
			Direct Contact	On Soil
Terrestrial Plants	Grasses	AB, C, D, E	Direct Contact	On Soil
	Sugar Maple	D, E	Direct Contact	On Soil
Terrestrial Mammals	Eastern Cottontail	AB, C, D, E	Direct Contact	On Soil
			Ingestion	Water Soil Grasses
	Meadow Vole	AB, C, D, E	Direct Contact	On Soil
			Ingestion	Water Soil Grasses
	White-tailed Deer	AB, C	Direct Contact	On Soil
			Ingestion	Water Soil Grasses
		D, E	Direct Contact	On Soil
			Ingestion	Water Soil Grasses Sugar Maple trees
	Common Shrew	AB, C, D, E	Direct Contact	On Soil
			Ingestion	Water Soil Caterpillars
	Raccoon	AB	Direct Contact	On Soil
			Ingestion	Water Soil Grasses Fruit Caterpillar Benthic Invertebrates Meadow Voles
		C	Direct Contact	On Soil
			Ingestion	Water Soil Grasses Fruit Caterpillars Meadow Voles
		D, E	Direct Contact	On Soil
			Ingestion	Water

VEC Category	VEC	Location	Exposure Pathways	Environmental Media
	Red Fox			Soil Grasses Sugar Maple trees Fruit Caterpillars Meadow Voles
			Direct Contact	In and on Soil
		AB	Ingestion	Water Soil Grasses Bufflehead Mallard Eastern Cottontail Rabbits Meadow Voles
		C, D, E	Direct Contact	In and on Soil
			Ingestion	Water Soil Grasses Eastern Cottontail Rabbits Meadow Voles
	Short-tailed Weasel	AB, C, D, E	Direct Contact	On Soil
			Ingestion	Water Soil Meadow Voles

For organism losses by entrainment/impingement, the conceptual model illustrated in CSA N288.6 is appropriate. This conceptual model Figure 4-8 represents the relationship between the individual losses and possible population or community effects.

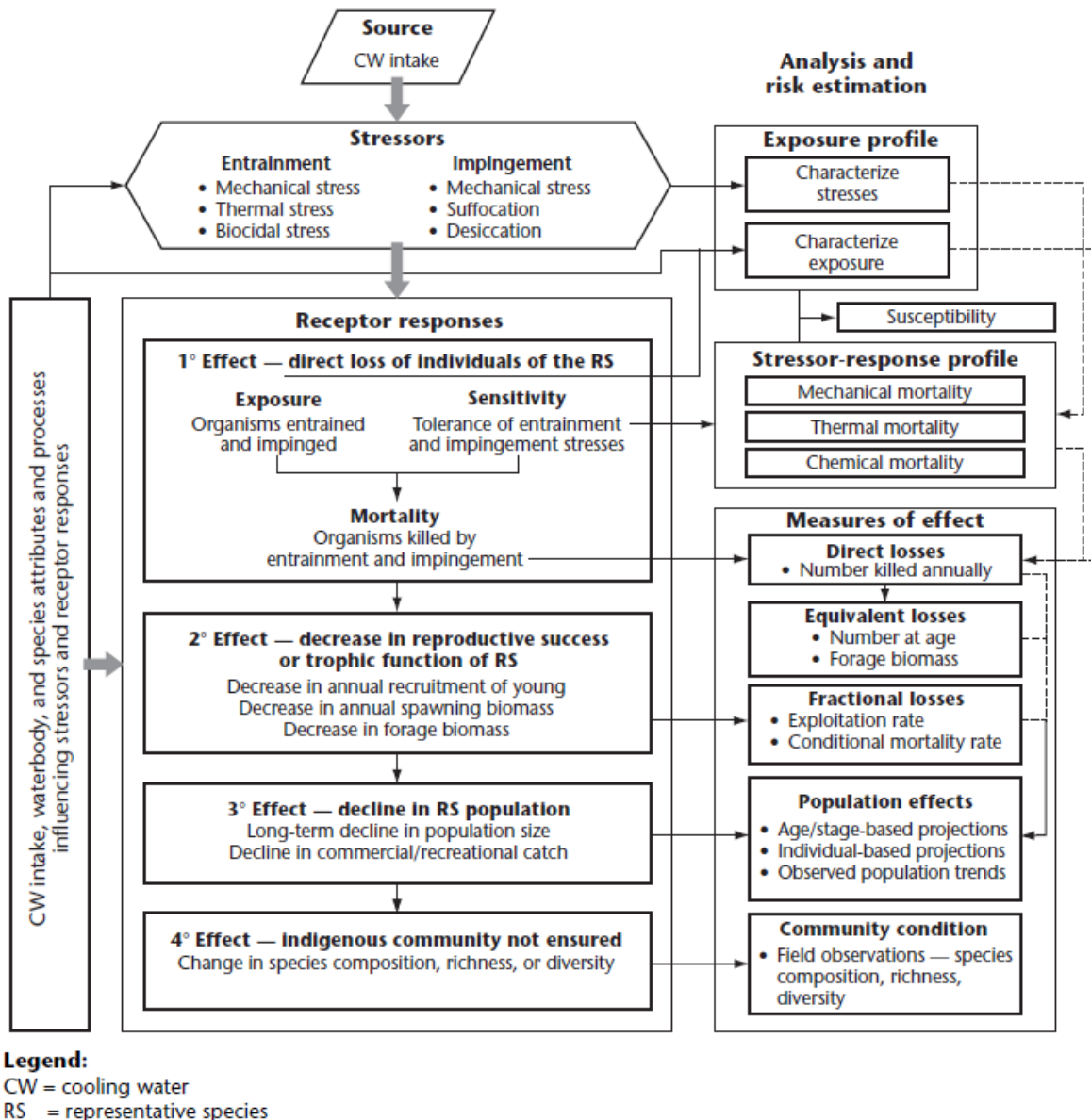


Figure 4-8: Generic Conceptual Model for Relationships between Individual Endpoints and Population/Community Endpoints (CSA, 2012)

4.1.7 Uncertainty in Problem Formulation

The data used in the assessment were concluded to be of adequate quality and quantity to support the objectives of the EcoRA. Maximum measured concentrations were selected for COPC screening; this is considered conservative and is not reflective of typical ecological exposures, with the exception of stationary receptors such as plants; for plants, this selection is realistic. The ecological screening benchmarks for water were generally the

lower of applicable provincial and federal aquatic life objectives and guidelines, which is a conservative approach, ensuring that the list of COPCs would be as comprehensive as possible. The COPC screening also considered several media as potential exposure routes, such as air, surface water, soil, ground water, and sediment, and including effluent and stormwater. As such, the COPC screening has resulted in a conservative list of COPCs.

Uncertainties were also inherent in the selected ecological screening benchmarks. Several of the screening benchmarks (e.g., MECP PSO and BM component values) are based on Lowest Observed Adverse Effect Levels (LOAELs), and not on No Observed Adverse Effect Levels (NOAELs). Others were conservatively based on background concentrations for lake water or soil. These concentrations are not based on toxicological considerations. In addition, the CCME does not make available its derivation for the 1991 ICSQCs that were used as screening criteria for tin and several other parameters, and the basis for these guidelines is unknown. Nevertheless, these values represent the best available screening criteria for the parameters in question, and are considered to be suitable for screening purposes in the context of a risk assessment.

More generally, the problem formulation has been conservative in its assumptions, to accommodate uncertainties, and to ensure that the subsequent EcoRA does not overlook any issues of potential concern. The conceptual model for ecological health is considered to be complete for the majority of ecological exposures in the vicinity of the DN site. The comprehensive selection of COPCs and receptors is expected to represent all important exposures to contaminants in the vicinity of the DN site.

4.2 Exposure Assessment

4.2.1 Exposure Points

Measured concentrations of COPCs in Table 4-6 were generally available for the various media and biota at the receptor locations listed in Table 4-7. The exposure point concentrations for the different polygons and various media and biota are discussed in Section 4.2.6. The majority of the exposure point concentrations were obtained from various reference reports listed in Table 4-8:.

Table 4-8: Environmental data used as exposure point concentrations

Sample Medium	Location	Reported COPCs	Reference
Surface Water	Lake Ontario (DN intake, nearshore, offshore, St. Marys (future) embayment), Darlington Creek, Coot's Pond and Treefrog Pond	Radiological and non-radiological parameters	2019 Environmental Studies (Ecometrix, 2020)
Sediment	Lake Ontario (offshore, proposed infill area, St. Marys (future) embayment), Coot's Pond and Treefrog Pond	Radiological and non-radiological parameters	2019 Environmental Studies (Ecometrix, 2020)
Sediment	Darlington Harbour and near-shore locations immediately to the west of the harbour	Radiological and non-radiological parameters	2018 Sediment Studies (Ecometrix, 2018, 2019)
Soil	Across DN Site.	Radiological and non-radiological parameters	2019 Environmental Studies (Ecometrix, 2020)
Air	At the property line of the DN Site	Radiological and non-radiological parameters. Modelled maximum POI	ESDM Reports (OPG, 2017c, 2018c, 2019d, 2020d)
Aquatic Biota	• Coot's Pond (Northern Redbelly Dace)	Radiological and non-radiological parameters	Ecological Risk Assessment and Assessment of Effects on Non-human Biota Technical Support Document, (SENES, 2009a)
	• Lake Ontario (Alewife, Round Whitefish, White Sucker and Mussel);		
	• Coot's Pond and Treefrog Pond (aquatic vegetation);	Radiological parameters	2011 OPG EMP Report, (OPG, 2012b)
	• Treefrog Pond (Frogs);		
Terrestrial Biota	• Lake Ontario (Round Whitefish (sampling discontinued since 2012))	Radiological parameters	2016-2019 OPG EMP Reports (OPG, 2017b, 2018b, 2019a, 2020b)
	• Lake Ontario (White Sucker)		
	• Polygons AB, C, D and E (Fruit)	Radiological and non-radiological parameters	Ecological Risk Assessment and Assessment of Effects on Non-human Biota Technical Support Document, (SENES, 2009a)
Terrestrial Biota	• Polygons AB, C and D (terrestrial vegetation, Caterpillar and Earthworm)		
	• South-west corner of the DN Site (terrestrial vegetation)	Radiological and non-radiological parameters	Non-human Health (Ecological Risk Assessment) Technical Support Document (SENES, 2011b)

4.2.2 Exposure Averaging

When multiple measurements and samples were available for a given COPC in a particular medium at an assessed exposure location, the upper confidence limit of the mean from all sampling points at this location, was calculated, whenever possible, and used as an exposure value.

This approach is conservative. Birds and mammals are likely to experience something close to the mean concentrations as they move around the area. For less mobile organisms such as plants and invertebrates, both average and upper limit concentrations represent exposures that would be experienced by some organisms on a long-term basis.

Concentration data were combined across seasons to determine the exposure point concentrations. While seasonal effects were not evident for the selected COPCs, no statistical analysis of seasonality was conducted.

4.2.3 Exposure and Dose Calculations

Exposure and dose calculations were performed for each radiological COPC for each ecological receptor for each receptor location as outlined in the ecological conceptual model (Ecological Health Conceptual Model). For non-radiological COPCs, dose calculation was only calculated for birds and mammals. For other receptors, the concentrations of COPCs at exposure points were used as exposure values, as the toxicity benchmark values are typically expressed as concentrations (CSA, 2012).

4.2.3.1 Radiological Dose Calculations

Radiological dose calculations were estimated using the Ecometrix software IMPACT™ DRL Version 5.5.2 (IMPACT). IMPACT™ is consistent with the equations outlined in CSA N288.1 and the methods outlined in CSA N288.6 (CSA, 2012, 2014). IMPACT™ uses the specific activity model for tritium and C-14 as per CSA N288.1 and as recommended by CSA N288.6 (CSA, 2012, 2014).

The radiation doses for the aquatic biota were estimated using the methods outlined in CSA N288.6. The dose for each radionuclide is comprised of an internal dose component, and an external dose component, which is driven by water and sediment. The 0.5 in the equation is for semi-infinite exposure to activity in water, for the time the organism spends at water surface, or at sediment surface, and for semi-infinite exposure to activity in sediment, for the time the organism spends at sediment surface. The aquatic biota dose was calculated using the following equations:

$$D_{\text{int}} = DC_{\text{int}} \cdot C_t$$

$$D_{\text{ext}} = DC_{\text{ext}} \cdot [(OF_w + 0.5 \cdot OF_{ws} + 0.5 \cdot OF_{ss}) \cdot C_w + (OF_s + 0.5 \cdot OF_{ss}) \cdot C_s]$$

where,

D_{int}	=	internal radiation dose ($\mu\text{Gy/d}$)
D_{ext}	=	external radiation dose ($\mu\text{Gy/d}$)
DC_{int}	=	internal dose conversion factor ($(\mu\text{Gy/d})/(\text{Bq/kg})$)
DC_{ext}	=	external dose coefficient ($(\mu\text{Gy/d})/(\text{Bq/kg})$)
C_t	=	whole body tissue concentration (Bq/kg fw)
C_w	=	water concentration (Bq/L)
C_s	=	sediment concentration (Bq/kg fw)
OF_w	=	occupancy factor in water (unitless)
OF_{ws}	=	occupancy factor at water surface (unitless)
OF_{ss}	=	occupancy factor at sediment surface (unitless)
OF_s	=	occupancy factor in sediment (unitless)

The radiation dose to terrestrial biota is estimated using a method similar to that for aquatic biota, except the external dose component is driven by soil rather than water and sediment. The equations used to estimate radiation dose are:

$$D_{int} = DC_{int} \cdot C_t$$

$$D_{ext} = DC_{ext,s} \cdot OF_s \cdot C_s + DC_{ext,ss} \cdot OF_{ss} \cdot C_s$$

where,

DC_{int}	=	internal dose coefficient ($(\mu\text{Gy/d})/(\text{Bq/kg})$)
$DC_{ext,s}$	=	external dose coefficient (in soil) ($(\mu\text{Gy/d})/(\text{Bq/kg})$)
$DC_{ext,ss}$	=	external dose coefficient (on soil surface) ($(\mu\text{Gy/d})/(\text{Bq/kg})$)
C_t	=	whole body tissue concentration (Bq/kg fw)
C_s	=	soil concentration (Bq/kg dw)
OF_s	=	occupancy factor in soil (unitless)
OF_{ss}	=	occupancy factor at soil surface (unitless)

For aquatic riparian biota, such as Muskrats and waterfowl, sediment was substituted for soil in calculating the external dose, since these animals are typically in shoreline situations.

The total radiation dose to biota is the sum of the internal and external dose components for each radionuclide ($D_{int} + D_{ext}$). External exposure through the air immersion and inhalation pathway are considered to be minor compared to the ingestion pathway, and were ignored, with the exception of noble gases, which were initially considered (CSA, 2012). However, the DN boundary average dose rates for noble gases (Ar-41, Xe-133, Xe-135, and Ir-192) are typically below the detection limits; therefore, the air kerma presented in OPG's annual EMP reports are not added to the total radiation dose.

The dose coefficients and occupancy factors used in the radiological dose estimation are provided in Section 4.2.4

4.2.3.2 Non-Radiological Dose Calculations

The non-radiological dose (D_{ing}) for mammals and birds was estimated using the methods described in CSA (2012), as follows:

$$D_{\text{ing}} = \sum C_x \cdot I_x / W$$

where,

- C_x = concentration in the ingested item (x) (mg/kg)
- I_x = ingestion rate of item x (kg/day)
- W = body weight of consumer (kg fw)

For receptors that drink from contaminated water, the drinking water component was considered. The concentrations in the water and the ingestion rate were in units of volume. In addition, for receptors that have incidental contaminated soil or sediment ingestion, this pathway was considered on a dry weight basis. Other ingested items (foods) were considered on a fresh weight basis. As with the radiological dose calculations, inhalation exposure is considered minor compared to the ingestion exposure, and was ignored (CSA, 2012).

4.2.3.3 Tissue Concentration Calculations

In cases where tissue concentrations (C_t) were not measured in plants, fruits, invertebrates or fish, the tissue concentrations were derived using bioaccumulation factors (BAFs), as per CSA N288.6, as follows:

$$C_t = C_m \cdot \text{BAF}$$

where,

- C_t = whole body tissue concentration (Bq/kg fw)
- C_m = media concentration (Bq/L or Bq/kg)
- BAF = bioaccumulation factor (L/kg or kg/kg)

For birds and mammals, tissue concentrations were estimated using transfer factors (TFs), or biomagnification factors (BMFs) and the concentrations in their food, as follows:

$$C_t = \sum C_x \cdot I_x \cdot \text{TF} = C_f \cdot \text{BMF}$$

where,

- C_x = concentration in the ingested item x (Bq/kg fw)
- I_x = ingestion rate of item x (kg fw/d)
- TF = ingestion transfer factor (d/kg)
- C_f = average concentration in food (Bq/kg fw)

BMF = biomagnification factor (unitless)

The BMF is equivalent to the total food intake rate times the transfer factor:

$$BMF = \sum I_x \cdot TF$$

The BAFs, TFs and ingestion rates used for the calculation of tissue concentrations in biota are further described in Section 4.2.4.

4.2.4 Exposure Factors

There are several COPC- and biota-specific exposure factors required for the dose calculations. These parameters include intake rates, body weights, occupancy factors, BAFs, TFs, and dose coefficients (DCs).

4.2.4.1.1 Body Weight and Intake Rates

The body weight and intake rates are required for the calculation of exposure to birds and mammals. The body weights and total feed intake rates were taken from the U.S. EPA (U.S. EPA, 1993), 2009 EcoRA (SENES, 2009a), and (SENES, 2000), where the assumptions and values were considered to be applicable. For receptors, such as the Common Shrew that were not assessed in the 2009 ERA (SENES, 2009a), body weights were obtained from the Federal Contaminated Sites Action Plan *Module 3: Standardization of Wildlife Receptor Characteristics* (FCSAP, 2012) and other sources. The feed intake rates were proportioned to body weight using allometric equations from the (US EPA, 1993). The water intake and inhalation rates were determined using allometric equations from the U.S. EPA for all birds and mammals (US EPA, 1993). The incidental ingestion of soil and sediment was estimated based on the feed intake. As described by Beyer et al. incidental ingestion varied from 2% to 10.4% of dry weight food intake depending on the biota (Beyer et al., 1994). The values are summarized in Table 4-9.

Table 4-9: Bird and Mammal Body Weights and Intake Rates

Receptor	Body Weight	Total Feed Intake		Dietary Components	Feed Type Fraction		Feed Intake		Moisture ^f	Intake of Soil / Sediment ^g	Basis of the Soil and Sediment Intake Value	Total Soil/ Sediment Intake ^h	Water Intake	Inhalation Rate
	kg	kg dw/d	kg fw/d		fw	Dw	kg dw/d	kg fw/d	unitless	%		kg dw/d	L/d	m³/d
White-tailed Deer	110 ^a	3.274	16.37	Grass ^a	0.5	0.50	1.64	8.19	0.80	2.0	White-tailed Deer	0.0655	6.8	23.5
				Sugar Maple ^a	0.5	0.50	1.64	8.19	0.80					
Eastern Cottontail	1.216 ^a	0.0807	0.404	Grass ^a	1	1.00	0.081	0.404	0.80	6.3	Black-Tailed Jackrabbit	0.00508	0.118	0.63
Common Shrew	0.0041 ^b	0.00138	0.0081	Caterpillar ^a	1	1.00	0.00138	0.0081	0.83	2.0	assuming a default rate of 2% in soil in the diet on a dry weight basis	0.0000275	0.0007	0.0067
Short-tailed Weasel	0.18 ^a	0.0168	0.0559	Meadow Vole ^a	1	1	0.017	0.056	0.70	5	average of small mammals	0.0008	0.02115	0.138
Meadow Vole	0.03400 ^c	0.0022	0.011	Grass ^a	1	1.00	0.0022	0.011	0.80	2.4	Meadow vole	0.0000528	0.00472	0.048
Raccoon - Polygon C,D,E	5.7	0.287	1.60	Grass ^a	0.125	0.14	0.04	0.2	0.80	9.4	Raccoon	0.027	0.47	2.32
				Sugar Maple ^a	0.125	0.14	0.04	0.2	0.80					
				Fruit ^a	0.15	0.08	0.02	0.2	0.90					
				Caterpillar ^a	0.5	0.47	0.14	0.8	0.83					
				Meadow Vole ^a	0.1	0.17	0.05	0.16	0.70					
Raccoon-Polygon A, B	5.7	0.287	1.53	Grass ^a	0.25	0.27	0.08	0.4	0.80	9.4	Raccoon	0.027	0.47	2.32
				Fruit	0.15	0.08	0.02	0.2	0.90					
				Caterpillar ^e	0.4	0.36	0.10	0.6	0.83					
				Meadow Vole ^a	0.1	0.16	0.05	0.2	0.70					
				Aquatic Invertebrates ^e	0.1	0.13	0.04	0.2	0.75					
Red Fox - Polygon C, D, E	4.54	0.0876	0.313	Grass ^a	0.2	0.143	0.013	0.063	0.80	2.8	Red fox	0.2454	0.386	1.850
				Eastern Cottontail ^e	0.48	0.514	0.045	0.150	0.70					
				Meadow Vole ^e	0.32	0.343	0.030	0.100	0.70					
Red Fox - Polygon A, B	4.54	0.0876	0.313	Grass ^a	0.2	0.143	0.013	0.063	0.80	2.8	Red fox	0.2454	0.386	1.850
				Eastern Cottontail ^e	0.3	0.321	0.028	0.094	0.70					
				Meadow Vole ^e	0.2	0.214	0.019	0.063	0.70					
				Bufflehead ^e	0.15	0.161	0.014	0.047	0.70					
				Mallard ^e	0.15	0.161	0.014	0.047	0.70					
Common Muskrat - Polygon A, B	1.18	0.088	0.353 ^c	Freshwater Plants ^e	1	1.00	0.088	0.353	0.75	3.3	based on Mallard	0.00291	0.115	0.59
Song Sparrow	0.021	0.0047	0.044	Fruit ^a	0.9	0.841	0.0040	0.0396	0.90	5.0	based on non-dwelling birds	0.000235	0.00443	0.021
				Caterpillar ^a	0.1	0.159	0.0007	0.0044	0.83					
Bank Swallow	0.015 ^a	0.00378	0.0222	Caterpillar ^a	1	1.00	0.00378	0.022	0.83	5.0	based on non-dwelling birds	0.000189	0.004	0.016
Yellow Warbler	0.01 ^a	0.0029	0.0178	Fruit ^a	0.1	0.06	0.00018	0.0018	0.90	5.0	based on non-dwelling birds (5%) same approach SENES (2009) used	0.000145	0.0027	0.012
				Caterpillar ^a	0.9	0.94	0.00272	0.016	0.83					
American Robin	0.077 ^a	0.0119	0.093	Fruit	0.6	0.47	0.0056	0.056	0.90	9.9	based on the average for the American Woodcock (10.4%) and Wild Turkey (9.3%)	0.00118	0.011	0.057
				Earthworms ^a	0.4	0.53	0.0063	0.037	0.83					

Receptor	Body Weight	Total Feed Intake		Dietary Components	Feed Type Fraction		Feed Intake		Moisture ^f	Intake of Soil / Sediment ^g	Basis of the Soil and Sediment Intake Value	Total Soil/ Sediment Intake ^h	Water Intake	Inhalation Rate
	kg	kg dw/d	kg fw/d		fw	Dw	kg dw/d	kg fw/d	%	%		kg dw/d	L/d	m ³ /d
Bufflehead - Lake Ontario	0.473 ^a	0.0357	0.143	Aquatic Invertebrates ^e	1	1.00	0.0357	0.143	0.75	1.1	average for birds	0.000386	0.036	0.230
Bufflehead - Polygon AB	0.473 ^a	0.0357	0.143	Freshwater Plants ^e	0.1	0.10	0.004	0.014	0.75	1.1	average for birds	0.000386	0.036	0.230
				Aquatic Invertebrates ^e	0.9	0.90	0.032	0.129	0.75					
Mallard - Lake Ontario	1.082 ^a	0.0625	0.250 ^a	Aquatic Invertebrates ^e	1	1.00	0.063	0.250	0.75	3.3	based on Mallard	0.00206	0.0622	0.45
Mallard - Polygon AB	1.082 ^a	0.0625	0.250 ^a	Freshwater Plants ^e	0.25	0.25	0.016	0.063	0.75	3.3	based on Mallard	0.00206	0.0622	0.45
				Aquatic Invertebrates ^e	0.75	0.75	0.047	0.188	0.75					
Green Heron – Polygon AB	0.175 ^d	0.0187	0.075	Fish ^d	1	1.00	0.019	0.075	0.75	2.0	based on Blue-winged teal	0.00037	0.0184	0.107

Notes:

- US EPA (1993), unless otherwise indicated
- ^a SENES (2009a); Common Shrew was not assessed. The feed type fraction was assumed to be on a wet weight basis
- ^b FCSAP (2012)
- ^c SENES (2000)
- ^d Encyclopedia of Life <https://eol.org/pages/45511342>
- ^e Fraction of diet feed type was assumed.
- ^f CSA (2014)
- ^g Beyer et al. (1994)
- ^h Calculated by multiplying the total feed intake by the intake of soil/sediment fraction.

4.2.4.1.2 Fraction of Time on Site and Occupancy Factors

With the exception of riparian and terrestrial birds, the fraction of time a receptor resides in the different DN areas (e.g., Lake Ontario, Polygon AB (which includes Coot's Pond), C, D (which includes Treefrog, Dragonfly and Polliwog ponds) is assumed to be one. For the Bufflehead, Mallard, Green Heron, American Robin, Bank Swallow and Yellow Warbler the fraction of time these birds reside in the DN area(s) is assumed to be 0.5, whereas the fraction of time the Song Sparrow resides in the DN areas is assumed to be 0.8. The fractions of time for these birds are consistent with assumptions in the previous new nuclear EcoRA (SENES, 2009a), except for the Green Heron, which is a new VC.

An occupancy factor is defined as the fraction of time the receptor species spends in or on various media. The occupancy factors are based on the experience and judgement of the risk assessor and the known behaviour of the receptor. The occupancy factors used in the radiological dose estimation are given in Table 4-10.

Table 4-10: Receptor Occupancy Factors

Aquatic and Riparian Biota	OF _s	OF _{ss}	OF _w	Terrestrial Biota	OF _s	OF _{ss}
Northern Redbelly Dace		0.5	0.5	Earthworm	1	
Round White Fish		0.5	0.5	American Robin		1
White Sucker		0.5	0.5	Bank Swallow		0.5
Alewife			1	Song Sparrow		1
Lake Trout			1	Yellow Warbler		0.5
American Eel		0.5	0.5	Terrestrial Plants (Grass and Sugar maple)		1
Turtles		0.5	0.5	Eastern Cottontail		1
Frogs		0.5	0.5	Meadow Vole		1
Aquatic Plants			1	White-tailed Deer		1
Benthic Invertebrates	1			Common Shrew		1
Bufflehead		0.5		Raccoon		1
Mallard		0.5		Red Fox	0.2	0.8
Green Heron		0.5		Short-tailed Weasel		1
Muskrat		0.5				

Notes:

OF_s = occupancy factor in soil/sediment

OF_{ss} = occupancy factor on soil/sediment surface

OF_w = occupancy factor in water

4.2.4.1.3 Bioaccumulation Factors

Bioaccumulation factors relate the COPCs in the environmental media to the concentration in the receptor. In cases where tissue concentrations were not available for the receptors at the DN site, BAFs were used to calculate COPC concentrations in plant, invertebrate and

fish tissues. These factors vary throughout the literature. For the exposure assessment, BAFs were taken from CSA, IAEA and literature sources, including those suggested in CSA N288.6 (CSA, 2012, 2014; IAEA, 2010).

The BAFs used in the assessment are presented in Table 4-11 to Table 4-14. Bioaccumulation factors for tritium and carbon-14 are calculated using the specific activity model in IMPACT™.

No BAFs are presented in Table 4-11 to Table 4-14 for NO_x, TSS, TOC, TKN, ammonia, iron, and phosphorus because these COPCs do not bioaccumulate; they will be qualitatively assessed for mammals and birds in the risk assessment in Section 4.3.1. Similarly, for cyanide and PHC F4, BAFs for transfer from soil to soil invertebrates and terrestrial plants are not warranted as these parameters do not bioaccumulate through the food chain (CCME, 1997, 2008).

BAFs are not presented for selenium and vanadium in Table 4-12 because these two COPCs were only identified as sediment COPCs in Treefrog Pond, located at Polygon D. No riparian bird and mammal receptors are identified in this polygon to consume aquatic biota.

To estimate fruit concentrations, the measured or estimated Terrestrial Plant concentrations on a dry weight basis are adjusted to a wet weight basis using a moisture content of 90% for generic fruits and vegetables reported in CSA (CSA, 2014).

Table 4-11: Bioaccumulation Factors (BAFs) for Fish, Aquatic Plants, and Benthic Invertebrates (L/kg fw) in Lake Ontario

COPC	Fish	Aquatic Plant	Benthic Invertebrate
Cobalt-60	5.40E+01 ¹	7.90E+02 ¹	1.10E+02 ¹
Cesium-134	3.50E+03 ¹	2.20E+02 ¹	9.90E+01 ¹
Cesium-137	3.50E+03 ¹	2.20E+02 ¹	9.90E+01 ¹
Iodine-131	6.00E+00 ¹	7.10E+01 ¹	9.60E+00 ¹
Barium	NA	6.30E+01 ¹	1.80E+02 ¹
Cesium	NA	2.2E+02 ¹	9.90E+01 ¹
Strontium	NA	3.70E+02 ¹	2.70E+02 ²
Zinc	NA	1.40E+03 ¹	1.8E+03 ¹
PHC F3	NA	7.09E+02 ^{3,4}	7.09E+02 ^{3,4}
Benzo(a)pyrene	NA	5.26E+03 ³	4.70E+03 ³
Chrysene	NA	5.26E+03 ³	9.8E+02 ³
Dibenzo(a,h)anthracene	NA	5.26E+03 ³	7.1E+02 ³
Phenanthrene	NA	3.21E+02 ^{3,4}	3.21E+02 ^{3,4}
Pyrene	NA	7.09E+02 ^{3,4}	7.09E+02 ^{3,4}

Notes:

NA= BAF for non-radionuclides are only needed for an ecological receptor that will be consumed by another ecological receptor.

¹ CSA (2014)

² IAEA (2010)

³ US EPA (1999)

⁴ Kow values are from Risk Assessment Information System (RAIS): https://rais.ornl.gov/cgi-bin/tools/TOX_search. Accessed on September 18, 2020

Table 4-12: Bioaccumulation Factors (BAFs) for Fish, Turtles and Frogs, Aquatic Plants, and Benthic Invertebrates (L/kg fw) in Coot's Pond (Polygon AB) and Treefrog Pond (Polygon D)

COPC	Fish	Turtle and Frog	Aquatic Plant	Benthic Invertebrate
Cobalt-60	5.40E+01 ¹	5.40E+01 ¹	7.90E+02 ¹	1.10E+02 ¹
Cesium-134	3.50E+03 ¹	3.50E+03 ¹	2.20E+02 ¹	9.90E+01 ¹
Cesium-137	3.50E+03 ¹	3.50E+03 ¹	2.20E+02 ¹	9.90E+01 ¹
Iodine-131	6.00E+00 ¹	6.00E+00 ¹	7.10E+01 ¹	9.60E+00 ¹
Barium	9.30E-01 ¹	NA	6.30E+01 ¹	1.80E+02 ¹
Cadmium	1.40E+02 ³	NA	1.90E+04 ⁴	1.00E+02 ²
Chromium	5.50E+01 ¹	NA	1.0E+01 ¹	3.9E+02 ¹
Copper	2.70E+02 ²	NA	3.00E+03 ²	4.20E+01 ²
Manganese	2.40E+02 ¹	NA	4.40E+03 ¹	6.90E+02 ¹
Nickel	2.10E+01 ¹	NA	5.2E+01 ¹	1.0E+02 ¹
Zinc	5.00E+03 ¹	NA	1.4E+03 ¹	1.8E+03 ¹

Notes:

BAF for Non-radionuclide COPCs in Treefrog Pond was not listed, as there is no receptor being consumed by other VC in the Treefrog Pond.

NA= BAF for non-radionuclides are only needed for an ecological receptor that will be consumed by another ecological receptor.

¹ CSA (2014)

² IAEA (2010)

³ Sheppard et al. (2009)

Table 4-13: Bioaccumulation Factors (BAFs) for Soil Invertebrates and Terrestrial Plants (kg-dw soil/kg-dw)

COPC	Soil Invertebrate (Earthworm and Caterpillar)	Reference	Terrestrial Plant (Grass, Fruit and Sugar Maple)	Reference
Arsenic	2.20E-01	Sample et al., 1998 ¹	2.50E-01	CSA 2014
Cadmium	1.24E+01	Beresford, 2008 ²	2.10E+00	IAEA 2010 ⁴
Chromium	3.10E-01	Sample et al., 1998 ¹	8.20E-03	CSA 2014
Cobalt	3.58E-02	Beresford, 2008 ²	4.70E-02	CSA 2014
Copper	5.20E-01	Sample et al., 1998 ¹	8.00E-01	IAEA, 2010
Lead	1.68E-01	Beresford, 2008 ²	3.10E-01	IAEA 2010 ⁵
Molybdenum	9.53E-01	Sample et al., 1998 ¹	3.60E-01	CSA 2014
Nickel	3.84E-01	Beresford, 2008 ²	4.70E-01	CSA 2014
Selenium	8.71E+00	Beresford, 2008 ²	4.50E-01	CSA 2014
Sodium	4.32E+00	Sample et al., 1998 ¹	1.20E-01	CSA 2014
Strontium	5.28E-02	Sample et al., 1998 ¹	8.70E-01	CSA 2014
Tin	1.68E-01	Use lead as a surrogate ³	4.10E-01	CSA 2014
Zinc	3.20E+00	Sample et al., 1998 ¹	1.30E+00	CSA 2014

Notes:

¹ Sample et al. (1998). Medium uptake factor was used to represent soil to Earthworm BAFs.

² Beresford et al. (2008). Table 6, using a dry fresh weight ratio of 0.17 for terrestrial invertebrates

³ There was no soil to Earthworm BAF available for Tin. This parameter from lead was used as a surrogate.

⁴ The mean soil to plant transfer factor for cadmium in stem and shoots of cereals in all soil types was selected.

⁵ The mean soil to plant transfer factor for lead in stem and shoots of grasses in all soil types was selected.

**Table 4-14: Bioaccumulation Factors (BAFs) for Soil Invertebrates and Terrestrial Plants
(kg-dw soil/kg-dw) for Radiological COPCs**

COPC	Soil Invertebrate (Earthworm and Caterpillar)	Terrestrial Plant (Grass, Fruit and Sugar Maple)
Cobalt-60	3.58E-02 ¹	4.70E-02 ²
Cesium-134	5.26E-01 ¹	5.30E-02 ²
Cesium-137	5.26E-01 ¹	5.30E-02 ²
Iodine-131	9.18E-01 ¹	5.00E-02 ²

Notes:

1 Beresford et al, 2008, using a dry weight ratio of 0.17 for earthworms

2 CSA, 2014, using a dry fresh weight ratio of 0.2 for forage and 0.1 for generic fruits and vegetables (CSA, 2014)

4.2.4.1.4 Transfer Factors

Transfer factors represent the fraction of daily COPC intake transferred to the tissue of birds and mammals. Ingestion transfer factors are COPC and biota-specific. Transfer factors from feed to tissue for agricultural livestock are available in CSA (2014). The transfer factors for rabbit and deer reported in CSA (2014) were applied directly to the Eastern Cottontail and White-tailed Deer, respectively (CSA, 2014). An allometric equation (transfer factor proportional to a $-3/4$ power of body weight), was applied to transfer factors available for beef and poultry, to estimate the transfer factors for mammal and bird receptors, respectively (CSA, 2012). The derived transfer factors are presented in Table 4-15, Table 4-16 and Table 4-17. The transfer factors for tritium and carbon-14 were derived using specific activity methods in IMPACTTM.

Transfer factors are not presented for pH, TKN, TOC, TSS, ammonia, calcium, iron, magnesium, phosphorus, and potassium because these COPCs do not bioaccumulate; they will be qualitatively assessed for mammals and birds.

Transfer factors are not presented for selenium because selenium was only identified as a sediment COPC in Treefrog Pond, located at Polygon D. There are no bird and mammal receptors identified in this polygon.

Table 4-15: Transfer Factors for Riparian Birds and Muskrat (d/kg fw)

COPC	Bufflehead	Mallard	Green Heron	Muskrat
Cobalt-60	2.86E+00	1.54E+00	6.03E+00	4.60E-02
Cesium-134	7.96E+00	4.28E+00	1.68E+01	2.36E+00
Cesium-137	7.96E+00	4.28E+00	1.68E+01	2.36E+00
Iodine-131	2.57E-02	1.38E-02	5.41E-02	7.17E-01
Barium	5.60E-02	3.01E-02	NA	NA
Cadmium	5.01E+00	2.69E+00	NA	NA
Cesium	7.96E+00	4.28E+00	NA	NA
Chromium	2.71E+00	1.46E+00	NA	NA
Cobalt	2.86E+00	1.54E+00	NA	NA
Copper	8.26E-01	4.44E-01	NA	NA
Lead	1.15E+00	6.18E-01	NA	NA
Manganese	5.60E-03	3.01E-03	NA	NA
Nickel	9.14E-01	4.91E-01	NA	NA
Strontium	5.90E-02	3.17E-02	NA	NA
Vanadium	8.26E-02	4.44E-02	NA	NA
Zinc	1.39E+00	7.45E-01	NA	NA

Notes:

Radionuclide transfer factors were derived from beef and poultry transfer factors from CSA (CSA, 2014), with the exception of cadmium, copper, lead and vanadium.

Cadmium transfer factor for poultry and beef are from IAEA (IAEA, 2010).

Copper, lead, and vanadium transfer factors for poultry are from Sheppard (Sheppard et al., 2009).

N/A indicates not applicable. Transfer factors for non-radionuclides are only needed for an ecological receptor that will be consumed by another ecological receptor.

Table 4-16: Transfer Factors for Terrestrial Birds (d/kg fw)

COPC	American Robin	Bank Swallow	Song Sparrow	Yellow Warbler
Cobalt-60	1.12E+01	3.81E+01	2.96E+01	5.16E+01
Cesium-134	3.11E+01	1.06E+02	8.23E+01	1.44E+02
Cesium-137	3.11E+01	1.06E+02	8.23E+01	1.44E+02
Iodine-131	1.00E-01	3.41E-01	2.65E-01	4.63E-01

Table 4-17: Transfer Factors for Terrestrial Mammals (d/kg fw)

COPC	Eastern Cottontail	Meadow Vole	White-tailed Deer	Common Shrew	Raccoon	Red fox	Short-tailed Weasel
Cobalt-60	4.50E-02	6.58E-01	1.53E-03	3.22E+00	1.41E-02	1.68E-02	1.89E-01
Cesium-134	2.30E+00	3.37E+01	7.85E-02	1.65E+02	7.23E-01	8.58E-01	9.65E+00
Cesium-137	2.30E+00	3.37E+01	7.85E-02	1.65E+02	7.23E-01	8.58E-01	9.65E+00
Iodine-131	7.01E-01	1.03E+01	2.39E-02	5.01E+01	2.20E-01	2.61E-01	2.94E+00
Arsenic	2.09E+00	3.06E+01	NA	NA	NA	NA	NA
Cadmium	6.07E-01	8.88E+00	NA	NA	NA	NA	NA
Chromium	1.15E+00	1.68E+01	NA	NA	NA	NA	NA
Cobalt	4.50E-02	6.58E-01	NA	NA	NA	NA	NA
Copper	7.64E-01	1.12E+01	NA	NA	NA	NA	NA
Iron	1.47E+00	2.14E+01	NA	NA	NA	NA	NA
Lead	7.33E-02	1.07E+00	NA	NA	NA	NA	NA
Molybdenum	1.05E-01	1.53E+00	NA	NA	NA	NA	NA
Nickel	5.23E-01	7.66E+00	NA	NA	NA	NA	NA
Selenium	1.05E+01	1.53E+02	NA	NA	NA	NA	NA
Sodium	1.57E+00	2.30E+01	NA	NA	NA	NA	NA
Strontium	1.36E-01	1.99E+00	NA	NA	NA	NA	NA
Tin	1.15E+00	1.68E+01	NA	NA	NA	NA	NA
Zinc	1.68E+01	2.45E+02	NA	NA	NA	NA	NA

Notes:

Transfer factors for non-radionuclides were not required for the American Robin, Bank Swallow, Song Sparrow, Yellow Warbler, White-tailed Deer, Common Shrew, Raccoon, Red Fox and Short-tailed Weasel because tissue concentrations were not required for the exposure calculation.

Radionuclide and non-radionuclide transfer factors were derived from beef, rabbit, deer, and poultry transfer factors from CSA (CSA, 2014), with the following exceptions: the beef transfer factor for copper was obtained from Sheppard (Sheppard et al., 2009), and the beef transfer factor for lead was obtained from IAEA (IAEA, 2010).

NA indicates not applicable. Transfer factors for non-radionuclides are only needed for an ecological receptor that will be consumed by another ecological receptor (e.g., the Meadow Vole is consumed by the Red Fox)

4.2.4.1.5 Dose Coefficients

Radiation dose coefficients (DCs) used for terrestrial and aquatic biota are shown in Table 4-18. These DCs were taken from ICRP (2008) and the ERICA Tool 1.2.1 (2016; (Brown et al., 2008)). The surrogate organisms from these sources were selected to represent the VECs in this ERA, considering similarities in body size and likely external exposure media. The DC values for tritium in both sources ((ICRP, 2008) and ERICA Tool 1.2.1, 2016; (Brown et al., 2008)) do not incorporate radiation quality factors for relative biological effectiveness (RBE). Therefore, the “low beta” components of the DCs were multiplied by 2 (as per CSA N288.6-12) in order to represent its greater relative effectiveness.

Table 4-18: Dose Coefficients of Surrogate Receptors Used for Radiological Exposure Calculations

Radionuclide	Earthworm		Grass		Pine Tree		Insect Larvae	
	Internal DC ($\mu\text{Gy/hr}/(\text{Bq/kg fw})$)	External DC (in soil) ($\mu\text{Gy/hr}/(\text{Bq/kg dw})$)	Internal DC ($\mu\text{Gy/hr}/(\text{Bq/kg fw})$)	External DC ($\mu\text{Gy/hr}/(\text{Bq/m}^2)$)	Internal DC ($\mu\text{Gy/hr}/(\text{Bq/kg fw})$)	External DC ($\mu\text{Gy/hr}/(\text{Bq/m}^2)$)	Internal DC ($\mu\text{Gy/hr}/(\text{Bq/kg fw})$)	External DC ($\mu\text{Gy/hr}/(\text{Bq/kg})$)
Carbon-14	2.83E-05	0.00E+00	2.83E-05	0.00E+00	2.83E-05	0.00E+00	2.80E-05	8.20E-07
Cobalt-60	7.50E-05	1.29E-03	7.50E-05	1.79E-05	7.50E-04	5.42E-06	5.20E-05	1.40E-03
Cesium-134	1.08E-04	8.33E-04	1.04E-04	1.21E-05	5.83E-04	3.58E-06	7.20E-05	9.20E-04
Cesium-137	1.42E-04	3.04E-04	1.42E-04	4.58E-06	3.25E-04	1.29E-06	9.80E-05	3.70E-04
Tritium	5.76E-06	0.00E+00	5.76E-06	0.00E+00	5.76E-06	0.00E+00	5.78E-06	2.40E-13
Iodine-131	1.13E-04	1.92E-04	1.08E-04	3.08E-06	2.46E-04	9.17E-07	8.70E-05	2.40E-04
Radionuclide	Seaweed		Trout		Tadpole		Duck	
	Internal DC ($\mu\text{Gy/hr}/(\text{Bq/kg fw})$)	External DC ($\mu\text{Gy/hr}/(\text{Bq/kg fw})$)	Internal DC ($\mu\text{Gy/hr}/(\text{Bq/kg})$)	External DC (in water) ($\mu\text{Gy/hr}/(\text{Bq/kg})$)	Internal DC ($\mu\text{Gy/hr}/(\text{Bq/kg fw})$)	External DC (in water) ($\mu\text{Gy/hr}/(\text{Bq/kg})$)	Internal DC ($\mu\text{Gy/hr}/(\text{Bq/kg fw})$)	External DC (on soil) ($\mu\text{Gy/hr}/(\text{Bq/m}^2)$)
Carbon-14	2.83E-05	2.17E-07	2.83E-05	1.79E-08	2.83E-05	2.29E-07	2.83E-05	0.00E+00
Cobalt-60	8.75E-05	1.42E-03	2.13E-04	1.29E-03	6.25E-05	1.42E-03	2.38E-04	7.50E-06
Cesium-134	1.13E-04	8.75E-04	2.04E-04	7.92E-04	9.58E-05	9.17E-04	2.21E-04	5.00E-06
Cesium-137	1.38E-04	3.29E-04	1.83E-04	2.83E-04	1.33E-04	5.42E-07	1.88E-04	1.79E-06
Tritium	5.76E-06	2.33E-09	5.76E-06	3.54E-13	5.76E-06	1.33E-11	5.76E-06	0.00E+00
Iodine-131	1.13E-04	2.21E-04	1.38E-04	1.92E-04	1.04E-04	2.25E-04	1.42E-04	1.21E-06
Radionuclide	Rat							
	Internal DC ($\mu\text{Gy/hr}/(\text{Bq/kg fw})$)	External DC (on soil) ($\mu\text{Gy/hr}/(\text{Bq/m}^2)$)	External DC (in soil) ($\mu\text{Gy/hr}/(\text{Bq/kg dw})$)					
Carbon-14	2.83E-05	0.00E+00	0.00E+00					
Cobalt-60	1.67E-04	7.92E-06	1.21E-03					
Cesium-134	1.71E-04	5.00E-06	7.92E-04					
Cesium-137	1.71E-04	1.88E-06	2.83E-03					
Tritium	5.76E-06	0.00E+00	0.00E+00					
Iodine-131	1.29E-04	1.29E-06	1.79E-04					

Notes:

Earthworm, grass, pine tree, seaweed, rat, trout, tadpole and duck DCs from ICRP (ICRP, 2008)

Insect larvae DCs from ERICA Assessment Tool 1.2.1. (Brown et al., 2008)

Earthworm is the surrogate for earthworms and caterpillars; grass is the surrogate for grass, pine tree is the surrogate for fruits and Sugar Maple, insect larvae is the surrogate for aquatic invertebrates, seaweed is the surrogate for aquatic plants, trout is the surrogate for all fish, tadpole is the surrogate for frogs and turtles, rat is the surrogate for all mammals, and duck is the surrogate for all birds.

4.2.4.1.6 Specific Activity Model for Tritium

IMPACT™ was used to estimate tritium and C-14 tissue concentrations using specific activity models as outlined in CSA (2014) and as recommended in Clause 7.3.4.3.7 of CSA (CSA, 2014).

Aquatic BAFs for tritium assume that the specific activity in the aqueous component of the aquatic animal or plant is the same as the specific activity in the water. BAFs are used to calculate tritium concentrations in plant, invertebrate and fish tissues. Therefore, the BAF (L/kg-fw) is:

$$BAF_{a\_HTO} = 1-DW_a$$

or

$$BAF_{p\_HTO} = 1-DW_p$$

where,

1-DW_a = water content of the animal (L water /kg-fw)
1-DW_p = water content of the plant (L water /kg-fw plant)

Aquatic BAFs for OBT assume that the specific activity of tritium in the combustion water of the dry matter of the organism is equal to the specific activity in the aqueous phase, apart from an isotopic discrimination factor. Because the concentration in the aqueous phase is equal to the surface water concentration, the BAF from HTO concentration in surface water to OBT in aquatic organism (L/kg-fw) is:

$$BAF_{a\_OBT} = DW_{aa} \cdot ID_{aa} \cdot WE_{aa}$$

or

$$BAF_{p\_HTO} = DW_{ap} \cdot ID_{ap} \cdot WE_{ap}$$

where,

DW_{aa} = dry weight of aquatic animal food product per total fresh weight (kg dw/kg fw)
ID_{aa} = isotopic discrimination factor for aquatic animal metabolism (unitless)
WE_{aa} = water equivalent of the aquatic animal dry matter (L/kg dw)
DW_{ap} = dry weight of aquatic plant per total fresh weight (kg dw/kg fw)
ID_{ap} = isotopic discrimination factor for aquatic plant metabolism (unitless)
WE_{ap} = water equivalent of the aquatic plant dry matter (L/kg dw)

All aquatic BAFs for HTO and OBT, which are derived from a specific activity model, are summarized in Table 4-19.

Table 4-19: Summary of BAFs for Tritium, OBT and Carbon-14

Receptor	Units	Tritium	OBT	Carbon-14	References
Fish	L/kg fw	7.50E-01	1.4E-01	5.70E+03	CSA, 2014
Turtles and Frogs	L/kg fw	7.50E-01	1.4E-01	5.70E+03	CSA, 2014 using fish as a surrogate
Aquatic Plants	L/kg fw	7.50E-01	1.1E-01	5.90E+03	CSA, 2014
Benthic Invertebrates	L/kg fw	7.50E-01	1.4E-01	5.20E+03	CSA, 2014

BAFs for terrestrial plants and soil invertebrates are not required for modelling tritium but are handled through the transfer from air as outlined in Clause 6.4.6.2 CSA (CSA, 2014).

For HTO and OBT, the majority of the tritium taken into the animal is from water ingestion and food consumption. The soil ingestion pathway is negligible for HTO and OBT. Consistent with the CSA equations, IMPACT™ was used to determine the transfer of HTO to animals ($P_{\text{HTOwater\_animal}}$, L/kg-fw) through water ingestion and is calculated as follows (CSA, 2014):

$$P_{\text{HTOwater\_animal}} = k_{\text{aw}} \cdot f_{\text{w-w}} \cdot (1 - \text{DW}_a)$$

where,

k_{aw} = fraction of water from contaminated sources
 $f_{\text{w-w}}$ = fraction of the animal water intake derived from direct ingestion of water
 DW_a = dry/fresh weight ratio for animal products (kg-dw/kg-fw), 0.3 from (CSA, 2014)

Similarly, IMPACT™ was used to determine the transfer of OBT to animals ($P_{\text{OBTwater\_animal}}$, L/kg-fw) through water ingestion, which is calculated as follows:

$$P_{\text{OBTwater\_animal}} = P_{\text{HTOwater\_animal}} \cdot f'_{\text{OBT}} \cdot (1 - \text{DW}_a)$$

where,

$P_{\text{HTOwater\_animal}}$ = transfer of HTO from drinking water to the portion of water in the animal derived from drinking water.
 f'_{OBT} = OBT/HTO ratio in the animal as a result of HTO ingestion (unitless)

The transfer of HTO to animals through food ingestion ($P_{\text{HTOfood\_animal}}$, unitless) was also determined in IMPACT™ using the specific activity model from CSA, and is calculated as follows (CSA, 2014):

$$P_{\text{HTOfood\_animal}} = k_{\text{af}} \cdot ((1 - f_{\text{OBT}}) \cdot f_{\text{w-pw}} + 0.5 \cdot f_{\text{w-dw}}) \cdot (1 - \text{DW}_a) / (1 - \text{DW}_p)$$

where,

k_{af}	=	fraction of food from contaminated sources
f_{w-pw}	=	fraction of the animal water intake derived from water in the plant feed
f_{w-dw}	=	fraction of the animal water intake that results from the metabolic decomposition of the organic matter in the feed
f_{OBT}	=	fraction of total tritium in the animal product in the form of OBT as a result of HTO ingestion
$1-DW_a$	=	water content of the animal product (L water/kg-fw)
$1-DW_p$	=	water content of the plant/food (L water/kg-fw plant)

The transfer of OBT to animals through food ingestion ($P_{OBTfood\_animal}$, unitless) was also determined in IMPACTTM using the specific activity model from CSA, and is calculated as follows (CSA, 2014):

$$P_{OBTfood\_animal} = k_{af} \cdot ((1-f_{OBT}) \cdot f_{w-pw} + 0.5 \cdot f_{w-dw}) \cdot DW_a \cdot WE_a / (DW_p \cdot WE_p)$$

where,

k_{af}	=	fraction of food from contaminated sources
f_{w-pw}	=	fraction of the animal water intake derived from water in the plant feed
f_{w-dw}	=	fraction of the animal water intake that results from the metabolic decomposition of the organic matter in the feed
f_{OBT}	=	fraction of total tritium in the animal product in the form of OBT as a result of HTO ingestion
WE_a	=	water equivalent of the animal product dry matter (L water/kg dw product)
WE_p	=	water equivalent of the plant/food dry matter (L water/kg dw product)
DW_a	=	dry/fresh weight ratio for animal products (L water/kg-fw)
DW_p	=	dry/fresh weight ratio for the plant/food (L water/kg-fw plant)

For each receptor, the transfer from each food item is calculated separately based on the water content of the individual food items in the receptor's diet.

Input parameters for the specific activity models can be found in Table 4-20 and Table 4-9.

Table 4-20: Input Parameters for Specific Activity Calculations for Tritium and Carbon-14

Receptor	f_{w_fw}	f_{w_pw}	f_{w_dw}	f_{OBT}	S_a (gC/kg-fw)
Bufflehead	0.22	0.65	0.121	0.10	244
Mallard	0.22	0.65	0.121	0.10	244
Muskrat	0.413	0.509	0.071	0.11	201
American Robin	0.22	0.65	0.121	0.10	244
Bank Swallow	0.22	0.65	0.121	0.10	244
Song Sparrow	0.22	0.65	0.121	0.10	244
Yellow Warbler	0.22	0.65	0.121	0.10	244
Eastern Cottontail	0.413	0.509	0.071	0.11	201
Meadow Vole	0.413	0.509	0.071	0.11	201
White-tailed Deer	0.33	0.582	0.081	0.11	201
Common Shrew	0.413	0.509	0.071	0.11	201
Raccoon	0.413	0.509	0.071	0.11	201
Red fox	0.413	0.509	0.071	0.11	201
Short-tailed Weasel	0.413	0.509	0.071	0.11	201

Notes:

f_{w_w} , f_{w_pw} , f_{w_dw} , and f_{OBT} are from Table 16 and 17 in CSA (CSA, 2014).

S_a are the beef and poultry values from Table 18 in CSA (CSA, 2014)

¹ Polygon AB

² Polygon C, D, and E

4.2.4.1.7 Specific Activity Model for Carbon-14

Aquatic BAFs for C-14 assume that the C-14 to stable carbon ratio in aquatic animals is equal to the ratio in dissolved inorganic carbon in the water. Therefore, the BAF (L/kg-fw) for aquatic animals, invertebrates, and plants is calculated as follows:

$$BAF_{C14} = S_a/S_w$$

where,

S_a = stable carbon content in the aquatic animal/invertebrate/plant (gC/kg-fw)

S_w = mass of stable carbon in the dissolved inorganic phase in water (gC/L)

Consistent with CSA (2014), S_w is 0.0213 gC/L. The stable carbon content for fish of 121.75 gC/kg-fw was used (CSA, 2014). The fish stable carbon content was considered appropriate for frogs and turtles. For freshwater invertebrates the stable carbon content for marine crustaceans of 111 gC/kg-fw was considered appropriate. For aquatic plants the stable carbon content for terrestrial plants of 500 gC/kg-dw or 125 gC/kg-fw was considered appropriate (CSA, 2014).

The stable carbon concentrations for terrestrial plants, fruits and terrestrial invertebrates are presented in Table 4-21.

Table 4-21: Stable Carbon Content for Food Types

Food Type	Stable Carbon Content (S_a , S_p) (gC/kg-fw)	Reference
Aquatic Plants	125	CSA, 2014
Benthic Invertebrates	111	CSA, 2014
Bufflehead	244	CSA, 2014
Mallard	244	CSA, 2014
Earthworms/Caterpillars	111	CSA, 2014
Grass/Sugar Maple	100	CSA, 2014
Fruit	50	CSA, 2014
Eastern Cottontail	201	CSA, 2014
Meadow Vole	201	CSA, 2014

BAFs for terrestrial plants and soil invertebrates are not required for modelling tritium and C-14 but are handled through the transfer from air as outlined in Clause 6.4.9.2 of CSA (CSA, 2014).

For C-14, food consumption contributes to the majority of the carbon ingested by the animal, compared to inhalation, water and soil ingestion. Consistent with CSA (2014), the specific activity model in IMPACT™ was used to determine the transfer of C-14 from food to animals, as follows:

$$P_{C14_{food\_animal}} = k_{af} \cdot S_a / S_p$$

where,

S_a = stable carbon content in the animal (gC/kg-fw), X_{5_C} (CSA, 2014)
 S_p = stable carbon content in the food (gC/kg-fw), ($X_{4\_C} \cdot DW_p$) (CSA, 2014)

The stable carbon content in the animal was obtained from CSA (CSA, 2014). The beef value was applied for all mammals and the poultry value was applied for all birds. This is reasonable since the stable carbon values presented by IAEA (IAEA, 2010) for various domestic species within each category are all very close to each other, and since values are not available for wild species. N288.1 has noted this, and has used poultry values for wild waterfowl.

For each receptor, the transfer from each food item is calculated separately based on the carbon content of the food item (S_p). Input parameters for the specific activity models can be found in Table 4-21 and Table 4-9.

4.2.5 Dispersion Models

HTO concentrations were not measured in soil for Polygon C, D and E. IMPACT™ version 5.5.2 was used to estimate HTO concentrations in pore water based on atmospheric

emissions of HTO and elemental tritium from 2016 to 2019, based on a maximum monthly emissions and average monthly emission. Emissions are modelled conservatively as a ground level release. Uncertainties in the model are discussed in Section 4.2.7.

IMPACT follows the CSA N288.1-14 model which uses a number of site specific input parameters that are specified in N288.1 based on previous model calibrations. Additional model calibrations were not performed for this assessment.

4.2.6 Exposure Point Concentrations and Doses

4.2.6.1 Exposure Point Concentrations

The measured concentrations used for the exposure evaluation for the different polygons are listed in Table 4-22 through Table 4-26. In cases where a measured concentration is not provided, the concentration is modelled using exposure factors discussed in Section 4.2.4. The emissions used for modelling are provided in Table 4-27. Modelled concentrations are presented in Appendix C.

As indicated in Section 4.2.1, media-specific concentrations were available for surface water, sediment, soil, fish, frogs, aquatic plants, benthic invertebrates, soil invertebrates, insects and terrestrial plants, for the different waters (e.g., Lake Ontario, Coot's Pond and Treefrog Pond) and for different land polygons (AB, C, D, and E). Most of this data was obtained from the environmental studies to support DNNP site preparation licence renewal (Ecometrix, 2020) and the SENES EcoRA in support of the EA (SENES, 2009a), supplemented with soil and terrestrial data from the SENES EcoRA (SENES, 2011b) of the southwest corner, and surface water, sediment and fish monitoring data from the OPG Annual EMP reports for 2011 to 2019. In cases where data were available in the OPG Annual EMP report and in SENES (2009a) and SENES (2011b) for the same media or biota, the OPG EMP results were used because these results represented more recent data (SENES, 2009a, 2011b).

The majority of environmental data collected in 2019 are uncensored, which means that data below detection were reported as the value generated by the analytical instrument, rather than the detection limit. These data were used to calculate the upper limit and the upper confidence of the mean (UCLM) concentrations. Environmental data collected prior to 2019 are mostly censored, i.e. reported as less than detection limit when analyte not clearly present. For this assessment, to be conservative, in those instances the detection limit was considered to be a measured value and was used in the dataset to calculate the maximum and the UCLM, likely overestimating the concentrations found at the location.

In some occasions, the UCLM values were greater than the maximum values because of small sample sizes (typically $n < 4$). In these instances, the maximum values were used to represent the UCLM exposure point concentrations. In some other cases, a UCLM could not be estimated using the available dataset because only the minimum and maximum results were provided. In these cases, the mean of the minimum and maximum results was

used to estimate a midpoint value of the dataset. This midpoint value was used to represent the UCLM exposure point concentration.

For Polygon D, although cadmium, selenium and vanadium were identified as sediment COPCs for Treefrog Pond, the VECs identified for Polygon D do not consume food exposed to sediment or ingest sediment from Treefrog Pond; therefore, the exposure pathway for sediment is incomplete. As such, sediment exposure point concentrations for Polygon D have been excluded from Table 4-25.

Table 4-22: Exposure Point Concentrations for Lake Ontario

	Surface Water ¹		Sediment ²		Round Whitefish ³		White Sucker ⁴		Alewife ⁵		Mussels ⁶	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Radionuclides												
Unit	Bq/L	Bq/L	Bq/kg(dw)	Bq/kg(dw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)
Carbon-14	2.30E-01	3.13E-02	9.89E-01	2.47E-01	3.40E+01	3.24E+01	3.40E+01	3.07E+01	3.46E+01	3.37E+01	3.85E+01	3.54E+01
Cobalt-60	3.14E-01	3.46E-02	2.08E-01	8.01E-02	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Cesium-134	5.75E-01	9.41E-02	5.44E-01	1.86E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Cesium-137	7.25E-01	1.42E-01	1.11E+00	3.19E-01	3.00E-01	2.42E-01	1.70E-01	1.33E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Tritium	1.54E+01	1.72E+00	1.35E+01	5.96E+00	5.00E+00	4.92E+00	1.52E+01	6.63E+00	2.30E+01	2.19E+01	1.00E+01	1.00E+01
Iodine-131	1.10E+00	4.10E-01	1.32E+00	6.48E-01	8.00E+00	8.00E+00	3.00E+00	3.00E+00	1.30E+01	1.30E+01	1.04E+02	1.04E+02
Non-Radionuclides												
Unit	mg/L	mg/L	mg/kg(dw)	mg/kg(dw)	-	-	-	-	-	-	mg/kg (fw)	mg/kg (fw)
Total Kjeldahl Nitrogen	-	-	9.44E+02	2.23E+02	-	-	-	-	-	-	-	-
Total Organic Carbon	-	-	9.10E+03	2.46E+03	-	-	-	-	-	-	-	-
Total Suspended Solids	3.30E+01	3.99E+00	-	-	-	-	-	-	-	-	-	-
Ammonia (un-ionized)	2.60E-01	1.32E-02	-	-	-	-	-	-	-	-	-	-
Barium	3.23E-02	2.33E-02	4.22E+01	1.53E+01	-	-	-	-	-	-	5.34E+01	3.85E+01
Cesium	8.70E-05	6.33E-06	3.94E-01	1.38E-01	-	-	-	-	-	-	3.10E-02	2.37E-02
Iron	1.78E-01	1.67E-02	-	-	-	-	-	-	-	-	-	-
Phosphorus	-	-	1.01E+03	6.70E+02	-	-	-	-	-	-	-	-
Strontium	6.25E-01	2.20E-01	2.76E+02	1.67E+02	-	-	-	-	-	-	3.84E+02	2.68E+02
Zinc ⁷	1.30E-02	1.47E-03	2.59E+01	1.24E+01	-	-	-	-	-	-	3.77E+00	2.82E+00
PHC F3	1.70E-01	7.40E-02	6.20E+01	2.34E+01	-	-	-	-	-	-	1.21E+02	5.25E+01
Benzo(a)pyrene	1.59E-05	3.01E-06	4.00E-02	7.59E-03	-	-	-	-	-	-	7.46E-02	1.42E-02
Chrysene	1.06E-06	3.38E-07	5.00E-02	9.07E-03	-	-	-	-	-	-	1.04E-03	3.31E-04
Dibenzo(a,h)anthracene	1.13E-04	2.04E-05	5.00E-03	1.59E-03	-	-	-	-	-	-	8.00E-02	1.45E-02
Phenanthrene	2.24E-04	5.24E-05	1.30E-02	1.96E-03	-	-	-	-	-	-	7.20E-02	1.68E-02
Pyrene	9.72E-05	1.47E-05	3.00E-02	7.00E-03	-	-	-	-	-	-	6.89E-02	1.04E-02

Notes:
¹ 2019 Environmental Study (Ecometrix, 2020) (C-14, Co-60, Cs-134, Cs-137, HTO, I-131).

² 2019, 2018 Environmental Study (Ecometrix, 2018, 2019, 2020) (C-14, Co-60, Cs-134, Cs-137, HTO, I-131); C-14 was converted from Bg/kg-C using a measured carbon content of 1.7g/kg C.

³(SENES, 2009a) (I-131); EMP 2011 (C-14, Co-60, Cs-134, Cs-137, HTO). C-14 was converted from Bg/kg-C using a freshwater fish tissue of 121.75 gC/kg FW (CSA, 2014)

⁴(SENES, 2009a) (I-131); EMP 2019 (Cs-137, C-14, HTO); REMP 2011-2015 (Co-60, Cs-134). C-14 was converted from Bg/kg-C using a freshwater fish tissue of 121.75 gC/kg FW (CSA, 2014)

⁵(SENES, 2009a). C-14 was converted from Bg/kg-C using a freshwater fish tissue of 121.75 gC/kg FW (CSA, 2014)

⁶(SENES, 2009a); mussels used to represent aquatic invertebrates. C-14 was converted from Bg/kg-C using an aquatic invertebrate tissue of 111 gC/kg FW (CSA, 2014)

⁷Concentrations of dissolved Zinc in surface water was used as exposure concentration, as dissolved Zinc is more bioavailable.

"- " indicates not applicable (not measured, or not a COPC in the corresponding environmental medium)

Table 4-23: Exposure Point Concentrations for Polygon AB

	Surface Water ¹		Sediment ²		Northern Redbelly Dace ³		Aquatic Plants ⁴		Soil ⁵		Earthworm ⁶		Caterpillar ⁶		Terrestrial Vegetation ⁷		Fruit ⁸	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	Mean	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Radionuclides																		
Unit	Bq/L	Bq/L	Bq/kg(dw)	Bq/kg(dw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(dw)	Bq/kg(dw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)
Carbon-14	7.00E-02	6.16E-02	7.10E+00	7.08E+00	3.49E+01	3.18E+01	3.89E+01	3.51E+01	2.35E+00	2.35E+00	3.06E+01	2.93E+01	3.09E+01	2.68E+01	2.88E+01	2.80E+01	1.18E+01	1.18E+01
Cobalt-60	1.19E-01	9.03E-02	1.21E-01	1.09E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	0*	0*	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Cesium-134	1.46E-01	1.46E-01	3.38E-01	3.38E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	2.00E-01	2.00E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Cesium-137	2.09E-01	1.95E-01	1.51E+00	1.50E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	5.50E+00	5.50E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Tritium	4.68E+01	4.05E+01	4.29E+01	4.13E+01	7.70E+01	7.25E+01	4.30E+01	4.16E+01	1.72E+02	1.72E+02	1.50E+01	1.50E+01	5.30E+01	5.15E+01	4.95E+02	3.15E+02	8.60E+01	8.60E+01
Iodine-131	3.85E+00	2.31E+00	8.68E-01	8.36E-01	3.18E+02	3.18E+02	2.00E+00	2.00E+00	2.20E+00	2.20E+00	1.00E+01	1.00E+01	6.00E+00	6.00E+00	1.70E+01	1.70E+01	2.00E+00	2.00E+00
Non-Radionuclides																		
Unit	mg/L	mg/L	mg/kg (dw)	mg/kg (dw)	mg/kg (fw)	mg/kg (fw)	-	-	mg/kg (dw)	mg/kg (dw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	-	-
Total Kjeldahl Nitrogen	-	-	3.78E+03	3.78E+03	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Organic Carbon	-	-	3.10E+04	3.10E+04	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammonia (un-ionized)	4.80E-02	2.61E-02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	5.55E-02	5.14E-02	1.59E+02	1.57E+02	4.13E+01	3.70E+01	-	-	1.04E+02	1.04E+02	3.12E+01	2.24E+01	3.50E+00	2.75E+00	3.14E+01	2.01E+01	-	-
Cadmium	7.40E-06	6.29E-06	1.60E+00	1.26E+00	2.00E-02	2.00E-02	-	-	2.85E-01	2.85E-01	7.67E+00	4.27E+00	5.00E-02	5.00E-02	2.60E-02	1.35E-02	-	-
Chromium	1.58E-03	9.92E-04	3.07E+01	2.91E+01	2.17E+00	2.11E+00	-	-	2.22E+01	2.22E+01	7.15E+00	5.85E+00	1.62E-01	1.27E-01	5.16E-01	3.32E-01	-	-
Copper	1.72E-03	1.13E-03	4.05E+01	3.66E+01	4.59E+00	4.28E+00	-	-	1.68E+01	1.68E+01	7.84E+00	6.95E+00	5.72E+00	4.09E+00	3.64E+00	2.06E+00	-	-
Iron	4.33E-01	2.94E-01	2.37E+04	2.42E+04	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manganese	6.85E-02	4.74E-02	5.40E+02	5.40E+02	5.72E+01	5.18E+01	-	-	4.43E+02	4.43E+02	1.51E+02	1.24E+02	3.80E+00	3.80E+00	1.35E+01	8.07E+00	-	-
Nickel	8.80E-04	7.54E-04	2.02E+01	2.02E+01	1.79E+00	1.64E+00	-	-	1.30E+01	1.30E+01	4.41E+00	3.53E+00	1.57E-01	9.10E-02	5.04E-01	2.46E-01	-	-
Phosphorus	-	-	8.12E+02	8.12E+02	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Strontium	5.01E-01	4.84E-01	4.42E+02	4.42E+02	1.86E+02	1.68E+02	-	-	1.74E+02	1.74E+02	1.04E+02	7.86E+01	1.84E+01	1.07E+01	3.12E+01	2.58E+01	-	-
Vanadium	2.53E-03	2.13E-03	5.96E+01	5.51E+01	1.50E+00	1.25E+00	-	-	3.67E+01	3.67E+01	1.01E+01	8.17E+00	5.00E-02	5.00E-02	6.40E-01	2.86E-01	-	-
Zinc	2.62E-03	1.92E-03	1.70E+02	1.55E+02	3.52E+02	3.41E+02	-	-	6.30E+01	6.30E+01	3.24E+02	2.82E+02	1.31E+01	1.04E+01	2.61E+01	1.72E+01	-	-

Notes:

¹ 2019 Environmental Study (Ecometrix, 2020) (C-14, Co-60, Cs-134, Cs-137, HTO, I-131).

² 2019 Environmental Study (Ecometrix, 2020) (C-14, Co-60, Cs-134, Cs-137, HTO, I-131). C-14 was converted from Bg/kg-C using a measured carbon content of 24 g C /kg.

³(SENES, 2009a) C-14 was converted from Bg/kg-C using a freshwater fish tissue of 121.75 gC/kg FW (CSA, 2014)

⁴(SENES, 2009a) C-14 was converted from Bg/kg-C using an aquatic plant tissue of 125 gC/kg FW (CSA, 2014)

⁵ 2019 Environmental Study (Ecometrix, 2020) (C-14, Co-60, Cs-134, Cs-137, HTO, I-131). C-14 was converted from Bg/kg-C using a measured carbon content of 1.75% , HTO presented in Bq/L

⁶(SENES, 2009a) C-14 was converted from Bg/kg-C using an aquatic invertebrate tissue of 111 gC/kg FW (CSA, 2014)

⁷The greater values of the 2009 and 2011 EcoRA data was used as a conservative approach.

⁸(SENES, 2009a) C-14 was converted from Bg/kg-C using an terrestrial vegetation tissue (fruit) of 50 gC/kg FW (CSA, 2014). Non-radionuclide fruit concentrations were not measured. Fruit concentrations were estimated using measured terrestrial vegetation concentrations on a dry weight basis and a dry fresh weight ratio of 0.1 for fruit (CSA, 2014)

"-" indicates not applicable (not measured, or not a COPC in the corresponding environmental medium)

*indicates negative value in the uncensored data

Table 4-24: Exposure Point Concentrations for Polygon C

	Soil ¹		Earthworm ²		Caterpillar ²		Terrestrial Vegetation ³		Fruit ⁴	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Radionuclides										
Unit	Bq/kg(dw)	Bq/kg(dw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)
Carbon-14	6.69E-01	6.69E-01	3.51E+01	3.51E+01	4.83E+01	4.83E+01	5.77E+01	5.77E+01	1.27E+01	1.27E+01
Cobalt-60	0*	0*	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Cesium-134	1.00E-01	1.00E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Cesium-137	7.00E-01	7.00E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Tritium	2.80E+00	2.80E+00	3.70E+01	3.70E+01	1.85E+02	1.85E+02	2.66E+02	2.66E+02	1.51E+02	1.51E+02
Iodine-131	2.40E+00	2.40E+00	9.00E+00	9.00E+00	8.00E+00	8.00E+00	1.40E+01	1.40E+01	2.00E+00	2.00E+00
Non-Radionuclides										
Unit	mg/kg (dw)	mg/kg (dw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)
Strontium	1.12E+02	1.12E+02	2.60E+01	2.60E+01	2.00E+00	2.00E+00	1.04E+01	9.27E+00	-	-

Notes:

¹ 2019 Environmental Study (Ecometrix, 2020) (C-14, Co-60, Cs-134, Cs-137, HTO, I-131). C-14 was converted from Bg/kg-C with a measured carbon content of 1.99%, HTO presented in Bq/L

²(SENES, 2009a) C-14 was converted from Bg/kg-C using an aquatic invertebrate tissue of 111 gC/kg FW (CSA, 2014)

³(SENES, 2009a) C-14 was converted from Bg/kg-C using an terrestrial vegetation tissue (forage) of 100 gC/kg FW (CSA, 2014).

⁴(SENES, 2009a) C-14 was converted from Bg/kg-C using an terrestrial vegetation tissue (fruit) of 50 gC/kg FW (CSA, 2014). Non-radionuclide fruit concentrations were not measured. Fruit concentrations were estimated using measured terrestrial vegetation concentrations on a dry weight basis and a dry fresh weight ratio of 0.1 for fruit (CSA, 2014)

"-" not measured

*indicates negative value in the uncensored data

Table 4-25: Exposure Point Concentrations for Polygon D

	Surface Water ¹		Sediment ²		Frogs ³		Aquatic Plants ⁴		Soil ^{1, 5}		Earthworm ⁶		Caterpillar ⁶		Terrestrial Vegetation ⁷		Fruit ⁸	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Radionuclides																		
Unit	Bq/L	Bq/L	Bq/kg(dw)	Bq/kg(dw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(dw)	Bq/kg(dw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)	Bq/kg(fw)
Carbon-14	8.90E-02	8.90E-02	6.75E+01	6.75E+01	3.38E+01	3.38E+01	5.75E+01	5.75E+01	7.17E+00	7.17E+00	3.55E+01	3.55E+01	3.26E+01	3.26E+01	5.68E+01	4.87E+01	1.46E+01	1.42E+01
Cobalt-60	5.55E-02	5.55E-02	0*	0*	1.00E+00	1.00E+00	1.00E+00	1.00E+00	0*	0*	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Cesium-134	7.11E-02	7.11E-02	3.35E-01	3.35E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	2.00E-01	2.00E-01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Cesium-137	6.69E-02	6.69E-02	7.03E+00	6.71E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	6.30E+00	6.30E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Tritium	5.80E+01	5.80E+01	5.01E+01	4.77E+01	3.80E+01	3.80E+01	5.80E+01	5.80E+01	3.00E+01	3.00E+01	1.90E+01	1.90E+01	9.20E+01	9.20E+01	5.50E+01	4.25E+01	9.30E+01	8.80E+01
Iodine-131	2.21E-01	2.21E-01	5.30E-01	5.26E-01	2.20E+01	2.20E+01	3.00E+00	3.00E+00	3.00E-01	3.00E-01	1.20E+01	1.20E+01	4.00E+00	4.00E+00	2.30E+01	2.30E+01	2.00E+00	2.00E+00
Non-Radionuclides																		
Unit	mg/L	mg/L	-	-	-	-	-	-	mg/kg (dw)	mg/kg (dw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	mg/kg (fw)	-	-
Ammonia (un-ionized)	5.00E-03	5.00E-03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Barium	3.98E-02	3.98E-02	-	-	-	-	-	-	1.07E+02	1.07E+02	7.13E+01	4.68E+01	1.50E+00	1.50E+00	8.48E+00	5.74E+00	-	-
Cadmium	5.00E-06	5.00E-06	-	-	-	-	-	-	2.74E-01	2.74E-01	1.77E+00	1.48E+00	5.00E-02	5.00E-02	5.70E-02	3.35E-02	-	-
Copper	3.88E-04	3.88E-04	-	-	-	-	-	-	1.51E+01	1.51E+01	7.10E+00	6.47E+00	3.88E+00	3.88E+00	2.93E+00	2.27E+00	-	-
Iron	5.20E-01	5.20E-01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium	1.14E-04	1.14E-04	-	-	-	-	-	-	2.94E-01	2.94E-01	2.72E+00	1.70E+00	5.90E-02	5.90E-02	1.12E-02	1.00E-02	-	-
Strontium	2.25E-01	2.25E-01	-	-	-	-	-	-	1.42E+02	1.42E+02	5.58E+01	3.46E+01	7.60E+00	7.60E+00	1.66E+01	1.11E+01	-	-
Vanadium	4.00E-04	4.00E-04	-	-	-	-	-	-	3.02E+01	3.02E+01	9.53E+00	8.75E+00	2.50E-02	2.50E-02	5.06E-02	3.96E-02	-	-

Notes:

¹ 2019 Environmental Study (Ecometrix, 2020) (C-14, Co-60, Cs-134, Cs-137, HTO, I-131).

² 2019 Environmental Study (Ecometrix, 2020) (C-14, Co-60, Cs-134, Cs-137, HTO, I-131). C-14 was converted from Bg/kg-C with a measured carbon content of 144 g C/kg, HTO presented in Bq/L

³ SENES (2009a). C-14 was converted from Bg/kg-C using a freshwater fish tissue of 121.75 gC/kg FW (CSA, 2014)

⁴ SENES (2009a). C-14 was converted from Bg/kg-C using an aquatic plant tissue of 125 gC/kg FW (CSA, 2014)

⁵ SENES (2009a). C-14 was converted from Bg/kg-C with a measured carbon content of 2.77%

⁶ SENES (2009a). C-14 was converted from Bg/kg-C using an aquatic invertebrate tissue of 111 gC/kg FW (CSA, 2014)

⁷ SENES (2009a). C-14 was converted from Bg/kg-C using a terrestrial vegetation tissue (forage) of 100 gC/kg FW (CSA, 2014). A dry to fresh weight ratio of 0.2 was used to convert non-radionuclide terrestrial vegetation concentrations reported on a dry weight to a wet weight basis (CSA, 2014)

⁸ SENES (2009a). C-14 was converted from Bg/kg-C using a terrestrial vegetation tissue (fruit) of 50 gC/kg FW (CSA, 2014). Non-radionuclide fruit concentrations were not measured. Fruit concentrations were estimated using measured terrestrial vegetation concentrations on a dry weight basis and a dry fresh weight ratio of 0.1 for fruit (CSA, 2014)

"- " indicates not measured in the case of fruit, and not applicable for sediment, frogs and aquatic plants for non-radionuclides

*indicates negative value in the uncensored data

Table 4-26: Exposure Point Concentrations for Polygon E

	Surface Water ¹		Soil ²		Fruit ³	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Radionuclides						
Unit	Bq/L	Bq/L	Bq/kg(dw)	Bq/kg(dw)	Bq/kg(fw)	Bq/kg(fw)
Carbon-14	2.30E-01	3.13E-02	1.86E+00	4.46E-01	1.49E+01	1.49E+01
Cobalt-60	3.14E-01	3.46E-02	6.00E-01	8.50E-02	1.00E+00	1.00E+00
Cesium-134	5.75E-01	9.41E-02	4.00E-01	1.82E-01	1.00E+00	1.00E+00
Cesium-137	7.25E-01	1.42E-01	4.60E+00	9.00E-01	1.00E+00	1.00E+00
Tritium	1.54E+01	1.72E+00	1.67E+02	5.31E+01	1.86E+02	1.86E+02
Iodine-131	4.03E+01	7.03E+00	2.20E+00	5.65E-01	2.00E+00	2.00E+00
Non-Radionuclides						
Unit	mg/L	mg/L	mg/kg(dw)	mg/kg(dw)	mg/kg(fw)	mg/kg(fw)
Arsenic	8.40E-04	7.69E-04	1.33E+02	1.54E+01	-	-
Cadmium	1.60E-05	3.81E-06	3.75E+00	4.90E-01	-	-
Chromium	1.35E-03	1.81E-04	7.48E+01	1.86E+01	-	-
Cobalt	9.10E-05	1.74E-05	1.59E+02	1.97E+01	-	-
Copper	1.00E-03	6.62E-04	2.23E+03	2.41E+02	-	-
Iron	1.78E-01	1.67E-02	9.49E+04	2.02E+04	-	-
Lead	1.57E-04	2.05E-05	5.89E+02	6.84E+01	-	-
Molybdenum	1.35E-03	1.18E-03	4.23E+01	4.77E+00	-	-
Nickel	7.03E-04	4.59E-04	1.29E+02	2.13E+01	-	-
Selenium	1.89E-04	1.40E-04	6.12E+00	7.65E-01	-	-
Sodium	3.96E+01	1.82E+01	1.92E+03	3.76E+02	-	-
Strontium	6.25E-01	2.20E-01	7.55E+02	3.21E+02	-	-
Tin	4.05E-04	3.17E-05	1.08E+02	1.18E+01	-	-
Zinc ⁴	1.30E-02	1.47E-03	9.32E+03	1.01E+03	-	-
PHC F4 (sg)	-	-	3.90E+03	2.57E+00	-	-
Cyanide (free)	-	-	3.30E-01	4.04E-02	-	-

Notes:

¹ 2019 Environmental Study (Ecometrix, 2020) (C-14, Co-60, Cs-134, Cs-137, HTO, I-131).

² 2019 Environmental Study (Ecometrix, 2020) (C-14, Co-60, Cs-134, Cs-137, HTO, I-131). C-14 was converted from Bq/kg-C with a measured carbon content of 0.79%, HTO presented in Bq/L

³C-14 was converted from Bq/kg-C assuming a carbon content of 5%

⁴Concentrations of dissolved Zinc in surface water was used as exposure concentration, as dissolved Zinc is more bioavailable.

"-" indicates not measured

Table 4-27: Emissions to Air used to Model Exposure Point Concentrations

			Air	
			Maximum ¹	UCLM ¹
Radionuclides				
	Unit		Bq/s	Bq/s
Carbon-14			1.26E+05	4.04E+04
Cobalt-60			2.88E+00	9.18E-01
Cesium-134			*	*
Cesium-137			*	*
Tritium Oxide (HTO)			1.75E+07	6.99E+06
Elemental Tritium (HT)			1.10E+08	3.22E+06
Iodine-131			5.65E+00	4.52E+00

Notes:

1. Maximum and UCLM were determined based on weekly air emission reporting data between 2016-2019 (OPG, 2016h, 2016i, 2016j, 2017k, 2017l, 2017m, 2017n, 2018m, 2018n, 2018o, 2018p, 2019k, 2019l, 2019m, 2019n, 2020k). UCLM was calculated as mean+2×standard error.

* The particulate emissions data were used as the model source. It is conservatively assumed to be Co-60.

4.2.6.2 Exposure Doses

The exposure concentrations in Section 4.2.6.1, along with the exposure factors in Section 4.2.4, were applied in the equations in Section 4.2.3 to estimate the radiological dose to all biota and non-radiological dose to birds and mammals. The estimated radiological doses are presented in Table 4-28 to Table 4-32. The estimated non-radiological doses are presented in Table 4-33 to Table 4-37.

Table 4-28: Estimated Radiation Doses for VECs for Lake Ontario (mGy/d)

Receptor	Carbon-14		Cobalt-60		Cesium-134		Cesium-137		HTO		OBT		Iodine-131		Total Dose	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Round Whitefish	2.31E-05	2.20E-05	8.32E-07	6.34E-07	1.01E-06	6.67E-07	1.70E-06	1.17E-06	6.91E-07	6.80E-07	2.98E-07	3.33E-08	2.67E-05	2.65E-05	5.43E-05	5.18E-05
White Sucker	2.31E-05	2.09E-05	8.32E-07	6.34E-07	1.01E-06	6.67E-07	1.13E-06	6.94E-07	2.10E-06	9.17E-07	2.98E-07	3.33E-08	1.02E-05	1.00E-05	3.87E-05	3.39E-05
Alewife	2.35E-05	2.29E-05	5.10E-06	5.10E-06	4.90E-06	4.90E-06	4.40E-06	4.40E-06	3.18E-06	3.03E-06	2.98E-07	3.33E-08	4.29E-05	4.29E-05	8.43E-05	8.33E-05
Lake Trout	8.91E-04	1.21E-04	9.62E-05	1.06E-05	9.87E-03	1.62E-03	1.12E-02	2.19E-03	1.60E-06	1.78E-07	2.98E-07	3.33E-08	2.68E-05	1.00E-05	2.21E-02	3.95E-03
American Eel	8.91E-04	1.21E-04	9.41E-05	1.05E-05	9.87E-03	1.62E-03	1.12E-02	2.19E-03	1.60E-06	1.78E-07	2.98E-07	3.33E-08	2.59E-05	9.68E-06	2.21E-02	3.94E-03
Benthic Invertebrates	2.59E-05	2.38E-05	2.65E-06	1.79E-06	4.13E-06	2.55E-06	4.32E-06	2.92E-06	1.39E-06	1.39E-06	2.99E-07	3.34E-08	2.19E-04	2.18E-04	2.57E-04	2.50E-04
Bufflehead	2.88E-05	2.65E-05	1.45E-06	1.25E-06	3.78E-06	3.20E-06	3.28E-06	2.72E-06	2.25E-06	2.10E-06	2.01E-07	1.85E-07	8.42E-07	7.43E-07	4.06E-05	3.67E-05
Mallard	2.88E-05	2.65E-05	1.37E-06	1.18E-06	3.58E-06	3.02E-06	3.10E-06	2.57E-06	2.25E-06	2.10E-06	2.01E-07	1.85E-07	8.03E-07	7.04E-07	4.01E-05	3.62E-05

Notes:

No values exceed the aquatic benchmark of 9.6 mGy/d or the terrestrial benchmark of 2.4 mGy/d.

Table 4-29: Estimated Radiation Doses for VECs for Polygon AB (mGy/d)

Receptor	Carbon-14		Cobalt-60		Cesium-134		Cesium-137		Tritium		OBT		Iodine-131		Total Dose	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Northern Redbelly Dace	2.38E-05	2.16E-05	5.29E-06	5.27E-06	5.22E-06	5.22E-06	4.91E-06	4.91E-06	1.06E-05	1.00E-05	9.06E-07	7.84E-07	1.05E-03	1.05E-03	1.10E-03	1.10E-03
Turtles	2.71E-04	2.39E-04	1.29E-05	9.80E-06	1.18E-03	1.18E-03	2.34E-03	2.19E-03	4.85E-06	4.20E-06	9.06E-07	7.84E-07	7.36E-05	4.42E-05	3.88E-03	3.66E-03
Frogs	2.71E-04	2.39E-04	1.29E-05	9.80E-06	1.18E-03	1.18E-03	2.34E-03	2.19E-03	4.85E-06	4.20E-06	9.06E-07	7.84E-07	7.36E-05	4.42E-05	3.88E-03	3.66E-03
Aquatic Plants	2.64E-05	2.39E-05	2.10E-06	2.10E-06	2.70E-06	2.70E-06	3.30E-06	3.30E-06	5.94E-06	5.75E-06	7.12E-07	6.16E-07	5.40E-06	5.40E-06	4.66E-05	4.37E-05
Benthic Invertebrates	2.45E-04	2.15E-04	1.71E-05	1.31E-05	2.65E-05	2.65E-05	5.13E-05	4.81E-05	4.86E-06	4.21E-06	9.08E-07	7.86E-07	7.82E-05	4.73E-05	4.24E-04	3.55E-04
Bufflehead	2.47E-04	2.18E-04	1.40E-05	1.07E-05	3.99E-05	3.99E-05	4.85E-05	4.53E-05	3.124E-06	2.87E-06	1.792E-07	1.72E-07	3.41E-07	2.51E-07	3.54E-04	3.17E-04
Mallard	2.10E-04	1.85E-04	1.12E-05	8.58E-06	3.18E-05	3.18E-05	3.85E-05	3.60E-05	3.173E-06	2.94E-06	1.792E-07	1.72E-07	2.97E-07	2.25E-07	2.96E-04	2.65E-04
Muskrat	4.25E-05	3.84E-05	2.98E-07	2.74E-07	3.99E-06	3.99E-06	4.36E-06	4.34E-06	6.34E-06	6.00E-06	4.36E-07	4.05E-07	2.83E-06	2.43E-06	6.08E-05	5.58E-05
Earthworm	2.08E-05	1.99E-05	1.80E-06	1.80E-06	2.60E-06	2.60E-06	3.40E-06	3.40E-06	2.07E-06	2.07E-06	1.49E-05	1.49E-05	2.70E-05	2.70E-05	7.26E-05	7.17E-05
American Robin	2.13E-05	2.08E-05	3.00E-06	2.99E-06	1.09E-05	1.09E-05	3.79E-05	3.79E-05	3.33E-06	3.26E-06	2.59E-07	2.51E-07	8.37E-06	8.37E-06	8.51E-05	8.45E-05
Bank Swallow	2.31E-05	2.00E-05	2.46E-06	2.45E-06	7.97E-06	7.97E-06	2.11E-05	2.11E-05	3.62E-06	3.50E-06	2.72E-07	2.62E-07	4.23E-06	4.22E-06	6.27E-05	5.95E-05
Song Sparrow	3.22E-05	3.14E-05	5.99E-06	5.98E-06	2.05E-05	2.05E-05	6.29E-05	6.29E-05	7.13E-06	7.01E-06	4.98E-07	4.85E-07	1.33E-05	1.33E-05	1.43E-04	1.42E-04
Yellow Warbler	2.29E-05	2.00E-05	2.66E-06	2.65E-06	8.48E-06	8.48E-06	2.16E-05	2.15E-05	3.68E-06	3.56E-06	2.75E-07	2.65E-07	4.23E-06	4.22E-06	6.37E-05	6.07E-05
Green Heron	2.38E-05	2.17E-05	1.44E-06	1.42E-06	3.66E-06	3.66E-06	3.32E-06	3.31E-06	4.84E-06	4.58E-06	1.79E-07	1.72E-07	2.33E-06	2.32E-06	3.96E-05	3.71E-05
Terrestrial Plants (Grass)	1.96E-05	1.90E-05	1.80E-06	1.80E-06	2.50E-06	2.50E-06	3.40E-06	3.40E-06	6.84E-05	4.35E-05	1.40E-09	1.40E-09	4.42E-05	4.42E-05	1.40E-04	1.14E-04
Eastern Cottontail	3.94E-05	3.83E-05	7.52E-08	7.46E-08	1.02E-05	1.02E-05	6.87E-05	6.86E-05	3.29E-05	2.20E-05	1.75E-06	1.24E-06	3.24E-05	3.20E-05	1.85E-04	1.72E-04
Meadow Vole	3.94E-05	3.83E-05	3.04E-08	3.01E-08	7.85E-06	7.85E-06	6.60E-05	6.60E-05	3.29E-05	2.20E-05	1.75E-06	1.24E-06	2.38E-05	2.35E-05	1.72E-04	1.59E-04
White-tailed Deer	3.94E-05	3.83E-05	5.27E-07	5.21E-07	2.36E-05	2.36E-05	4.31E-05	4.31E-05	3.67E-05	2.43E-05	1.89E-06	1.32E-06	4.90E-05	4.75E-05	1.94E-04	1.79E-04
Common Shrew	3.80E-05	3.30E-05	1.06E-07	1.05E-07	1.18E-05	1.18E-05	7.00E-05	7.00E-05	6.65E-06	6.31E-06	5.71E-07	5.37E-07	2.51E-05	2.49E-05	1.52E-04	1.47E-04
Raccoon	3.18E-05	2.91E-05	1.82E-07	1.55E-07	1.66E-05	1.66E-05	7.80E-05	7.74E-05	1.32E-05	9.95E-06	8.57E-07	6.96E-07	2.95E-05	2.75E-05	1.70E-04	1.61E-04
Red Fox	8.19E-05	7.44E-05	2.14E-08	1.74E-08	8.81E-06	8.81E-06	1.30E-04	1.30E-04	1.63E-05	1.18E-05	7.09E-07	5.87E-07	1.86E-05	1.81E-05	2.57E-04	2.44E-04
Short-tailed Weasel	3.94E-05	3.83E-05	2.22E-09	1.76E-09	7.24E-06	7.24E-06	6.56E-05	6.56E-05	1.97E-05	1.41E-05	5.96E-07	5.19E-07	1.95E-05	1.92E-05	1.52E-04	1.45E-04

Notes:

No values exceed the aquatic benchmark of 9.6 mGy/d or the terrestrial benchmark of 2.4 mGy/d.

Table 4-30: Estimated Radiation Doses for VECs for Polygon C (mGy/d)

Receptor	Carbon-14		Cobalt-60		Cesium-134		Cesium-137		HTO		OBT		Iodine-131		Total Dose	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Earthworm	2.39E-05	2.39E-05	1.80E-06	1.80E-06	2.60E-06	2.60E-06	3.40E-06	3.40E-06	5.11E-06	5.11E-06	1.05E-05	1.05E-05	2.43E-05	2.43E-05	7.15E-05	7.15E-05
American Robin	2.38E-05	2.38E-05	2.96E-06	2.96E-06	9.22E-06	9.22E-06	1.05E-05	1.05E-05	9.83E-06	9.83E-06	8.79E-07	8.79E-07	9.12E-06	9.12E-06	6.62E-05	6.62E-05
Song Sparrow	3.74E-05	3.74E-05	5.92E-06	5.92E-06	1.78E-05	1.78E-05	1.93E-05	1.93E-05	1.94E-05	1.94E-05	1.58E-06	1.58E-06	1.45E-05	1.45E-05	1.16E-04	1.16E-04
Yellow Warbler	3.52E-05	3.52E-05	2.61E-06	2.61E-06	7.54E-06	7.54E-06	7.73E-06	7.73E-06	1.35E-05	1.35E-05	1.05E-06	1.05E-06	4.62E-06	4.62E-06	7.22E-05	7.22E-05
Terrestrial Plants (Grass)	3.92E-05	3.92E-05	1.80E-06	1.80E-06	2.50E-06	2.50E-06	3.40E-06	3.40E-06	3.68E-05	3.68E-05	9.85E-10	9.85E-10	3.64E-05	3.64E-05	1.20E-04	1.20E-04
Eastern Cottontail	7.89E-05	7.89E-05	7.26E-08	7.26E-08	6.93E-06	6.93E-06	1.20E-05	1.20E-05	3.89E-05	3.89E-05	3.48E-06	3.48E-06	3.07E-05	3.07E-05	1.71E-04	1.71E-04
Meadow Vole	7.89E-05	7.89E-05	2.90E-08	2.90E-08	4.64E-06	4.64E-06	9.71E-06	9.71E-06	3.89E-05	3.89E-05	3.48E-06	3.48E-06	2.39E-05	2.39E-05	1.59E-04	1.59E-04
White-tailed Deer	7.89E-05	7.89E-05	5.02E-07	5.02E-07	2.09E-05	2.09E-05	1.46E-05	1.46E-05	3.67E-05	3.67E-05	3.06E-06	3.06E-06	3.97E-05	3.97E-05	1.94E-04	1.94E-04
Common Shrew	5.95E-05	5.95E-05	1.04E-07	1.04E-07	8.59E-06	8.59E-06	1.37E-05	1.37E-05	3.37E-05	3.37E-05	3.25E-06	3.25E-06	2.86E-05	2.86E-05	1.47E-04	1.47E-04
Raccoon	6.07E-05	6.07E-05	8.15E-08	8.15E-08	7.57E-06	7.57E-06	1.27E-05	1.27E-05	3.50E-05	3.50E-05	3.26E-06	3.26E-06	2.74E-05	2.74E-05	1.47E-04	1.47E-04
Red Fox	7.44E-05	7.44E-05	4.59E-09	4.59E-09	3.73E-06	3.73E-06	1.69E-05	1.69E-05	4.06E-05	4.06E-05	3.13E-06	3.13E-06	1.88E-05	1.88E-05	1.58E-04	1.58E-04
Short-tailed Weasel	7.89E-05	7.89E-05	3.06E-10	3.06E-10	3.94E-06	3.94E-06	9.04E-06	9.04E-06	4.21E-05	4.21E-05	3.10E-06	3.10E-06	2.01E-05	2.01E-05	1.57E-04	1.57E-04

Notes:

No values exceed the terrestrial benchmark of 2.4 mGy/d.

Table 4-31: Estimated Radiation Doses for VECs for Polygon D (mGy/d)

Receptor	Carbon-14		Cobalt-60		Cesium-134		Cesium-137		HTO		OBT		Iodine-131		Total Dose	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Turtles	3.45E-04	3.45E-04	5.91E-06	5.91E-06	5.74E-04	5.74E-04	7.52E-04	7.52E-04	6.01E-06	6.01E-06	1.12E-06	1.12E-06	4.35E-06	4.35E-06	1.69E-03	1.69E-03
Frogs	2.30E-05	2.30E-05	1.50E-06	1.50E-06	2.67E-06	2.67E-06	6.05E-06	5.92E-06	5.25E-06	5.25E-06	1.12E-06	1.12E-06	5.52E-05	5.52E-05	9.48E-05	9.47E-05
Aquatic Plants	3.91E-05	3.91E-05	2.10E-06	2.10E-06	2.70E-06	2.70E-06	3.30E-06	3.30E-06	8.02E-06	8.02E-06	8.82E-07	8.82E-07	8.10E-06	8.10E-06	6.42E-05	6.42E-05
Earthworm	2.42E-05	2.42E-05	1.80E-06	1.80E-06	2.60E-06	2.60E-06	3.40E-06	3.40E-06	2.63E-06	2.63E-06	9.39E-06	9.39E-06	3.24E-05	3.24E-05	7.64E-05	7.64E-05
American Robin	2.54E-05	2.51E-05	2.98E-06	2.98E-06	1.09E-05	1.09E-05	4.23E-05	4.23E-05	3.23E-06	3.15E-06	2.35E-07	2.31E-07	1.22E-06	1.22E-06	8.62E-05	8.59E-05
Song Sparrow	3.87E-05	3.79E-05	5.95E-06	5.95E-06	2.04E-05	2.04E-05	6.99E-05	6.99E-05	7.35E-06	7.12E-06	4.78E-07	4.67E-07	1.87E-06	1.87E-06	1.45E-04	1.44E-04
Yellow Warbler	2.44E-05	2.43E-05	2.63E-06	2.63E-06	8.40E-06	8.40E-06	2.37E-05	2.37E-05	4.78E-06	4.77E-06	3.07E-07	3.07E-07	6.15E-07	6.15E-07	6.48E-05	6.48E-05
Terrestrial Plants (Grass)	3.86E-05	3.31E-05	1.80E-06	1.80E-06	2.50E-06	2.50E-06	3.40E-06	3.40E-06	7.60E-06	5.88E-06	8.84E-10	8.84E-10	5.98E-05	5.98E-05	1.14E-04	1.06E-04
Terrestrial Plants (Sugar Maple)	3.86E-05	3.31E-05	1.80E-05	1.80E-05	1.40E-05	1.40E-05	7.80E-06	7.80E-06	7.60E-06	5.88E-06	8.84E-06	8.84E-06	1.36E-04	1.36E-04	2.31E-04	2.23E-04
Eastern Cottontail	7.76E-05	6.66E-05	7.38E-08	7.38E-08	1.01E-05	1.01E-05	7.79E-05	7.79E-05	6.68E-06	5.94E-06	5.58E-07	5.24E-07	2.10E-05	2.10E-05	1.94E-04	1.82E-04
Meadow Vole	7.76E-05	6.66E-05	2.97E-08	2.97E-08	7.81E-06	7.81E-06	7.53E-05	7.53E-05	6.68E-06	5.94E-06	5.58E-07	5.24E-07	9.83E-06	9.83E-06	1.78E-04	1.66E-04
White-tailed Deer	7.76E-05	6.66E-05	5.14E-07	5.14E-07	2.30E-05	2.30E-05	4.71E-05	4.71E-05	6.68E-06	5.83E-06	5.22E-07	4.84E-07	5.09E-05	5.09E-05	2.06E-04	1.94E-04
Common Shrew	4.02E-05	4.02E-05	1.05E-07	1.05E-07	1.17E-05	1.17E-05	7.93E-05	7.93E-05	8.67E-06	8.67E-06	6.47E-07	6.47E-07	7.07E-06	7.07E-06	1.48E-04	1.48E-04
Raccoon	5.16E-05	4.73E-05	8.30E-08	8.30E-08	1.08E-05	1.08E-05	7.88E-05	7.88E-05	7.52E-06	7.25E-06	5.86E-07	5.75E-07	1.08E-05	1.08E-05	1.60E-04	1.56E-04
Red Fox	7.32E-05	6.28E-05	6.03E-09	6.03E-09	6.71E-06	6.71E-06	1.46E-04	1.46E-04	4.19E-06	3.79E-06	1.95E-07	1.88E-07	4.29E-06	4.29E-06	2.34E-04	2.23E-04
Short-tailed Weasel	7.76E-05	6.66E-05	1.20E-09	1.20E-09	7.15E-06	7.15E-06	7.48E-05	7.48E-05	6.69E-06	6.33E-06	4.62E-07	4.59E-07	3.68E-06	3.68E-06	1.70E-04	1.59E-04

Note:

No values exceed the aquatic benchmark of 9.6 mGy/d or the terrestrial benchmark of 2.4 mGy/d.

Table 4-32: Estimated Radiation Doses for VECs for Polygon E (mGy/d)

Receptor	Carbon-14		Cobalt-60		Cesium-134		Cesium-137		HTO		OBT		Iodine-131		Total Dose	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Earthworm	2.69E-05	2.69E-05	1.86E-05	2.64E-06	8.09E-06	3.68E-06	3.50E-05	6.84E-06	1.69E-04	1.69E-04	1.70E-05	1.70E-05	1.11E-05	2.85E-06	2.86E-04	2.29E-04
American Robin	2.72E-05	2.72E-05	1.60E-05	3.79E-06	1.15E-05	7.59E-06	3.16E-05	9.33E-06	2.89E-05	2.88E-05	1.44E-06	1.43E-06	8.31E-06	2.15E-06	1.25E-04	8.03E-05
Bank Swallow	2.95E-05	2.95E-05	7.18E-06	1.02E-06	4.01E-06	1.64E-06	1.59E-05	3.12E-06	4.76E-05	4.74E-05	2.31E-06	2.30E-06	4.15E-06	1.07E-06	1.11E-04	8.61E-05
Song Sparrow	4.07E-05	4.07E-05	2.80E-05	8.54E-06	2.47E-05	1.85E-05	5.47E-05	2.01E-05	2.27E-05	2.25E-05	1.21E-06	1.18E-06	1.33E-05	3.46E-06	1.85E-04	1.15E-04
Yellow Warbler	2.92E-05	2.92E-05	7.43E-06	1.27E-06	4.61E-06	2.29E-06	1.64E-05	3.66E-06	4.52E-05	4.50E-05	2.20E-06	2.18E-06	4.15E-06	1.07E-06	1.09E-04	8.48E-05
Terrestrial Plants (Grass)	3.46E-05	3.46E-05	6.71E-05	9.54E-06	3.02E-05	1.37E-05	1.32E-04	2.58E-05	1.63E-04	1.63E-04	1.60E-09	1.60E-09	4.25E-05	1.10E-05	4.69E-04	2.58E-04
Terrestrial Plants (Sugar maple)	3.46E-05	3.46E-05	2.04E-05	2.92E-06	9.00E-06	4.10E-06	3.75E-05	7.33E-06	1.63E-04	1.63E-04	1.60E-05	1.60E-05	1.27E-05	3.30E-06	2.94E-04	2.32E-04
Eastern Cottontail	6.95E-05	6.95E-05	2.97E-05	4.20E-06	1.32E-05	5.80E-06	5.50E-05	1.08E-05	7.24E-05	7.19E-05	3.45E-06	3.39E-06	1.81E-05	4.72E-06	2.61E-04	1.70E-04
Meadow Vole	6.95E-05	6.95E-05	2.96E-05	4.20E-06	1.29E-05	5.74E-06	5.44E-05	1.06E-05	7.24E-05	7.19E-05	3.45E-06	3.39E-06	1.79E-05	4.64E-06	2.60E-04	1.70E-04
White-tailed Deer	6.95E-05	6.95E-05	1.52E-05	2.16E-06	1.11E-05	3.69E-06	3.02E-05	5.91E-06	8.23E-05	8.19E-05	3.88E-06	3.83E-06	9.79E-06	2.69E-06	2.22E-04	1.70E-04
Common Shrew	4.87E-05	4.87E-05	2.96E-05	4.20E-06	1.30E-05	5.82E-06	5.65E-05	1.11E-05	7.24E-05	7.19E-05	3.45E-06	3.39E-06	1.83E-05	4.71E-06	2.42E-04	1.50E-04
Raccoon	5.25E-05	5.25E-05	2.97E-05	4.21E-06	1.42E-05	6.58E-06	5.70E-05	1.17E-05	5.93E-05	5.87E-05	2.73E-06	2.67E-06	1.86E-05	5.06E-06	2.34E-04	1.41E-04
Red Fox	6.55E-05	6.55E-05	2.72E-05	3.85E-06	1.24E-05	5.39E-06	1.07E-04	2.09E-05	4.09E-05	4.02E-05	1.02E-06	9.46E-07	1.65E-05	4.27E-06	2.70E-04	1.41E-04
Short-tailed Weasel	6.95E-05	6.95E-05	2.96E-05	4.20E-06	1.32E-05	5.80E-06	5.49E-05	1.07E-05	3.80E-05	3.72E-05	6.31E-07	5.59E-07	1.80E-05	4.65E-06	2.24E-04	1.33E-04

Note:

No values exceed the terrestrial benchmark of 2.4 mGy/d.

Table 4-33: Estimated Non-Radiological Doses for Riparian Birds at Lake Ontario (mg/kg·d)

COPC	Bufflehead		Mallard	
	Maximum	UCLM	Maximum	UCLM
Barium	8.08E+00	5.83E+00	6.21E+00	4.47E+00
Cesium	4.85E-03	3.63E-03	3.96E-03	2.87E-03
Strontium	5.81E+01	4.05E+01	4.46E+01	3.11E+01
Zinc	5.80E-01	4.31E-01	4.61E-01	3.38E-01
PHC F3	1.82E+01	7.94E+00	1.40E+01	6.09E+00
Benzo(a)pyrene	1.13E-02	2.14E-03	8.65E-03	1.64E-03
Chrysene	1.78E-04	5.37E-05	1.68E-04	4.69E-05
Dibenzo(a,h)anthracene	1.21E-02	2.19E-03	9.26E-03	1.68E-03
Phenanthrene	1.09E-02	2.54E-03	8.33E-03	1.95E-03
Pyrene	1.04E-02	1.58E-03	7.99E-03	1.21E-03

Note:
The doses are calculated from exposure concentrations presented in Table 4-22, following equations presented in Section 4.2.3.

Table 4-34: Estimated Non-Radiological Doses for Birds and Mammals at Polygon AB (mg/kg·d)

COPC	Bufflehead		Mallard		Green Heron		Common Muskrat		American Robin		Bank Swallow		Song Sparrow	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Barium	1.48E+00	1.37E+00	1.12E+00	1.05E+00	9.02E+00	8.09E+00	1.44E+00	1.36E+00	1.40E+01	9.86E+00	3.26E+00	2.71E+00	2.52E+01	1.66E+01
Cadmium	2.88E-03	2.41E-03	5.65E-03	4.71E-03	1.01E+00	1.01E+00	4.60E-02	3.89E-02	1.86E+00	1.04E+00	3.88E-02	3.88E-02	3.05E-02	2.12E-02
Chromium	9.66E-02	6.46E-02	8.32E-02	6.16E-02	2.50E+00	2.48E+00	8.06E-02	7.48E-02	1.99E+00	1.64E+00	2.60E-01	2.34E-01	6.16E-01	4.70E-01
Copper	1.04E-01	7.28E-02	1.94E-01	1.37E-01	4.03E+00	3.95E+00	1.64E+00	1.11E+00	2.68E+00	2.18E+00	4.34E+00	3.14E+00	3.86E+00	2.39E+00
Manganese	1.12E+01	7.82E+00	1.33E+01	9.38E+00	1.68E+01	1.57E+01	9.15E+01	6.38E+01	4.22E+01	3.48E+01	5.62E+00	5.62E+00	1.48E+01	1.07E+01
Nickel	2.09E-02	1.91E-02	2.82E-02	2.69E-02	5.40E+00	5.37E+00	6.36E-02	6.16E-02	1.26E+00	9.97E-01	1.98E-01	1.49E-01	5.23E-01	3.17E-01
Strontium	2.14E+01	2.07E+01	1.75E+01	1.69E+01	4.64E+01	4.25E+01	5.66E+01	5.47E+01	3.22E+01	2.51E+01	1.49E+01	9.15E+00	2.83E+01	2.29E+01
Vanadium	1.65E-01	1.41E-01	1.54E-01	1.34E-01	7.38E+00	7.33E+00	2.68E-01	2.38E-01	2.85E+00	2.31E+00	2.69E-01	2.69E-01	8.20E-01	5.53E-01
Zinc	7.65E-01	5.74E-01	6.76E-01	5.25E-01	8.37E+01	8.13E+01	1.52E+00	1.19E+00	8.35E+01	7.16E+01	1.01E+01	8.10E+00	2.24E+01	1.53E+01

COPC	Yellow Warbler		Eastern Cottontail		Meadow Vole		White-tailed Deer		Common Shrew		Raccoon		Red Fox		Short-tailed Weasel	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Barium	4.97E+00	3.87E+00	1.09E+01	7.12E+00	1.03E+01	6.68E+00	4.74E+00	3.06E+00	7.62E+00	6.14E+00	3.88E+00	2.80E+00	4.99E-01	3.42E-01	4.98E-01	4.95E-01
Cadmium	4.33E-02	4.27E-02	9.82E-03	5.69E-03	8.86E-03	4.83E-03	4.04E-03	2.19E-03	1.01E-01	1.01E-01	9.08E-03	7.96E-03	9.41E-04	6.49E-04	1.58E-03	1.47E-03
Chromium	3.14E-01	2.77E-01	2.64E-01	2.03E-01	2.02E-01	1.42E-01	9.01E-02	6.26E-02	4.69E-01	3.99E-01	1.87E-01	1.60E-01	3.11E-02	2.55E-02	1.14E-01	1.11E-01
Copper	4.87E+00	3.49E+00	1.28E+00	7.54E-01	1.20E+00	6.93E-01	5.52E-01	3.17E-01	1.14E+01	8.19E+00	1.03E+00	7.07E-01	9.17E-02	5.67E-02	1.21E-01	1.03E-01
Manganese	6.87E+00	6.63E+00	6.33E+00	4.53E+00	5.05E+00	3.30E+00	2.27E+00	1.47E+00	1.05E+01	1.05E+01	4.96E+00	4.10E+00	4.44E-01	3.64E-01	2.09E+00	2.08E+00
Nickel	2.43E-01	1.78E-01	2.22E-01	1.36E-01	1.83E-01	9.99E-02	8.28E-02	4.44E-02	3.97E-01	2.67E-01	1.26E-01	9.56E-02	1.79E-02	1.29E-02	6.52E-02	6.31E-02
Strontium	1.75E+01	1.11E+01	1.11E+01	9.33E+00	1.04E+01	8.68E+00	4.77E+00	3.97E+00	3.76E+01	2.24E+01	9.21E+00	7.78E+00	6.26E-01	5.42E-01	9.35E-01	9.22E-01
Vanadium	3.35E-01	3.20E-01	3.66E-01	2.49E-01	2.64E-01	1.50E-01	1.17E-01	6.45E-02	3.46E-01	3.45E-01	2.62E-01	2.27E-01	3.06E-02	2.51E-02	1.73E-01	1.72E-01
Zinc	1.21E+01	9.56E+00	8.92E+00	5.99E+00	8.54E+00	5.68E+00	3.92E+00	2.60E+00	2.63E+01	2.10E+01	6.02E+00	4.28E+00	5.15E+00	3.45E+00	6.93E+00	4.70E+00

Note:

The doses are calculated from exposure concentrations presented in Table 4-23, following equations presented in Section 4.2.3.

Table 4-35: Estimated Non-Radiological Dose for Birds and Mammals at Polygon C (mg/kg·d)

COPC	American Robin		Song Sparrow		Yellow Warbler		Eastern Cottontail		Meadow Vole	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Strontium	9.03E+00	8.82E+00	9.20E+00	8.33E+00	2.88E+00	2.83E+00	3.93E+00	3.54E+00	3.55E+00	3.17E+00

COPC	White-tailed Deer		Common Shrew		Raccoon		Red Fox		Short-tailed Weasel	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Strontium	1.62E+00	1.45E+00	4.70E+00	4.70E+00	1.77E+00	1.66E+00	2.31E-01	2.13E-01	5.45E-01	5.42E-01

Note:
The doses are calculated from exposure concentrations presented in Table 4-24, following equations presented in Section 4.2.3.

Table 4-36: Estimated Non-Radiological Doses for Birds and Mammals at Polygon D (mg/kg-d)

COPC	American Robin		Song Sparrow		Yellow Warbler		Eastern Cottontail		Meadow Vole	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Barium	1.96E+01	1.32E+01	7.61E+00	5.55E+00	2.37E+00	2.24E+00	3.27E+00	2.36E+00	2.92E+00	2.03E+00
Cadmium	4.32E-01	3.60E-01	1.94E-02	1.59E-02	4.25E-02	4.23E-02	4.93E-03	3.37E-03	4.11E-03	2.59E-03
Copper	2.36E+00	2.09E+00	3.00E+00	2.50E+00	3.35E+00	3.32E+00	1.04E+00	8.17E-01	9.71E-01	7.59E-01
Selenium	6.62E-01	4.16E-01	2.10E-02	2.01E-02	4.99E-02	4.99E-02	4.96E-03	4.56E-03	4.10E-03	3.71E-03
Strontium	1.76E+01	1.15E+01	1.51E+01	1.09E+01	7.92E+00	7.67E+00	6.12E+00	4.29E+00	5.62E+00	3.83E+00
Vanadium	2.54E+00	2.35E+00	3.13E-01	3.05E-01	2.41E-01	2.41E-01	1.43E-01	1.39E-01	6.33E-02	5.98E-02

COPC	White-tailed Deer		Common Shrew		Raccoon		Red Fox		Short-tailed Weasel	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Barium	1.33E+00	9.20E-01	3.69E+00	3.69E+00	1.50E+00	1.24E+00	1.81E-01	1.42E-01	5.06E-01	5.05E-01
Cadmium	1.86E-03	1.16E-03	1.01E-01	1.01E-01	9.39E-03	8.95E-03	4.54E-04	3.40E-04	1.39E-03	1.35E-03
Copper	4.45E-01	3.47E-01	7.76E+00	7.76E+00	8.94E-01	8.32E-01	8.86E-02	7.10E-02	1.05E-01	9.73E-02
Selenium	1.85E-03	1.67E-03	1.18E-01	1.18E-01	1.13E-02	1.11E-02	2.87E-03	2.65E-03	3.36E-03	3.18E-03
Strontium	2.57E+00	1.74E+00	1.60E+01	1.60E+01	3.28E+00	2.77E+00	3.67E-01	2.77E-01	7.24E-01	7.12E-01
Vanadium	2.55E-02	2.39E-02	2.52E-01	2.52E-01	1.51E-01	1.50E-01	1.80E-02	1.78E-02	1.41E-01	1.41E-01

Note:
The doses are calculated from exposure concentrations presented in Table 4-25, following equations presented in Section 4.2.3.

Table 4-37: Estimated Non-Radiological Doses for Birds and Mammals at Polygon E (mg/kg·d)

COPC	American Robin		Bank Swallow		Song Sparrow		Yellow Warbler		Eastern Cottontail	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Arsenic	3.42E+00	3.96E-01	4.52E+00	5.23E-01	7.04E+00	8.14E-01	5.25E+00	6.06E-01	2.76E+00	3.19E-01
Cadmium	2.22E+00	2.89E-01	5.86E+00	7.65E-01	2.54E+00	3.32E-01	6.41E+00	8.37E-01	5.38E-01	7.03E-02
Chromium	1.55E+00	3.84E-01	3.39E+00	8.42E-01	1.42E+00	3.54E-01	3.71E+00	9.20E-01	3.54E-01	8.78E-02
Cobalt	1.72E+00	2.13E-01	1.72E+00	2.12E-01	2.71E+00	3.36E-01	1.99E+00	2.47E-01	1.16E+00	1.44E-01
Copper	1.29E+02	1.40E+01	1.60E+02	1.73E+01	3.22E+02	3.48E+01	1.90E+02	2.05E+01	1.28E+02	1.38E+01
Iron	8.84E+02	1.88E+02	1.03E+03	2.18E+02	1.02E+03	2.17E+02	1.16E+03	2.46E+02	4.28E+02	9.10E+01
Lead	1.52E+01	1.76E+00	1.61E+01	1.87E+00	3.56E+01	4.14E+00	1.93E+01	2.25E+00	1.46E+01	1.69E+00
Molybdenum	2.53E+00	2.86E-01	5.34E+00	6.03E-01	3.83E+00	4.32E-01	5.93E+00	6.70E-01	1.19E+00	1.34E-01
Nickel	5.22E+00	8.61E-01	7.04E+00	1.16E+00	1.17E+01	1.93E+00	8.21E+00	1.36E+00	4.56E+00	7.53E-01
Selenium	2.33E+00	2.92E-01	6.75E+00	8.44E-01	1.99E+00	2.49E-01	7.32E+00	9.16E-01	2.08E-01	2.61E-02
Sodium	3.69E+02	7.38E+01	1.07E+03	2.12E+02	2.97E+02	6.03E+01	1.16E+03	2.29E+02	2.72E+01	6.33E+00
Strontium	3.13E+01	1.33E+01	9.94E+00	4.21E+00	1.07E+02	4.55E+01	1.69E+01	7.18E+00	4.68E+01	1.99E+01
Tin	3.17E+00	3.46E-01	2.96E+00	3.22E-01	8.16E+00	8.89E-01	3.64E+00	3.97E-01	3.39E+00	3.69E-01
Zinc	1.74E+03	1.88E+02	3.81E+03	4.14E+02	2.76E+03	3.00E+02	4.24E+03	4.60E+02	8.43E+02	9.15E+01

COPC	Meadow Vole		White-tailed Deer		Common Shrew		Raccoon		Red Fox		Short-tailed Weasel	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Arsenic	2.36E+00	2.73E-01	1.07E+00	1.24E-01	1.07E+01	1.24E+00	2.00E+00	2.32E-01	4.51E-01	5.21E-02	8.49E-01	9.82E-02
Cadmium	5.15E-01	6.73E-02	2.37E-01	3.09E-02	1.56E+01	2.03E+00	1.27E+00	1.66E-01	4.03E-02	5.27E-03	3.20E-02	4.18E-03
Chromium	1.56E-01	3.87E-02	6.29E-02	1.56E-02	8.29E+00	2.06E+00	9.22E-01	2.29E-01	6.06E-02	1.50E-02	3.57E-01	8.87E-02
Cobalt	7.30E-01	9.03E-02	3.17E-01	3.92E-02	2.98E+00	3.68E-01	1.03E+00	1.27E-01	1.09E-01	1.35E-02	7.43E-01	9.19E-02
Copper	1.19E+02	1.28E+01	5.44E+01	5.87E+00	4.04E+02	4.36E+01	7.21E+01	7.78E+00	1.10E+01	1.19E+00	1.46E+01	1.58E+00
Iron	1.78E+02	3.78E+01	7.06E+01	1.50E+01	1.78E+03	3.79E+02	5.44E+02	1.15E+02	8.07E+01	1.72E+01	4.55E+02	9.66E+01
Lead	1.27E+01	1.48E+00	5.79E+00	6.72E-01	3.71E+01	4.31E+00	8.49E+00	9.86E-01	8.75E-01	1.02E-01	2.79E+00	3.24E-01
Molybdenum	1.05E+00	1.19E-01	4.79E-01	5.41E-02	1.38E+01	1.56E+00	1.44E+00	1.63E-01	7.12E-02	8.12E-03	2.02E-01	2.30E-02
Nickel	4.12E+00	6.81E-01	1.88E+00	3.11E-01	1.75E+01	2.88E+00	2.93E+00	4.83E-01	3.57E-01	5.89E-02	7.02E-01	1.16E-01
Selenium	1.88E-01	2.35E-02	8.56E-02	1.07E-02	1.79E+01	2.24E+00	1.38E+00	1.72E-01	1.20E-01	1.50E-02	1.20E-01	1.50E-02
Sodium	2.34E+01	6.03E+00	1.04E+01	2.69E+00	2.81E+03	5.51E+02	2.15E+02	4.29E+01	6.82E+00	2.23E+00	1.49E+01	4.15E+00
Strontium	4.38E+01	1.86E+01	2.00E+01	8.52E+00	1.85E+01	7.88E+00	1.66E+01	7.08E+00	2.59E+00	1.10E+00	3.87E+00	1.64E+00
Tin	3.03E+00	3.30E-01	1.38E+00	1.50E-01	6.80E+00	7.41E-01	1.80E+00	1.96E-01	3.76E-01	4.09E-02	6.66E-01	7.25E-02
Zinc	7.98E+02	8.66E+01	3.66E+02	3.97E+01	1.01E+04	1.09E+03	1.16E+03	1.26E+02	7.53E+02	8.18E+01	6.64E+02	7.20E+01

Note:

The doses are calculated from exposure concentrations presented in Table 4-26, following equations presented in Section 4.2.3.

4.2.6.2.1 Darlington Waste Management Facility

The dose rate for ecological receptors in close proximity to the DWMF (approximately 5 m from any wall) could be up to 1 $\mu\text{Gy/h}$ (0.024 mGy/d), assuming full capacity of the DWMF (OPG, 2016a).

The dose rate to any ecological VEC at the DWMF property boundary could be up to 0.5 $\mu\text{Gy/h}$ (0.012 mGy/d), assuming full capacity of the DWMF (OPG, 2016a). Based on measured dose rates at the DWMF property boundary from 2016 to 2019, the average dose rate was 0.08 $\mu\text{Gy/h}$ (0.002 mGy/d). The average dose rate at the RWSB perimeter was 0.06 $\mu\text{Gy/h}$ (0.0014 mGy/d) based on the 2017 to 2019 monitoring results.

The above dose rates estimated for ecological receptors are conservative as it assumes the receptor is always located at the DWMF and does not incorporate an occupancy factor based on the fraction of time a receptor is likely to be in close proximity to the DWMF. Based on expected radiological dose rates to ecological receptors in Polygon E (Table 4-32) located on the DN site, the dose from the DWMF at full capacity, would be the largest contributor to total dose.

4.2.7 Uncertainties in Exposure Assessment

Uncertainties in the exposure assessment include the representativeness of media concentrations used in the assessment at each location. The UCLM concentrations of COPCs were used for each location and media, where possible, and are considered to be representative for all mobile receptors. Maximum concentrations found in various sources were also used as an upper bound on exposure. These values are, by definition, not representative for mobile organisms that can move around the site, effectively averaging their exposure concentrations. Maximum values are representative for exposures of any sessile organisms that reside at the location of the maximum value.

Although the majority of data comes from measured values, BAFs were used to calculate uptake into tissues. In some cases, BAFs for a species of interest or a certain COPC were unavailable, and surrogate values were used, e.g., fish values used for frog; the soil to Earthworm BAF for lead was used for tin. The BAFs used for the exposure assessment were not site-specific, and were taken from reputable sources and are considered to be representative of the conditions found at the site.

Wildlife exposure factors, such as intake rates and diets, are a potential source of uncertainty. Reputable sources are used for these factors and are considered to be representative of the organisms assessed.

Dose coefficients were obtained from reputable sources for reference organisms, but have not been derived specifically for all the organisms assessed. Dose coefficients for surrogate organisms were often used. They were selected with attention to similar body size and exposure habits, and are believed to adequately represent the organism

assessed. Dose coefficients for each receptor were not adjusted for body size and dimensions.

A radiation weighting factor (RBE) of 2 was applied to the low beta component of the tritium DCs, as recommended by CSA N288.6; however, a range of 1 to 3 is used in the literature. Therefore, the tritium internal dose coefficient for all ecological receptors presented in Table 4-18 could be either higher or lower, modified by factors of 1.43 or 0.57, respectively.

Radiation doses were calculated from measured concentrations of radionuclides such as cobalt-60, cesium-134, and cesium-137 in water. When only censored data were available for older data, the majority of samples resulted in concentrations below the detection limit. Doses were calculated assuming these concentrations were at the detection limit. This is a conservative assumption and doses resulting from these radionuclides are likely lower than presented.

Uncertainty in the HTO air and soil pore water predictions arises from inherent uncertainty in the air model in IMPACT. The model reports an average concentration, and typically over-predicts this concentration by a factor of 1.5 (COG, 2013a). Uncertainty in the predictions arises from the following assumptions made in the air model:

- The activity in the plume has a normal distribution in the vertical plane;
- The effects of building-induced turbulence on the effective release height and plume spread have been generalized, while data suggest that effects of building wakes vary substantially depending upon the geometry of the buildings and their orientation with respect to wind direction.
- A given set of meteorological and release conditions leads to a unique air concentration, where in reality measured concentrations can vary by a factor of 2 under identical conditions.

The main uncertainties associated with the exposure assessment are summarized in Table 4-38.

Table 4-38: Summary of Major Uncertainties in the Ecological Exposure Assessment

Risk Assessment Assumption	Justification	Over/Under Estimate Risk?
BAFs, intake rates, etc. are from literature when measured information was not available	Reputable literature sources were used	Neither (value is best estimate)
BAF (fish) for hydrazine is based on QSAR model and not measured bioaccumulation data.	Limited information exists on bioaccumulation of hydrazine, although it is expected to be low. Only one study (Slonim and Giscard, 1976) exists on hydrazine bioaccumulation, and there is large uncertainty surrounding the methods and results.	Neither (value is best estimate)
Dose coefficients for each receptor were not adjusted for exact VEC body size and dimensions	Surrogates selected with attention to similar body size and exposure habits,	Neither (value is best estimate)

4.3 Effects Assessment

The potential for ecological effects from COPC exposure at each location (Section 4.1) was assessed by comparing the exposure levels to toxicological, radiation, and thermal benchmarks. These benchmarks values (BVs) are taken from literature and are compared to the exposure values (EVs) to determine the potential for adverse ecological effects. The assessment and measurement endpoints used for the effects assessment for the listed VECs are described in Section 4.1.3.

4.3.1 Toxicological Benchmarks

All aquatic benchmarks for fish, aquatic plants and benthic invertebrates are summarized in Table 4-39. The benchmarks were obtained from Suter and Tsao (Suter and Tsao, 1996), CCME (1999), Fargasova et al., (1999), Borgmann et al. (Borgmann et al., 2005), BC MOE (BC MOE, 2008), MECP (2011), EC (EC, 2013a), WHO (WHO, 1996, 2001), and the U.S. EPA ECOTOX AQUIRE database. In cases where a chronic benchmark was not found and an acute benchmark was available, the acute benchmark was converted to a chronic benchmark by dividing by a factor of 10. This conversion factor has been used to derive the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 1999), and is the most conservative factor cited in Suter et al. (1993).

Consistent with CSA and FCSAP guidance (CSA, 2012; FCSAP, 2012), assessment of benthic invertebrates, toxicity benchmarks have been presented as water concentrations. Considering that benthic invertebrates also reside in sediment, sediment toxicity benchmarks are presented for COPCs with MECP Lowest Effect Levels (LELs) for assessment of benthic invertebrates (MOE, 2011; MOEE, 1993). In the absence of these

objectives and guidelines, sediment screening benchmarks were obtained from Thompson et al. (2005) for vanadium. These benchmarks are summarized in Table 4-40.

Cadmium, copper, selenium, and vanadium were identified as COPCs in the sediment, but not the surface water for Treefrog Pond located at Polygon D. Because the benthic invertebrates are not considered VECs for this Polygon, exposure and risks from these COPCs via the sediment was not considered for Treefrog Pond.

Sediment benchmarks for cesium, strontium and PHC F3 are not available. These three COPCs will be assessed qualitatively in Section 4.4.2.

Table 4-39: Toxicological Benchmarks for Aquatic Receptors

COPC	Receptor	Water TRV (mg/L)	Endpoint	Test Species	Reference
Ammonia (un-ionized; as NH ₃)	Fish and Frog	1.70E-03	LCV	Pink Salmon (<i>Oncorhynchus gorbuscha</i>)	Rice and Bailey, 1980 (cited in Suter and Tsao, 1996)
	Benthic Invertebrate	6.30E-01	LCV	Daphnia magna	EPA, 1985 (cited in Suter and Tsao, 1996)
	Aquatic Plants	2.40E+00	LCV	Chlorella vulgaris	EPA, 1985 (cited in Suter and Tsao, 1996)
Barium	Fish and Frog	5.00E+01	acute LC50 converted to chronic LC50	Sheepshead minnow (<i>Cyprinodon variegatus</i>)	Heitmuller et al., 1981 (cited in WHO, 2001)
	Benthic Invertebrate	3.15E-01	1-week (acute)LC50/10 to convert to chronic	Hyalella azteca	Borgmann et al., 2005
	Aquatic Plants	2.30E+00	91.3-day LOEL (growth)	Chlorella vulgaris	De Jong 1985 (cited in MOE, 2011)
Cadmium	Fish and Frog	1.70E-03	LCV	Early life stage test on brook trout (<i>Salvelinus fontinalis</i>)	Sauter et al., 1976 (cited in Suter and Tsao, 1996)
	Benthic Invertebrate	1.50E-04	LCV	Reproduction for Daphnia magna	Chapman et al., n.d. (cited in Suter and Tsao, 1996)
	Aquatic Plants	2.00E-03	LCV (LOEL)	Growth of <i>Asterionella formosa</i>	Conway, 1977 (cited in Suter and Tsao, 1996)
Copper	Fish and Frog	3.80E-03	LCV	Early life stage test on brook trout (<i>Salvelinus fontinalis</i>)	Sauter et al., 1976 (cited in Suter and Tsao, 1996)
	Benthic Invertebrate	6.07E-03	LCV	<i>Gammarus pseudolimnaeus</i>	Arthur and Leonard, 1970, (cited in Suter and Tsao, 1996)
	Aquatic Plants	1.00E-03	LCV	Growth of <i>Chlorella pyrenoidosa</i>	Steeman-Nielsen and Wium-Anderson, 1970 (cited in Suter and Tsao, 1996)
Iron	Fish and Frog	1.30E+00	LCV	Rainbow trout (<i>Oncorhynchus mykiss</i>)	Amelung, 1981 (cited in Suter and Tsao, 1996)
	Benthic Invertebrate	3.00E-00	The safe concentration for reproduction and growth	<i>Gammarus minus</i>	Sykora et al., 1975 (Cited in MOE1979)
	Aquatic Plants	1.49E+00	acute value converted to chronic	<i>Lemna minor</i>	Wang, 1986 (cited in BC MOE, 2008)
Zinc	Fish and Frog	3.64E-02	LCV	Life-cycle tests with <i>Jordanella floridae</i>	Spehar, 1976 (cited in Suter and Tsao, 1996)
	Benthic Invertebrate	4.67E-02	LCV	Daphnia magna	Chapman et al., n.d. (cited in Suter and Tsao, 1996)
	Aquatic Plants	3.00E-02	LCV	7-day growth tests with <i>Selenastrum capricornutum</i>	Bartlett et al., 1974 (cited in Suter and Tsao, 1996)

Notes:

LCV: Lowest Chronic Value

LOEL: Lowest Observed Effect Level

LC₅₀: Lethal Concentration of 50%

Table 4-40: Toxicological Benchmarks for Benthic Invertebrates

COPC	Benthic Invertebrate (Sediment) Benchmark (mg/kg dw)	Reference
TKN	5.50E+02	Sediment LEL (MOE, 2011)
TOC	1.00E+04	Sediment LEL (MOE, 2011)
Cadmium	6.00E-01	Sediment LEL (MOE, 2011)
Chromium	2.60E+01	Sediment LEL (MOE, 2011)
Cesium	nd	nd
Copper	1.60E+01	Sediment LEL (MOE, 2011)
Iron	2.12E+04	Sediment LEL (MOE, 1993)
Manganese	4.60E+02	Sediment LEL (MOE, 1993)
Nickel	1.60E+01	Sediment LEL (MOE, 2011)
Strontium	nd	nd
Vanadium	3.50E+01	Sediment LEL (Thompson et al., 2005)
Zinc	1.20E+02	Sediment LEL (MOE, 2011)
Phosphorous	6.00E+02	Sediment LEL (MOE, 1993)
PHC-F3	nd	nd
Benzo(a)pyrene	3.70E-01	Sediment LEL (MOE, 2011)
Dibenzo(a,h)anthracene	6.00E-02	Sediment LEL (MOE, 2011)
Chrysene	3.40E-01	Sediment LEL (MOE, 2011)
Phenanthrene	5.60E-01	Sediment LEL (MOE, 2011)
Pyrene	4.90E-01	Sediment LEL (MOE, 2011)

Note:

nd- No Data. Cesium, Strontium and PHC F3 for benthic invertebrates are qualitatively assessed in Section 4.4.2.

LEL: Lowest Effect Level

Terrestrial plant and soil invertebrate benchmarks are based on soil concentrations. The values are Canadian soil quality guidelines (agricultural soil contact values) (CCME, 1999), provincial soil quality guidelines (residential/parkland plant and soil organism values) (MOE, 2011) or Lowest Observable Effect Concentration (LOEC) soil concentrations from Efroymsen et al. (1997a,b). The Efroymsen values are specific to either Earthworms (1997a) or plants (1997b) and are conservative values.

There are no guidelines available for strontium, and no values are provided by Efroymsen (1997a,b). A WHO (2010) report on strontium cites an effect level for invertebrates of 10,600 mg/kg. This effect level is used as a benchmark for soil invertebrates. A benchmark for strontium for terrestrial plants was estimated from the study of Hara et al. (1977) that found symptoms of injury to cabbage plants exposed to strontium in culture water at a water concentration of 25 mg/L (LOEC). In order to estimate a LOEC for strontium soil concentrations, the strontium LOEC of 25 mg/L was multiplied by the K_d of 69 L/kg dw for loam soils reported in CSA (2014). This estimated LOEC soil concentration of 1725 mg/kg dw was used as the benchmark for terrestrial plants.

There are no guidelines available for tin, and no values reported in Efroymsen (1997b) for soil invertebrates. As such, a soil invertebrate benchmark for tin was not selected. However, Efroymsen (1997b) reports a LOEC of 50 mg/kg for plants. This LOEC is used as a benchmark for terrestrial plants.

There are no guidelines or toxicological benchmarks for iron for terrestrial biota. This COPC will be discussed qualitatively in Section 4.4.2. The terrestrial plant and soil invertebrate benchmarks are summarized in Table 4-41.

Table 4-41: Toxicological Benchmarks for Soil for Terrestrial Invertebrates and Plants

Parameter	Soil Organism TRV mg/kg dw	Reference	Plant TRV mg/kg dw	Reference
Arsenic	6.00E+01	Efroymsen, 1997a	2.00E+01	MOE, 2011
Cadmium	2.00E+01	Efroymsen, 1997a	1.20E+01	MOE, 2011
Chromium	3.10E+02	MOE, 2011	3.10E+02	MOE, 2011
Cobalt	4.00E+01	MOE, 2011	4.00E+01	MOE, 2011
Copper	1.40E+02	MOE, 2011	1.40E+02	MOE, 2011
Iron	nd	nd	nd	nd
Lead	5.00E+02	Efroymsen, 1997a	2.50E+02	MOE, 2011
Molybdenum	4.00E+01	MOE, 2011	4.00E+01	MOE, 2011
Nickel	1.00E+02	MOE, 2011	1.00E+02	MOE, 2011
Selenium	1.00E+01	MOE, 2011	1.00E+01	MOE, 2011
Sodium	nd	nd	nd	nd
Strontium	1.06E+04	WHO, 2010	1.73E+03	Hara et al., 1977

Parameter	Soil Organism TRV mg/kg dw	Reference	Plant TRV mg/kg dw	Reference
Tin	nd	nd	5.00E+01	Kabata-Pendias and Pendias, 1984 as cited in Efroymsen et al., 1997
Zinc	2.00E+02	Efroymsen, 1997a	2.00E+02	CCME, 1999a
PHC-F4	4.80E+03	CCME 2008	9.10E+03	CCME 2008

Note:

nd- No Data. The risk of iron, sodium and tin for soil organisms are qualitatively assessed in Section 4.4.2.

The mammal and bird benchmarks used are summarized in Table 4-42 and Table 4-43, respectively.

The benchmark values for birds and mammals (riparian and terrestrial) are based on doses. The benchmark doses used are the LOAEL values from Sample *et al.* (1996) for mammals and birds, the U.S. EPA (2005) for barium and cobalt for mammals, and the U.S. EPA (2005) for cobalt for birds. There were no data available for the toxicity of iron and sodium for mammals, and cesium, iron, sodium, strontium, PHC F3, and PAHs for birds.

Phosphorus was considered to be essentially non-toxic and not directly bioavailable for mammals and birds. Phosphorus is an essential nutrient for normal muscle growth in animals and egg formation in birds and is important for the transfer and utilization of energy (Li et al., 2016). Exposure to bioavailable forms of phosphorus for birds and mammals is through the food chain. Phosphorus is actively regulated in birds and mammals with excess phosphorus being excreted in urine and feces.

Adverse health effects for birds and mammals are not expected from elevated levels of iron in surface water. Iron is generally present in surface water as salts in its trivalent form (Fe_3^+) when the pH is above 7 (HC, 1978). Most of the iron salts are insoluble and settle to or become bound to the sediments. Therefore, most iron in surface water is associated with particulate matter and is not bioavailable. Absorption of iron in the body (mammals and birds) is regulated, and very little is metabolised. Iron ingested from drinking water is efficiently expelled from the body (HC, 1978).

Additionally, adverse health effects for birds and mammals are not expected from ammonia in surface water. When ammonia is dissolved in water, it exists in two forms simultaneously: the non-ionized form (NH_3) and the ammonium cation (NH_4^+). The equilibrium between the two species is governed in large part by pH and temperature. The sum of the two forms is known as total ammonia (HC, 2013). Ammonia is produced in the body and efficiently metabolized in healthy individuals (HC, 2013). The odour threshold for ammonia in water is 1.5 mg/L (HC, 2013). Concentrations above 1.5 mg/L may provoke avoidance behaviours for mammals and birds and thereby limit ingestion of surface water with elevated levels of ammonia, because of undesirable odour and taste in the water.

Overall, TRVs for birds and mammals for the major ions, phosphorus, iron, and ammonia are not warranted.

Because mammals were not identified as VECs for the Lake Ontario Polygon, mammal benchmarks for Lake Ontario COPCs are not listed in Table 4-42.

Table 4-42: Selected Toxicity Reference Values for Mammals (Riparian and Terrestrial)

Parameter	TRV (LOAEL) mg/kg bw/day	Test Species	Test Duration	Reference
Arsenic	1.26	Mouse	3 generations (>1 yr)	Schroeder and Mitchner 1971 (cited in Sample et al., 1996)
Barium	1.21E+02	Rat	92 days	Dietz <i>et al.</i> , 1992 (cited in U.S. EPA, 2005)
Cadmium	10	Rat	6 weeks through mating and gestation	Sutou et al. 1980 (cited in Sample et al., 1996)
Chromium	2.74E+03	Rat	2 years	Ivankovic and Preussmann, 1975 (cited in Sample et al., 1996)
Cobalt	8.76E+00	Mouse	12 weeks	Haga <i>et al.</i> , 1996 (cited in the U.S. EPA 2005b)
Copper	1.51E+01	Mink	357 days	Aulerich et al., 1982 (cited in Sample et al., 1996)
Iron	nd	nd	nd	Nd
Lead	8.00E+01	Rat	3 generations	Azar <i>et al.</i> , 1973 (cited in Sample <i>et al.</i> , 1996)
Manganese	2.84E+02	Rat	critical life stage (224 days)	Laskey et al., 1982 (cited in Sample et al., 1996)
Molybdenum	2.60E+00	Mouse	> 1 yr and during critical lifestage	Schroeder and Mitchner 1971 (cited in Sample et al., 1996)
Nickel	8.00E+01	Rat	> 1 yr and during critical lifestage	Ambrose et al. 1976 (cited in Sample et al., 1996)
Selenium	3.30E-01	Rat	1 year, through 2 generations	Rosenfeld and Beath 1954 (cited in Sample et al., 1996)
Strontium	2.63E+02	Rat	3 years	Skoryna, 1981 ((cited in Sample et al., 1996)
Vanadium	2.10E+00	Rat	60 days prior to gestation, during gestation, delivery and lactation	Domingo et al., 1986 (cited in Sample et al., 1996)
Tin	3.50E+01	Mouse	days 6-15 of gestation	Davis et al., 1987 (cited in Sample et al., 1996)
Zinc	3.20E+02	Rat	days 1-16 of gestation	Schlicker and Cox, 1968 (cited in Sample et al., 1996)
Sodium	nd	nd	nd	Nd

Notes:

nd = no data available. The risk of iron and sodium for mammals were qualitatively assessed in Section 4.4.2.
The chromium and strontium TRVs are NOAELs because LOAELs are not available

Table 4-43: Selected Toxicity Reference Values for Birds

Parameter	TRV (LOAEL) mg/kg bw/day	Test Species	Endpoint	Test Duration	Reference
Arsenic	7.38E+00	Brown-headed Cowbird	Mortality	7 months	USFWS 1969 (cited in Sample et al., 1996)
Barium	4.17E+01	1-day old chicks	mortality	4 weeks	A LOAEL-NOEL uncertainty factor of 0.1 was added to the sub-chronic study; Johnson et al. 1960 (cited in Sample et al., 1996)
Cadmium	2.00E+01	Mallard Duck	Reproduction	90 days	White and Finley 1978 (cited in Sample et al., 1996)
Cesium	nd	nd	nd	Nd	nd
Chromium	5.00E+00	Black Duck	Reproduction	critical life stage (10 months)	Haseltine et al., unpubl. Data, (cited in Sample et al., 1996)
Cobalt	7.80E+00	Chicken	growth	5 week	Hill, 1979 as cited in the U.S. EPA Eco SSL, 2005
Copper	6.17E+01	1 day old chicks	growth, mortality	10 weeks	Mehring <i>et al.</i> , 1960 (cited in Sample <i>et al.</i> , 1996)
Iron	nd	nd	nd	Nd	nd
Lead	1.13E+01	Japanese Quail	reproduction	12 weeks	Edens <i>et al.</i> , 1976 (cited in Sample et al., 1996)
Molybdenum	3.53E+01	Chicken	Reproduction	21 day through reproduction	Lepore and Miller 1965 (cited in Sample et al., 1996)
Manganese	9.77E+02	Japanese quail	growth, aggressive behaviour	75 days	Laskey and Edens, 1985 (cited in Sample et al., 1996)
Nickel	1.07E+02	Mallard duckling	mortality, growth, behavior	90 day	Cain and Pafford 1981 (cited in Sample et al., 1996)
Selenium	8.00E-01	Mallard duckling	Reproduction	100 days	Heinz et al. 1989 (cited in Sample et al., 1996)
Sodium	nd	nd	nd	Nd	nd
Strontium	nd	nd	nd	Nd	nd
Vanadium	1.14E+01	Mallard Duck	mortality, body weight, blood chemistry	12 weeks	White and Dieter, 1978 (cited in Sample et al., 1996)
Tin	1.69E+01	Japanese Quail	reproduction	6 weeks	Schlatterer et al., 1993 (cited in Sample et al., 1996)
Zinc	1.31E+02	White Leghorn hens	Reproduction	44 weeks	Stahl et al., 1990 (cited in Sample et al., 1996)
PHC F3	nd	nd	nd	Nd	nd

Parameter	TRV (LOAEL) mg/kg bw/day	Test Species	Endpoint	Test Duration	Reference
Benzo(a)pyrene	nd	nd	nd	Nd	nd
Chrysene	nd	nd	nd	Nd	nd
Dibenzo(a,h)anthracene	nd	nd	nd	Nd	nd
Phenanthrene	nd	nd	nd	Nd	nd
Pyrene	nd	nd	nd	Nd	nd

Notes:

nd = no data available. Parameters without benchmarks were qualitatively assessed in Section 4.4.2.

The manganese and vanadium TRVs are NOAELs because LOAELs are not available.

The barium and cobalt TRVs are sub-chronic values divided by 10 to convert to chronic.

4.3.2 Radiation Benchmarks

Radiation dose benchmarks of 400 $\mu\text{Gy/h}$ (9.6 mGy/d) and 100 $\mu\text{Gy/h}$ (2.4 mGy/d) (UNSCEAR, 2008) were selected for the DN assessment of effects on aquatic biota and terrestrial biota, respectively, as recommended in the CSA N288.6-12 standard. This is a total dose benchmark, therefore the dose to biota due to each radionuclide of concern is summed to compare against this benchmark.

The aquatic biota dose benchmark of 10 mGy/d was initially developed by the NCRP (NCRP, 1991) and was recommended by the IAEA which concluded that limiting the dose rate to individuals in an aquatic population to a maximum of 10 mGy/d would provide adequate protection for the population (IAEA, 1992). Later reviews by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) have supported this recommendation (UNSCEAR, 1996, 2008).

The aquatic biota considered by UNSCEAR are organisms such as fish and benthic invertebrates that reside in water. Birds and mammals with riparian habits are considered to be terrestrial biota. Dose calculations in this ERA follow the same convention.

For terrestrial biota, a level of 1 mGy/d has been widely used as an acceptable level based on IAEA and UNSCEAR (IAEA, 1992; UNSCEAR, 1996). More recently, UNSCEAR has supported a slightly higher exposure level of 100 $\mu\text{Gy/h}$ (2.4 mGy/d) as the threshold for effects of population significance in terrestrial organisms (UNSCEAR, 2008). UNSCEAR updated its review of radiation effects on natural biota, and noted that the 0.04 mGy/h (1 mGy/d) exposure produced no effect in the most sensitive mammalian study (with dogs), while 0.18 mGy/h produced eventual sterility (UNSCEAR, 2008). Therefore, UNSCEAR chose an intermediate exposure level of 0.1 mGy/h (2.4 mGy/d) as the threshold for effects of population significance in terrestrial organisms. UNSCEAR concluded that lower dose rates to the most highly exposed individuals would be unlikely to have significant effects on most terrestrial communities.

It is recognized that the selection of reference dose levels is a topic of ongoing debate. For example, the CNSC has recommended dose limit values of 0.6 mGy/d for fish, 3 mGy/d for aquatic plants (algae and macrophytes), 6 mGy/d for invertebrates, and 3 mGy/d for mammals and terrestrial plants (EC/HC, 2003). The dose limit value for fish was based on a reproductive effects study in carp in a Chernobyl cooling pond with a history of higher exposures (Makeyeva et al., 1995). A value of 0.6 mGy/d was found to be in the range where both effects and no effects were observed. The aquatic plant benchmark was based on information related to terrestrial plants (conifers), which are considered to be sensitive to the effects of radiation. Reproductive effects in polychaete worms were used to derive the dose limit for benthic invertebrates.

The International Commission on Radiological Protection (ICRP) has suggested “derived consideration levels” as a range of dose rates reflecting a range in potential for effect, for

each of several taxonomic groups (ICRP, 2008). The ICRP states that the ranges of dose rates they provide are preliminary and need to be revised as more data become available.

Considering the history and discussions surrounding the selection of radiation benchmarks, 400 $\mu\text{Gy/h}$ (9.6 mGy/d) and 100 $\mu\text{Gy/h}$ (2.4 mGy/d) (UNSCEAR, 2008) were selected for the assessment of effects on aquatic biota and terrestrial biota, respectively. These benchmarks were recommended in CSA N288.6 (CSA, 2012), and are appropriate for this assessment.

4.3.3 Thermal Benchmarks

Golder (2012b) cited an optimal temperature range of 1°C to 5°C for Round Whitefish embryos (Wismer and Christie, 1987) and a continuous ΔT of 3.5°C or a periodic (6h/day) ΔT of 5°C (Griffiths, 1980) as being consistent with adequate embryonic survival over the winter embryo development period. More recent studies of Round Whitefish embryo survival (Patrick et al., 2014) found that a reduction to 90% survival required a ΔT of 3.7°C as an average over the embryonic period.

In 2016, OPG, with the assistance from Professor M. Pandey at the University of Waterloo, developed a hybrid thermal response model for early development of Round Whitefish using the lower temperature exposures from the COG (2014) study (as low as 3.25 °C) and the higher temperature exposures of the Griffiths (1980) study (as high as 9.68 °C), to be included in the monitoring plan for the DNGS thermal study in 2017-2018. Additional model development was performed to address regulator comments on the monitoring plan. The data sets represented the use of fixed and variable temperatures as well as data considering biological life-cycle imperatives. Threshold temperature, defined as the temperature that corresponds to a 90% probability of survival, was estimated for each model assessed. Results suggested little variability among the various models examined. For the most comprehensive dataset that includes 15 treatments, the predicted threshold temperature was 6.2 °C. A threshold temperature of 6.3°C was predicted based on a dataset which was considered most realistic based on visual inspection and biological arguments. In 2017, OPG, ECCC and CNSC agreed to a threshold temperature of 6 °C based on the hybrid model presented above to be used for the DNGS thermal plume monitoring study in 2017-18 (OPG, 2017a). This threshold temperature (6 °C) is also used to assess thermal effects in the current ERA.

COG (2017) summarized and consolidated findings from the COG 2014 report with the literature on the thermal effects on whitefish eggs, and developed science-based thermal benchmarks. Critical thermal methods (CTM) with CT_{Min} and CT_{Max} for minimum and maximum values, and incipient lethal temperatures (ILT), were recommended as acute thermal toxicity benchmarks for whitefish. The mean weekly average temperature (MWAT) was not recommended as a whitefish thermal benchmark due to ambient temperature variability and problematic assumptions. Although the short-term maximum (ST_{max}) is more conservative than the MWAT, it uses the upper incipient lethal temperature (UILT) and assumes that a value 2°C lower will be protective. However, it is unknown if this

temperature has no effect or potentially causes immobility or death with chronic exposure. For these reasons, this benchmark was also not recommended. A delta T value of $\Delta 3^{\circ}\text{C}$ above ambient temperature was recommended as a conservative benchmark for Round Whitefish, lower than the previously suggested 3.7°C . The new benchmark of $\Delta 3^{\circ}\text{C}$ was used in assessment of potential for thermal effects on Round Whitefish embryos in the vicinity of the DN thermal discharge.

SENEC (2011e) and Golder (2010) considered MWATs in the vicinity of the DN thermal discharge, and compared these to MWAT criteria for other fish species known to occur in the area, including emerald shiner, Alewife, White Sucker and Lake Trout. The MWAT criteria are species-specific values below which thermal conditions are considered suitable, either for growth of juveniles and adults, or for embryonic development (US EPA, 1977). The relevant MWAT criteria are shown in Table 4-44.

Ecometrix performed a literature review to summarize thermal benchmarks for ECCC as an update to Canada's guidance document for Environmental Effects Assessment of Freshwater Thermal Discharge (ECCC, 2019; Ecometrix, 2016). In this document, thermal benchmarks were summarized for a wide range of species from published literature and government documents. CTM and ILT were recommended benchmarks for acute thermal toxicity measurements for a wide variety of warmwater, coolwater and coldwater species. The Chronic Lethal Methodology (CLM) test was also recommended as it is more realistic relative to thermal plumes, although data is limited for this relatively new benchmark. Thermal benchmarks for a few ecological VECs, including Alewife, White Sucker, and Lake Trout were summarized in that document. The most conservative values presented in the document are summarized in Table 4-44.

Table 4-44: Thermal Benchmarks for Fish VEC in Lake Ontario other than Round Whitefish

Fish Species	UILT ($^{\circ}\text{C}$) ¹	CT _{max} ($^{\circ}\text{C}$) ¹	MWAT Criteria for Growth ($^{\circ}\text{C}$) ²	MWAT Criteria for Embryos ($^{\circ}\text{C}$) ²	Embryonic Period ²
Alewife	22.8	28.3	N/A ³	22	April-July
White Sucker	28.1	31.6	28	N/A ⁴	N/A
Lake Trout	14.8	ND ⁵	N/A ³	9	Dec-April

Notes:

1. Ecometrix (2016).
2. USEPA (1977).
3. Alewife and Lake trout move offshore soon after hatching; conditions near DN not relevant to their growth.
4. White suckers spawn in tributaries; conditions near DN discharge not relevant to their embryonic period.
5. ND: No CTmax is reported in Ecometrix (2016).

4.3.4 Uncertainties in the Effects Assessment

Toxicological benchmarks used in the risk assessment were selected from sources recommended in the CSA N288.6 standard (CSA, 2012), and other reputable sources. These BVs represent the low end of threshold effect levels in literature for each receptor category. BVs for the test species were not adjusted for body weight and were considered directly applicable to the wildlife species. The BVs are considered to be conservatively representative of the effect threshold for the COPC for the receptor of interest. There is

uncertainty because most species of interest have not been tested to determine their effect thresholds. Nevertheless, it is expected that few species will be much more sensitive than indicated by the selected benchmark values.

Also, toxicological benchmarks are not available for certain COPCs (e.g., strontium for terrestrial birds and terrestrial plants or tin for soil organisms), therefore no quantitative assessment could be carried out. Without the benchmark value, it is difficult to determine potential quantitative effects for these biota; however, in these cases a qualitative assessment was carried out.

While there is uncertainty related to some low values that have been suggested as radiation dose benchmarks based on field studies around Chernobyl, the radiation dose benchmarks chosen follow UNSCEAR and CSA N288.6-12 (CSA, 2012; UNSCEAR, 2008) in giving more credence to values based on controlled laboratory studies and demonstrated low levels of effect.

Thermal benchmarks represent a variety of species, life stages and endpoints, and vary among literature sources. Selected values vary among literature sources and have varied somewhat among studies of thermal effects at Darlington.

4.4 Risk Characterization

4.4.1 Risk Estimation

Ecological risk from radiological COPCs is assessed through comparison with the benchmarks of 2.4 mGy/d and 9.6 mGy/d for terrestrial and aquatic biota, respectively. The dose to considered VECs from all pathways is presented in Table 4-45. For non-radiological COPCs, the ecological risk is estimated by dividing the EV (Section 4.2.6) by the BV (Section 4.3) for a given COPC and receptor species, yielding a HQ. When the EV for an organism at a site exceeds the BV ($HQ > 1$), a potential for adverse ecological effects is inferred, with bolded/shaded values indicating benchmark exceedances. A summary of non-radiological HQs for each receptor by COPC and polygon is presented in Table 4-46 through Table 4-50.

Table 4-45: Summary of Total Radiation Dose Estimates for VECs for Lake Ontario, Polygon AB, C, D, and E (mGy/d)

Receptor	Lake Ontario		AB		C		D		E	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Round Whitefish	5.43E-05	5.18E-05	-	-			-	-	-	-
White Sucker	3.87E-05	3.39E-05	-	-	-	-	-	-	-	-
Alewife	8.43E-05	8.33E-05	-	-	-	-	-	-	-	-
Lake Trout	2.21E-02	3.95E-03	-	-	-	-	-	-	-	-
American Eel	2.21E-02	3.94E-03	-	-	-	-	-	-	-	-
Northern Redbelly Dace	-	-	1.10E-03	1.10E-03	-	-	-	-	-	-
Turtles	-	-	3.88E-03	3.66E-03	-	-	1.69E-03	1.69E-03	-	-
Frogs	-	-	3.88E-03	3.66E-03	-	-	9.48E-05	9.47E-05	-	-
Aquatic Plants	-	-	4.66E-05	4.37E-05	-	-	6.42E-05	6.42E-05	-	-
Benthic Invertebrates	2.57E-04	2.50E-04	4.24E-04	3.55E-04	-	-	-	-	-	-
Bufflehead	3.67E-05	3.67E-05	3.54E-04	3.17E-04	-	-	-	-	-	-
Mallard	3.62E-05	3.62E-05	2.96E-04	2.65E-04	-	-	-	-	-	-
Muskrat	-	-	6.08E-05	5.58E-05	-	-	-	-	-	-
Earthworm	-	-	7.26E-05	7.17E-05	7.15E-05	7.15E-05	7.64E-05	7.64E-05	2.86E-04	2.29E-04
American Robin	-	-	8.51E-05	8.45E-05	6.62E-05	6.62E-05	8.62E-05	8.59E-05	1.25E-04	8.03E-05
Bank Swallow	-	-	6.27E-05	5.95E-05	-	-	-	-	1.11E-04	8.61E-05
Song Sparrow	-	-	1.43E-04	1.42E-04	1.16E-04	1.16E-04	1.45E-04	1.44E-04	1.85E-04	1.15E-04
Yellow Warbler	-	-	6.37E-05	6.07E-05	7.22E-05	7.22E-05	6.48E-05	6.48E-05	1.09E-04	8.48E-05
			3.96E-05	3.71E-05						
Terrestrial Plants (Grass)	-	-	1.40E-04	1.14E-04	1.20E-04	1.20E-04	1.14E-04	1.06E-04	4.69E-04	2.58E-04
Terrestrial Plants (Sugar Maple)	-	-	-	-	-	-	2.31E-04	2.23E-04	2.94E-04	2.32E-04
Eastern Cottontail	-	-	1.85E-04	1.72E-04	1.71E-04	1.71E-04	1.94E-04	1.82E-04	2.61E-04	1.70E-04
Meadow Vole	-	-	1.72E-04	1.59E-04	1.59E-04	1.59E-04	1.78E-04	1.66E-04	2.60E-04	1.70E-04
White-tailed Deer	-	-	1.94E-04	1.79E-04	1.94E-04	1.94E-04	2.06E-04	1.94E-04	2.22E-04	1.70E-04
Common Shrew	-	-	1.52E-04	1.47E-04	1.47E-04	1.47E-04	1.48E-04	1.48E-04	2.42E-04	1.50E-04
Raccoon	-	-	1.70E-04	1.61E-04	1.47E-04	1.47E-04	1.60E-04	1.56E-04	2.34E-04	1.41E-04
Red Fox	-	-	2.57E-04	2.44E-04	1.58E-04	1.58E-04	2.34E-04	2.23E-04	2.70E-04	1.41E-04
Short-tailed Weasel	-	-	1.52E-04	1.45E-04	1.57E-04	1.57E-04	1.70E-04	1.59E-04	2.24E-04	1.33E-04

Note:
There are no exceedances of the aquatic benchmark of 9.6 mGy/d or the terrestrial benchmark of 2.4 mGy/d

Table 4-46: Non-Radiological Hazard Quotients for Biota for Lake Ontario

COPC	TKN		Ammonia		Barium		Cesium		Strontium		Zinc	
	Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM
Fish	-	-	1.28E+00	1.42E-01	6.46E-04	4.66E-04	-	-	-	-	3.57E-01	4.02E-02
Benthic Invertebrates (Water)	-	-	8.10E-02	9.00E-03	1.03E-01	7.40E-02	-	-	-	-	2.78E-01	3.14E-02
Benthic Invertebrates (Sediment)	1.72E+00	4.05E-01	-	-	-	-	nd	nd	nd	nd	-	-
Bufflehead	-	-	-	-	1.94E-01	1.40E-01	nd	nd	nd	nd	4.43E-03	3.29E-03
Mallard	-	-	-	-	1.49E-01	1.07E-01	nd	nd	nd	nd	3.52E-03	2.58E-03

COPC	Phosphorus		PHC F3		Benzo(a)pyrene		Chrysene		Dibenzo(a,h)anthracene		Phenanthrene		Pyrene	
	Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM
Fish	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benthic Invertebrates (Water)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benthic Invertebrates (Sediment)	1.68E+00	1.12E+00	nd	nd	1.08E-01	2.05E-02	1.47E-02	4.68E-03	8.33E-01	1.51E-01	2.32E-02	3.51E-03	6.12E-02	1.43E-02
Bufflehead	-	-	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Mallard	-	-	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

Notes:

1. Bold and shaded values indicate a HQ > 1
2. - denotes that HQs were not calculated because COPC is not of toxicological concern to receptor
3. nd indicates that a HQ could not be estimated because there was no TRV selected.

Table 4-47: Non-Radiological Hazard Quotients for Biota for Polygon AB

Receptor	TKN		TOC		Ammonia		Barium		Cadmium		Chromium		Copper	
	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean
Northern Redbelly Dace	-	-	-	-	1.20E+00	6.52E-01	1.11E-03	1.03E-03	-	-	-	-	-	-
Turtles	-	-	-	-	1.20E+00	6.52E-01	1.11E-03	1.03E-03	-	-	-	-	-	-
Frogs	-	-	-	-	1.20E+00	6.52E-01	1.11E-03	1.03E-03	-	-	-	-	-	-
Aquatic Plants	-	-	-	-	2.00E-02	1.09E-02	2.41E-02	2.23E-02	-	-	-	-	-	-
Benthic Invertebrates (Water)	-	-	-	-	7.62E-02	4.14E-02	1.76E-01	1.67E-01	-	-	-	-	-	-
Benthic Invertebrates (Sediment)	6.9E+00	6.9E+00	3.1E+00	3.1E+00	-	-	-	-	2.67E+00	2.10E+00	1.18E+00	1.12E+00	2.53E+00	2.29E+00
Bufflehead	-	-	-	-	-	-	3.54E-02	3.29E-02	1.44E-04	1.20E-04	1.93E-02	1.29E-02	1.69E-03	1.18E-03
Mallard	-	-	-	-	-	-	2.69E-02	2.51E-02	2.82E-04	2.35E-04	1.66E-02	1.23E-02	3.14E-03	2.22E-03
Green Heron	-	-	-	-	-	-	2.16E-01	1.94E-01	5.02E-02	5.02E-02	5.00E-01	4.96E-01	6.52E-02	6.41E-02
Muskrat	-	-	-	-	-	-	1.19E-02	1.12E-02	4.60E-03	3.89E-03	2.95E-05	2.73E-05	1.09E-01	7.32E-02
Earthworm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
American Robin	-	-	-	-	-	-	3.36E-01	2.36E-01	9.29E-02	5.17E-02	3.98E-01	3.28E-01	4.35E-02	3.53E-02
Bank Swallow	-	-	-	-	-	-	7.82E-02	6.49E-02	1.94E-03	1.94E-03	5.20E-02	4.67E-02	7.04E-02	5.08E-02
Song Sparrow	-	-	-	-	-	-	6.04E-01	3.98E-01	1.53E-03	1.06E-03	1.23E-01	9.41E-02	6.25E-02	3.87E-02
Yellow Warbler	-	-	-	-	-	-	1.19E-01	9.27E-02	2.16E-03	2.13E-03	6.28E-02	5.55E-02	7.88E-02	5.65E-02
Terrestrial Plants	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eastern Cottontail	-	-	-	-	-	-	8.97E-02	5.88E-02	9.82E-04	5.69E-04	9.65E-05	7.42E-05	8.44E-02	4.98E-02
Meadow Vole	-	-	-	-	-	-	8.53E-02	5.52E-02	8.86E-04	4.83E-04	7.37E-05	5.19E-05	7.95E-02	4.58E-02
White-tailed Deer	-	-	-	-	-	-	3.91E-02	2.53E-02	4.04E-04	2.19E-04	3.29E-05	2.29E-05	3.64E-02	2.09E-02
Common Shrew	-	-	-	-	-	-	6.30E-02	5.07E-02	1.01E-02	1.01E-02	1.71E-04	1.46E-04	7.53E-01	5.41E-01
Raccoon	-	-	-	-	-	-	3.21E-02	2.31E-02	9.08E-04	7.96E-04	6.85E-05	5.86E-05	6.77E-02	4.67E-02
Red Fox	-	-	-	-	-	-	4.13E-03	2.83E-03	9.41E-05	6.49E-05	1.14E-05	9.32E-06	6.05E-03	3.74E-03
Short-tailed Weasel	-	-	-	-	-	-	4.12E-03	4.09E-03	1.58E-04	1.47E-04	4.18E-05	4.06E-05	8.00E-03	6.80E-03

Notes:

1. Bold and shaded values indicate a HQ > 1.
2. "-" denotes that HQs were not calculated because COPC is not of toxicological concern to receptor.
3. nd indicates that a HQ could not be estimated because there was no TRV selected.
4. Copper, manganese, phosphorous, and vanadium were identified as COPCs in the sediment, but not the surface water. As such VECs with no exposure link to the sediment exposure pathway for these COPCs were not assessed.

Cont'd: Non-Radiological Hazard Quotients for Biota for Polygon AB

Receptor	Iron		Manganese		Nickel		Phosphorus		Strontium		Vanadium		Zinc	
	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean
Northern Redbelly Dace	3.33E-01	2.26E-01	-	-	-	-	-	-	-	-	-	-	-	-
Turtles	3.33E-01	2.26E-01	-	-	-	-	-	-	-	-	-	-	-	-
Frogs	3.33E-01	2.26E-01	-	-	-	-	-	-	-	-	-	-	-	-
Aquatic Plants	2.91E-01	1.98E-01	-	-	-	-	-	-	-	-	-	-	-	-
Benthic Invertebrates (Water)	1.44E-01	9.81E-02	-	-	-	-	-	-	-	-	-	-	-	-
Benthic Invertebrates (Sediment)	1.12E+00	1.12E+00	1.17E+00	1.17E+00	1.26E+00	1.26E+00	1.35E+00	1.35E+00	nd	nd	1.70E+00	1.57E+00	1.42E+00	1.29E+00
Bufflehead	nd	nd	1.15E-02	8.01E-03	1.96E-04	1.79E-04	-	-	nd	nd	1.44E-02	1.23E-02	5.84E-03	4.38E-03
Mallard	nd	nd	1.36E-02	9.60E-03	2.64E-04	2.52E-04	-	-	nd	nd	1.35E-02	1.18E-02	5.16E-03	4.01E-03
Green Heron	nd	nd	1.72E-02	1.60E-02	5.05E-02	5.02E-02	-	-	nd	nd	6.48E-01	6.43E-01	6.39E-01	6.20E-01
Muskrat	nd	nd	3.22E-01	2.25E-01	7.95E-04	7.71E-04	-	-	2.15E-01	2.08E-01	1.28E-01	1.13E-01	4.73E-03	3.71E-03
Earthworm	nd	nd	-	-	-	-	-	-	1.64E-02	1.64E-02	-	-	-	-
American Robin	nd	nd	4.32E-02	3.56E-02	1.17E-02	9.32E-03	-	-	nd	nd	2.50E-01	2.02E-01	6.37E-01	5.47E-01
Bank Swallow	nd	nd	5.75E-03	5.75E-03	1.85E-03	1.40E-03	-	-	nd	nd	2.36E-02	2.36E-02	7.71E-02	6.18E-02
Song Sparrow	nd	nd	1.51E-02	1.10E-02	4.89E-03	2.97E-03	-	-	nd	nd	7.20E-02	4.85E-02	1.71E-01	1.17E-01
Yellow Warbler	nd	nd	7.04E-03	6.78E-03	2.27E-03	1.67E-03	-	-	nd	nd	2.94E-02	2.80E-02	9.25E-02	7.29E-02
Terrestrial Plants	nd	nd	-	-	-	-	-	-	1.01E-01	1.01E-01	-	-	-	-
Eastern Cottontail	nd	nd	2.23E-02	1.60E-02	2.77E-03	1.70E-03	-	-	4.23E-02	3.55E-02	1.74E-01	1.18E-01	2.79E-02	1.87E-02
Meadow Vole	nd	nd	1.78E-02	1.16E-02	2.29E-03	1.25E-03	-	-	3.96E-02	3.30E-02	1.26E-01	7.13E-02	2.67E-02	1.77E-02
White-tailed Deer	nd	nd	8.00E-03	5.17E-03	1.03E-03	5.55E-04	-	-	1.81E-02	1.51E-02	5.58E-02	3.07E-02	1.23E-02	8.14E-03
Common Shrew	nd	nd	3.69E-02	3.69E-02	4.97E-03	3.34E-03	-	-	1.43E-01	8.51E-02	1.65E-01	1.65E-01	8.22E-02	6.55E-02
Raccoon	nd	nd	1.75E-02	1.44E-02	1.58E-03	1.20E-03	-	-	3.50E-02	2.96E-02	1.25E-01	1.08E-01	1.88E-02	1.34E-02
Red Fox	nd	nd	1.56E-03	1.28E-03	2.23E-04	1.61E-04	-	-	2.38E-03	2.06E-03	1.46E-02	1.20E-02	1.61E-02	1.08E-02
Short-tailed Weasel	nd	nd	7.35E-03	7.33E-03	8.15E-04	7.89E-04	-	-	3.56E-03	3.51E-03	8.25E-02	8.21E-02	2.17E-02	1.47E-02

Notes:

1. Bold and shaded values indicate a HQ > 1.
2. "-" denotes that HQs were not calculated because COPC is not of toxicological concern to receptor.
3. nd indicates that a HQ could not be estimated because there was no TRV selected.
4. Copper, manganese, phosphorous, and vanadium were identified as COPCs in the sediment, but not the surface water. As such VECs with no exposure link to the sediment exposure pathway for these COPCs were not assessed.

Table 4-48: Non-Radiological Hazard Quotients for Biota for Polygon C

Receptor	Strontium	
	Maximum	UCLM
Earthworm	1.06E-02	1.06E-02
American Robin	nd	nd
Song Sparrow	nd	nd
Yellow Warbler	nd	nd
Terrestrial Plants	6.49E-02	6.49E-02
Eastern Cottontail	1.49E-02	1.35E-02
Meadow Vole	1.35E-02	1.21E-02
White-tailed Deer	6.15E-03	5.50E-03
Common Shrew	1.79E-02	1.79E-02
Raccoon	6.73E-03	6.32E-03
Red Fox	8.78E-04	8.08E-04
Short-tailed Weasel	2.07E-03	2.06E-03

Notes:

- 1. Bold and shaded values indicate a HQ > 1
- 2. - denotes that HQs were not calculated because COPC is not of toxicological concern to receptor
- 3. nd indicates that a HQ could not be estimated because there was no TRV selected.

Table 4-49: Non-Radiological Hazard Quotients for Biota for Polygon D

Receptor	Ammonia		Barium		Cadmium		Copper		Iron		Strontium	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Turtles	1.25E-01	1.25E-01	7.96E-04	7.96E-04	2.94E-03	2.94E-03	1.02E-01	1.02E-01	4.00E-01	4.00E-01	-	-
Frogs	1.25E-01	1.25E-01	7.96E-04	7.96E-04	2.94E-03	2.94E-03	1.02E-01	1.02E-01	4.00E-01	4.00E-01	-	-
Aquatic Plants	2.08E-03	2.08E-03	1.73E-02	1.73E-02	2.50E-03	2.50E-03	3.88E-01	3.88E-01	3.49E-01	3.49E-01	-	-
Earthworm	-	-	-	-	-	-	-	-	-	-	1.34E-02	1.34E-02
American Robin	-	-	4.70E-01	3.16E-01	2.16E-02	1.80E-02	3.83E-02	3.39E-02	-	-	nd	nd
Song Sparrow	-	-	1.83E-01	1.33E-01	9.70E-04	7.93E-04	4.85E-02	4.05E-02	-	-	nd	nd
Yellow Warbler	-	-	5.67E-02	5.38E-02	2.12E-03	2.11E-03	5.42E-02	5.38E-02	-	-	nd	nd
Terrestrial Plants	-	-	-	-	-	-	-	-	-	-	8.23E-02	8.23E-02
Eastern Cottontail	-	-	2.70E-02	1.95E-02	4.93E-04	3.37E-04	6.84E-02	5.40E-02	-	-	2.33E-02	1.63E-02
Meadow Vole	-	-	2.41E-02	1.68E-02	4.11E-04	2.59E-04	6.42E-02	5.01E-02	-	-	2.14E-02	1.46E-02
White-tailed Deer	-	-	1.10E-02	7.61E-03	1.86E-04	1.16E-04	2.94E-02	2.29E-02	-	-	9.77E-03	6.63E-03
Common Shrew	-	-	3.05E-02	3.05E-02	1.01E-02	1.01E-02	5.13E-01	5.13E-01	-	-	6.08E-02	6.08E-02
Raccoon	-	-	1.24E-02	1.03E-02	9.39E-04	8.95E-04	5.90E-02	5.49E-02	-	-	1.25E-02	1.05E-02
Red Fox	-	-	1.49E-03	1.17E-03	4.54E-05	3.40E-05	5.85E-03	4.69E-03	-	-	1.39E-03	1.05E-03
Short-tailed Weasel	-	-	4.18E-03	4.17E-03	1.39E-04	1.35E-04	6.93E-03	6.43E-03	-	-	2.75E-03	2.71E-03

Notes:

- 1. Bold and shaded values indicate a HQ > 1
- 2. - denotes that HQs were not calculated because COPC is not of toxicological concern to receptor
- 3. nd indicates that a HQ could not be estimated because there was no TRV selected.

Table 4-50: Non-Radiological Hazard Quotients for Biota for Polygon E

Receptor	Arsenic		Cadmium		Chromium		Cobalt		Copper		Iron		Lead		Molybdenum	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Earthworm	2.22E+00	2.56E-01	1.88E-01	2.45E-02	2.41E-01	5.99E-02	3.98E+00	4.92E-01	1.59E+01	1.72E+00	nd	nd	1.18E+00	1.37E-01	1.06E+00	1.19E-01
American Robin	4.64E-01	5.36E-02	1.11E-01	1.45E-02	3.09E-01	7.68E-02	2.21E-01	2.73E-02	2.10E+00	2.26E-01	nd	nd	1.34E+00	1.56E-01	7.17E-02	8.09E-03
Bank Swallow	6.13E-01	7.08E-02	2.92E-01	3.82E-02	6.78E-01	1.68E-01	2.20E-01	2.72E-02	2.59E+00	2.80E-01	nd	nd	1.43E+00	1.66E-01	1.51E-01	1.71E-02
Song Sparrow	9.54E-01	1.10E-01	1.27E-01	1.66E-02	2.85E-01	7.07E-02	3.48E-01	4.30E-02	5.22E+00	5.63E-01	nd	nd	3.15E+00	3.66E-01	1.08E-01	1.22E-02
Yellow Warbler	7.11E-01	8.22E-02	3.20E-01	4.18E-02	7.41E-01	1.84E-01	2.56E-01	3.16E-02	3.08E+00	3.32E-01	nd	nd	1.71E+00	1.99E-01	1.68E-01	1.90E-02
Terrestrial Plants	6.65E+00	7.68E-01	3.13E-01	4.08E-02	2.41E-01	5.99E-02	3.98E+00	4.92E-01	1.59E+01	1.72E+00	nd	nd	2.36E+00	2.74E-01	1.06E+00	1.19E-01
Eastern Cottontail	2.19E+00	2.53E-01	5.38E-02	7.03E-03	1.29E-04	3.21E-05	1.33E-01	1.64E-02	8.44E+00	9.11E-01	nd	nd	1.82E-01	2.12E-02	4.57E-01	5.16E-02
Meadow Vole	1.87E+00	2.16E-01	5.15E-02	6.73E-03	5.70E-05	1.42E-05	8.34E-02	1.03E-02	7.85E+00	8.48E-01	nd	nd	1.59E-01	1.85E-02	4.04E-01	4.57E-02
White-tailed Deer	8.48E-01	9.81E-02	2.37E-02	3.09E-03	2.30E-05	5.70E-06	3.62E-02	4.48E-03	3.59E+00	3.88E-01	nd	nd	7.23E-02	8.40E-03	1.84E-01	2.08E-02
Common Shrew	8.50E+00	9.83E-01	1.56E+00	2.03E-01	3.03E-03	7.52E-04	3.40E-01	4.20E-02	2.67E+01	2.88E+00	nd	nd	4.64E-01	5.38E-02	5.31E+00	6.00E-01
Raccoon	1.59E+00	1.84E-01	1.27E-01	1.66E-02	3.37E-04	8.36E-05	1.17E-01	1.45E-02	4.76E+00	5.14E-01	nd	nd	1.06E-01	1.23E-02	5.55E-01	6.26E-02
Red Fox	3.58E-01	4.14E-02	4.03E-03	5.27E-04	2.21E-05	5.49E-06	1.24E-02	1.54E-03	7.30E-01	7.88E-02	nd	nd	1.09E-02	1.27E-03	2.74E-02	3.12E-03
Short-tailed Weasel	6.74E-01	7.79E-02	3.20E-03	4.18E-04	1.31E-04	3.24E-05	8.48E-02	1.05E-02	9.65E-01	1.04E-01	nd	nd	3.49E-02	4.05E-03	7.79E-02	8.83E-03

Receptor	Nickel		Selenium		Sodium		Strontium		Tin		Zinc		PHC F4-sg		Cyanide	
	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Earthworm	1.29E+00	2.13E-01	6.12E-01	7.65E-02	nd	nd	7.12E-02	3.03E-02	nd	nd	4.66E+01	5.06E+00	8.13E-01	5.36E-04	3.67E-01	4.49E-02
American Robin	4.87E-02	8.05E-03	2.92E+00	3.65E-01	nd	nd	nd	nd	1.88E-01	2.05E-02	1.32E+01	1.44E+00	-	-	-	-
Bank Swallow	6.58E-02	1.09E-02	8.43E+00	1.05E+00	nd	nd	nd	nd	1.75E-01	1.91E-02	2.91E+01	3.16E+00	-	-	-	-
Song Sparrow	1.09E-01	1.81E-02	2.49E+00	3.11E-01	nd	nd	nd	nd	4.83E-01	5.26E-02	2.11E+01	2.29E+00	-	-	-	-
Yellow Warbler	7.68E-02	1.27E-02	9.16E+00	1.14E+00	nd	nd	nd	nd	2.16E-01	2.35E-02	3.23E+01	3.51E+00	-	-	-	-
Terrestrial Plants	1.29E+00	2.13E-01	6.12E-01	7.65E-02	nd	nd	4.38E-01	1.86E-01	2.16E+00	2.35E-01	4.66E+01	5.06E+00	4.29E-01	2.82E-04	3.67E-01	4.49E-02
Eastern Cottontail	5.70E-02	9.42E-03	6.31E-01	7.90E-02	nd	nd	1.78E-01	7.57E-02	9.69E-02	1.05E-02	2.63E+00	2.86E-01	-	-	-	-
Meadow Vole	5.15E-02	8.51E-03	5.69E-01	7.12E-02	nd	nd	1.66E-01	7.07E-02	8.67E-02	9.43E-03	2.50E+00	2.71E-01	-	-	-	-
White-tailed Deer	2.35E-02	3.88E-03	2.59E-01	3.25E-02	nd	nd	7.62E-02	3.24E-02	3.95E-02	4.30E-03	1.14E+00	1.24E-01	-	-	-	-
Common Shrew	2.18E-01	3.61E-02	5.43E+01	6.79E+00	nd	nd	7.05E-02	3.00E-02	1.94E-01	2.12E-02	3.15E+01	3.42E+00	-	-	-	-
Raccoon	3.66E-02	6.04E-03	4.18E+00	5.22E-01	nd	nd	6.33E-02	2.69E-02	5.14E-02	5.60E-03	3.64E+00	3.95E-01	-	-	-	-
Red Fox	4.46E-03	7.37E-04	3.64E-01	4.56E-02	nd	nd	9.86E-03	4.18E-03	1.07E-02	1.17E-03	2.35E+00	2.55E-01	-	-	-	-
Short-tailed Weasel	8.77E-03	1.45E-03	3.63E-01	4.54E-02	nd	nd	1.47E-02	6.24E-03	1.90E-02	2.07E-03	2.07E+00	2.25E-01	-	-	-	-

Notes:

1. Bold and shaded values indicate a HQ > 1
2. - denotes that HQs were not calculated because COPC is not of toxicological concern to receptor
3. nd indicates that a HQ could not be estimated because there was no TRV selected.
4. PHC F4-sg and Cyanide do not bioaccumulate, and therefore, they are not assessed for birds and mammals.

4.4.2 Discussion of Chemical and Radiation Effects

4.4.2.1 Effects Monitoring Evidence

Data used for the problem formulations, screening and ecological risk assessment were taken from the most recent environmental studies at the site (Ecometrix, 2020), ERAs (Ecometrix, 2017; SENES, 2009a, 2011b) and associated TSDs, annual EMP reports (from years 2011 to 2019), ECA reports (from years 2016 to 2019) prepared for the DN site, and the 2016 effluent characterization study. Data used in this ERA update is listed in Table 4-8. No additional data are available beyond what is presented at this time to clarify potential effects at the site.

4.4.2.2 Likelihood of Effects

4.4.2.2.1 Atmospheric Contaminants

No significant effects are expected from NO_x on ecological receptors at the DN site. Nitrogen oxides exceed the short-term air screening benchmark (MECP AAQC), based on the 2016 ESDM modelled maximum POI $\frac{1}{2}$ hour value of $639 \mu\text{g}/\text{m}^3$. Adverse effect levels for NO_x under long term exposure are $5,000 \mu\text{g}/\text{m}^3$ for plants (Doull et al., 1980) and $47,000 \mu\text{g}/\text{m}^3$ for dogs (Heck, 1964). It is rather conservative to use the modelled maximum $\frac{1}{2}$ hour concentration to estimate long-term effects. However, as the maximum POI concentrations during 2016 to 2019 are all below these adverse effect levels in small mammals and plants, no significant effects are expected from NO_x .

Using the modelled data to assess risk of NO_x is a very conservative approach. OPG has recently initiated a one-year air monitoring program at the DN Site. It would be valuable to incorporate NO_2 concentrations measured during this program in the next ERA to refine the risk estimates for ecological receptors provided in this ERA and provide a more realistic interpretation.

4.4.2.2.2 Lake Ontario

Radiological

There are no exceedances of the $9.6 \text{ mGy}/\text{d}$ radiation benchmark for the aquatic biota at the SSA in Lake Ontario, including fish and benthic invertebrates. The $2.4 \text{ mGy}/\text{d}$ radiation benchmark has also not been exceeded for the Bufflehead and Mallard, riparian biota in Lake Ontario.

Non-Radiological

Ecological receptors in Lake Ontario are not at toxicological risk from DN operations. A summary of the results of the aquatic assessment in Lake Ontario is provided below:

- Maximum surface water concentrations for the SSA in Lake Ontario exceeded the benchmarks for ammonia for fish; however, the UCLM water concentration did not exceed the fish benchmark.
- Maximum sediment concentrations for Lake Ontario exceeded the sediment benchmark for TKN for benthic invertebrates. Both the maximum and the UCLM sediment concentration of phosphorus exceeded the sediment benchmark. Since benthic invertebrates cannot move around, a few benthic invertebrates may experience prolonged exposure at the maximum, and assessment at maximum sediment concentrations is appropriate.
- There was no exceedance of the HQ target of 1 for riparian birds in Lake Ontario, and there are no mammals considered as ecological receptors in this polygon.

Because fish are more mobile around a wider area, the HQs for UCLM water concentrations for ammonia are more representative of fish exposure than maximum concentrations. The maximum concentration of un-ionized ammonia in Lake Ontario, but not the UCLM concentration, exceeded the selected benchmark. In addition, the relevant input of surface water COPCs from DN operations to Lake Ontario is through effluent discharge from the CCW at the diffuser, and from stormwater runoff. Based on the 2016 to 2019 ECA reports, the maximum concentrations of ammonia in both the CCW, and the estimated nearshore concentration in Lake Ontario from stormwater, were below the selected benchmark. Therefore, the elevated ammonia concentration in Lake Ontario is not likely resulting from the DN operations. As such, fish are not at toxicological risk from DN operations.

No significant risk is expected from TKN, phosphorus, and PHC F3 in the sediment for benthic invertebrates. There is uncertainty surrounding the risk associated with TKN and phosphorus exceedance in the sediment for benthic invertebrates. There is evident input of agricultural runoff in Lake Ontario in the area, and these two parameters are not likely elevated because of operation at DN. In addition, there is no available benchmark for PHC F3 in sediment for benthic invertebrates. Sediment in Lake Ontario is transient and the invertebrate community is mainly epifaunal. This suggests that the sediment exposure pathway is unlikely to be the primary exposure route for benthic invertebrates in Lake Ontario.

Cesium and strontium are not likely to cause toxic effects on ecological receptors in Lake Ontario. Cesium and strontium were identified as sediment COPCs as they exceeded the upper limit background concentrations in Lake Ontario sediment. There is no available benchmark for cesium and strontium for aquatic and riparian ecological receptors. However, the maximum concentrations of these two elements fall within the range of background concentrations for the continental USA (Dragun and Chiasson, 1991), between 0.25-25 mg/kg and 5-3000 mg/kg for cesium and strontium, respectively.

Toxic effects of PHCs are not expected for birds. While, toxicity reference values are not available for PHC F3 and PAH compounds, including benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, phenanthrene, and pyrene, for birds, these compounds are readily metabolized by vertebrates, and are not anticipated to accumulate in birds and mammals, especially at environmental concentrations (CCME 2008). The major pathway for riparian birds to be exposed to PAHs is through ingestion of benthic invertebrates and sediment. The maximum PAH concentrations in the Lake Ontario SSA exceeded the CCME sediment quality guideline during one sampling event at Darlington Harbour. No exceedances were identified in all other sampling events from sampling areas within the SSA. As the Lake Ontario sediment is not depositional, and the invertebrate community is mainly epifaunal, the risk for riparian birds to be exposed to toxic level of PAHs is very low.

No adverse effects from pH are expected in Lake Ontario, since the UCLM pH measured in Lake Ontario was 8.4 and the aquatic environment is productive. However, the maximum pH observed in Lake Ontario was 9.2, exceeding the MECP water quality objective for pH of a range from 6.5 to 8.5 and the CCME water quality objective for pH of a range of 6.5 to 9.0. The MECP considers the PWQO for pH to be the range within which waters are the most productive (MOE, 1979). Surface waters with pH above the upper limit of the PWQO may be less productive. Lake Ontario is a productive habitat for aquatic biota, which is evident from the SENES 2009 and recent aquatic community studies (Ecometrix, 2020; Golder and SENES, 2009), which document diverse populations of fish, phytoplankton and zooplankton, as well as benthic invertebrates. ,

The American Eel, a species at risk, is not at toxicological risk from DN operations. Since the American Eel is a species at risk, the assessment endpoint is the health of the individual. As discussed above, the fish benchmarks were exceeded for maximum water concentrations of ammonia, but not for UCLM water concentrations. Since fish are more mobile around a wider area, the UCLM water concentration is more appropriate than the maximum for assessment of toxicological risk to the American Eel.

4.4.2.2.3 Polygon AB

Radiological

There are no exceedances of the 9.6 mGy/d radiation benchmark for the aquatic biota in Coot's Pond (Polygon AB). Aquatic biota include: Northern Redbelly Dace, turtles, frogs, aquatic plants and benthic invertebrates.

There are no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial and riparian biota for Polygon AB. Terrestrial and riparian biota include: Bufflehead, Mallard and Muskrat at Coot's Pond, Earthworms, terrestrial plants (grass), American Robin, Bank Swallow (a species at risk), Song Sparrow, Yellow Warbler, Green Heron, Eastern Cottontail, Meadow Vole, White-tailed Deer, Common Shrew, Raccoon, Red Fox, and Short-tailed Weasel.

The radiation dose to any of the receptors located in Coot's Pond (in Polygon AB) was below the radiation dose benchmarks for aquatic and terrestrial receptors. The HTO concentration measured in Coot's Pond likely originates from atmospheric emissions from DN and subsequent deposition to Coot's Pond. Although Coot's Pond receives runoff from the DN landfill it does not receive effluent from the DN site, other than through atmospheric deposition. The maximum tritium concentration measured in 2019 in Lake Ontario in the vicinity of DN was much lower than the maximum measured in Coot's Pond (15.4 Bq/L maximum in Lake Ontario compared to 46.8 Bq/L in Coot's Pond). DN releases tritium in the effluent to Lake Ontario, but the concentration of tritium in Lake Ontario is much lower than the concentration of tritium in Coot's Pond. The average measured HTO concentration in McLaughlin Bay west of DN in 2019 was 22.9 Bq/L, while Lake Ontario in the vicinity of DN was 14.8 Bq/L (OPG, 2020b). This indicates that a portion of HTO in McLaughlin Bay comes from atmospheric deposition. The higher HTO concentration in Coot's Pond as compared to McLaughlin Bay is likely due to the closer proximity of Coot's Pond to the DN atmospheric source. Overall, this comparison confirms that the source of tritium in Coot's Pond is atmospheric deposition from DN.

Non-Radiological

A summary of the results of the aquatic assessment in Coot's Pond (Polygon AB) is provided below:

- Maximum ammonia (un-ionized) concentrations in surface water in Coot's Pond exceeded the fish (Northern Redbelly Dace) and turtle/frog benchmarks.
- Maximum and UCLM sediment concentrations in Coot's Pond exceeded the sediment target benchmarks for TKN, TOC, cadmium, chromium, copper, iron, manganese, nickel, phosphorus, vanadium, and zinc for benthic invertebrates.
- There was no exceedance of the HQ target of 1 for birds and mammals in Polygon AB.

The UCLM pH measured at Coot's Pond was 9.0 and the aquatic environment is productive, so no adverse effects from pH are expected at Coot's Pond. However, the maximum pH observed in Coot's Pond was 9.6, exceeding the MECP water quality objective for pH of a range from 6.5 to 8.5 and the CCME water quality objective for pH of a range from 6.5 to 9.0. The MECP considers the PWQO for pH to be the range within which waters are the most productive (MOE, 1979). Surface water with pH above the upper limit of the PWQO may be less productive.

The productive nature of Coot's Pond is evident from the descriptions by Golder and SENES and from recent biodiversity studies (Beacon, 2019a; Golder and SENES, 2009). Coot's Pond is described as an open water wetland habitat, with mostly open water in the eastern portion of the pond, and emergent and submerged aquatic vegetation present along the edges of the pond and abundant in the western portion of the pond (Golder and

SENES, 2009). This area is dominated by grasses including both native and non-native species; Phragmites has increased since 2013 (Beacon, 2019a). Coot's Pond supports aquatic invertebrates and an introduced population of Northern Redbelly Dace (Golder and SENES, 2009). Coot's Pond also provides habitat and breeding areas for amphibians, turtles and migrant birds. In 2018, bats were observed foraging over Coot's Pond, while Bank Swallows were found to be roosting in the reeds (Beacon, 2019a).

Although potential risks were identified to aquatic receptors at Coot's Pond from a number of COPCs, the source of these COPCs in Coot's Pond is not the result of emissions from the DN site, but is attributable to the pond having been designed as a settling pond for stormwater runoff, and to being adjacent to a licensed landfill section of the site. OPG has an Environmental Compliance Approval (ECA) for the landfill, and conducts and reports on quarterly monitoring and semi-annual inspections. There is no pathway from DN liquid effluent to Coot's Pond. There is potential for DN air emissions to deposit at the pond; however, the chemical signature in Coot's Pond is characteristic of landfill runoff (maximum concentrations above benchmark for ammonia in water, plus metals and phosphorus in sediment). The elevated TKN, TOC, ammonia and phosphorus concentrations in the sediment also suggest agricultural inputs in Coot's Pond.

The maximum concentrations of strontium in soil in the Coot's Pond area falls within the range of background concentrations for the continental USA (Dragun and Chiasson, 1991) between 5-3000 mg/kg. In addition, strontium competes with calcium but it does not have a toxic effect on bone in chicks. A study cited in Skoryna (1981) found that there were no deleterious effects on chicks until very high doses of strontium were given. This dose is reported to be much higher than the benchmark value used to assess strontium effects on mammals. Since there were no data to determine strontium benchmarks for birds, the mammal benchmark might be used as a surrogate, in which case there would be no exceedances.

Adverse health effects for birds and mammals are not expected from elevated levels of iron in surface water and sediment. Iron is generally present in surface water as salts in its trivalent form (Fe_3^+) when the pH is above 7 (HC, 1978). Most of the iron salts are insoluble and settle to or become bound to the sediments. Therefore, most iron in surface water is associated with particulate matter and is not bioavailable. In the sediment, iron is mainly present in the form of particulates, and is not bioavailable. Absorption of iron in the body (mammals and birds) is regulated, and very little is metabolised. Iron ingested from drinking water is efficiently expelled from the body (HC, 1978).

4.4.2.2.4 Polygon C

Radiological

There are no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial biota at Polygon C. Terrestrial biota include Earthworms, terrestrial plants (grass), American Robin,

Song Sparrow, Yellow Warbler, Eastern Cottontail, Meadow Vole, White-tailed Deer, Common Shrew, Raccoon, Red Fox, and Short-tailed Weasel.

Non-Radiological

Where data were available, the HQ target of 1 was not exceeded for terrestrial biota for strontium. No risks were identified for terrestrial biota for polygon C.

There were no data to determine strontium benchmarks for birds. Similar as discussed above, the maximum strontium concentration in soil in Polygon C falls within the range of background concentrations for the continental USA. In addition, when strontium benchmark values for birds are set to strontium benchmarks for mammals, there are no exceedances for polygon C.

4.4.2.2.5 Polygon D

Radiological

There are no exceedances of the 9.6 mGy/d radiation benchmark for the aquatic biota present at Treefrog Pond. Aquatic biota at Treefrog Pond include: turtles, frogs, and aquatic plants.

There are no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial and riparian biota for Polygon AB. Terrestrial and riparian biota include: Bufflehead, Mallard and Muskrat at Coot's Pond, Earthworms, terrestrial plants (grass and Sugar Maple), American Robin, Bank Swallow (a species at risk), Song Sparrow, Yellow Warbler, Eastern Cottontail, Meadow Vole, White-tailed Deer, Common Shrew, Raccoon, Red Fox, and Short-tailed Weasel.

Because Dragonfly and Polliwog Ponds are known to dry up at different times of the year, the surface water and sediment concentrations at Treefrog Pond, along with the aquatic biota present at this pond, have been used to represent surface water and sediment concentrations along with the presence of potential aquatic biota at Dragonfly and Polliwog ponds.

Non-Radiological

Where data were available, the HQ target of 1 was not exceeded for aquatic and terrestrial biota in Polygon D. No risks were identified to ecological receptors in the Treefrog Pond area.

As discussed above, the maximum strontium concentration in soil in Polygon D falls within the range of background concentrations in the continental USA (Dragun and Chiasson, 1991). There were no data to determine strontium benchmarks for birds; however, when strontium benchmark values for birds are set to strontium benchmarks for mammals, there are no exceedances for Polygon D.

4.4.2.2.6 Polygon E

Radiological

There are no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial biota at Polygon E. Terrestrial biota include Earthworms, terrestrial plants (grass and Sugar Maple), American Robin, Song Sparrow, Yellow Warbler, Eastern Cottontail, Meadow Vole, White-tailed Deer, Common Shrew, Raccoon, Red Fox, and Short-tailed Weasel.

Non-Radiological

Exceedances of the HQ target of 1 for terrestrial receptors in Polygon E are localized and associated with elevated metals concentrations in soil in the yard waste and building materials storage area. A summary of the results of the terrestrial assessment in Polygon E is provided below:

- Maximum arsenic, cobalt, copper, lead, molybdenum, nickel, and zinc concentrations exceeded the benchmarks for Earthworm.
- Maximum arsenic, cobalt, copper, lead, molybdenum, nickel, tin and zinc concentrations exceeded the benchmarks for terrestrial plants.
- The HQ target of 1 was exceeded for copper, lead, selenium and zinc for terrestrial birds.
- The HQ target of 1 was exceeded for arsenic, cadmium, copper, molybdenum, selenium and zinc for terrestrial mammals.

All metals assessed in this ecological risk assessment were identified as COPCs because they exceeded selected screening criteria at the yard waste and building materials storage area (Location DN6, DN6A, see map in Appendix B-4 (Ecometrix, 2020)). In fact, the majority of metal COPCs only exceeded the selected screening criteria in 1 (DN6) of the 31 samples collected in polygon E, except copper and zinc which also exceeded at location DN6A 15m southwest of DN6. Therefore, the impacted soil with elevated metal concentrations is localized, and is not deposition from atmospheric release. For terrestrial invertebrates (Earthworms) and terrestrial plants, although individuals may be affected by the maximum concentrations of these metal COPCs, the population should not be affected.

The HQ did not exceed the target of 1 for American Robin, Bank Swallow, Song Sparrow, and Yellow Warbler exposed to the UCLM concentrations for copper and lead. The HQ target of 1 was exceeded for copper and lead for American Robin, Bank Swallow, Song Sparrow, and Yellow Warbler exposed to the maximum concentration of these COPCs; however, birds are likely to experience something close to the UCLM concentrations as they move around the area. Therefore, these terrestrial birds are not at risk in Polygon E from copper and lead.

The HQ for selenium did not exceed 1 for American Robin and Song Sparrow based on exposure to the UCLM concentration, but did exceed for the maximum selenium concentration. Therefore, these two species are not likely at risk in Polygon E because of elevated selenium. The HQ for selenium exceeded 1 for Bank Swallow and Yellow Warbler exposed to either maximum or UCLM concentrations. In addition, the HQ values for zinc exceeded the target of 1 for American Robin, Bank Swallow, Song Sparrow and Yellow Warbler exposed to both maximum and UCLM concentrations. Therefore, risk could not be ruled out from selenium and zinc to terrestrial birds in Polygon E.

For terrestrial mammals, based on exposure to the UCLM concentrations in polygon E, the HQ values were below 1, with the exception of the Common Shrew f HQs for copper, selenium, and zinc. The HQ for exposure to maximum arsenic, cadmium, copper, molybdenum, selenium and zinc exceeded the target value of 1 for one or more mammals, including Eastern Cottontail, Meadow Vole, White-tailed Deer, Common Shrew, Raccoon, Red Fox, and Short-tailed Weasel (Table 4-50). As mammals move around the area, they are likely exposed to COPC concentrations close to the UCLM. Therefore, it is not likely that these terrestrial mammals are at risk in Polygon E because of metal COPCs.

The HQ values for Common Shrew were greater than 1 based on exposure to both maximum and UCLM concentrations of copper, selenium, and zinc. It is possible that elevated concentrations of these three metals pose a risk to Common Shrew in Polygon E.

As discussed above, the maximum strontium concentration in soil in Polygon E falls within the range of background concentrations for the continental USA. There were no data to determine strontium benchmarks for birds; however, when strontium benchmark values for birds are set to strontium benchmarks for mammals, there are no exceedances for polygon E.

Adverse effects from iron and sodium are not expected in Polygon E. While there were no data to determine iron and sodium benchmarks for selected terrestrial receptors in Polygon E, iron is present in soil mostly in the form of particulate, and it is not bioavailable. Absorption of iron in the body (mammals and birds) is regulated, and very little is metabolised. Iron ingested from drinking water is efficiently expelled from the body (HC, 1978). Therefore, adverse effects from iron in Polygon E are not expected for birds and mammals. Sodium is generally not considered as a toxicant for birds and mammals, as it is effectively regulated in the body. In addition, the elevated sodium concentration at polygon E (compared to the Ontario rural parkland background value) is likely seasonal and due to road salt used in de-icing activities. One impact of sodium to soil health is through interacting with other ions and affecting dispersion of organic matter and clay particles. This impact is generally quantified as sodium adsorption ratio, with high sodium adsorption ratio values suggesting degradation of soil structure and health. Sodium adsorption ratio was measured in soil samples from polygon E, and all results are below the CCME soil quality guideline.

No adverse effect is expected from tin for soil invertebrates when a sediment effect concentration is used as a surrogate for soil. There were no data to determine tin benchmarks for soil invertebrates. As such, there are uncertainties associated with the effects assessment for soil invertebrates exposed to tin concentrations in soil. Borgmann et al. (2005) reported an acute one week LC_{50} of > 1 mg/L for epibenthic *Hyalella azteca* exposed to tin in water obtained from Lake Ontario. If an acute to chronic factor of 10 is applied to the acute value in order to adjust it to a chronic value, and then multiplied by a K_d of 1300 L/kg dw for freshwater sediments obtained from CSA (2014), this results in a sediment concentration of 130 mg/kg dw. If this sediment value is used as a surrogate for soil concentrations to investigate the effects of tin exposure to soil invertebrates, it is unlikely that there would be adverse effects to soil invertebrates due to tin exposure because the maximum tin soil concentration in Polygon E is 15 mg/kg dw, below the surrogate soil concentration of 130 mg/kg dw.

Since birds and mammals usually move around, they are more likely to experience UCLM concentrations than maximum concentrations. Exceedances of the HQ of 1 for UCLM concentrations for some birds and mammals were identified for copper, selenium, and zinc. The localized exceedances of the HQ target of 1 for metal COPCs in Polygon E, in the vicinity of the yard waste and building materials storage area, include:

- Bank Swallow and Yellow Warbler from selenium and zinc;
- American Robin and Song Sparrow from zinc;
- Common Shrew from copper, selenium and zinc.

As Bank Swallow is a threatened species at both federal and provincial level, the assessment end point is the health of individuals. Bank Swallows nest at the shoreline, and therefore the yard waste and building materials storage area is not suitable nesting habitat. However, as it is possible that Bank Swallows occasionally forage at the contaminated area, the risk caused by selenium and zinc could not be ruled out.

Adverse effects of chemical COPCs on Barn Swallow are not expected. Bank Swallow was used as a surrogate to assess risk to Barn Swallow. Barn Swallows typically nest in small openings in man-made buildings, and are annual breeders all around the existing station. As Polygon E is mostly open field, it is not a suitable habitat for Barn Swallow. Although it is possible for Barn Swallows to forage in Polygon E, the exposure will be much lower than the estimated UCLM values.

Darlington Waste Management Facility

The maximum dose rate to any ecological VEC residing in close proximity (5 m) to the DWMF could be up to 0.024 mGy/d, lower than the 2.4 mGy/d radiation benchmark for terrestrial biota. The dose also remains below the radiation benchmark if the maximum dose from the DWMF is combined with the maximum dose to terrestrial ecological VECs in Polygon E from being exposed to radionuclides ($4.69E-4$ mGy/d) through other existing DN operations (Table 4-28). The radiological dose rates from the DWMF at full capacity would

be the largest contributor to total dose, but still remain lower than the terrestrial benchmark of 2.4 mGy/d.

4.4.3 Thermal Effects

An assessment of thermal effects from the warm cooling water discharged by DN was conducted in 2011 and 2012 by Golder (2012b). In this study, continuous temperature data were obtained from temperature loggers installed at 31 locations in and around the discharge, and at reference (ambient) locations, over an eight-month period from January through September 2011, and from December 2011 to April 2012. At 25 locations, the temperature loggers were installed at two or more depths.

The assessment focused on near surface temperatures. This is conservative during the warm water period (June – September) when some thermal stratification is evident. During the cold-water period (January – May) there is generally less than 1°C difference between surface and bottom temperatures.

Figure 4-9 illustrates the maximum extent of the thermal plume, based on the 95th percentile of temperature increase above ambient (ΔT). The extent of the ΔT of 1°C was measured to extend up to 6.9 km to the west and up to 3.5 km to the east. The areal extent of the ΔT of 1°C was usually small with a maximum area of 7.5 km². The ΔT of 2°C did not extend beyond the turbulent mixing zone which has an area of approximately 1 km².

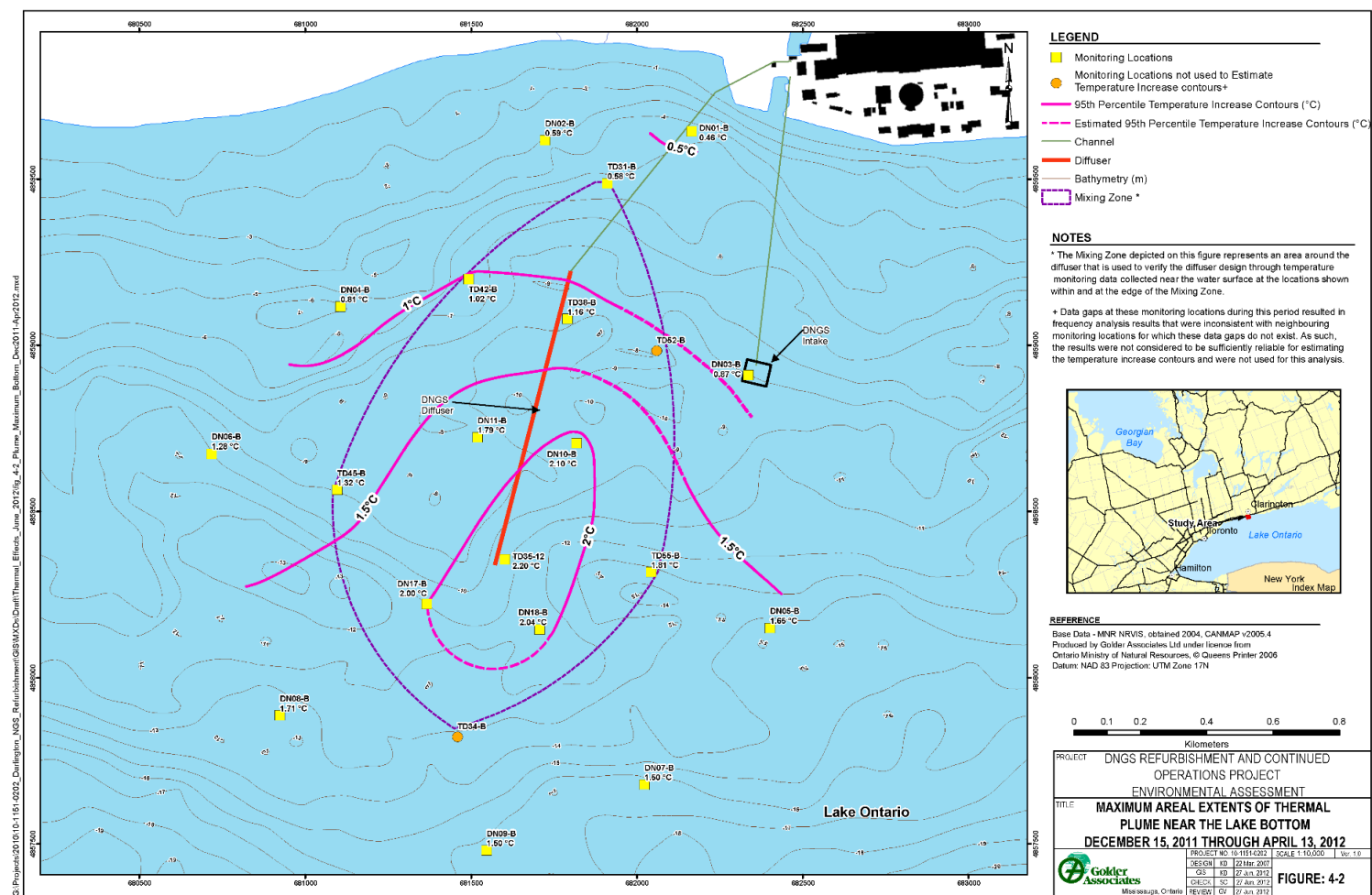


Figure 4-9: 2011-2012 Maximum Extent of Thermal Plume – Temperature above Ambient (Golder, 2012b)

Table 4-51 shows the frequency of various ΔT values at individual locations either inside the turbulent mixing zone, at the edge of this zone, or outside this zone. These data indicate that a ΔT of 3°C is a rare occurrence within the mixing zone, and never occurs outside this zone.

Table 4-51: Frequency of Hourly Average Bottom Water Temperatures Increases Over Ambient - Period of December 15, 2011 through April 13, 2012 (Second Winter Period)

Location	Water Depth (m)	No. of Data Points	Increase Over Ambient							
			Average	75 th Percentile	95 th Percentile	Frequency of Exceedance				
						1°C	2°C	3°C	4°C	5°C
Inside Mixing Zone										
TD38-B	10	1,713	-0.11	0.36	1.16	7.4%	0.0%	0.0%	0.0%	0.0%
TD35-12	12	2,903	0.69	1.26	2.20	37%	6.8%	1.7%	0.7%	0.0%
DN10-B	11	2,122	1.11	1.56	2.10	57%	7.5%	0.0%	0.0%	0.0%
DN11-B	10	1,966	0.28	0.97	1.79	24%	2.8%	0.0%	0.0%	0.0%
DN17-B	12.5	2,904	0.45	1.15	2.00	30%	5.0%	0.0%	0.0%	0.0%
DN18-B	12.5	2,904	0.54	1.36	2.04	38%	5.8%	0.2%	0.0%	0.0%
Edge of Mixing Zone (Clockwise from Nearshore – starting at TD31)										
TD31-B	6	2,904	-0.20	0.08	0.58	0.3%	0.0%	0.0%	0.0%	0.0%
TD52-B	10	1,210	0.81	1.09	1.64	31%	1.2%	0.0%	0.0%	0.0%
TD55-B	15	2,904	0.21	1.00	1.81	25%	2.9%	0.0%	0.0%	0.0%
TD34-B	14	966	-0.34	0.56	1.53	11%	1.4%	0.0%	0.0%	0.0%
TD45-B	10	2,904	0.13	0.64	1.32	12%	0.4%	0.0%	0.0%	0.0%
TD42-B	8	1,875	0.04	0.47	1.02	5.7%	0.0%	0.0%	0.0%	0.0%
Outside Regulated Mixing Zone (Clockwise from Nearshore – starting at DN01)										
DN01-B	6	1,030	-0.27	0.12	0.46	0.2%	0.0%	0.0%	0.0%	0.0%
DN03-B	11	1,694	-0.43	0.23	0.87	2.7%	0.0%	0.0%	0.0%	0.0%
DN05-B	15	2,904	0.18	0.97	1.65	24%	2.0%	0.0%	0.0%	0.0%
DN07-B	18	2,904	0.15	0.94	1.50	22%	0.8%	0.0%	0.0%	0.0%
DN09-B	18	2,365	0.01	0.84	1.50	18%	0.3%	0.0%	0.0%	0.0%
DN08-B	14	2,904	0.30	0.95	1.71	23%	2.3%	0.0%	0.0%	0.0%
DN06-B	12	1,920	0.03	0.61	1.28	11%	0.2%	0.0%	0.0%	0.0%
DN04-B	7	1,921	-0.08	0.28	0.81	3.0%	0.0%	0.0%	0.0%	0.0%
DN02-B	5	2,901	-0.18	0.08	0.59	0.5%	0.0%	0.0%	0.0%	0.0%

Source: Golder, 2012b

The Golder (2012b) assessment of thermal effects focused on the Round Whitefish because its sensitive embryonic life stage is expected to be present in the diffuser area from January through March. Eggs are typically deposited sometime in December, at water depths of 5-10m, and hatch in late March or early April. After hatch, the larvae move inshore to feed over the summer, and then move offshore in the fall.

Golder (2012b) cited an optimal temperature range of 1°C to 5°C for Round Whitefish embryos (Wismer and Christie, 1987) and used a continuous ΔT of 3.5°C or a periodic (6h/day) ΔT of 5°C (Griffiths, 1980) as the benchmark considering these values to be consistent with adequate embryonic survival. Using 7 day average lake temperatures for comparison to the optimal range, and ΔT as shown in Table 4-51, it was concluded at that time that no benchmarks for adverse effect are exceeded as a result of the DN thermal discharge, and that no adverse effects on Round Whitefish embryos are expected.

Since the studies by Griffiths (1980) used an unrealistic temperature regime (base temperature for 16 h/day followed by an abrupt shift to the increased temperature for 8h/day) and had relatively poor survival even at ambient temperature. COG funded new studies of Round Whitefish embryo survival using a naturally varying base temperature. In these studies, survival was 99% under the ambient temperature condition (Patrick et al., 2014). The COG (2014) study found that a reduction to 90% survival required a temperature increase of 3.7°C above ambient. In more recent studies (COG, 2017), more refined benchmarks, ΔT at 3.0 °C above ambient, and a threshold temperature of 6 °C were recommended (OPG, 2017a). The ΔT values around the DN diffuser are well below these levels.

Various statistical models can be fit to the COG data on temperature and Round Whitefish embryo survival, and used to predict Round Whitefish survival for any sequence of temperatures measured over the embryonic period. First the duration of the embryonic period must be predicted, since this also depends on the temperature regime. OPG (2014) used a degree day model, fit to the COG data, to predict this duration at specific locations where temperature was continuously recorded, assumed three different fertilization dates in December, and then used a logistic quadratic model to predict survival at each location based on average temperature over the period. The results are shown in Table 4-52.

As seen in Table 4-52, the predicted survival over the winter of 2011-2012 was greater than 95%. The largest predicted survival loss (as compared to an average of Thickson Point and Bonnie Brae reference locations) was 1.1%, well below the 10% threshold used by the CNSC in the Darlington Refurbishment EA to demark a moderate risk.

Table 4-52: Predicted Egg Survival for Round Whitefish at DN and Farfield Locations for the Winter of 2011-2012 Based on the COG Model (Patrick et al., 2014)

Location	1-Dec-11				15-Dec-11				30-Dec-11			
	Predicted Hatch Date	Average Temp	Survival	Relative Survival Loss	Predicted Hatch Date	Average Temp	Survival	Relative Survival Loss	Predicted Hatch Date	Average Temp	Survival	Relative Survival Loss
ADCP	1-Mar-12	3.6	97.4%	0.1%	18-Mar-12	3.4	97.6%	0.0%	1-Apr-12	3.5	97.5%	0.3%
DN02-B	7-Mar-12	3.0	97.9%	-0.4%	21-Mar-12	3.0	97.9%	-0.3%	2-Apr-12	3.4	97.6%	0.2%
DN04-B	3-Mar-12	3.4	97.6%	-0.1%	19-Mar-12	3.3	97.7%	-0.1%	31-Mar-12	3.6	97.5%	0.4%
DN05-B	27-Feb-12	4.0	97.0%	0.5%	15-Mar-12	3.7	97.3%	0.3%	30-Mar-21	3.7	97.3%	0.6%
DN07-B	28-Feb-12	3.9	97.1%	0.4%	15-Mar-12	3.7	97.3%	0.3%	30-Mar-12	3.7	97.3%	0.5%
DN08-B	28-Feb-12	4.0	97.0%	0.5%	15-Mar-12	3.7	97.3%	0.3%	28-Mar-12	3.9	97.1%	0.7%
DN09-B	6-Mar-12	4.1	96.9%	0.6%					4-Apr-12	4.0	96.9%	0.9%
DN10-B	25-Feb-12	4.3	96.5%	1.0%	12-Mar-12	4.1	96.9%	0.7%				
DN13-B	28-Feb-12	3.9	97.1%	0.4%	16-Mar-12	3.6	97.4%	0.2%	30-Mar-12	3.7	97.3%	0.5%
DN15-5	4-Mar-12	3.4	97.6%	-0.1%	19-Mar-12	3.3	97.7%	-0.1%	31-Mar-12	3.6	97.5%	0.4%
DN16-B	1-Mar-12	3.7	97.3%	0.2%	17-Mar-12	3.5	97.6%	0.1%	31-Mar-12	3.6	97.4%	0.4%
DN17-B	26-Feb-12	4.1	96.9%	0.6%	14-Mar-12	3.8	97.2%	0.4%	27-Mar-12	4.0	97.0%	0.8%
DN18-B	25-Feb-12	4.2	96.7%	0.8%	12-Mar-12	4.0	97.0%	0.6%				
PG1-B	8-Mar-12	2.9	97.9%	-0.5%	23-Mar-12	2.9	98.0%	-0.4%	4-Apr-12	3.2	97.8%	0.0%
TD31-B	6-Mar-12	3.1	97.8%	-0.3%	21-Mar-12	3.1	97.9%	-0.2%	2-Apr-12	3.4	97.6%	0.2%
TD35-B	26-Feb-12	4.1	96.8%	0.7%	13-Mar-12	3.9	97.1%	0.6%	26-Mar-12	4.2	96.7%	1.1%
TD45-B	1-Mar-12	3.7	97.4%	0.1%	17-Mar-12	3.5	97.5%	0.1%	30-Mar-12	3.7	97.3%	0.5%
TD55-B	27-Feb-12	4.0	96.9%	0.6%	15-Mar-12	3.7	97.3%	0.3%	29-Mar-12	3.7	97.3%	0.6%
Totals	29-Feb-12	3.8	97.2%	0.3%	16-Mar-12	3.5	97.5%	0.2%	22-Oct-12	3.7	97.3%	0.5%

Note:

DN10 and TD35 are within the turbulent mixing zone; other stations are at the edge or outside this zone. Far-field locations are Port Darlington (ADCP) and Port Granby (PG1-B), 11 and 18 km east of DN, respectively

SENES (2011b) and Golder (2010) considered maximum weekly average temperatures (MWATs) in the vicinity of the DN thermal discharge, and compared these to MWAT criteria for other fish species known to occur in the area, including emerald shiner, Alewife, White Sucker and Lake Trout. The measured weekly average temperatures were calculated from temperature records collected using dataloggers installed at 35 locations in and around the DN thermal discharge over the period 1993-1996 (Golder, 2011a, Appendix C). The measured MWATs did not exceed any of the relevant MWAT criteria. It was concluded that no effects are expected on local fishes due to the influence of the DN thermal discharge.

Follow-up thermal plume monitoring was conducted during the winter of 2017-2018 to address commitment IIP EA-012 Tasks 4 and 5 of the DNGS Integrated Implementation Plan (OPG, 2015b), as part of the DNGS Refurbishment Follow-up Monitoring Program (OPG, 2013a). The monitoring was completed from November 2017 to May 2018 during a refurbishment outage (OPG, 2018f).

Average winter temperatures in 2017-2018 were cooler than in 2011-2012, and cooler than the long-term average (OPG, 2018f). Plume temperature differences between study years were most prevalent during the time of early Round Whitefish egg development stages beginning in December. During late egg development stages ending in March/April, plume

temperature was 0.7 °C cooler in 2017-2018, and are all below the threshold temperature of 6.0 °C (OPG, 2018f).

Consistent with previous monitoring in 2011-2012, elevated plume temperatures were observed relative to reference locations in 2017-2018. The average of all plume locations together was approximately 0.4 °C greater than the average of ambient locations during the period of early Round Whitefish embryo development, and 0.1 °C greater during the period of late Round Whitefish embryo development (OPG, 2018f). As the elevated plume temperature was no greater than the thermal benchmark of ΔT of 3°C recommended in the most updated COG study (COG, 2017), no adverse impact is expected. In this study, it was also concluded that effects of the plume ranged from a relative survival gain of 0.1% to a loss of 0.4%, which is a negligible effect and well below the 10% loss threshold that CNSC uses as a criterion for further mitigation measures (OPG, 2018f).

4.4.4 Impingement and Entrainment

4.4.4.1 Fish Impingement

Fish impingement sampling was conducted between May 2010 and April 2011 (SENES, 2011a). Each sample was collected from the travelling screens at one unit over a 24-hour period. Samples were collected at least weekly, and twice per week during May-July and February-March. At least four samples were collected in each month, at one to four units in each month.

Daily impingement rates by species were calculated for each unit in each month. Based on the number of days operating and the number of pumps operating at each unit in each month, the daily rates were used to calculate monthly rates for the station when operating at full capacity.

The monthly impingement rates by species, and the estimated annual total, are shown in Table 4-53. Thirteen fish species were taken at DN, assuming that *Cottus* sp. is the slimy sculpin, with Alewife and Round Goby representing 97% of the counts. The estimated annual total was 274,931 fish impinged.

The monthly fish biomass taken by species, and the estimated annual total, are shown in Table 4-54. Alewife and Round Goby represented 97% of the biomass taken. The estimated annual total was 2,362 kg of fish biomass.

Table 4-53: Estimates of Total Annual Impingement (Counts), May 2010 – April 2011 (SENES, 2011a)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
Alewife	3240	26	17	11	550	3926	8255	4280	2142	4176	1921	86950	115465	42.1
American eel	0	5	0	0	0	0	0	0	0	0	0	0	5	0.0
Brown bullhead	0	0	4	0	0	0	0	0	0	0	0	0	4	0.0
Emerald Shiner	0	5	21	0	0	0	0	0	0	0	0	60	86	0.0
Pumpkinseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Rainbow smelt	180	31	27	43	1349	829	1150	872	10	94	339	933	5857	2.1
Round goby	21240	5238	8924	21410	23576	10920	24513	9216	728	3169	4317	18261	151510	55.1
Slimy sculpin	0	16	63	34	0	0	0	0	0	0	0	0	113	0.0
Smallmouth bass	0	0	0	0	0	0	0	8	0	0	0	0	8	0.0
Spoonhead sculpin*	0	256	94	83	481	325	276	40					1555	0.6
Threespine stickleback	0	5	0	0	0	0	0	0	0	0	0	0	5	0.0
<i>Cottus</i> sp.	0	157	4	0	0	0	0	0	0	0	0	0	161	0.1
Sunfish (unident.)	0	5	0	0	0	0	0	0	0	0	0	0	5	0.0
White sucker	0	5	0	0	0	0	34	0	0	0	0	0	39	0.0
Yellow perch	0	5	0	6	0	0	0	0	0	0	0	0	11	0.0
Total	24660	5755	9154	21587	25955	16000	34232	14416	2881	7439	6577	106276	274931	100

Note:

Examination of photographs presented in the source document by experienced fish taxonomists suggested misidentification. It is probably Mottled Sculpin or Slimy Sculpin, as the preopercular spine was not curved enough for a Spoonhead Sculpin.

Table 4-54: Estimates of Total Annual Impingement (Biomass) (kg), May 2010 – April 2011 (SENES, 2011a)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
Alewife	29.20	0.27	0.10	0.02	4.28	36.16	33.61	31.02	4.11	11.57	9.85	833.92	994	42.1
American eel	0	7.48	0	0	0	0	0	0	0	0	0	0	7.5	0.3
Brown bullhead	0	0	0.01	0	0	0	0	0	0	0	0	0	0.0	0.0
Emerald Shiner	0	0.01	0.04	0	0	0	0	0	0	0	0	0.27	0.3	0.0
Pumpkinseed	0	0	0	0	0	0	0.27	0	0	0	0	0.22	0.5	0.0
Rainbow smelt	1.50	0.22	0.12	0.47	8.97	4.21	5.99	5.06	0.10	1.22	1.56	3.98	33	1.4
Round goby	164.7	41.59	70.55	192.7	217.8	117.6	219.7	92.21	5.27	28.75	41.8	115.3	1308	55.4
Slimy sculpin	0	0.12	0.62	0.34	0	0	0	0	0	0	0	0	1.1	0.0
Smallmouth bass	0	0	0	0	0	0	0	0.08	0	0	0	0	0.0	0.0
Spoonhead sculpin	0	2.84	1.03	0.78	3.71	2.02	2.31	0.34					13	0.6
Threespine stickleback	0	0.01	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Cottus sp.	0	1.71	0.04	0	0	0	0	0	0	0	0	0	1.8	0.1
Sunfish (unident.)	0	0.04	0	0	0	0	0	0	0	0	0	0	0.0	0.0
White sucker	0	2.02	0	0	0	0	.34	0	0	0	0	0	2.4	0.1
Yellow perch	0	0.14	0	0.04	0	0	0	0	0	0	0	0	0.2	0.0
Total	195.4	56.45	72.52	194.3	234.7	160.0	262.2	128.7	9.49	41.55	53.2	953.7	2362	100

Both numbers and biomass of fish impinged in 2010-2011 were higher than the estimates made in 2006-2007 (26,024 fish, 893 kg, assuming all units impinged similar amounts as Unit 4). The greater impingement in 2010-11 was explained partly by population changes in Round Goby and Alewife. The Round Goby is an invasive species which had likely increased in the area as it invaded Lake Ontario. Alewife is a non-native species. The Alewife population had increased in Lake Ontario, following a previous decline. According to the MNR (2010), the Alewife population (age 1 and over) was estimated at 1650 metric tonnes (MT) in 2006, and 5298 MT in 2009. The age 1 year class had particularly increased, with the 2010 age 1 year class being the third largest in the past 15 years (Walsh and Connerton, 2011). In addition, the sampling in 2010-11 was more intensive, likely providing more accurate estimates, and the new travelling screens installed in 2010 was likely more efficient. The large counts of Alewife in December 2010 (75% of the annual counts) may have been associated with an upwelling event, as suggested by SENES (2011a).

Impinged American Eels were reported to the MNRF annually as a condition of the ESA permit. From 2016 to 2019, the number of incidental impinged American Eel at DNGS was reported at 13 (April 2016 - March 2017), 24 (April 2017- March 2018), 5 (April 2018 - March 2019), and 0 (April 2019 - March 2020), respectively (Ecometrix, 2020).

4.4.4.1.1 Equivalent Loss Metrics

Various “equivalent loss” metrics can be calculated from the counts of fish impinged, as recommended in CSA N288.6-12. These metrics, including equivalent age 1, equivalent fishery yield, and production foregone, are more relevant to effect on the population than are the raw counts (Dey, 2002; EPRI, 2004; US EPA, 2002), and facilitate comparison to fishery statistics. These metrics were calculated using the 2010-2011 fish impingement data (SENES, 2011a). The results are presented in Table 4-55.

Equivalent Age 1 values were calculated for most fish species, using standard life history parameters as described by SENES (2011a). The unidentified sculpin (*Cottus* sp.) were considered to be slimy sculpin. The unidentified sunfish were considered to be pumpkinseed. As calculated by SENES, the equivalent age 1 values can be greater than the annual counts if the fish taken at the station are mainly older than age 1. This was particularly evident for Round Goby because the individuals taken were mainly at 2+ and 3+ ages.

Production foregone values represent the loss of future biomass due to the foregone growth of the fish taken at the station. This metric is usually calculated for forage fish, since their ecological value is in the production of prey biomass. It was calculated by SENES (2011a) for most fish species. The production foregone over all species considered was 905 kg, mainly from Alewife, Round Goby and Rainbow Smelt. Adding this to the biomass of fish lost at the time of impingement (2355 kg) a total biomass loss of 3260 kg was calculated.

Lost Fishery Yield was calculated only for species with commercial or recreational fisheries. This metric represents the loss of future fishery yield (expressed as biomass) that will not be harvested as a result of fish taken at the station. The Lost Fishery Yield was only 89 kg and consisted almost exclusively of rainbow smelt.

Table 4-55: Estimates of Annual Equivalent Loss from Impingement at the Darlington Nuclear Generating Station, May 2010 – April 2011 (SENES, 2011a)

Taxa	Number of Equivalent Age 1+	Total Annual Impingement Weight (kg)	Total Future Production Foregone (kg)	Total Biomass Lost (kg)	Lost Fishery Yield (kg)
Alewife	56,515	994.14	576.65	1,570.79	N/A
Brown bullhead	7	0.01	0.60	0.61	0.21
Emerald shiner	1,006	0.32	0.09	0.41	N/A
Pumpkinseed	132	0.49	2.59	3.09	0.75
Rainbow smelt	20,114	33.42	111.93	145.35	87.30
Round goby	3,860,403	1,307.85	207.27	1,515.12	N/A
Slimy sculpin	26,573	1.08	0.09	1.17	N/A
Smallmouth bass	0	0.08	0.04	0.12	0.01
Spoonhead sculpin	237,962	13.02	2.44	15.46	N/A
Threespine stickleback	20	0.01	0.00	0.01	N/A
Unidentified sculpin	39,281	1.75	0.13	1.88	N/A
Unidentified sunfish	8	0.04	0.14	0.18	0.04
White sucker	21	2.35	2.57	4.92	0.56
Yellow perch	10	0.18	0.93	1.11	0.35
Total	4,242,050	2,354.75	905.47	3,260.22	89.22

Notes:

N/A = not applicable

Unidentified sculpin – likely slimy sculpin

4.4.4.1.2 Comparison to Fishery Statistics

The Alewife population in Lake Ontario in 2009 was estimated at 134 million age 1 and older fish, with a biomass of 5298 metric tonnes (MNR, 2010). The take of Alewife at DN in 2010-2011 was equivalent to 56,515 age 1 fish, or 0.04% of the population. The total biomass lost, including production foregone, was 1571 kg, or 0.03% of the population biomass. These losses are negligible.

The rainbow smelt population in Lake Ontario in 2009 was estimated at 311 million age 1 and older fish, with a biomass of 1714 metric tonnes (MNR, 2010). The take of rainbow smelt at DN in 2010-2011 was 5857 fish, or 0.002% of the population. The total biomass lost, including production foregone, was 145 kg, or 0.008% of the population biomass. These losses are negligible.

The invasive Round Goby has increased rapidly in Lake Ontario since appearing in 2002, with a concurrent decline in the native benthic prey species such as the slimy sculpin (NYDEC, 2014). Based on bottom trawl surveys on the U.S. side of the lake, Round Goby density was approximately 0.03/m², with a biomass of 0.2 g/m² (NYDEC, 2014). For a lake area of 18,960 km², Lake Ontario may contain around 568 million Round Goby, and a biomass of around 3.8 million kg. These are very rough estimates. The take of Round Goby at DN in 2010-2011 was 151,510 fish, or 0.27% of the population. On a biomass basis, the total biomass lost, including production foregone, was 1515 kg, or 0.04% of the population. These losses are negligible.

Overall, fish losses due to impingement at DN were considered negligible when considering the Lake Ontario populations of the impinged organisms (Ecometrix, 2020; SENES, 2011e, 2011a). OPG has a DFO Fisheries Authorization for the impingement and entrainment of fish at DNGS. OPG will continue to meet the conditions of the Fisheries Authorization, which includes conducting two years of impingement monitoring at DNGS in 2024 and 2025. Note that the DFO Fisheries Authorization does not allow for impingement and entrainment of federal species at risk (SARA Schedule 1) and provides conditions for monitoring and reporting should a SARA Schedule 1 species become impinged or entrained. Impingement and entrainment of provincial species at risk (SARO) is covered under the ESA and associated regulations.

4.4.4.2 Fish Entrainment

Entrainment Studies of fish egg and larval entrainment at DN were conducted in 2004 (June – August), 2006 (March – September) (Ager et al., 2005, 2006), 2010, and 2015/2016 (which are all reported in (Ecometrix, 2020). The most recent sampling effort was a follow-up program to the environmental assessment for DN refurbishment and continued operation, where more intensive studies of fish (eggs and larvae) and macro benthic invertebrate entrainment were completed. Entrainment sampling was conducted in the DN forebay from December 2015 to November 2016, for a total of 64 sampling events. Sampling focused on continuous 24-hr collections and each sampling event had a day time and night time sample, approximately 12-hrs each depending on daylight hours, and a total of 124 samples were collected. Samples were collected on a weekly basis in December 2015, and March, August, and September 2016; twice weekly from April to July 2016; and biweekly in January, February, October, and November 2016. In addition, as part of the DNGS benthic invertebrate community characterization study, larval tows occurred in the area of the DN intake, and in two reference areas (vicinity of Bond Head and Thicksen Point), over three epifauna sampling events in 2016 (May, late June, and late August). Infauna sampling occurred in late August/early September of 2016. In each sampling area, sampling occurred at three water depths (approximately 5 m, 10 m, and 15 m). In the 2015/2016 entrainment study, a total of 2613 fish eggs were entrained, all collected from the end of April to early August, 2016. Eggs entrained were mainly identified as Alewife (90%), Walleye (9.2%), and Round Goby (0.4%). There were also 9 eggs entrained that were likely Slimy or Mottled Sculpin and 2 unidentified eggs. A total of 122 fish larvae were

entrained over the study period, mainly Round Goby (89%) and Deepwater Sculpin (7%). Alewife and Burbot larvae were also entrained, with one larva of each species collected during the study period. The 2015/2016 study used a more statistically robust method compared to previous studies, which enabled observation of species not previously entrained (i.e., Deepwater Sculpin) and species of lower density (e.g., Walleye) (Ecometrix, 2020).

The estimated annual entrainment was comprised of 94,482,521 eggs and 10,983,411 larvae. This number was higher than the 2004 and 2006 studies, likely because of the more robust sampling method used. The estimated annual biomass lost to entrainment in the 2015/2016 study was 589 kg, comprised mainly of Round Goby, Walleye, and Deepwater Sculpin. Loss estimates for Deepwater Sculpin were likely overestimated. Walleye was the only entrained species subject to fishing. The lost fishery yield for Walleye was 149 kg. Deepwater Sculpin is a Species of Special Concern under the federal SARA. Although its larvae were entrained, no eggs were captured in the 2015/2016 study. It was noted that the Deepwater Sculpin population in Lake Ontario is recovering (Weidel et al., 2017), and may be near its carrying capacity in Lake Ontario (MNR, 2019). Overall, losses from fish entrainment were considered too low to measurably affect Lake Ontario fish populations (Ecometrix, 2020).

Benthic invertebrates were entrained in all months of the study period with a total of approximately 22,301 individuals collected. The estimated annual entrainment of benthic invertebrates was 1,548,288,043, with the highest numbers entrained for Echinogammarus and other Amphipods (91% of the benthic invertebrate total). From the 2016 epifauna and infauna sampling, it was shown that the benthic invertebrate community in the vicinity of the DNGS does not differ from communities in the reference location in a manner that reflects a station-related effect, therefore, entrainment at the DNGS is not considered to be negatively impacting local benthic invertebrate populations (Ecometrix, 2020).

The 2015/2016 entrainment program was more comprehensive compared to previous studies. In the 2004 and 2006 studies, samples were collected using larval tows in the forebay. The 2004 samples were comprised mainly of rainbow smelt and Alewife. The annualized estimates of entrainment were 15,631,833 eggs, and 1,201,943 larvae, representing 1,318 age-1 equivalent fish. The production foregone was estimated at 46.2 kg. The 2006 samples were comprised mainly of Alewife, common carp and freshwater drum. The annualized estimates of entrainment were 605,059 eggs and 6,996,246 larvae, representing 11,548 age-1 equivalent fish.

Limited sampling was conducted in the forebay in April and July, 2010 (SENES, 2011d). Both fish and aquatic invertebrates were enumerated in these samples. Fish in the samples included larvae of Round Goby, Round Whitefish, and Alewife. Invertebrates included two species of freshwater shrimp (*Mysis relicta*, and the invasive *Hemimysis anomala*). The sampling effort was considered insufficient to support the calculation of annualized losses or equivalent loss metrics.

4.4.5 Uncertainties in the Risk Characterization

There are uncertainties associated with the components contributing to the overall risk assessment. This includes receptor exposure factors, such as transfer factors, intake rates and bioaccumulation factors, dose coefficients and averaging assumptions (discussed in Section 4.1), as well as benchmark values used to determine risk of potential effects (discussed in Section 4.3).

Overall, considering uncertainties in the exposure assessments and the benchmark values, it is reasonable to consider that HQs above 1 for a COPC, receptor and location are indicative of a potential for adverse effects. However, it does not necessarily imply adverse effects. In some cases, field studies may be appropriate to clarify whether effects are occurring.

A probabilistic risk assessment (PRA) to quantify uncertainty in the risk estimate has not been performed and is not considered necessary. Based on the quantity of data available for the current risk assessment, uncertainties in the current deterministic risk assessment could not be accurately quantified using a PRA. According to CSA N288.6 (2012), a PRA should be conducted only if the results of the PRA are beneficial and provide a better basis for risk management/decision making, and a qualitative or semi-quantitative evaluation of uncertainty is considered sufficient for evaluation of uncertainty.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 Conclusions of Human Health Risk Assessment (HHRA)

5.1.1.1 Radiological HHRA

In summary, there are no health risks for human receptors as a result of radiological exposure. For exposure of human receptors to radiological COPCs, the relevant exposure pathways and human receptors (potential critical groups) were those presented in the annual OPG EMP reports. Radiological dose calculations followed the methodology outlined in CSA N288.1-14. The 2016 to 2019 public dose estimates for the critical groups are at most approximately 0.08% of the regulatory public dose limit of 1 mSv/a, and at most approximately 0.06% of the dose from background radiation in the vicinity of DN (1.4 mSv/year excluding medical doses). Demonstration that these critical groups are protected implies that other receptor groups near DN with anticipated lower exposure are also protected.

5.1.1.2 Non-Radiological HHRA

The COPCs assessed in the non-radiological HHRA included NO_x in air; and lithium, zirconium, and hydrazine in water and fish. Potential risks to human receptors were characterized quantitatively in terms of Hazard Quotients (HQs) for non-carcinogens (lithium, zirconium) and Incremental Lifetime Cancer Risks (ILCRs) for potential carcinogens (hydrazine). The target risk level is 0.2 for non-cancer risk (HQ) and 10⁻⁶ for cancer risk (ILCR).

In summary, there are no health risks for human receptors due to exposure to hydrazine, lithium, and zirconium in drinking water and in fish. There are no long-term risks due to inhalation of nitrogen oxides for any of the receptors; however, air quality monitoring planned to be initiated in 2021 at the DN site should be used to reduce the uncertainty regarding short-term risks due to inhalation of nitrogen oxides

The detailed results of the quantitative HHRA are as follows.

- The target for non-cancer risk was not exceeded for all potential critical groups based on modelled annual average air concentrations for nitrogen oxides. However, there is uncertainty around the short-term (1-hr) air concentrations at the potential critical group locations. Based on available data in the ESDM reports, a hazard quotient for short-term exposure was calculated for the Sport Fisher, which exceeded the target for non-cancer risk. Since other potential critical groups are farther away, it is anticipated that the hazard quotient for the other receptors will be lower than that for the Sport Fisher. To provide a more realistic interpretation of risk,

NO₂ data from air quality monitoring planned to be initiated at the DN site in 2021 should be used to refine the risk estimates.

- No risk to human receptors is expected resulting from exposure to lithium or zirconium in surface water at DN. The target non-cancer risk was not exceeded for any human receptors due to exposure to lithium and zirconium in drinking water and fish.
- Health risks to human receptors are not expected due to exposure to hydrazine in drinking water. The acceptable cancer risk level was not exceeded for any of the receptors based on exposure to the UCLM hydrazine concentration in drinking water (based on hydrazine released with the effluent and hydrazine measured in Lake Ontario). While exposure to maximum estimated hydrazine concentration from the effluent resulted in exceedances of the acceptable cancer risk level at the Oshawa/Courtice and Bowmanville Urban Residents, and for Campers, the maximum is not considered representative of long-term exposure and results should be interpreted based on the UCLM.
- The Sport Fisher and Camper were conservatively assumed to eat all of the fish portion of diet and half of the fish portion of diet, respectively, from Lake Ontario fish caught at DN. The acceptable cancer risk level was not exceeded for any human receptors due to exposure to UCLM concentrations of hydrazine in fish. Based on maximum concentrations of hydrazine in fish the acceptable cancer risk level was exceeded for the Sport Fisher and the Camper; however, the maximum is not considered representative of long-term exposure and results should be interpreted based on the UCLM since fish move around in the lake.

In summary, health risks are not expected for human receptors due to exposure to hydrazine, lithium, and zirconium in drinking water and in fish. Long-term risks due to inhalation of nitrogen oxides are not expected for any of the receptors; however, the uncertainty regarding short-term risks due to inhalation of nitrogen oxides should be clarified based on results of air quality monitoring planned to be initiated in 2021 at the DN site.

5.1.2 Conclusions Ecological Risk Assessment (EcoRA)

5.1.2.1 Radiological EcoRA

Radiation dose benchmarks of 400 µGy/h (9.6 mGy/d) and 100 µGy/h (2.4 mGy/d) (UNSCEAR, 2008) were selected for the assessment of effects on aquatic biota and terrestrial biota, respectively, as recommended in the CSA N288.6-12 standard (CSA, 2012).

Lake Ontario

There are no exceedances of the 9.6 mGy/d radiation benchmark for the aquatic biota at the SSA in Lake Ontario, including fish and benthic invertebrates. The 2.4 mGy/d radiation

benchmark for riparian biota has also not been exceeded for any riparian receptors, including Bufflehead and Mallard.

Polygon AB

There are no exceedances of the 9.6 mGy/d radiation benchmark for the aquatic biota in Coot's Pond (in Polygon AB). Aquatic biota include: Northern Redbelly Dace, Turtles, Frogs, aquatic plants and benthic invertebrates.

There are no exceedances of the 2.4 mGy/d radiation benchmark for the terrestrial and riparian biota assessed in Polygon AB. Terrestrial and riparian biota include: Bufflehead, Mallard, Green Heron, and Muskrat at Coot's Pond, as well as Earthworms, terrestrial plants (grass), American Robin, Bank Swallow (a species at risk), Song Sparrow, Yellow Warbler, Eastern Cottontail, Meadow Vole, White-tailed Deer, Common Shrew, Raccoon, Red Fox, and Short-tailed Weasel in Polygon AB outside of Coot's Pond.

The radiation dose to all receptors located in Coot's Pond (in Polygon AB) was below the radiation dose benchmarks for aquatic and terrestrial receptors. The HTO concentration measured in Coot's Pond likely originates from atmospheric emissions from DN and subsequent deposition to Coot's Pond. Although Coot's Pond receives runoff from the DN landfill it does not receive effluent from the DN site, other than through atmospheric deposition. The maximum tritium concentration measured in 2019 in Lake Ontario in the vicinity of DN was much lower than the maximum measured in Coot's Pond (15.4 Bq/L maximum in Lake Ontario compared to 46.8 Bq/L in Coot's Pond). DN releases tritium in the effluent to Lake Ontario, but the concentration of tritium in Lake Ontario is much lower than the concentration of tritium in Coot's Pond. The average measured HTO concentration in McLaughlin Bay west of DN in 2019 was 22.9 Bq/L, while Lake Ontario in the vicinity of DN was 14.8 Bq/L (OPG, 2020b). This indicates that a portion of HTO in McLaughlin Bay comes from atmospheric deposition. The higher HTO concentration in Coot's Pond as compared to McLaughlin Bay is likely due to the closer proximity of Coot's Pond to the DN atmospheric source. Overall, this comparison confirms that the source of tritium in Coot's Pond is from atmospheric deposition from DN.

Polygon C

There are no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial biota at Polygon C. Terrestrial biota include Earthworms, terrestrial plants (grass), American Robin, Song Sparrow, Yellow Warbler, Eastern cottontail, Meadow Vole, White-tailed Deer, Common Shrew, Raccoon, Red Fox, and Short-tailed Weasel.

Polygon D

There are no exceedances of the 9.6 mGy/d radiation benchmark for the aquatic biota present at Treefrog Pond in Polygon D. Aquatic biota at Treefrog Pond include: Turtles, Frogs, and aquatic plants.

Because Dragonfly and Polliwog Ponds are known to dry up at different times of the year, the surface water and sediment radionuclide concentrations at Treefrog Pond, along with the aquatic biota present at this pond, have been used to represent surface water and sediment radionuclide concentrations along with the presence of potential aquatic biota at Dragonfly and Polliwog Ponds.

Polygon E

There are no exceedances of the 2.4 mGy/d radiation benchmark for terrestrial biota at Polygon E. Terrestrial biota include: Earthworms, terrestrial plants (grass and Sugar Maple), American Robin, Song Sparrow, Yellow Warbler, Eastern Cottontail, Meadow Vole, White-tailed Deer, Common Shrew, Raccoon, Red Fox, and Short-tailed Weasel.

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The maximum dose rate to any ecological VEC residing in close proximity (5 m from the DWMF wall) to the DWMF could be up to 0.024 mGy/d, lower than the 2.4 mGy/d radiation benchmark for terrestrial biota. The dose also remains below the radiation benchmark if the maximum dose from the DWMF is combined with the dose to ecological VECs from being exposed to radionuclides through other existing DN operations, since the expected radiological dose rates from the DWMF at full capacity would be the largest contributor to total dose.

5.1.2.2 Non-Radiological EcoRA

The potential for ecological effects was assessed by comparing exposure levels to toxicological benchmarks, and characterized quantitatively in terms HQs. A HQ greater than 1 indicates a need to more closely assess the risk to the concerned VEC.

DN Site - Atmospheric Contaminants

No significant effects are expected from nitrogen oxides (NO_x) to ecological receptors at the DN site. NO_x exceeds the short-term air screening benchmark (MECP AAQC), based on the 2016 ESDM modelled maximum ½ hour POI value of 639 µg/m³, and therefore was carried forward in the quantitative risk assessment. Adverse effect levels for NO_x under long term exposure are 5,000 µg/m³ for plants (Doull et al., 1980) and 47,000 µg/m³ for dogs (Heck, 1964). It is rather conservative to use the modelled maximum 1/2 hour concentration to estimate long-term effects. However, as the maximum POI concentrations during 2016 to 2019 are all below these adverse effect levels in small mammals and plants, no significant effects are expected from NO_x.

There is some uncertainty around the risk from NO_x as modelled concentrations were used as the basis for the assessment. OPG has recently initiated a one-year air monitoring program at the DN Site. It would be valuable to incorporate NO₂ concentrations measured

during this program in the next ERA to refine the risk estimates for ecological receptors provided in this ERA and provide a more realistic interpretation.

Lake Ontario

Fish in Lake Ontario are not at toxicological risk from DN operations. The UCLM concentration of unionized ammonia (0.013 mg/L) did not exceed the benchmark for ammonia for fish, while the maximum surface water concentration for unionized ammonia (0.26 mg/L) in the nearshore Lake Ontario exceeded the benchmark...As fish are generally mobile, the UCLM concentration is a more representative estimate of the exposure. In addition, in 2016 to 2019, the maximum concentrations of ammonia in both the CCW, and the estimated nearshore concentration in Lake Ontario from stormwater, were below the selected benchmark. Therefore, the elevated ammonia concentration in Lake Ontario is not likely arising from the DN operations. As such, fish species are not at toxicological risk from DN operations. This includes American Eel, which is identified as a species at risk in the study area.

Sediment in Lake Ontario is transient and the invertebrate community is mainly epifaunal. This suggests that the sediment exposure pathway is unlikely to be the primary exposure route for benthic invertebrates in Lake Ontario. Although a few benthic invertebrates may experience nutrient enrichment effects at the maximum TKN level in sediment, the benthic community as a whole is not expected to be affected. Since benthic invertebrates cannot move around, exposure to maximum sediment concentrations is appropriate, since a few benthic invertebrates may experience prolonged exposure at the maximum. Maximum sediment concentrations for Lake Ontario exceeded the sediment benchmark for TKN and phosphorus for benthic invertebrates, whereas the UCLM sediment concentrations for Lake Ontario did not exceed the benthic invertebrate benchmarks for TKN, but did exceed for phosphorus.

There was no exceedance of the HQ target of 1 for riparian birds in Lake Ontario, and there are no mammals identified as ecological receptors in this polygon.

Cesium and strontium are not having a toxic effect on ecological receptors in the Lake Ontario near shore area. Although, there is no available toxicity benchmark for cesium and strontium for aquatic and riparian ecological receptors, the maximum concentrations of cesium (0.39 mg/kg) and strontium (276 mg/kg) fall within the lower range of background concentrations for the continental USA (Dragun and Chiasson, 1991) between 0.25-25mg/kg and 5-3000 mg/kg for cesium and strontium, respectively.

The risk for riparian birds to be exposed to toxic levels of PAHs is very low. Although toxicity reference values are not available for PHC F3 and PAH compounds in the Lake Ontario SSA, adverse effects of PHCs are not expected for birds as PHCs are readily metabolized by vertebrates, and are not anticipated to accumulate in birds and mammals. The likelihood that birds are exposed to toxicological effects from PAHs is also low, as the

PAHs in the sediment only exceeded the sediment benchmark during one sampling event in 2018, and the Lake Ontario sediment is transient (COG, 2013b).

Lake Ontario is a productive habitat for aquatic biota. The maximum pH observed in Lake Ontario (9.2), exceeded the MECP water quality objective for pH of a range from 6.5 to 8.5; however, the UCLM pH measured in Lake Ontario was 8.4 which is within the range of the MECP and CCME guidelines. The MECP considers the PWQO for pH to be the range within which waters are the most productive (MOE, 1979). Surface water with pH above the upper limit of the PWQO may be less productive. Therefore, no adverse effects from pH are expected at Lake Ontario.

Polygon AB

An aquatic and terrestrial assessment of VECs located in Polygon AB (Coot's Pond) was performed.

The results of the aquatic assessment in Coot's Pond showed exceedances of the HQ target of 1 for:

- ammonia for fish and turtles/frogs based on the maximum concentration in water; and
- TKN, TOC, cadmium, chromium, copper, iron, manganese, nickel, phosphorus, vanadium, and zinc for benthic invertebrates based on maximum and UCLM concentrations in sediment.

No risk has been identified in Coot's Pond associated with emissions from DNGS operations for aquatic receptors. Although potential risks were identified for aquatic receptors at Coot's Pond from a number of COPCs, the source of these COPCs in Coot's Pond is not the result of emissions from the DN site, but is attributable to the pond having been designed as a settling pond for stormwater runoff, and to being adjacent to a licensed landfill section of the site (Golder and SENES, 2009). OPG has an Environmental Compliance Approval (ECA) for the landfill and conducts and reports on quarterly monitoring and semi-annual inspections. The elevated TKN, TOC, ammonia and phosphorus concentrations in the sediment also suggest agricultural inputs in Coot's Pond. Based on field studies conducted during the Darlington NND EA and subsequent biodiversity studies, Coot's Pond has provided and continues to provide valuable habitat and breeding areas for fish (Northern Redbelly Dace), amphibians, birds, and mammals.

The results of the terrestrial assessment in Polygon AB showed no exceedances of the HQ target of 1 for ecological receptors.

Polygon C

Where data were available, the HQ target of 1 was not exceeded for terrestrial biota for strontium. No risks were identified for terrestrial biota for polygon C.

The maximum soil concentration of strontium in Polygon C falls within the lower range of background concentration in continental USA (Dragun and Chiasson, 1991). There were no data to determine strontium benchmarks for birds; however, when strontium benchmark values for birds are set to strontium benchmarks for mammals, there are no exceedances for Polygon C.

Polygon D

Where data were available, the HQ target of 1 was not exceeded for both aquatic and terrestrial biota. No risks were identified for aquatic and terrestrial biota for Polygon D.

The maximum soil concentration of strontium in Polygon D falls within the range of background concentrations in the continental USA. There were no data to determine strontium benchmarks for birds; however, when strontium benchmark values for birds are set to strontium benchmarks for mammals, there are no exceedances for this polygon.

Polygon E

Exceedances of the HQ of 1 for terrestrial receptors in Polygon E are localized and associated with elevated metals concentrations in soil in the yard waste and building materials storage area.

The results of the terrestrial assessment showed exceedances of the HQ target of 1 for:

- Maximum arsenic, cobalt, copper, lead, molybdenum, nickel, and zinc for Earthworms;
- Maximum arsenic, cobalt, copper, lead, molybdenum, nickel, tin and zinc for terrestrial plants;
- Maximum copper, lead, selenium, and zinc for terrestrial birds;
- Maximum arsenic, cadmium, copper, molybdenum, selenium and zinc for terrestrial mammals.

All metals assessed in this ecological risk assessment were identified as COPCs because they exceeded selected screening criteria at the yard waste and building materials storage area. Therefore, the impacted soil with elevated metal concentrations is localized, and not due to deposition from the atmospheric release. For terrestrial invertebrates (Earthworms) and terrestrial plants, although individuals may be affected by the maximum concentrations of these metal COPCs, the population should not be affected.

Metals at Polygon E are not likely to cause adverse effects on birds and mammals. Birds and mammals usually move around, and are likely to see exposures similar to UCLM concentrations as they move around the area. The HQ target of 1 is exceeded only at the maximum concentration, but not the UCLM concentration.

The HQ for selenium exceeded 1 for Bank Swallow and Yellow Warbler based on both maximum and UCLM concentrations. The HQ values for zinc also exceeded the target of 1 for American Robin, Bank Swallow, Song Sparrow and Yellow Warbler exposed to both maximum and UCLM concentrations. In addition, the HQ values for Common Shrew were greater than 1 based on both maximum and UCLM concentrations of copper, selenium, and zinc. These results suggest that there is potential for adverse effects to some birds and mammals in Polygon E associated with the yard waste and building materials storage area.

Bank Swallow is identified as a species at risk, and is known to nest in the banks along the shore of Lake Ontario, south of Polygon E. HQs above 1 based on maximum soil concentrations (copper, lead, selenium, zinc) and UCLM concentrations (selenium, zinc) in Polygon E were identified. While Bank Swallows do not nest at the yard waste and building materials storage area, they may spend some time there foraging. It is understood that a soil characterization study of the yard waste and building materials storage area is currently being undertaken by OPG, and next steps for soil management will be determined based on the results of the soil characterization study.

Adverse effects of chemical COPCs to Barn Swallow are not expected. Bank Swallow was used as a surrogate to assess risk to Barn Swallow. Barn Swallows typically nest in small openings in man-made buildings, and are annual breeders all around the existing station. As Polygon E is mostly open field, it is not a suitable habitat for Barn Swallows. Although it is possible for Barn Swallows to forage in Polygon E, the exposure will be much lower than the estimated UCLM values.

There were no data to determine benchmarks for tin for terrestrial invertebrates, strontium for birds, or iron and sodium for all terrestrial receptors. These COPCs are not likely to cause adverse effects on ecological receptors for the reasons below:

- The maximum tin concentration in soil in Polygon E was 108 mg/kg dw, below the derived sediment effects concentration of 130 mg/kg dw which is considered protective of benthic invertebrates.
- There were no data to determine strontium benchmarks for birds. As discussed above, maximum strontium concentration in soil in Polygon E falls within the range of background concentrations for the continental USA, and when the strontium benchmark value for birds is set to the mammal benchmark, there would be no exceedances for Polygon E.
- Iron is present in soil mostly in the form of particulate, and it is not bioavailable. Absorption of iron in the body (mammals and birds) is regulated, and very little is metabolised. Iron ingested from drinking water is efficiently expelled from the body (HC, 1978).
- Sodium is generally not considered as a toxicant for birds and mammals, as it is effectively regulated in the body. In addition, the elevated sodium concentration at polygon E (compared to the Ontario rural parkland background value) is likely seasonal and due to road salt used in de-icing activities.

Thermal Effects

An assessment of thermal effects from the warm cooling water discharged by DN was conducted in 2011 and 2012 by Golder (2012b) at 31 locations in and around the discharge, and at reference (ambient) locations. These data indicate that a ΔT of 3°C is a rare occurrence within the mixing zone, and never occurs outside this zone.

The Golder (2012b) assessment of thermal effects focused on Round Whitefish because its sensitive embryonic life stage is expected to be present in the diffuser area from January through March. Eggs are typically deposited sometime in December, at water depths of 5-10m, and hatch in late March or early April. After hatch, the larvae move inshore to feed over the summer, and then move offshore in the fall. Golder (2012b) cited an optimal temperature range of 1°C to 5°C for Round Whitefish embryos (Wismer and Christie, 1987) and a continuous ΔT of 3.5°C or a periodic (6h/day) ΔT of 5°C (Griffiths, 1980) as being consistent with adequate embryonic survival.

Since the studies by Griffiths (1980) used an unrealistic temperature regime (base temperature for 16 h/day followed by an abrupt shift to the increased temperature for 8h/day) and had poor survival even at ambient temperature. COG funded new studies of Round Whitefish embryo survival using a naturally varying base temperature. In these studies (Patrick et al., 2014), survival was 99% under the ambient temperature condition. The COG study found that a reduction to 90% survival required a temperature increase of 3.7°C above ambient. COG published a more recent report summarized and consolidated findings from the COG 2014 report with the literature on the thermal effects on whitefish eggs, and developed science-based thermal benchmarks (COG, 2017). In this updated report, a more conservative ΔT value at 3 °C was recommended. The ΔT values around the DN diffuser are well below this level.

Round Whitefish survival for any sequence of temperatures measured over the embryonic period can be predicted. The predicted survival over the winter of 2011-2012 was greater than 95%.

In 2016, OPG, with the assistance from Professor M. Pandey at the University of Waterloo, developed a hybrid thermal response model for early development of Round Whitefish using the lower temperature exposures from the COG (2014) study and the higher temperature exposures of the Griffiths (1980) study, to be included in the monitoring plan for the DNGS thermal study in 2017-2018. Additional model development was performed based on the most realistic dataset, and predicted a threshold temperature – corresponding to a 90% probability of survival – of 6.3 °C. Based on the result, ECCC, CNSC and OPG agreed on a conservative temperature threshold at 6 °C protective of Round Whitefish embryos. OPG (2017a) used this threshold as an action level in a follow-up thermal plume monitoring conducted during the winter 2017-2018 during a refurbishment outage. The average winter temperatures during this monitoring season were cooler than in 2011-2012, all well below the threshold value of 6 °C. Consistent with the previous monitoring event, elevated plume temperatures were observed relative to reference locations. The average

of all plume locations together was approximately 0.4 °C greater than the average of ambient locations during the period of early Round Whitefish embryo development, and 0.1 °C greater during the period of late Round Whitefish embryo development, well below the thermal benchmark at 3 °C above ambient.

Impingement/Entrainment

In summary, when considering the Lake Ontario populations of the impinged species, fish losses due to impingement were considered negligible. Fish impingement sampling was conducted between May 2010 and April 2011 (SENES, 2011a). Thirteen fish species were taken at DN, with Alewife (non-native species) and Round Goby (invasive species) representing 97% of the counts. The estimated annual total was 274,931 fish impinged. By fish biomass, Alewife and Round Goby represented 97% of the biomass taken. The estimated annual total was 2,362 kg of fish biomass. Additionally, OPG has a Fisheries and Oceans Canada authorization related to operation of DNGS where offsetting measures are undertaken to counterbalance the impingement and entrainment of fish.

Studies of fish egg and larval entrainment at DN were conducted in 2004 (June – August) and 2006 (March – September), April and July 2010, and December 2015 - November 2016. A total of 2613 fish eggs were collected, all from the end of April to early August, 2016. Eggs collected were mainly identified as Alewife (90%), Walleye (9.2%), and Round Goby (0.4%). A total of 122 fish larvae were entrained over the study period, mainly Round Goby (89%) and Deepwater Sculpin (7%). The estimated annual entrainment was comprised of 94,482,521 eggs and 10,983,411 larvae. By fish biomass, the estimated annual biomass loss to entrainment was 589 kg, comprised mainly of Round Goby (invasive species), Walleye, and Deepwater Sculpin. Overall, fish losses from entrainment were considered too low to measurably affect Lake Ontario fish populations.

Entrainment studies of benthic invertebrates were also carried out during the 2015-2016. Benthic invertebrates were collected in all months of the study period with a total of approximately 22,301 individuals collected. The estimated annual entrainment of benthic invertebrates was 1,548,288,043, with the highest numbers of entrained being for *Echinogammarus* and other Amphipods (91% of the benthic invertebrate total). In a 2016 study characterizing the benthic invertebrate community, it was shown that the benthic invertebrate community in the vicinity of the DNGS does not differ from communities in the reference location in a manner that reflects a station-related effect; therefore, entrainment at the DNGS is not considered to be negatively impacting local benthic invertebrate populations.

5.2 Recommendations for the Monitoring Program

If radiation or chemical doses were predicted to exceed benchmarks, and the exceedances are reasonably expected to be facility-related, it is recommended that OPG confirm exposure conditions, and proceed either to monitor for the effects relevant to benchmark exceedance, or to evaluate options for risk management if the need for risk management is

clear. The confirmation of exposure may involve refinement of exposure estimates from existing data, or obtaining new monitoring data where exposures were based on predicted concentrations. In general, sufficient monitoring data were available for use in the risk assessment from sampling programs that were initiated to support the 2009 NND EA and 2011 Refurbishment and Continued Operations EA. Monitoring data from the EAs were supplemented with data collected from 2016 to 2019 as part of the annual EMP, ECA, and MISA, the 2016 Effluent Characterization Study, the 2018 sediment sampling at the DNGS harbour, and 2019 environmental studies to support DNNP site preparation licence renewal.

5.2.1 Recommendations for Monitoring from the 2016 ERA

In order to clarify risk in future human and ecological assessments, the following specific recommendations for monitoring were provided in the 2016 DN ERA (Ecometrix, 2017):

- Lake water samples should be collected along and at the outlet of the DN diffuser, analyzed using a lower detection limit for hydrazine to help reduce the uncertainty surrounding human exposure to hydrazine through drinking water and fish ingestion.
 - Lake water samples were collected to support the DNNP site preparation licence renewal and analyzed for hydrazine (Ecometrix, 2020). The 2016 ERA recommended a method detection limit of 0.05 µg/L for hydrazine in water, since the human health screening benchmark is 0.01 µg/L at the WSPs; however, the lowest available detection limit was 0.1 µg/L, based on best available technology available at the lab that does low level hydrazine analysis. Additional recommendations are provided in Section 5.2.2.
- Filtered and unfiltered aluminum effluent samples in the CCW should be collected as part of a supplementary study to clarify risks to ecological receptors in Lake Ontario.
 - While filtered and unfiltered aluminum was not collected in the CCW, lake water samples collected as part of the DNNP site preparation licence renewal (Ecometrix, 2020) were analyzed for filtered and unfiltered aluminum, and no concentrations above screening criteria were observed. No further action is needed and the supplementary study does not need to be completed.

5.2.2 New Recommendations for the Monitoring Program

In order to clarify risk and reduce uncertainty in future human and ecological assessments, the following specific recommendations for monitoring are provided:

- Lake water samples should be collected along and at the outlet of the DN diffuser for hydrazine and compared against the human and ecological screening criteria

used in the ERA. While no exceedance was identified for UCLM concentrations, additional lake water data can be used as another line of evidence, in combination with CCW effluent concentrations, to confirm there is no effect of hydrazine on human receptors that may drink water or eat fish from Lake Ontario. Additional data will help characterize the influence of hydrazine in effluent on lake water concentrations, considering hydrazine is released to the lake as a batch release. Lake water samples should be collected in 5 years, prior to the next DN ERA update. The need for subsequent lake water sampling can be re-evaluated at that time. The lowest detection limit available for hydrazine in surface water in the most recent study was 0.1 µg/L. A lower detection limit (e.g., 0.05 µg/L) should be used in future studies, if achievable. OPG currently monitors hydrazine in effluent in accordance with its provincial Environmental Compliance Approval (ECA) requirements, and operates below the prescribed ECA limits.

- NO₂ data from the air quality monitoring planned to be initiated at the DN site in 2021 should be used in the next ERA to refine the risk estimates for human and ecological receptors provided in this ERA and provide a more realistic interpretation of risk.

5.3 Risk Management Recommendations

It is understood that a soil characterization study of the yard waste and building materials storage area is currently being undertaken by OPG. It is recommended to use the results of the soil characterization study to determine the next steps for management of soil from the yard waste and building material storage area (identified as location DN6 and DN6A in Figure B-4, Appendix B, and zone F15 in (OPG, 2018a), so as to mitigate potential risks to ecological receptors.

6.0 REFERENCES

- Ager, D.D., Cord, I., Patrick, P.H., 2005. Entrainment Sampling at Darlington Generating Station-2004. Kinectrics Report No. 010970-001-RA-001-R00. January.
- Ager, D.D., Cord, I., Patrick, P.H., 2006. Entrainment Sampling at Darlington Generating Station-2006. Kinectrics Report No. 012647-001-RA-001-R00. December.
- Barber, L.B., Keefe, S.H., Antweiler, R.C., Taylor, H.E., Wass, R.D., 2006. Accumulation of contaminants in fish from wastewater treatment wetlands. *Environmental science & technology* 40(2), 603–611.
- BC MOE (British Columbia Ministry of Environment), 2008. Ambient Aquatic Guidelines for Iron. Prepared for Science and Information Branch, Water Stewardship Division, Ministry of Environment. February.
- Beacon (Beacon Environmental), 2009a. Terrestrial Environment Assessment of Environmental Effects Technical Support Document New Nuclear – Darlington Environmental Assessment NK054-REP-07730-00014-R000. August.
- Beacon (Beacon Environmental), 2009b. Terrestrial Environment Existing Environmental Conditions Technical Support Document New Nuclear - Darlington Environmental Assessment NK054-REP-07730-00004-R000. September.
- Beacon (Beacon Environmental), 2011. Terrestrial Environment Technical Support Document Darlington Nuclear Generating Station Refurbishment and Continued Operation Environmental Assessment NK38-REP-07730-10006-R000. December.
- Beacon (Beacon Environmental), 2012. Darlington Nuclear Generating Station Biodiversity Monitoring Program Annual Report 2011. Report No. NK38- REP- 07811–10026. November.
- Beacon (Beacon Environmental), 2013. Darlington Nuclear Generating Station Biodiversity Program Annual Report 2012. Report No. NK38- REP- 07811–10027. April.
- Beacon (Beacon Environmental), 2014. Darlington Nuclear Generating Station Biodiversity Program Annual Report 2013. Report No. NK38- REP- 07811–0665577. February.
- Beacon (Beacon Environmental), 2015. Darlington Nuclear Site Biodiversity Program Annual Report 2014. Report No. NK38- REP- 07811–0665580. April.
- Beacon (Beacon Environmental), 2016a. Darlington Nuclear Site Biodiversity Program Annual Report 2015. Report No. NK38- REP- 07811–0665583. March.
- Beacon (Beacon Environmental), 2016b. Darlington Nuclear Site Species at Risk Summary 2015. March.

- Beacon (Beacon Environmental), 2017. Darlington Nuclear Site Biodiversity Monitoring Program Annual Report 2016. Report No. NK38- REP- 07811–0664729. June.
- Beacon (Beacon Environmental), 2018. Darlington Nuclear Site Biodiversity Monitoring Program Annual Report 2017. Report No. NK38- REP- 07811–0696802. May.
- Beacon (Beacon Environmental), 2019a. Darlington New Nuclear Project Terrestrial Environmental Existing Conditions. 2010-2019 Baseline Update. Report No. NK054- REP- 07730–0801575. December.
- Beacon (Beacon Environmental), 2019b. 2019 Darlington Biodiversity Program Technical Memo. Report No. D-REP-07811-0816313. December.
- Beacon (Beacon Environmental), 2019c. Darlington Nuclear Site Biodiversity Monitoring Program Annual Report 2018. Report No. D-REP-07811-0745517. February.
- Beresford, N.A., Barnett, C.L., Howard, B.J., Scott, W.A., Brown, J.E., Copplestone, D., 2008. Derivation of transfer parameters for use within the ERICA Tool and the default concentration ratios for terrestrial biota. *Journal of Environmental Radioactivity*, 99. 1393-1407.
- Beyer, W.N., Connor, E., Gerould, S., 1994. Estimates of Soil Ingestion by Wildlife. *J. Wildl. Manage.* 58.
- Borgmann, U., Couillard, Y., Doyle, P., Dixon, D.G., 2005. Toxicity of Sixty-three Metals and Metalloids to *Hyalella Azteca* at Two Levels of Water Hardness. *Environmental Toxicology and Chemistry* 24, 641–652.
- Brown, J.E., Alfonso, B., Avila, R., Beresford, N.A., Copplestone, D., Prohl, G., Ulanovsky, A., 2008. The ERICA Tool. *Journal of Environmental Radioactivity*, 99. 1393-1407 99, 1371–1383. September.
- CCME (Canadian Council of Ministers of the Environment), 1991. Interim Canadian Environmental Quality Criteria for Contaminated Sites. Report No. CCME EPC-Cs34. September.
- CCME (Canadian Council of Ministers of the Environment), 1997. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health - Cyanide (Free).
- CCME (Canadian Council of Ministers of the Environment), 1999. Canadian Environmental Quality Guidelines.
- CCME (Canadian Council of Ministers of the Environment), 2001. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life.

- CCME (Canadian Council of Ministers of the Environment), 2002. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Nonylphenol and its Ethoxylates.
- CCME (Canadian Council of Ministers of the Environment), 2008. Canada-wide standard for petroleum hydrocarbons (PHC) in soil: scientific rationale : supporting technical document.
- CCME (Canadian Council of Ministers of the Environment), 2010a. Canadian Environmental Quality Guidelines - Canadian Water Quality Guidelines for the Protection of Aquatic Life and Recreational Water Quality Guidelines and Aesthetics.
- CCME (Canadian Council of Ministers of the Environment), 2010b. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health – Polycyclic Aromatic Hydrocarbons.
- CCME (Canadian Council of Ministers of the Environment), 2020. Ecological Risk Assessment Guidance Document. Report No. PN 1585.
- CCREM (Council of Resource and Environment Ministers), 1987. Canadian Water Quality Guidelines.
- CH2M Hill, 2011. Geological and Hydrogeological Environment Technical Support Document Darlington Nuclear Generating Station Refurbishment and Continued Operation Environmental Assessment. NK38-REP-07730- 10003. December.
- CH2M Hill, Kinectrics, 2009. Geological and Hydrogeological Environment Existing Environmental conditions TSD. Report No. NK054- REP- 07730- 00005- R000. September.
- Chant, L.A., Hartwig, D.S., Totland, M., 2000. Site-Specific Aquatic Transfer Factors for CANDU sites in Canada. Report No. AECL RC-2457.
- CLOCA (Central Lake Ontario Conservation Authority), 2011. 2010 Aquatic Monitoring Report.
- CNSC (Canadian Nuclear Safety Commission), 2012. Closure of Environmental Assessment Follow-up and Monitoring Program for the Darlington Waste Management Facility (DWMF). Report No. 00044-CORR-00531–00417. March.
- CNSC (Canadian Nuclear Safety Commission), 2013. Record of Proceedings - Environmental Assessment on the Refurbishment and Continued Operation of the Darlington Nuclear Generating Station. Report No. NK38- CORR- 00531–16265. March.

- CNSC (Canadian Nuclear Safety Commission), 2017a. Environmental Protection. Environmental Principles, Assessments and Protection Measures. Report No. REGDOC-2.9.1. April.
- CNSC (Canadian Nuclear Safety Commission), 2017b. Radionuclide Information Booklet. February.
- CNSC, DFO (Canadian Nuclear Safety Commission and Fisheries and Oceans Canada), 2012. Proposed Environmental Assessment Screening Report: The Refurbishment and Continued Operation of the Darlington Nuclear Generating Station, Municipality of Clarington, Ontario. Report No. 11- 01-62516. September.
- COG (Candu Owners Group), 2013a. Derived Release Limits Guidance. Report No. COG-06-3090-R3-I, 2013-12.
- COG (CANDU Owners Group), 2013b. Results of Site-Specific Sampling and Analysis of Sediments near Canadian CANDU Facilities. Report No. COG-12-3045. January.
- COG (Candu Owners Group), 2017. Impacts of Temperature on whitefish Egg Survival. COG Report Report No. COG-15-3051.
- COSEWIC (Committee on the Status of Endangered Wildlife in Canada), 2008. COSEWIC assessment and status report on the Canada Warbler *Wilsonia Canadensis* in Canada. Committee on the Status of Endangered Wildlife in Canada.
- CSA (Canadian Standards Association), 2010. Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills. Report No. CSA N288.4-10. May.
- CSA (Canadian Standards Association), 2011. Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills. Report No. CSA N288.5-11.
- CSA (Canadian Standards Association), 2012. Environmental risk assessments at Class I nuclear facilities and uranium mines and mills. Report No. CSA N288.6-12.
- CSA (Canadian Standards Association), 2014. Guidelines for calculating derived release limits for radioactive material in airborne or liquid effluents for normal operation of nuclear facilities. Report No. CSA N288.1-14. March.
- CSA (Canadian Standards Association), 2019. Environmental monitoring programs at nuclear facilities and uranium mines and mills. Report No. CSA N288.4-19. September.
- Dey, W.P., 2002. Use of equivalent loss models under Section 316(b) of the Clean Water Act. *The Scientific World* 2, 254–270.

- Doull, J., Klaassen, C.D., Amdur, M.D., 1980. Casarett and Doull's Toxicology (2nd ed). Macmillan Publishing, NY 266.
- Dragun, J., Chiasson, A., 1991. Elements in North American Soils. Hazardous Materials Control Resources Institute.
- DRHD (Durham Region Health Department), 2007. Radiation & Health in Durham Region. April.
- DRHD (Durham Region Health Department), 2019. Population at a Glance.
- Dunstall, T., 2002. Darlington Nuclear Generating Division – EV009: Follow-up Storm Water Control Study of Four Drainage Outfalls. Report No. 8396- 050- RA- 0001- R00. July.
- Dunstall, T., Kinectrics, 2000. Darlington Nuclear Generating Division: EV009 - Storm Water Remediation Report. Report No. 8396- 020-2000- RA- 0001- R00. December.
- Dunstall, T., Kinectrics, 2001. Darlington Nuclear Generating Division: EV009 - Storm Water Remediation – 2001. Report No. 8396- 030-2000- RA- 0001- R00. December.
- Durham Region, 2019. 2019 Durham Region Business Count. Planning and Economic Development Department.
- Durham Region, 2020. Durham Region Profile Demographic and Socio-economic Data. Planning and Economic Development Department. October.
- EC (Environment Canada), 2013a. Canadian Environmental Protection Act, 1999 Federal Environmental Quality Guidelines - Hydrazine. February.
- EC (Environment Canada), 2013b. Canadian Environmental Protection Act, 1999 Federal Environmental Quality Guidelines – Alcohol Ethoxylates. February.
- EC, HC (Environment Canada and Health Canada), 2011. Screening Assessment for the Challenge. Hydrazine. Report No. CAS Registry Number 302-01-2.
- ECCC (Environment and Climate Change Canada), 2017. Canadian Ambient Air Quality Standards (CAAQS). December.
- ECCC (Environment and Climate Change Canada), 2019. Guidance document : environmental effects assessment of freshwater thermal discharge. February.
- ECCC (Environment and Climate Change Canada), 2020. Canadian Climate Normals Web Site 1981-2010. September.

- Ecometrix, 2012. Darlington Nuclear Generating Station Groundwater Monitoring Program Design. Report No. NK38- REP-10140–10012. November.
- Ecometrix, 2016. Update to Environment and Climate Change Canada's Guidance Document: Environmental Effect Assessment of Freshwater Thermal Discharge. Report prepared for: Environment and Climate Change Canada. March.
- Ecometrix, 2017. Darlington Nuclear Environmental Risk Assessment. Prepared for Ontario Power Generation Report No. NK38- REP- 07701– 00001. November.
- Ecometrix, 2018. Darlington Harbour Substrate Characterization Study. Prepared for Ontario Power Generation Report No. NK38- REP- 09701–0746864. July.
- Ecometrix, 2019. Darlington Harbour Substrate Characterization Study – December 2018. Prepared for Ontario Power Generation Report No. NK38- REP- 09701–0746266. January.
- Ecometrix, 2020. Darlington New Nuclear Project Supporting Environmental Studies – Environment. Prepared for Ontario Power Generation Report No. NK054- REP- 01210– 0001. May.
- EPRI (Electric Power and Research Institute), 2004. Extrapolating Impingement and Entrainment Losses to Equivalent Adults and Production Foregone. Final Report. July.
- European Commission, 2006. Review of QSAR Models for Bioconcentration. EUR 22327 EN. Institute for Health and Consumer Protection Toxicology and Chemical Substances Unit European Chemicals Bureau.
- Fargasova, A., Bumbalova, A., Havranek, E., 1999. Ecotoxicological Effects and Uptake of Metals (Cu⁺, Cu²⁺, Mn²⁺, Mo⁶⁺, Ni²⁺, V⁵⁺) in Freshwater Alga *Scenedesmus quadricauda*. Chemosphere 38(5), 1165–1173.
- FCSAP (Federal Contaminated Sites Action Plan), 2012. Ecological Risk Assessment Guidance, Module 3: Standardization of Wildlife Receptor Characteristics. Prepared for: Environment Canada (Government of Canada), Vancouver, B.C. March.
- Golder (Golder Associate), 2009. Surface Water Environment Existing Environmental Conditions Technical Support Document New Nuclear – Darlington Environmental Assessment. Report No. NK054- REP- 07730- 00002- R000. September.
- Golder (Golder Associate), 2010. Aquatic Environment Prediction of Temperature Effects on Fish Species from Operation of the NND Diffuser Based on Modelled Temperature Changes. Report No. NK054- REP- 07730- 0313784-T25. January.

- Golder (Golder Associate), 2011a. Surface Water Environment Technical Support Document Darlington Nuclear Generating Station Refurbishment and Continued Operation Environmental Assessment. Report No. NK38- REP- 07730-10004-R000. December.
- Golder (Golder Associate), 2011b. Follow-up Stormwater Control Study for SW Outfalls – Phase I, Fall 2010 Darlington Nuclear Generation Station Refurbishment and Continued Operation Project Environmental Assessment. Report No. NK 38-REP- 07730-0375404-T20. May.
- Golder (Golder Associate), 2011c. Follow-up Stormwater Control Study for SW Outfalls – Phase II, Spring 2011 Darlington Nuclear Generation Station Refurbishment and Continued Operation Project Environmental Assessment. Report No. NK 38-REP- 07730-0375412-T20. December.
- Golder (Golder Associate), 2012a. Thermal and Current Monitoring Program Darlington Nuclear Generation Station Refurbishment and Continued Operation Environmental Assessment. Report No. NK38- REP- 07730-10019- R000. January.
- Golder (Golder Associate), 2012b. Memorandum: 2011-2012 Thermal and Current Monitoring Program: Darlington Nuclear – Winter Monitoring Period: December 2011-April 2012. Report No. NK38- REP- 07730- 0435738- R000. July.
- Golder (Golder Associate), 2020. Results of Stormwater Sampling at DN Site – Final Report. Report No. D-REP-07730-00001. May.
- Golder, SENES (Golder and SENES Consultants Limited), 2009. Aquatic Environment Existing Environmental Conditions Technical Support Document New Nuclear – Darlington Environmental Assessment. Prepared for Ontario Power Generation Report No. NK054- REP- 07730- 00003- R000. September.
- Government of Canada, 2020. Species at Risk Public Registry [WWW Document]. October. URL <https://species-registry.canada.ca/index-en.html#/species?sortBy=commonNameSort&sortDirection=asc&pageSize=10> (accessed 10.28.20).
- Griffiths, J.S., 1980. Potential Effects of Unstable Thermal Discharges on Incubation of Round Whitefish Eggs. Ontario Hydro Research Division. Report No. 80-140- K.
- Hara, T., Furuta, T., Sonoda, Y., Iwai, I., 1977. Growth response of cabbage plants to beryllium and strontium under water culture conditions. Soil Science and Plant Nutrition 23, 373–380.
- HC (Health Canada), 1978. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Iron.

- HC (Health Canada), 2004. Federal contaminated site risk assessment in Canada. Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA). September.
- HC (Health Canada), 2010a. Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0. Contaminated Sites Program. September.
- HC (Health Canada), 2010b. Federal Contaminated Site Risk Assessment in Canada, Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals (DQRACHEM). September.
- HC (Health Canada), 2012. Guidelines for Canadian Drinking Water Quality - Summary Table. Water, Air and Climate Change Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.
- HC (Health Canada), 2013. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document — Ammonia. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.
- HC (Health Canada), 2016. Human Health Risk Assessment for Ambient Nitrogen Dioxide. Water and Air Quality Bureau, Safe Environments Directorate, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.
- HC (Health Canada), 2019. Guidelines for Canadian Drinking Water Quality—Summary Table. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.
- Heck, W., 1964. Plant injury induced by photochemical reaction products of propylene-nitrogen dioxide mixtures. J. Air Pollut. Control Assoc 14, 255–261.
- HERA, 2013. Human and Environmental Risk Assessment (HERA) on ingredients of European household cleaning products. Linear Alkylbenzene Sulphonate. Version 2.0. Report No. CAS No. 68411-30-3. September.
- IAEA (International Atomic Energy Agency), 1992. Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards., Technical Report Series No. 332.
- IAEA (International Atomic Energy Agency), 2010. Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments., Technical Report Series No. 472.
- ICRP (International Commission on Radiological Protection), 2008. Environmental Protection - the Concept and Use of Reference Animals and Plants., ICRP Publication 108.

- IJC (International Joint Commission), 1977. New and Revised Great Lakes Water Quality Objectives, Volume II. October.
- MacGregor, R., Casselman, J., Greig, L., Dettmers, J., Allen, W.A., McDermott, L., Haxton, T., 2013. American Eel (*Anguilla rostrata*) in Ontario, Ontario Recovery Strategy Series. Ministry of Natural Resources.
- Makeyeva, A., Yemel'yanova, N., Velova, N., Ryabou, I., 1995. Radiobiological analysis of Silver Carp, *Hypophthalmichthys molitrix*, from the cooling pond of the Chernobyl Nuclear Power Plant since the time of the accident. 2. Development of the Reproductive System in the First Generation of Offspring. *Journal of Ichthyology* 35.
- MECP, 2020. O. Reg. 230/08: SPECIES AT RISK IN ONTARIO LIST [WWW Document]. Ontario.ca. October. URL <https://www.ontario.ca/laws/view> (accessed 10.28.20).
- MNR (Ontario Ministry of Natural Resources), 2010. Lake Ontario Fish Communities and Fisheries: 2009 Annual Report of the Lake Ontario Management Unit.
- MNRF, 2019. Lake Ontario Fish Communities and Fisheries. 2018 Annual Report of the Lake Ontario Management Unit.
- MOE (Ontario Ministry of the Environment), 1979. Rationale for the Establishment of Ontario's Provincial Water Quality Objectives. September.
- MOE (Ontario Ministry of the Environment), 2008. Guidelines for Identifying, Assessing and Managing Contaminated Sediments in Ontario.
- MOE (Ontario Ministry of the Environment), 2009. Guidance for the Implementation of Air Standards in Ontario (GIASO). Version 2.0. March.
- MOE (Ontario Ministry of the Environment), 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario. Standards Development Branch. April.
- MOECC (Ontario Ministry of Environment and Climate Change), 2017. Air Dispersion Modelling Guideline for Ontario [Guideline A-11], Version 3.0. February.
- MOEE (Ontario Ministry of Environment and Energy), 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality Guidelines in Ontario. Ontario Ministry of the Environment and Energy, Toronto, Ontario, Queen's Printer for Ontario, August 1993 (reprinted March 1994). PIBS 1962. August.
- MOEE (Ontario Ministry of Environment and Energy), 1994. Water Management: Policies Guidelines Provincial Water Quality Objectives of the Ministry of Environment and Energy. Ontario Ministry of Environment and Energy, Queen's Printer for Ontario. July.

- MOEE (Ontario Ministry of Environment and Energy), 2003. Stormwater Management Planning and Design Manual.
- NCRP (National Council on Radiation Protection and Measurements), 1991. Effects of Ionizing Radiation on Aquatic Organisms. Report No. 109.
- NYDEC (New York Department of Environmental Conservation), 2014. 2013 Annual Report. Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit.
- OFAH (Ontario Federation of Anglers and Hunters), 2017. Bring Back the Salmon.
- OPG (Ontario Power Generation), 2007. Dosimetry and Radiological Environmental Quality Assurance Program Manual. Report No. N-MAN-03416.3-0020. November.
- OPG (Ontario Power Generation), 2011a. Darlington Waste Management Facility – EA Follow-Up and Monitoring Program – Closure Report. Report No. 00044-REP-07701-0400607-R000 LOF. September.
- OPG (Ontario Power Generation), 2011b. Derived Release Limits and Environmental Action Levels for Darlington Nuclear Generating Station. Report No. NK38- REP-03482-10001-R001. September.
- OPG (Ontario Power Generation), 2012a. Darlington Waste Management Facility Performance Report (2007 – 2012) in Support of the Licence Renewal Application. Report No. 00044-REP-00531–00019. September.
- OPG (Ontario Power Generation), 2012b. 2011 Results of Environmental Monitoring Programs. Report No. N-REP-03481-10010-R000. April.
- OPG (Ontario Power Generation), 2013a. Darlington Nuclear Refurbishment and Continued Operation Environmental Assessment Follow-Up Program. Report No. NK38- REP-07730-10022-R001. September.
- OPG (Ontario Power Generation), 2013b. 2012 Darlington Emissions Summary Dispersion Modelling Report. Report No. NK38- REP- 00541-10024- R000. March.
- OPG (Ontario Power Generation), 2013c. 2012 Results of Environmental Monitoring Programs. Report No. N-REP-03443-10011-R000. April.
- OPG (Ontario Power Generation), 2014. Memorandum: Reassessment of the impact of thermal plumes on round whitefish egg survival and hatch using the new COG model. Report No. N-REP-07250-0518222. October.
- OPG (Ontario Power Generation), 2015a. 2014 Darlington Emissions Summary Dispersion Modelling Report. Report No. NK38- REP- 00541-10031- R000. March.

- OPG (Ontario Power Generation), 2015b. Darlington NGS Integrated Implementation Plan. Report No. NK38- REP- 03680-10185-R002.
- OPG (Ontario Power Generation), 2016a. Darlington Waste Management Facility Safety Report. Report No. 00044-SR-01320-10002-R003. November.
- OPG (Ontario Power Generation), 2016b. 2015 MISA Annual Report - Darlington Nuclear (MISA Company Code 0049001506). Report No. NK38- REP- 00541.08-10096-R000. May.
- OPG (Ontario Power Generation), 2016c. 2015 Amended Environmental Compliance Approval Number 4051-9W8K4E Annual Performance Report – Darlington Nuclear. Report No. NK38- CORR- 00541–10478. May.
- OPG (Ontario Power Generation), 2016d. Derived Release Limits and Environmental Action Levels for Darlington Nuclear Generating Station. Report No. NK38- REP- 03482-100001-R002. November.
- OPG (Ontario Power Generation), 2016e. Darlington Waste Management Facility – Second Quarter 2016 Report. Report No. 00044-REP-00531–00038. September.
- OPG (Ontario Power Generation), 2016f. Darlington Waste Management Facility – Third Quarter 2016 Report. Report No. 00044-CORR-00531–00815. December.
- OPG (Ontario Power Generation), 2016g. Darlington Waste Management Facility – First Quarter 2016 Report. Report No. 00044-CORR-00531–00778. June.
- OPG (Ontario Power Generation), 2016h. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – Third Quarter 2016. Report No. NK38- REP- 00531–10011. December.
- OPG (Ontario Power Generation), 2016i. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – Second Quarter 2016. Report No. NK38- REP- 00531–10010. September.
- OPG (Ontario Power Generation), 2016j. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – First Quarter 2016. Report No. NK38- REP- 00531–10009. June.
- OPG (Ontario Power Generation), 2017a. Thermal Monitoring Plan For The Darlington Nuclear Follow Up Monitoring Program. Report No. NK38- PLAN- 07250- 00001-R000. February.
- OPG (Ontario Power Generation), 2017b. 2016 Results of Environmental Monitoring Programs. Report No. N-REP-03443-10016-R000. April.

- OPG (Ontario Power Generation), 2017c. 2016 Darlington Emissions Summary Dispersion Modelling Report. Report No. NK38- CORR- 00541–13066. June.
- OPG (Ontario Power Generation), 2017d. 2016 Darlington Nuclear Amended Environmental Compliance Approval (Number 4810-A78QUZ) Annual Performance Report. Report No. NK38- REP- 00541-10039- R000. May.
- OPG (Ontario Power Generation), 2017e. Darlington Waste Management Facility – Fourth Quarter 2016 Report. Report No. 00044-CORR-00531–00040. March.
- OPG (Ontario Power Generation), 2017f. Darlington Waste Management Facility – First Quarter 2017 Report. Report No. 00044-CORR-00531–00859. June.
- OPG (Ontario Power Generation), 2017g. Darlington Waste Management Facility – Second Quarter 2017 Report. Report No. 00044-REP-00531–00042. September.
- OPG (Ontario Power Generation), 2017h. Darlington Waste Management Facility – Third Quarter 2017 Report. Report No. 00044-REP-00531–00043. December.
- OPG (Ontario Power Generation), 2017i. 2016 MISA Annual Report - Darlington Nuclear (MISA Company Code 0049001506). Report No. NK38- REP- 00541.08-10103-N/A- R000. May.
- OPG (Ontario Power Generation), 2017j. 2016 Darlington Nuclear Groundwater Monitoring Program Results. Report No. NK38- REP-10140-10024- R000. July.
- OPG (Ontario Power Generation), 2017k. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – Third Quarter 2017. Report No. NK38- REP- 00531–10016. December.
- OPG (Ontario Power Generation), 2017l. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – Second Quarter 2017. Report No. NK38- REP- 00531–10015. September.
- OPG (Ontario Power Generation), 2017m. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – First Quarter 2017. Report No. NK38- REP- 00531–10014. June.
- OPG (Ontario Power Generation), 2017n. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – Fourth Quarter 2016. Report No. NK38- REP- 00531–10012. March.
- OPG (Ontario Power Generation), 2018a. Darlington New Nuclear Project - Site Preparation Licence Midterm Report. Report No. NK054- REP- 01210– 00101 R000. September.

- OPG (Ontario Power Generation), 2018b. 2017 Results of Environmental Monitoring Program. Report No. N-REP-03443-10017-R000. April.
- OPG (Ontario Power Generation), 2018c. 2017 Emissions Summary Dispersion Modelling Report for Darlington Nuclear Generating Station. Report No. NK38- REP- 00541-10045-R001. September.
- OPG (Ontario Power Generation), 2018d. 2017 Darlington Nuclear Groundwater Monitoring Program Results. Report No. NK38- REP-10140-10027- R000.
- OPG (Ontario Power Generation), 2018e. Review of the Darlington Nuclear Site Specific Survey. Report No. NK38- REP- 03443-10004- R000. December.
- OPG (Ontario Power Generation), 2018f. Darlington Refurbishment Follow-Up Monitoring Program: Thermal Plume Monitoring 2017-2018. Report No. NK38- REP- 07250-00001- R000.
- OPG (Ontario Power Generation), 2018g. Health and Safety Management System Program. Report No. OPG-PROG-0010-R004..
- OPG (Ontario Power Generation), 2018h. 2017 Darlington Nuclear Amended Environmental Compliance Approval (Number 4810-A78QUZ) Annual Performance Report. Report No. NK38- REP- 00541-10042- R000. May.
- OPG (Ontario Power Generation), 2018i. Darlington Waste Management Facility – Fourth Quarter 2017 Report. Report No. 00044-CORR-00531–00044. March.
- OPG (Ontario Power Generation), 2018j. Darlington Waste Management Facility – First Quarter 2018 Report. Report No. 00044-REP-00531–00045. June.
- OPG (Ontario Power Generation), 2018k. Darlington Waste Management Facility – Second Quarter 2018 Report. Report No. 00044-REP-00531–00046. September.
- OPG (Ontario Power Generation), 2018l. Darlington Waste Management Facility – Third Quarter 2018 Report. Report No. 00044-REP-00531–00047. December.
- OPG (Ontario Power Generation), 2018m. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – Fourth Quarter 2017. Report No. NK38- REP- 00531–10017. March.
- OPG (Ontario Power Generation), 2018n. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – Third Quarter 2018. Report No. NK38- REP- 00531–10021. December.

- OPG (Ontario Power Generation), 2018o. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – Second Quarter 2018. Report No. NK38-REP- 00531–10020. September.
- OPG (Ontario Power Generation), 2018p. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – First Quarter 2018. Report No. NK38-REP- 00531–10019. June.
- OPG (Ontario Power Generation), 2019a. 2018 Results of Environmental Monitoring Program. Report No. N-REP-03443-10019-R000. April.
- OPG (Ontario Power Generation), 2019b. Radiation Protection. Report No. N-PROG-RA-0013. R011. June.
- OPG (Ontario Power Generation), 2019c. 2018 Darlington Nuclear Groundwater Monitoring Program Results. Report No. NK38- REP-10140-10028- R000.
- OPG (Ontario Power Generation), 2019d. 2018 Emissions Summary Dispersion Modelling Report (AERMOD) for Darlington Nuclear Generating Station. Report No. NK38-REP- 00541-10049- R000. January.
- OPG (Ontario Power Generation), 2019e. 2018 Darlington Nuclear Amended Environmental Compliance Approval (Number 4810-A78QUZ) Annual Performance Report. Report No. NK38- REP- 00541-10050- R000. May.
- OPG (Ontario Power Generation), 2019f. Darlington Waste Management Facility – Fourth Quarter 2018 Report. Report No. 00044-CORR-00531–00048. March.
- OPG (Ontario Power Generation), 2019g. Darlington Waste Management Facility First Quarter 2019 Report. Report No. 00044-REP-00531-00049-R000. June.
- OPG (Ontario Power Generation), 2019h. Darlington Waste Management Facility – Second Quarter 2019 Report. Report No. 00044-REP-00531–00050. September.
- OPG (Ontario Power Generation), 2019i. Darlington Waste Management Facility – Third Quarter 2019 Report. Report No. 00044-REP-00531–00051. December.
- OPG (Ontario Power Generation), 2019j. 2018 Darlington Nuclear Groundwater Monitoring Program Results. Report No. NK38- REP-10140-10028- R000.
- OPG (Ontario Power Generation), 2019k. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – Third Quarter 2019. Report No. NK38-REP- 00531–10027. December.

- OPG (Ontario Power Generation), 2019l. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – Second Quarter 2019. Report No. NK38- REP- 00531–10026. September.
- OPG (Ontario Power Generation), 2019m. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – First Quarter 2019. Report No. NK38- REP- 00531–10024. June.
- OPG (Ontario Power Generation), 2019n. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – Fourth Quarter 2018. Report No. NK38- REP- 00531–10023. March.
- OPG (Ontario Power Generation), 2020a. Acoustic Assessment Report for New Nuclear Darlington Acoustic Conditions Update. Report No. D-REP-00541-00531606. June.
- OPG (Ontario Power Generation), 2020b. 2019 Results of Environmental Monitoring Programs. Report No. N-REP-03443-10023-R000. March.
- OPG (Ontario Power Generation), 2020c. Darlington Refurbishment Program.
- OPG (Ontario Power Generation), 2020d. 2019 Emissions Summary Dispersion Modelling Report for Darlington Nuclear Generating Station. Report No. NK38- REP- 00541- 10057- R000. June.
- OPG (Ontario Power Generation), 2020e. 2019 Darlington Nuclear Amended Environmental Compliance Approval (Number 4810-A78QUZ) Annual Performance Report. Report No. NK38- REP- 00541-10056- R000. May.
- OPG (Ontario Power Generation), 2020f. Darlington Waste Management Facility – Fourth Quarter Report - 2019. Report No. 00044-REP-00531–000052. March.
- OPG (Ontario Power Generation), 2020g. 2017 MISA Annual Report - Darlington Nuclear (MISA Company Code 0049001506). Report No. NK38- REP- 00541.08-10115- R000. April.
- OPG (Ontario Power Generation), 2020h. 2018 MISA Annual Report - Darlington Nuclear (MISA Company Code 0049001506). Report No. NK38- REP- 00541.08-10116- R000. April.
- OPG (Ontario Power Generation), 2020i. 2019 MISA Annual Report - Darlington Nuclear (MISA Company Code 0049001506). Report No. NK38- REP- 00541.08-10117- R000. April.
- OPG (Ontario Power Generation), 2020j. 2019 Darlington Nuclear Groundwater Monitoring Program Results. Report No. NK38- REP-10140-10030- R000. July.

- OPG (Ontario Power Generation), 2020k. Darlington Nuclear Regdoc-3.1.1 Quarterly Report on Safety Performance Indicators – Fourth Quarter 2019. Report No. NK38-REP- 00531–10029. March.
- Patrick, P., Parks, J., Mason, E., Powell, J., Garisto, N., Janes, A. (Candu Owners Group), 2014. Effects of fixed and fluctuation temperatures on mortality and hatch of Round Whitefish and Lake Whitefish eggs. Report No. COG-13-3025. September.
- Regional Municipality of Durham, 2009. Sewer Use By-Law No. 43-2004. June.
- Rowe, J.S., 1972. Forest Regions of Canada. Canadian Forestry Service Publication 1300, Department of Environment, Ottawa.
- Sample, B.E., Beauchamp, J.J., Efroymsen, R.A., Sutter II, G.W., Ashwood, T.L., 1998. Development and Validation of Bioaccumulation Models for Earthworms. October.
- SENES, AMEC (SENES Consultants Limited and AMEC NSS), 2009. Radiation and Radioactivity Environment Assessment of Environmental Effects Technical Support Document New Nuclear – Darlington Environmental Assessment. Report No. NK054- REP- 07730- 00018- R000. August.
- SENES, MMM (SENES Consultants Limited and MMM Group), 2009. Environmental Impact Statement New Nuclear – Darlington Environmental Assessment. Report No. NK054- REP- 07730– 00029. September.
- SENES, MMM (SENES Consultants Limited and MMM Group), 2011. Environmental Impact Statement Darlington Nuclear Generating Station Refurbishment and Continued Operation. Report No. NK38- REP- 07730–10002. September.
- SENES (SENES Consultants Limited), 2000. Ecological Risk Assessment of Pickering Nuclear Phase (ii) Pickering Nuclear Screening Ecological Risk Assessment. Report No. P-REP-07010-10008. September.
- SENES (SENES Consultants Limited), 2009a. Ecological Risk Assessment and Assessment of Effects on Non-Human Biota Technical Support Document New Nuclear – Darlington Environmental Assessment. Report No. NK054- REP- 07730- 00022- R000. September.
- SENES (SENES Consultants Limited), 2009b. Human Health Technical Support Document New Nuclear - Darlington Environmental Assessment. Report No. NK054- REP- 07730- 00025- R000. September.
- SENES (SENES Consultants Limited), 2009c. Atmospheric Environment Existing Environmental Conditions Technical Support Document New Nuclear – Darlington Environmental Assessment. Report No. NK054- REP- 07730- 00001- R000. September.

- SENES (SENES Consultants Limited), 2011a. Fish Impingement Sampling at Darlington Nuclear Generating Station. Report No. NK38- REP- 07730-10020- R000. October.
- SENES (SENES Consultants Limited), 2011b. Non-Human Health (Ecological Risk Assessment) Technical Support Document Darlington Nuclear Generating Station Refurbishment and Continued Operation Environmental Assessment. Report No. NK38- REP- 07730-10010- R000. December.
- SENES (SENES Consultants Limited), 2011c. Fall 2010 Fish Community Sampling Program Final Report. Report No. NK054- REP- 07730- 0388705 T–20. January.
- SENES (SENES Consultants Limited), 2011d. Spring 2011 Fish Community and Larval Sampling Program. Report No. NK054- REP- 07730– 00047. December.
- SENES (SENES Consultants Limited), 2011e. Aquatic Environment Technical Support Document Darlington Nuclear Generating Station Refurbishment and Continued Operation Environmental Assessment. Report No. NK38- REP- 07730-10005- R000. December.
- SENES (SENES Consultants Limited), 2011f. Human Health Technical Support Document Darlington Nuclear Generating Station Refurbishment and Continued Operation Environmental Assessment. Report No. NK38- REP- 07730-10012- R000. December.
- Sharma, J., 1997. Darlington Nuclear Generating Division Storm Water Control Study. Report No. NK38- REP- 07294- 001-R01. December.
- Sheppard, S.C., Long, J.M., Sanipelli, B., 2009. Field measurements of the transfer factors for iodine and other trace elements. Report No. NWMO TR-2009-35. December.
- Skoryna, S.C., 1981. Effects of Oral Supplementation with Stable Strontium. CMA Journal 125 703–712.
- Slonim, A.R., Gisclard, J.B., 1976. Hydrazine degradation in aquatic systems. Bull. Environ. Contam. Toxicol. 16, 301–309.
- Suter, G.W., Barnthouse, L.W., Bartell, S.M., Mill, T., Mackay, D., Paterson, S., 1993. Ecological Risk Assessment. Lewis Publishers, CHelsea, MI.
- Suter, G.W., Tsao, C.L., 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota. Report No. ES/ER/TM-96/R2. June.
- Tarandus (Tarandus Associates Limited), 1998. The Evaluation of Fish Communities in Armoured and Natural Habitats in the Vicinity of the DNGS. Report No. NK-38-REP-07000-016-R00. January.

- TCEQ, 2016. Effects Screening Levels (ESLs) Used in the Review of Air Permitting Data [WWW Document]. Texas Commission on Environmental Quality. URL https://www.tceq.texas.gov/toxicology/esl/list_main.html (accessed 10.28.20).
- Thompson, P.A., Kurias, J., Mihok, S., 2005. Derivation and use of sediment quality guidelines for ecological risk assessment of metals and radionuclides released to the environment from uranium mining and milling activities in Canada. *Environmental Monitoring and Assessment* 110:71–85.
- UNSCEAR, 1996. Sources and Effects of Ionizing Radiation, Report to the General Assembly with Scientific Annexes. United Nations Scientific Committee on the Effects of Atomic Radiation.
- UNSCEAR, 2008. Sources and Effects of Ionizing Radiation, Report to the General Assembly with Scientific Annexes. United Nations Scientific Committee on the Effects of Atomic Radiation.
- US EPA, IRIS (U.S. Environmental Protection Agency), 1988. Chemical Assessment Summary - Hydrazine/Hydrazine sulfate; CASRN 302-01-2. Drinking Water Concentration with 1 in 100,000 risk level.
- US EPA (U.S. Environmental Protection Agency), 1973. Quality criteria for water (the “Blue Book”). Report No. EPA 440/9-76-023.
- US EPA (U.S. Environmental Protection Agency), 1977. Temperature Criteria for Freshwater Fish: Protocol and Procedures. May.
- US EPA (U.S. Environmental Protection Agency), 1983. Water Quality of Typical Urban Runoff. US EPA NURP.
- US EPA (U.S. Environmental Protection Agency), 1986. National Recommended Water Quality Criteria - Aquatic Life Criteria Table.
- US EPA (U.S. Environmental Protection Agency), 1993. Wildlife Exposure Factors Handbook. Report No. EPA/600/R-93/187.
- US EPA (U.S. Environmental Protection Agency), 1999. Screening Level Risk Assessment Protocol for Hazardous Waste Combustion Facilities.
- US EPA (U.S. Environmental Protection Agency), 2002. Case Study Analysis for the Proposed Section 316(b) Phase II Existing Facilities Rule. Report No. EPA/821/R-02-002.
- US EPA (U.S. Environmental Protection Agency), 2008. Provisional Peer Reviewed Toxicity Values for Lithium. Report No. EPA/690/R-08/016F.

- US EPA (U.S. Environmental Protection Agency), 2012. Provisional Peer Reviewed Toxicity Values for Soluble Zirconium Compounds. Report No. EPA/690/R-12/038F.
- US EPA (U.S. Environmental Protection Agency), 2020. Regional Screening Levels (RSLs) for tap water. May.
- US EPA (U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response,), 2005. Ecological Soil Screening Level for Cobalt, Interim Final. March.
- Walsh, M.G., Connerton, M.J. (New York State Department of Environmental Conservation), 2011. Status of Alewife in the U.S. Waters of Lake Ontario, 2010. In: NYDEC. 2011. Annual Lake Ontario Report. March.
- Wanigaratne, S., Holowaty, E., Jiang, H., Norwood, T.A., Pietrusiak, M.A., Brown, P., 2013. Estimating cancer risk in relation to tritium exposure from routine operation of a nuclear-generating station in Pickering, Ontario. Chronic Diseases and Injuries in Canada 33. September.
- Weidel, B.C., Walsh, M., Connerton, M.J., Lantry, B.F., Lantry, J.R., Holden, J.P., Yuille, M.J., Hoyle, J.A., 2017. Deepwater Sculpin Status and Recovery in Lake Ontario. Journal of Great Lakes Research. <https://doi.org/10.1016/j.jglr.2016.12.011>
- WHO (World Health Organization), 1996. Environmental Health Criteria for Morpholine.
- WHO (World Health Organization), 2001. Barium and Barium Compounds. Concise International Chemical Assessment Document 33.
- WHO (World Health Organization), 2010. Strontium and Strontium Compounds. Concise International Chemical Assessment Document 77.
- Wisner, D.A., Christie, A.E. (Great Lakes Fishery Commission), 1987. Temperature Relationships of Great Lakes Fishes – A Data Compilation.

Appendix A Screening Tables for Chemical COPCs

Table A-1: Non-Radiological Screening of Air COPCs for Human Health

Contaminant	ESDM Modelling					Averaging Period (hrs)	Equivalent Max POI Concentration for Screening		Selected Human Health Screening Criteria	Regulation Schedule Number	Limiting Effect	Reference	Carried Forward as COPC?
	Maximum POI Concentration Yearly (µg/m3)				Maximum POI Concentration 2016-2019 (µg/m³)								
	2016	2017	2018	2019									
Armeen hdt (tallow alkyl)	-	-	0.3	0.3	0.3	24 hr	24 hr	0.3	9	Sch. 3	Health	MECP Health Based ¹	No
Ammonia	-	50.2	-	-	50.2	0.5 hr	0.5 hr	50.2	300	Sch. 2	Health	MECP Health Based	No
	-	17	11.1	11.1	17	24 hr	24 hr	17	100	Sch. 3	Health	MECP Health Based	No
Benzo(a)pyrene (sum of PAH)	-	8.9E-05	-	-	0.000089	0.5 hr	0.5 hr	0.000089	0.00015	Sch. 2	Health	MECP Health Based	No
	-	-	3.7E-05	3.7E-05	0.000037	24 hr	24 hr	0.000037	0.005	Sch. 6	URT	MECP Health Based	No
	-	-	3.6E-06	3.6E-06	0.000036	Annual	Annual	0.000036	0.0001	--	AAV	MECP Health Based	No
Cadmium	-	6.3E-04	-	-	0.00063	0.5 hr	0.5 hr	0.00063	0.075	Sch. 2	Health	MECP Health Based	No
	-	-	2.6E-04	2.6E-04	0.00026	24 hr	24 hr	0.00026	0.025	Sch. 3	Health	MECP Health Based	No
Calcium Hydroxide	-	0.22	-	-	0.22	0.5 hr	0.5 hr	0.22	27	Sch. 2	Corrosion	MECP Health Based ^b	No
Carbon Dioxide	-	39,451	-	-	39451	0.5 hr	0.5 hr	39451	767400	Sch. 2	Health	MECP Health Based	No
	-	-	16,228	16,228	16228	24 hr	24 hr	16228	255,800	Sch. 3	Health	MECP Health Based	No
chloride (as hydrogen chloride)	-	0.55	-	-	0.55	0.5 hr	0.5 hr	0.55	60	Sch. 2	Health	MECP Health Based	No
	-	-	0.23	0.23	0.23	24 hr	24 hr	0.23	20	Sch. 3	Health	MECP Health Based	No
Chromium (total)	-	4.2E-02	-	-	0.042	0.5 hr	0.5 hr	0.042	1.5	Sch. 2	Health	MECP Health Based	No
Chromium (VI)	-	2.03E-03	-	-	0.00203	0.5 hr	0.5 hr	0.00203	0.0021	Sch. 2	Health	MECP Health Based	No
	-	-	4.3E-04	4.3E-04	0.00043	24 hr	24 hr	0.00043	0.07	Sch. 6	URT	MECP Health Based	No
	-	-	3.7E-05	3.7E-05	0.000037	Annual	Annual	0.000037	0.0014	--	AAV	MECP Health Based	No
Cobalt	-	9.5E-03	-	-	0.0095	0.5 hr	0.5 hr	0.0095	0.3	Sch. 2	Health	MECP Health Based	No
	-	-	3.9E-03	3.9E-03	0.0039	24 hr	24 hr	0.0039	0.1	Sch. 3	Health	MECP Health Based	No
Fluoride	-	5.9E-02	-	-	0.059	0.5 hr	0.5 hr	0.059	No Health-Based Guideline Available				-
	-	-	-	-	-	Annual	Annual	0.0038	8.7	N/A	Health	TCEQ ESL ⁴	No
	-	-	0.02	0.02	0.02	24 hr	24 hr	0.02	No Health-Based Guideline Available				-
	-	-	-	-	-	Annual	Annual	0.0038	8.7	N/A	Health	TCEQ ESL	No
	-	-	6.1E-03	6.1E-03	0.0061	30 day	30 day	0.0061	No Health-Based Guideline Available				-
	-	-	-	-	-	Annual	Annual	0.0030	8.7	N/A	Health	TCEQ ESL	No
Hydrazine	-	3.9E-04	1.6E-04	1.6E-04	0.00039	Annual	Annual	0.00039	0.0004	Site Specific	MAXGLC	MECP Site Specific	No
Iron	-	0.59	-	-	0.59	0.5 hr	0.5 hr	0.59	10	Sch. 2	Health	MECP Health Based	No
	-	-	0.27	0.27	0.27	24 hr	24 hr	0.27	4	Sch. 3	Health	MECP Health Based	No
Lubricating Oil	-	6.4	-	-	6.4	0.5 hr	0.5 hr	6.4	100	Sch. 2	Health & Particulate	MECP Health Based	No
Manganese	-	0.15	-	-	0.15	0.5 hr	0.5 hr	0.15	1.2	Sch. 2	Health	MECP Health Based	No
	-	-	0.07	0.07	0.07	24 hr	24 hr	0.07	0.4	Sch. 3	Health	MECP Health Based	No
Morpholine	-	15.4	-	-	15.4	0.5 hr	0.5 hr	15.4	600	Sch. 2	Health	MECP Health Based	No
	-	-	3.6	3.6	3.6	24 hr	24 hr	3.6	200	Sch. 3	Health	MECP Health Based	No
Nickel	-	0.15	-	-	0.15	0.5 hr	0.5 hr	0.15	0.6	Sch. 2	Health	MECP Health Based	No
	-	-	0.06	0.06	0.06	24hr	24hr	0.06	2	Sch. 6	URT	MECP Health Based	No
	-	-	5.7E-03	5.7E-03	0.0057	Annual	Annual	0.0057	0.4	--	AAV	MECP Health Based	No
Nitrogen Oxides ^d	639 ^e	-	-	-	639	0.5 hr	0.5 hr	639	1880	N/A	Health	MECP Health Based Screening Level	No
	-	-	-	-	-	1 hr	1 hr	526	113	N/A	Health	ECCC CAAQS ²	Yes
	-	-	-	-	-	Annual	Annual	41	32	N/A	Health	ECCC CAAQS	Yes
	-	-	-	-	-	0.5 hr	0.5 hr	23.1	500	Sch. 2	Health	MECP Health Based	No
	-	23.1	-	-	23.1	0.5 hr	0.5 hr	19	113	N/A	Health	ECCC CAAQS	No
	-	-	-	-	-	Annual	Annual	1	32	N/A	Health	ECCC CAAQS	No
	-	-	205	205	205	1 hr	1 hr	205	113	N/A	Health	ECCC CAAQS	Yes
	-	-	30.2	30.2	30.2	24 hr	24 hr	30.2	200	Sch. 3	Health	MECP Health Based	No
	-	-	-	-	-	Annual	Annual	6	32	N/A	Health	ECCC CAAQS	No
Phosphorus	-	1.5E-02	-	-	0.015	0.5 hr	0.5 hr	0.015	1.5	Sch. 2	Health	MECP Health Based	No
	-	-	6.1E-03	6.1E-03	0.0061	24 hr	24 hr	0.0061	0.5	Sch. 3	Health	MECP Health Based	No
Sodium Hydroxide	-	0.36	-	-	0.36	0.5 hr	0.5 hr	0.36	No Health-Based Guideline Available				-
	-	-	-	-	-	Annual	Annual	0.02	2	N/A	Health	TCEQ ESL	No
Sodium Hypochlorite	-	2.3	-	-	2.3	0.5 hr	0.5 hr	2.3	27	Sch. 2	Health	MECP Health Based	No
	-	-	1.24	1.24	1.24	24 hr	24 hr	1.24	9	Sch. 3	Health	MECP Health Based	No
Sodium Sulfite	-	0.22	-	-	0.22	0.5 hr	0.5 hr	0.22	0.42	Sch. 2	Health	MECP Health Based	No
	-	-	0.07	0.07	0.07	24 hr	24 hr	0.07	0.14	Sch. 3	Health	MECP Health Based	No
Suspended Particulate Matter (Total)	-	4.65	-	-	4.65	0.5 hr	0.5 hr	4.65	100	Sch. 2	Visibility	MECP Health Based ^b	No
Sulphur Dioxide	-	33.6	-	-	33.6	0.5 hr	0.5 hr	33.6	830	Sch. 2	Health	MECP Health Based	No
	-	-	-	-	-	1 hr	1 hr	28	132	N/A	Health	ECCC CAAQS	No
	-	-	-	-	-	Annual	Annual	2	9	N/A	Health	ECCC CAAQS	No
	-	-	0.1	0.1	0.1	24 hr	24 hr	0.1	275	Sch. 3	Health & Vegetation	MECP Health Based	No
	-	-	-	-	-	Annual	Annual	0.019	9	N/A	Health	ECCC CAAQS	No
	-	-	1	1	1	1 hr	1 hr	1	132	N/A	Health	ECCC CAAQS	No
Sulphuric Acid	-	0.20	-	-	0.2	0.5 hr	0.5 hr	0.2	15	Sch. 2	Health	MECP Health Based	No
Vanadium	-	5.0E-02	-	-	0.05	0.5 hr	0.5 hr	0.05	5	Sch. 2	Health	MECP Health Based	No
	-	-	0.02	0.02	0.02	24 hr	24 hr	0.02	2	Sch. 3	Health	MECP Health Based	No

References

- Ministry of the Environment, Conservation and Parks (MECP), Ontario. Air Contaminants Benchmarks (ACB) List: Standards, guidelines and screening levels for assessing point of impingement concentrations of air contaminants. O. Reg. 419/05 Air Pollution – Local Air Quality.
- Environment and Climate Change Canada (ECCC), Canadian Ambient Air Quality Standards (CAAQS). Available from: <http://airquality-qualifiedelair.cmc.ca/en/>. Also available from Canada Gazette Part 1, Volume 151, December 9, 2017. <http://www.gazette.gc.ca/rp/p1/2017/2017-12-09/pdf/g1-15149.pdf>.
- Texas Commission on Environmental Quality. Effects Screening levels. List updated on November 2016. Accessed on July 2020. <https://www.tceq.texas.gov/toxicology/esl>

Notes

^a The max POI concentrations were converted to the averaging period of benchmarks by following instruction provided in Section 4.4 of the document "Air Dispersion Modelling Guideline for Ontario, Version 3.0" by MOECC.

^b In the absence of a health based guideline, the MECP corrosion guideline was used for calcium hydroxide and the MECP visibility guideline was used for total particulate matter.

^c In the absence of a health based guideline, a site specific Maximum Ground Level Concentration (MAXGLC) was used for hydrazine. This is based on approved ministry site specific request and does not have a ministry Point of Impingement (POI) Limit.

^d Nitrogen oxides (NO_x) are defined as the sum of nitrogen dioxide (NO₂) and nitric oxide (NO). Emissions of NO_x consist mainly of NO, with some NO₂. In ambient air, NO converts to NO₂. NO₂ has adverse health effects at much lower concentrations than NO. Therefore, air quality guidelines are typically based on the health effects of NO₂.

^e The 2016 POI concentration for nitrogen oxides is based on the emergency standby generators. Since a standby generator was operated for 75 hours in 2016 instead of the 60-hour limit per annum, and this exceeded the Section 20.4 exemption criteria of 60 hours per annum, this was accommodated in the ESDM emission summary table as a significant source. Thus, since the emergency standby generator concentration was considered as a significant source in 2016, it was included in this table.

Table A-2: Human Health Screening Criteria for Screening Surface Water COPCs

Analyte	Unit	Drinking Water CWQG (1)	ODWS/MOE GW1 Component Value (2)	Guideline from Other Source		95th Percentile Background, 2019 Environmental Study (3)	Detection Limit (3)	Selected Human Health Screening Criteria	Reference
Physical/Conventional Characteristics									
Field Temperature	Celsius	-	-	-	-	20.35	-	-	^a
Field pH	pH	None	-	-	-	8.81	-	None	^a
pH	pH	None	-	-	-	8.39	-	None	^a
Field Sp. Conductance	µS/cm	-	-	-	-	353.55	-	-	^a
Conductivity	umho/cm	-	-	-	-	330.00	1	-	^a
Field Turbidity	NTU	-	-	-	-	12.03	0.1	-	^a
Turbidity	NTU	-	-	-	-	5.45	0.1	-	^a
Alkalinity (Total as CaCO3)	mg/L	-	-	-	-	98.95	1	-	^a
Total Hardness (CaCO3)	mg/L	-	-	-	-	122.65	0.5 - 1	-	^a
Total Suspended Solids	mg/L	-	-	-	-	9.25	1 - 10	-	^a
Total Residual Chlorine	mg/L	Not Required	-	-	-	0.01	0.0012	Not Required	^a
Nutrients									
Dissolved Organic Carbon	mg/L	-	-	-	-	2.07	0.5	-	^a
Total Kjeldahl Nitrogen (TKN)	mg/L	-	-	-	-	0.26	0.1	-	^a
Total Ammonia-N	mg/L	None required	-	-	-	0.20	0.01 - 1	None required	^a
Total Un-ionized Ammonia	mg/L	-	-	-	-	0.01	0.00051 - 0.044	None required	^a
Total BOD	mg/L	-	-	-	-	2.00	2	-	^a
Total Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	7.36	4	-	^a
Orthophosphate (P)	mg/L	-	-	-	-	0.01	0.01	-	^a
Total Phosphorus	mg/L	-	-	-	-	0.02	0.02 - 2.51	-	^a
Anion									
Chloride (Cl)	mg/L	-	250000	-	-	-	-	250000	(2)
Nitrate (N)	mg/L	10	-	-	-	0.36	0.1	10	(1)
Nitrite (N)	mg/L	1	-	-	-	0.00	0.01	1	(1)
Hydrocarbons									
Benzene	µg/L	5	5	-	-	0.00	0.1 - 0.5	5	(1,2)
Ethylbenzene	µg/L	140	2.4	-	-	0.00	0.1 - 0.5	2.4	(2)
Toluene	µg/L	60	24	-	-	-	-	24	(2)
m,p-xylene	µg/L	-	-	-	-	-	-	90	(1)
o-xylene	µg/L	-	-	-	-	-	-	90	(1)
Xylene, Total	µg/L	90	300	-	-	-	-	90	(1)
F1 (C6-C10)	µg/L	-	820	-	-	0.00	25	820	(2)
F1 (C6-C10) - BTEX	µg/L	-	820	-	-	0.00	25	820	(2)
F2 (C10-C16 Hydrocarbons)	µg/L	-	300	-	-	0.00	100	300	(2)
F3 (C16-C34 Hydrocarbons)	µg/L	-	1000	-	-	147	200	1000	(2)
F4 (C34-C50 Hydrocarbons)	µg/L	-	1100	-	-	0.0	200	1100	(2)
Ethylene Glycol	mg/L	-	-	4	US EPA (4)	-	5	2	(4)
Propylene Glycol	mg/L	-	-	40	US EPA (4)	-	5	10	(4)
Biological									
Chlorophyll	µg/L	-	-	-	-	1.58	0.1 - 0.2	-	^a
Background	CFU/100mL	-	-	-	-	480.00	10	-	^a
Total Coliforms	CFU/100mL	Non detectable	-	-	-	62.50	10	63	(3)
Fecal coliform	CFU/100mL	-	-	-	-	10.00	10	10	(3) ^b
Escherichia coli	CFU/100mL	Non detectable	-	-	-	10.00	10	10	(3)
Metals									
Total Aluminum (Al)	µg/L	-	-	9500	BC CSR (5)	4.37	0.5 - 5	9500	(5)
Dissolved (0.2u) Aluminum (Al)	µg/L	-	-	-	-	4.95	5	9500	(5) ^c
Total Antimony (Sb)	µg/L	6	6	-	-	0.14	0.02 - 0.5	6	(1,2)
Total Arsenic (As)	µg/L	10	25	-	-	0.80	0.02 - 1	10	(1)
Total Barium (Ba)	µg/L	1000	1000	-	-	23.19	0.02 - 2	1000	(1,2)
Total Beryllium (Be)	µg/L	-	4	-	-	0.00	0.01 - 0.5	4	(2)
Total Bismuth (Bi)	µg/L	-	-	-	-	0.00	0.005 - 1	-	^a
Total Boron (B)	µg/L	5000	5000	-	-	23.36	10 - 50	5000	(1,2)
Total Cadmium (Cd)	µg/L	5	5	-	-	0.00	0.005 - 0.1	5	(1,2)
Total Calcium (Ca)	µg/L	-	-	-	-	34860.00	0.05 - 250	-	^a
Total Cesium (Cs)	µg/L	-	-	1	ATSDR (6)	0.00	0.05 - 0.2	1	(6)
Total Chromium (Cr)	µg/L	50	50	-	-	0.39	0.1 - 5	50	(1,2)
Chromium (+3)	µg/L	None	-	-	-	0.07	0.5 - 5	None	^a
Chromium (VI)	µg/L	50	25	-	-	0.29	0.5	25	(2)
Total Cobalt (Co)	µg/L	-	3	-	-	0.01	0.005 - 0.5	3	(2)
Total Copper (Cu)	µg/L	2000	1000	-	-	0.62	0.05 - 1	1000	(2)
Gadolinium (Gd)	µg/L	-	-	140	US EPA (7)	-	2	140	(7)
Total Iron (Fe)	µg/L	None	-	-	-	1.46	1 - 100	None	(1)
Total Lead (Pb)	µg/L	5	10	-	-	0.01	0.005 - 0.5	5	(1)
Total Lithium (Li)	µg/L	-	-	4	US EPA (4)	2.01	0.5 - 5	4	(4)
Total Magnesium (Mg)	µg/L	None required	-	-	-	8718	0.05 - 250	None required	^a
Total Manganese (Mn)	µg/L	120	-	-	-	0.31	0.05 - 2	120	(1)
Mercury (Hg)	µg/L	1	1	-	-	0.00	0.01	1	(1,2)
Total Molybdenum (Mo)	µg/L	-	70	-	-	1.22	0.05 - 1	70	(2)
Total Nickel (Ni)	µg/L	-	100	-	-	0.52	0.02 - 1	100	(2)
Total Potassium (K)	µg/L	-	-	-	-	1666.50	0.05 - 1000	-	^a
Total Selenium (Se)	µg/L	50	10	-	-	0.15	0.04 - 2	10	(2)
Total Silicon (Si)	µg/L	-	-	-	-	608.75	50	609	(3)
Total Silver (Ag)	µg/L	-	100	-	-	0.00	0.005 - 0.1	100	(2)
Total Sodium (Na)	µg/L	-	200000	-	-	14860.00	0.05 - 250	200000	(2)
Total Strontium (Sr)	µg/L	7000	-	-	-	195.00	0.05 - 1	7000	(1)
Total Tellurium (Te)	µg/L	-	-	-	-	-	0.5-1	-	^a
Total Thallium (Tl)	µg/L	-	2	-	-	0.01	0.002 - 0.05	2	(2)
Total Thorium (Th)	µg/L	-	-	250	WHO (8)	0.00	0.005 - 1	250	(8)
Total Tin (Sn)	µg/L	-	-	1200	US EPA (4)	0.03	0.2 - 5	1200	(4)
Total Titanium (Ti)	µg/L	-	-	15	WHO (9)	0.49	0.5 - 5	15	(9)
Total Tungsten (W)	µg/L	-	-	1.6	US EPA (4)	0.13	0.01 - 1	1.6	(4)
Total Uranium (U)	µg/L	20	20	-	-	0.39	0.002 - 0.1	20	(1,2)
Total Vanadium (V)	µg/L	-	6.2	-	-	0.18	0.2 - 5	6.2	(2)
Total Zinc (Zn)	µg/L	-	5000	-	-	1.09	0.1 - 5	5000	(2)
Dissolved Zinc (Zn)	µg/L	-	-	-	-	3.61	5	5000	(2) ^d
Total Zirconium (Zr)	µg/L	-	-	0.16	US EPA (4)	0.01	0.1 - 1	0.16	(4)
Other									
Hydrazine	µg/L	-	-	0.01	IRIS (10)	0.10	0.1	0.01	(10)
Morpholine	µg/L	-	-	1700	HC (11)	0.65	4	1700	(11)
Alcohol ethoxylates	µg/L	-	-	-	-	-	See Table A.6b	^a	^a
Polychlorinated Biphenyls	µg/L	-	3	-	-	-	-	3	(2)
Bromoform	µg/L	-	25	-	-	0.00	0.2 - 1	25	(2)
Chloroform	µg/L	-	25	-	-	0.00	0.1 - 0.5	25	(2)
Bromodichloromethane	µg/L	-	16	-	-	0.00	0.1 - 0.5	16	(2)
Trihalomethanes (THMs)	µg/L	100 ^d	-	-	-	-	-	100	(1) ^d

References:

- Health Canada. 2019. Guidelines for Canadian Drinking Water Quality—Summary Table. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.
- Ontario Ministry of the Environment (MOE). 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario. Standards Development Branch. April.
- Ecometrix. (2020). Darlington New Nuclear Project Supporting Environment Studies – Environment. Report prepared for OPG. Report No. NK054-REP-01210-0001. May.
- United States Environmental Protection Agency (US EPA). 2020. Regional Screening Levels (RSLs) for tap water (target hazard quotients (THQ) of 0.1). <https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>
- British Columbia Ministry of Environment and Climate Change Strategy. 2020. B.C. Source Drinking Water Quality Guidelines: Guideline Summary. Water Quality Guideline Series, WQG-01. Prov. B.C., Victoria B.C.
- Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Cesium. 2004. Cites background typically found in drinking water. <https://www.atsdr.cdc.gov/toxprofiles/tpr157.pdf>
- US EPA. 2018. Provisional Peer-Reviewed Toxicity Values for Stable (Nonradioactive) Gadolinium (CASRN 7440-54-2) and Soluble Salts. http://cfmnpub.epa.gov/eims/eimscmn/getfile?download_id=536757. [Converted RfD (0.04 mg/kgBW/day) to drinking water criterion.]
- World Health Organization (WHO). Guidelines for Drinking Water, Chapter 9 Radiological Aspects. https://www.who.int/water_sanitation_health/dwq/GDW9rev1and2.pdf?ua=1. [Converted thorium from Bq/L to mg/L.]
- World Health Organization (WHO). 1962. International Programme on Chemical Safety & WHO Task Group on Environmental Health Criteria for Titanium. Titanium / published under the joint sponsorship of the United Nations Environment Programme, the International Labour Organisation, and the World Health Organization. <http://www.inchem.org/documents/ehc/ehc/ehc24.htm>
- US EPA Integrated Risk Information System (IRIS). 1988. Chemical Assessment Summary - Hydrazine/hydrazine sulfate; CASRN 302-01-2. Drinking Water Concentration with 1 in 100,000 risk level. https://cfpub.epa.gov/nceas/iris/iris_documents/documents/subst/0352_summary.pdf?nameddest=cancerol
- Health Canada (2002). A Summary of the Health Hazard Assessment of Morpholine in Wax Coatings of Apples. <https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/information-product/summary-health-hazard-assessment-morpholine-coatings-apples.html>. [Converted TDI (0.48 mg/kgBW/day) to DW criterion.]

Notes:

- ^a The Analyte is not considered of human health concern, and therefore no screening benchmark is necessary.
- ^b the CWQG value for E.coli and total coliforms is used to screen fecal coliforms.
- ^c IPWQO values for both 1,2- and 1,3- propylene glycol were available. The lower value for 1,3-propylene glycol is illustrated here for a conservative approach.
- ^d Refers to the total of chlorodibromomethane, chloroform, bromodichloromethane and bromoform.
- ^e Screening criteria selection for alcohol ethoxylates is detailed in Table A.6b, c.
- ^f Total metal guideline is applied to dissolved.

Table A-3: Screening of Lake Water for Human Health

Analyte	Unit	Selected Benchmark	Reference	2019 Study Max	COPC in the 2016 ERA? ^a	Carried Forward as COPC?
Nutrients						
Nitrate (N)	mg/L	10	(1)	2.2	Yes	No
Nitrite (N)	mg/L	1	(1)	0.013	No	No
Hydrocarbons						
Benzene	µg/L	5	(1,2)	0.14	ND	No
Ethylbenzene	µg/L	2.4	(2)	0	ND	No
F1 (C6-C10)	µg/L	820	(2)	0	No	No
F1 (C6-C10) - BTEX	µg/L	820	(2)	0	No	No
F2 (C10-C16 Hydrocarbons)	µg/L	300	(2)	0	No	No
F3 (C16-C34 Hydrocarbons)	µg/L	1000	(2)	170	No	No
F4 (C34-C50 Hydrocarbons)	µg/L	1100	(2)	0	No	No
Biological						
Total Coliforms	CFU/100mL	63	(3)	2100	ND	No ^b
Fecal coliform	CFU/100mL	10	(3)	2000	ND	No ^b
Escherichia coli	CFU/100mL	10	(3)	2000	ND	No ^b
Metals						
Total Aluminum (Al)	µg/L	9500	(5)	142	No	No
Dissolved (0.2u) Aluminum (Al)	µg/L	9500	(5) ^c	21	No	No
Total Antimony (Sb)	µg/L	6	(1,2)	0.176	ND	No
Total Arsenic (As)	µg/L	10	(1)	0.841	ND	No
Total Barium (Ba)	µg/L	1000	(1,2)	32.3	ND	No
Total Beryllium (Be)	µg/L	4	(2)	0.007	ND	No
Total Boron (B)	µg/L	5000	(1,2)	27	ND	No
Total Cadmium (Cd)	µg/L	5	(1,2)	0.016	No	No
Total Cesium (Cs)	µg/L	1	(6)	0.087	ND	No
Total Chromium (Cr)	µg/L	50	(1,2)	1.346	No	No
Chromium (+3)	µg/L	None	-	0	No	No
Chromium (VI)	µg/L	25	(2)	0.34	No	No
Total Cobalt (Co)	µg/L	3	(2)	0.091	ND	No
Total Copper (Cu)	µg/L	1000	(2)	1	No	No
Total Iron (Fe)	µg/L	None	(1)	178	No	No
Total Lead (Pb)	µg/L	5	(1)	0.157	No	No
Total Lithium (Li)	µg/L	4	(4)	10.2	No	Yes
Total Manganese (Mn)	µg/L	120	(1)	18.1	ND	No
Mercury (Hg)	µg/L	1	(1,2)	0.0031	No	No
Total Molybdenum (Mo)	µg/L	70	(2)	1.35	No	No
Total Nickel (Ni)	µg/L	100	(2)	0.703	No	No
Total Selenium (Se)	µg/L	10	(2)	0.189	No	No
Total Silicon (Si)	µg/L	609	(3)	932	ND	No ^d
Total Silver (Ag)	µg/L	100	(2)	0.006	ND	No
Total Sodium (Na)	µg/L	200000	(2)	39600	ND	No
Total Strontium (Sr)	µg/L	7000	(1)	625	ND	No
Total Thallium (Tl)	µg/L	2	(2)	0.014	ND	No
Total Thorium (Th)	µg/L	250	(8)	0.014	ND	No
Total Tin (Sn)	µg/L	1200	(4)	0.405	ND	No
Total Titanium (Ti)	µg/L	15	(9)	5.2	ND	-
Total Tungsten (W)	µg/L	1.6	(4)	0.134	ND	No
Total Uranium (U)	µg/L	20	(1,2)	0.61	ND	No
Total Vanadium (V)	µg/L	6.2	(2)	0.64	ND	No
Total Zinc (Zn)	µg/L	5000	(2)	3.138	No	No
Dissolved Zinc (Zn)	µg/L	5000	(2) ^c	13	ND	No
Total Zirconium (Zr)	µg/L	0.16	(4)	0.34	ND	Yes
Other						
Hydrazine	µg/L	0.01	(10)	0.11	ND	Yes
Morpholine	µg/L	1700	(11)	2	No	No
Bromoform	µg/L	25	(2)	0	ND	No
Chloroform	µg/L	25	(2)	0	ND	No
Bromodichloromethane	µg/L	16	(2)	0	ND	No

References:

1. Health Canada. 2019. Guidelines for Canadian Drinking Water Quality—Summary Table. Water and Air Quality Bureau, Healthy Environmentsand Consumer Safety Branch, Health Canada, Ottawa, Ontario.
2. Ontario Ministry of the Environment (MOE). 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario. Standards Development Branch. April.
3. Ecometrix. (2020). Darlington New Nuclear Project Supporting Environmental Studies – Environment. Report prepared for OPG. Report No. NK054-REP-01210-0001. May.
4. United States Environmental Protection Agency (US EPA). 2020. Regional Screening Levels (RSLs) for tap water (target hazard quotients (THQ) of 0.1). <https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables>
5. British Columbia Ministry of Environment and Climate Change Strategy. 2020. B.C. Source Drinking Water Quality Guidelines: Guideline Summary. Water Quality Guideline Series, WQG-01. Prov. B.C., Victoria B.C.
6. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological Profile for Cesium. 2004. Cites background typically found in drinking water. <https://www.atsdr.cdc.gov/toxprofiles/tp157.pdf>
7. US EPA. 2018. Provisional Peer-Reviewed Toxicity Values for Stable (Nonradioactive) Gadolinium (CASRN 7440-54-2) and Soluble Salts. http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=536757. [Converted RfD (0.04 mg/kgBW/day) to drinking water criterion.]
8. World Health Organization (WHO). Guidelines for Drinking Water, Chapter 9 Radiological Aspects. https://www.who.int/water_sanitation_health/dwq/GDW9rev1and2.pdf?ua=1. [Converted thorium from Bq/L to mg/L.]
9. World Health Organization (WHO). 1982. International Programme on Chemical Safety & WHO Task Group on Environmental Health Criteria for Titanium. Titanium / published under the joint sponsorship of the United Nations Environment Programme, the International Labour Organisation, and the World Health Organization. <http://www.inchem.org/documents/ehc/ehc/ehc24.htm>
10. US EPA Integrated Risk Information System (IRIS). 1988. Chemical Assessment Summary - Hydrazine/Hydrazine sulfate; CASRN 302-01-2. Drinking Water Concentration with 1 in 100,000 risk level. https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0352_summary.pdf#nameddest=canceroral
11. Health Canada (2002). A Summary of the Health Hazard Assessment of Morpholine in Wax Coatings of Apples. <https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/information-product/summary-health-hazard-assessment-morpholine-coatings-apples.html>. [Converted TDI (0.48 mg/kgBW/day) to DW criterion.]

Notes:

- ^a ND: No Data
- ^b Not considered to be nuclear or hazardous substance, so are not COPCs under CSA N288.6 and not associated with Darlington Nuclear. The rationale for not carrying these parameters forward as COPCs is discussed in Section 3.1.2.2.1.
- ^c Total metal guideline is applied to dissolved.
- ^d There is no expected human health concern for silicon, so it was not carried forward as a COPC. See Section 3.1.2.2.1.

Table A-4: Screening of CCW Effluent (ECA Data) for Human Health

Parameters	Unit	Human Health Screening Criteria ^a	Measured Maximum Concentrations from ECAs				Max Concentrations in CCW	Estimated Max Mixing Zone Concentrations	Carried forward as COPC?
			2016	2017	2018	2019			
Unionized Ammonia	mg/L	None required	0.01	0.01	0.01	0.01	0.01	0.0014	No
Hydrazine	mg/L	0.00001	0.006	0.005	0.0051	0.005	0.006	0.0009	Yes
Morpholine	mg/L	1.7	0.005	0.003	0.0011	0.006	0.006	0.0009	No
pH	pH units	None	8.0-8.6	7.9-8.5	7.7-8.3	7.9-8.4	7.9-8.6	7.9-8.6 ^b	No
TRC	mg/L	Not Required	<0.001	<0.001	0.006	0.01	0.01	0.0014	No

Notes:
^a See Table A.2 for references of selected screening benchmarks.

^b The maximum pH in the CCW was directly compared, representing the possibly maximum mixing zone pH value.

Table A-5: Screening of MISA Control Point Effluents for Human Health

Parameter	Units	Intake Conc. (Golder, 2011a)	MISA Limit at Station Discharge	Estimated Maximum Concentration in Station Discharge (Section 3.1.2.2.2)	Estimated Max Mixing Zone Concentrations	Human Health Screening Criteria ^a	Carried Forward as COPC?
RLWMS							
Phosphorus	mg/L	0.0154	1	0.015	0.002	-	No
TSS	mg/L	5.175	73	5.176	0.739	-	No
Zinc	mg/L	0.0019	1	0.002	0.0003	5	No
Iron	mg/L	0.0282	9	0.028	0.004	None	No
Oil and Grease	mg/L	0	36	0.00038	0.0001	-	No
WTP							
Aluminum	mg/L	0.0377	13	0.038	0.005	9500	No
TSS	mg/L	5.175	70	5.179	0.740	-	No
Iron	mg/L	0.0282	2.5	0.028	0.004	None	No

^a See Table A.2 for references for these selected screening benchmarks.

Table A-6a: Screening of 2016 CCW Effluent for Human Health

Parameter	Units	Selected Human Health Screening Criteria ^a	Measured Stream Concentrations						Carried Forward as a COPC?
			RLW	BB	IAD	WTP	CCW	Estimated Max Mixing Zone Concentrations	
			Max_Value	Max_Value	Max_Value	Max_Value	Max_Value		
Morpholine	µg/L	1700	6					-	No
Gadolinium (Gd)	µg/L	140	46				9.6	1.37	No
Mercury (Hg)	µg/L	1	<0.1				<0.1	<0.014	No
Total Aluminum (Al)	µg/L	9500	59.9		19.2	0.012	150	21.43	No
Total Cadmium (Cd)	µg/L	5	0.257	0.013	0.008	4.76	0.015	0.002	No
Total Chromium (Cr)	µg/L	50	6.97	0.44	0.64	9.91	0.79	0.11	No
Total Copper (Cu)	µg/L	1000	15.5	0.914	3.25	13.8	1.92	0.27	No
Total Iron (Fe)	µg/L	None	32	13.1	37.7		250	35.71	No
Total Lead (Pb)	µg/L	5	19.8	0.213	0.086	0.199	0.335	0.05	No ^b
Total Lithium (Li)	µg/L	4	330				3.82	0.55	No
Total Molybdenum (Mo)	µg/L	70	7.78			65.6	1.59	0.23	No
Total Nickel (Ni)	µg/L	100	50.6	0.087	0.752	1.83	0.932	0.13	No
Total Selenium (Se)	µg/L	10	1	0.04	0.141	2.05	0.199	0.03	No
Total Zinc (Zn)	µg/L	5000	25.5	2.95		21.2	8.79	1.26	No
Nitrate (N)	mg/L	10				4.88	0.44	0.06	No
Total Phosphorus	mg/L	-	0.177				0.029	0.004	No
Ethylene Glycol	mg/L	2	<20		<5		<5	<0.71	No ^b
Propylene Glycol	mg/L	10	<20		<5		<5	<0.71	No ^b
F1 (C6-C10)	µg/L	820	<25			<25	<25	<3.57	No
F1 (C6-C10) - BTEX	µg/L	820	<25			<25	<25	<3.57	No
F2 (C10-C16 Hydrocarbons)	µg/L	300	<100			<100	<100	<14.29	No
F3 (C16-C34 Hydrocarbons)	µg/L	1000	<200			<200	<200	<28.57	No
Total Residual Chlorine (TRC)	µg/L	Not Required				4		-	No

Notes:
^a See Table A.2 for references for these selected screening benchmarks.

^b See discussion in Section 3.1.2.2.2.3.

RLW - Radioactive Liquid Waste

BB - Boiler Blowdown

IAD - Inactive Drainage

WTP - Water Treatment Plant

CCW - Condenser Cooling Water

Table A-6b: Screening of 2016 CCW Effluent for Human Health

Analyte	Unit	Detection Limit	Derived DW Screening Criteria (1)	Maximum Concentration in CCW (EcoMetrix, 2016)	Estimated Max Mixing Zone Concentrations	Carried forward to detailed screening?
Alcohol Ethoxylates C8-9	µg/L	0.03	None	ND ^a	ND	No ^b
Alcohol Ethoxylates C10-11	µg/L	0.03	None	ND	ND	No ^b
Alcohol Ethoxylates C12 -13	µg/L	0.03	None	108.7	15.5	No ^b
Alcohol Ethoxylates C14-15	µg/L	0.03	None	16	2.3	No ^b
Alcohol Ethoxylates C16-18	µg/L	0.03	None	1	0.1	No ^b
Total Alcohol Ethoxylates	µg/L	0.03	512500 ^b	121	17.3	No
Nonylphenol Ethoxycarboxylate	µg/L	0.01	None	ND	ND	No ^b
Linear Alkylbenzene Sulphonates C10	µg/L	0.06	None	1.1	0.2	No ^b
Linear Alkylbenzene Sulphonates C12	µg/L	0.06	None	15.3	2.2	No ^b
Total Linear Alkylbenzene Sulphonates	µg/L	0.06	929333 ^b	15.3	2.2	No

Reference

1. Revised Human and Environmental Risk Assessment (HERA) Report - Linear Alkylbenzene Sulphonate, Table 10 (HERA, 2013)

Notes:

^a ND = non-detect

^b See discussion in Section 3.1.2.2.2.3.

Table A-7 Screening of Analytes in 2019 Stormwater for Human Health

Analyte	Maximum Stormwater Loading		Modeled Diluted Concentration in Lake Water		Human Health Screening Benchmark ^a	Carried Forward as COPC?
	Value	Unit	Value	Unit		
Biological						
Escherichia coli	80972	CFU/s	0.83	CFU/100 ml	10	No
Fecal Coliform	2746200	CFU/s	28.25	CFU/100 ml	10	No ^b
Total Coliform	120152	CFU/s	1.24	CFU/100 ml	63	No
Anions						
Chloride	630792	mg/s	64.90	mg/L	250000	No
Nitrate as N	188.838	mg/s	0.02	mg/L	10	No
Nitrite as N	7.32036	mg/s	0.0008	mg/L	1	No
Dissolved Phosphorus	31.2144	mg/s	0.0032	Tab	0.02	No
Metals and Inorganics						
Total Aluminum (Al)	765085.14	µg/s	78.71	µg/L	9500	No
Dissolved Aluminum (Al)	24208.22944	µg/s	2.4906	µg/L	9500	No
Dissolved (0.2u) Aluminum (Al)	8896.86	µg/s	0.9153	µg/L	9500	No
Total Antimony (Sb)	211.83	µg/s	0.0218	µg/L	6	No
Dissolved Antimony (Sb)	211.83	µg/s	0.0218	µg/L	6	No
Total Arsenic (As)	423.66	µg/s	0.0436	µg/L	10	No
Dissolved Arsenic (As)	423.66	µg/s	0.0436	µg/L	10	No
Total Barium (Ba)	42052.8	µg/s	4.3264	µg/L	1000	No
Dissolved Barium (Ba)	39424.5	µg/s	4.0560	µg/L	1000	No
Total Beryllium (Be)	<211.83	µg/s	<0.0218	µg/L	4	No
Dissolved Beryllium (Be)	<211.83	µg/s	<0.0218	µg/L	4	No
Total Boron (B)	31214.4	µg/s	3.21	µg/L	5000	No
Dissolved Boron (B)	26755.2	µg/s	2.75	µg/L	5000	No
Total Cadmium (Cd)	85.8624	µg/s	0.0088	µg/L	5	No
Dissolved Cadmium (Cd)	42.366	µg/s	0.0044	µg/L	5	No
Total Chromium (Cr)	2540.096	µg/s	0.261	µg/L	50	No
Dissolved Chromium (Cr)	2118.3	µg/s	0.218	µg/L	50	No
Total Cobalt (Co)	465.088	µg/s	0.048	µg/L	3	No
Dissolved Cobalt (Co)	211.83	µg/s	0.022	µg/L	3	No
Total Copper (Cu)	5276.96	µg/s	0.543	µg/L	1000	No
Dissolved Copper (Cu)	1694.64	µg/s	0.174	µg/L	1000	No
Hexavalent Chromium	416.546354	µg/s	0.043	µg/L	25	No
Total Lead (Pb)	2879.968	µg/s	0.296	µg/L	5	No
Dissolved Lead (Pb)	211.83	µg/s	0.022	µg/L	5	No
Total Lithium (Li)	2499.594	µg/s	0.257	µg/L	4	No
Dissolved Lithium (Li)	2118.3	µg/s	0.218	µg/L	4	No
Total Manganese (Mn)	45435.52	µg/s	4.67	µg/L	120	No
Dissolved Manganese (Mn)	30245.6	µg/s	3.11	µg/L	120	No
Total Mercury (Hg)	4.2366	µg/s	0.00044	µg/L	1	No
Total Molybdenum (Mo)	402.477	µg/s	0.0414	µg/L	70	No
Dissolved Molybdenum (Mo)	377.0574	µg/s	0.0388	µg/L	70	No
Total Nickel (Ni)	1252.16	µg/s	0.1288	µg/L	100	No
Dissolved Nickel (Ni)	423.66	µg/s	0.0436	µg/L	100	No
Total Selenium (Se)	847.32	µg/s	0.087	µg/L	10	No
Dissolved Selenium (Se)	137.31	µg/s	0.014	µg/L	10	No
Total Silicon (Si)	1275141.9	µg/s	131.2	µg/L	609	No
Dissolved Silicon (Si)	630792	µg/s	64.9	µg/L	609	No
Total Silver (Ag)	42.366	µg/s	0.0044	µg/L	100	No
Dissolved Silver (Ag)	42.366	µg/s	0.0044	µg/L	100	No
Total Sodium (Na)	367962000	µg/s	37856	µg/L	200000	No
Dissolved Sodium (Na)	341679000	µg/s	35152	µg/L	200000	No
Total Strontium (Sr)	473094	µg/s	48.67	µg/L	7000	No
Dissolved Strontium (Sr)	473094	µg/s	48.67	µg/L	7000	No
Total Thallium (Tl)	21.183	µg/s	0.00218	µg/L	2	No
Dissolved Thallium (Tl)	21.183	µg/s	0.00218	µg/L	2	No
Dissolved Thorium (Th)	<137.31	µg/s	<0.014	µg/L	250	No
Total Thorium (Th)	847.32	µg/s	0.087	µg/L	250	No
Total Tin (Sn)	423.66	µg/s	0.044	µg/L	1200	No
Dissolved Tin (Sn)	423.66	µg/s	0.044	µg/L	1200	No
Total Titanium (Ti)	22952.5542	µg/s	2.36	µg/L	15	No
Dissolved Titanium (Ti)	2118.3	µg/s	0.2179	µg/L	15	No
Dissolved Tungsten (W)	423.66	µg/s	0.0436	µg/L	1.6	No
Total Tungsten (W)	438.048	µg/s	0.0451	µg/L	1.6	No
Total Vanadium (Va)	1341.6	µg/s	0.1380	µg/L	6.2	No
Dissolved Vanadium (Va)	353.217	µg/s	0.0363	µg/L	6.2	No
Total Uranium (U)	237.644	µg/s	0.0244	µg/L	20	No
Dissolved Uranium (U)	233.9187	µg/s	0.0241	µg/L	20	No
Total Zinc (Zn)	134160	µg/s	13.80	µg/L	5000	No
Dissolved Zinc (Zn)	23654.7	µg/s	2.43	µg/L	5000	No
Dissolved Zirconium (Zr)	423.66	µg/s	0.044	µg/L	0.16	No
Total Zirconium (Zr)	423.66	µg/s	0.044	µg/L	0.16	No
PCB						
Aroclor 1016	<21.183	µg/s	<0.0022	µg/L	- ^c	-
Aroclor 1221	<21.183	µg/s	<0.0022	µg/L	- ^c	-
Aroclor 1232	<21.183	µg/s	<0.0022	µg/L	- ^c	-
Aroclor 1242	<21.183	µg/s	<0.0022	µg/L	- ^c	-
Aroclor 1248	<21.183	µg/s	<0.0022	µg/L	- ^c	-
Aroclor 1254	<21.183	µg/s	<0.0022	µg/L	- ^c	-
Aroclor 1260	<21.183	µg/s	<0.0022	µg/L	- ^c	-
Aroclor 1262	<21.183	µg/s	<0.0022	µg/L	- ^c	-
Aroclor 1268	<21.183	µg/s	<0.0022	µg/L	- ^c	-
Polychlorinated Biphenyls	<21.183	µg/s	<0.0022	µg/L	3	No
PHC						
Petroleum Hydrocarbons - F1 (C6-C10)-BTEX	<10591.5	µg/s	<1.09	µg/L	820	No
Petroleum Hydrocarbons - F1 (C6-C10)	<10591.5	µg/s	<1.09	µg/L	820	No
Petroleum Hydrocarbons - F2 (C10-C16)	<42366	µg/s	<4.36	µg/L	300	No
Petroleum Hydrocarbons - F3 (C16-C34)	84732	µg/s	8.72	µg/L	1000	No
Petroleum Hydrocarbons - F4 (C34-C50)	<84732	µg/s	<8.72	µg/L	1100	No
Oil & Grease, Total Rec	445.92	mg/s	0.05	mg/L	- ^c	-
Benzene	<84.732	µg/s	<0.0087	µg/L	5	No
Ethylbenzene	<84.732	µg/s	<0.0087	µg/L	2.4	No
m,p-Xylenes	231.2904	µg/s	0.024	µg/L	90	No
o-Xylene	84.732	µg/s	0.009	µg/L	90	No
Toluene	420.368	µg/s	0.043	µg/L	24	No
Xylenes, Total	289.113	µg/s	0.030	µg/L	90	No

Notes:

^a See Table A.2 for references for these selected screening benchmarks. For all metals, the screening criteria for total metal and inorganics were also used to screen concentration of the dissolved metal ions.

^b Not considered to be a nuclear or hazardous substance, so are not COPCs under CSA N288.6 and not associated with Darlington Nuclear. The rationale for not carrying these parameters forward as COPCs is discussed in Section 3.1.2.2.3 and Section 3.1.2.2.1.

^c Individual polychlorinated biphenyl (PCB) congeners as well as total oil and grease are displayed, but without benchmarks since these parameters are encompassed by screenings of other parameters. See discussion in Section 3.1.2.2.3.

Table A-8: Maximum Concentrations Measured in Groundwater at DN (2016-2019) and Screening of Estimates for Lake Ontario Nearshore for Human Health

Parameter	Units	MOE GW1 Value ^a	Selected Benchmark ^b	Maximum Analyzed Concentration, All Wells				Maximum Modeled Diluted Concentration in Lake Ontario ^c	Carried Forward as COPC?
				2016	2017	2018	2019		
F1 (C6-C10)	µg/L	820	820	25	25	110	180	0.070	No
F1 (C6-C10) - BTEX	µg/L	820	820	25	25	110	170	0.067	No
F2 (C10-C16 Hydrocarbons)	µg/L	300	300	240	100	100	100	0.094	No
F3 (C16-C34 Hydrocarbons)	µg/L	1000	1000	200	200	200	200	0.078	No
F4 (C34-C50 Hydrocarbons)	µg/L	1100	1100	200	200	200	200	0.078	No
Benzene	µg/L	5	5	18	1.3	2	5.2	0.007	No
Ethylbenzene	µg/L	2.4	2.4	0.54	0.22	0.2	0.2	0.00021	No
o-Xylene	µg/L	300	90	0.7	0.2	0.2	0.2	0.00027	No
p+m-Xylene	µg/L	300	90	1.3	0.46	0.44	3.7	0.0014	No
Toluene	µg/L	24	24	0.74	0.22	0.4	0.59	0.00029	No
Total Xylenes	µg/L	300	90	2	0.46	0.44	3.7	0.00145	No

References:

- Standards Development Branch, Ontario Ministry of the Environment, 2011. Rationale for the Development of Soil and Ground Water
- OPG 2018. Review of the Darlington Nuclear Site Specific Study. Report No. NK38-REP-03443-10004-R0000. December

Notes:

^a MOE GW1 groundwater guidelines are shown for reference. All were used as the surface water selected benchmark, with the exception of xylenes.

^b See Table A.2 for references for these selected screening benchmarks. For all metals, the screening criteria for total metal and inorganics were also used to screen concentration of the dissolved metal ions.

^c Maximum in groundwater times nearshore dilution factor (DF); DF = groundwater flow / alongshore flow.

Groundwater flow = 3.17E-8 m/s (CSA N288.1-14) x seepage area (120m offshore x1000m alongshore).

Alongshore flow = 0.081 m/s (OPG, 2018)² x wave zone cross-sectional area (120m offshore x 2m water depth / 2).

Table A-9: Screening of Air Quality for Ecological Health

Contaminant	Max. POI Concentration (µg/m ³)				Averaging Period (hrs)	Max POI Concentration, 2016-2019 (µg/m ³)		Selected Ecological Screening Criteria	Screening Criteria Averaging period	Limiting Effect	Reference	Carried Forward as COPC?
	2016	2017	2018	2019		Concentration	Averaging Period (hrs) ^a					
Armeen hdt (tallow alkyl)	-	-	0.3	0.3	24hr	0.058	Annual	40	Annual	Health	TCEQ ¹	No
Ammonia	-	50.2	-	-	0.5 hr	16.981	24hr	100	24hr	Health	MECP AAQC ²	No
	-	17	11.1	11.1	24hr	11.1	24hr	100	24hr	Health	MECP AAQC	No
Benzo(a)pyrene (sum of PAH)	-	8.9E-05	-	-	0.5 hr	3.0E-05	24hr	0.00005	24hr	Health	MECP AAQC	No
	-	-	3.7E-05	3.7E-05	24hr	0.000037	24hr	0.00005	24hr	Health	MECP AAQC	No
	-	-	3.6E-06	3.6E-06	Annual	0.000036	Annual	0.00001	Annual	Health	MECP AAQC	No
Cadmium	-	6.3E-04	-	-	0.5 hr	2.1E-04	24hr	0.025	24hr	Health	MECP AAQC	No
	-	-	2.6E-04	2.6E-04	24hr	0.00026	24hr	0.025	24hr	Health	MECP AAQC	No
Calcium Hydroxide	-	0.22	-	-	0.5 hr	7.4E-02	24hr	12.5	24 hr	Corrosion	MECP AAQC	No
Carbon Dioxide	-	39,451	-	-	0.5 hr	3.9E+04	0.5 hr	Not applicable - major component of air				
	-	-	16,228	16,228	24hr	3.95E+04	24hr					
chloride (as hydrogen chloride)	-	0.55	-	-	0.5 hr	1.9E-01	24hr	20	24hr	Health	MECP AAQC	No
	-	-	0.23	0.23	24hr	0.23	24hr	20	24hr	Health	MECP AAQC	No
Chromium (total)	-	4.2E-02	-	-	0.5 hr	1.4E-02	24hr	0.5	24 hr	Health	MECP AAQC	No
Chromium (VI)	-	2.03E-03	-	-	0.5 hr	6.9E-04	24hr	1.40E-04	24hr	Health	MECP AAQC	No ^b
	-	-	4.3E-04	4.3E-04	24hr	4.30E-04	24hr	1.40E-04	24hr	Health	MECP AAQC	No ^b
	-	-	3.7E-05	3.7E-05	Annual	0.000037	Annual	0.00007	Annual	Health	MECP AAQC	No
Cobalt	-	9.5E-03	-	-	0.5 hr	3.2E-03	24hr	0.1	24hr	Health	MECP AAQC	No
	-	-	3.9E-03	3.9E-03	24hr	0.0039	24hr	0.1	24hr	Health	MECP AAQC	No
Fluoride	-	5.9E-02	-	-	0.5 hr	2.0E-02	24hr	1.72	24hr	Vegetation	MECP AAQC	No
	-	-	0.02	0.02	24hr	0.02	24hr	1.72	24hr	Vegetation	MECP AAQC	No
	-	-	6.1E-03	6.1E-03	30 day	0.0061	30 day	0.69	30 day	Vegetation	MECP AAQC	No
Hydrazine	-	3.9E-04	1.6E-04	1.6E-04	Annual	0.00039	Annual	6	Annual	Health	EC/HC, 2011 ^{3,b}	No
Iron	-	0.59	-	-	0.5 hr	2.0E-01	24hr	4	24hr	Health	MECP AAQC	No
	-	-	0.27	0.27	24hr	0.27	24hr	4	24hr	Health	MECP AAQC	No
Lubricating Oil	-	6.4	-	-	0.5 hr	4.1E-01	Annual	100	Annual	Health	TCEQ ⁴	No
Manganese	-	0.15	-	-	0.5 hr	5.1E-02	24hr	0.4	24hr	Health	MECP AAQC	No
	-	-	0.07	0.07	24hr	0.07	24hr	0.4	24hr	Health	MECP AAQC	No
Morpholine	-	15.4	-	-	0.5 hr	1.47	13 weeks	90000	13 weeks	Health	WHO, 1996 ^{1,d}	No
	-	-	3.6	3.6	24hr	1.02	13 weeks	90000	13 weeks	Health	WHO, 1996 ^{1,d}	No
Nickel	-	0.15	-	-	0.5 hr	5.1E-02	24hr	0.2	24hr	Health	MECP AAQC	No
	-	-	0.06	0.06	24hr	0.06	11.37	0.2	24hr	Health	MECP AAQC	No
	-	-	5.7E-03	5.7E-03	Annual	0.0057	Annual	0.04	Annual	Health	MECP AAQC	No
Nitrogen Oxides	639	23.1	-	-	0.5 hr	526	1hr	400	1hr	Health	MECP AAQC	Yes
	-	-	205	205	1hr	205	1hr	400	1hr	Health	MECP AAQC	No
	-	-	30.2	30.2	24hr	30.2	24hr	200	24hr	Health	MECP AAQC	No
Phosphorus	-	1.5E-02	-	-	0.5 hr	9.7E-04	Annual	0.1	Annual	Health	TCEQ	No
	-	-	6.1E-03	6.1E-03	24hr	1.2E-03	Annual	0.1	Annual	Health	TCEQ	No
Sodium Hydroxide	-	0.36	-	-	0.5 hr	1.2E-01	24hr	10	24 hr	Corrosion	MECP AAQC	No
Sodium Hypochlorite	-	2.3	-	-	0.5 hr	1.5E-01	Annual	5	Annual	Health	TCEQ	No
	-	-	1.24	1.24	24hr	0.24	Annual	5	Annual	Health	TCEQ	No
Sodium Sulfite	-	0.22	-	-	0.5 hr	7.4E-02	24hr	Not applicable - species of limited concern (per description of the TCEQ)				
	-	-	0.07	0.07	24hr	0.07	24hr					
Suspended Particulate Matter (Total)	-	4.65	-	-	0.5 hr	1.6E+00	24hr	120	24 hr	Visibility	MECP AAQC	No
Sulphur Dioxide	-	33.6	-	-	0.5 hr	11.37	24hr	275	24hr	Health & Vegetation	MECP AAQC	No
	-	-	0.1	0.1	24hr	0.1	24hr	275	24hr	Health & Vegetation	MECP AAQC	No
	-	-	1	1	1hr	1	1hr	690	1hr	Health & Vegetation	MECP AAQC	No
Sulphuric Acid	-	0.20	-	-	0.5 hr	6.8E-02	24hr	5	24 hr	Health	MECP AAQC	No
Vanadium	-	5.0E-02	-	-	0.5 hr	1.7E-02	24hr	2	24 hr	Health	MECP AAQC	No
	-	-	0.02	0.02	24hr	0.02	24hr	2	24 hr	Health	MECP AAQC	No

References

1. Texas Commission on Environmental Quality. Effects Screening levels. List updated on November 2016. Accessed on July 2020. <https://www.tceq.texas.gov/toxicology/esl>
2. MOECC. Ontario's Ambient Air Quality Criteria. Accessed on July, 2020. <https://www.ontario.ca/page/ontarios-ambient-air-quality-criteria-sorted-contaminant-name>
3. ECCC (2011). Screening Assessment for the Challenge, Hydrazine. January.
4. WHO. (1996). Environmental Health Criteria 179: Morpholine.

Notes

- a. The max POI concentrations were converted to the averaging period of benchmarks by following instructions provided in Section 4.4 of the document "Air Dispersion Modelling Guideline for Ontario, Version 3.0" by MOECC.
- b. The chronic value of hydrazine (inhalation non-neoplastic LOAEC) was modified by a safety factor of 10 (convert effect to no-effect), and used to screen max POI concentrations averaged annually.
- c. While the same chemical of lubricating oil does not have an effects screening level (ESL) from TCEQ, the ESL of other petroleum-based lubricating oil was used to screen this analyte.
- d. The NOAEL value of morpholine for rats at 90 mg/m³ was applied as a toxicity benchmark.
- e. Chromium (VI) partitions to soil, and therefore the inhalation pathway is negligible compared to the soil and food ingestion pathways. It is not carried forward as a COPC in air.

Table A-10: Ecological Screening Criteria for Surface Water COPCs

Analyte	Units	CCME CWQG (1)	FEQG (6-9)	PWQO (2)	Interim PWQO (2)	Suter and Tsao, 1996 (3) ^a	Borgmann et al. 2005 (4) ^b	95 th Percentile Background, 2019 Environmental Study (5)	Detection Limit (5)	Selected Ecological Screening Criteria	Reference
Physical/Conventional Characteristics											
Field Temperature	Celsius	-	-	-	-	-	-	20.3	-	-	J
Field pH	pH	6.5-9.0	-	6.5-8.5	-	-	-	8.8	-	6.5-8.5	(2)
pH	pH	6.5-9.0	-	6.5-8.5	-	-	-	8.4	-	6.5-8.5	(2)
Field Sp. Conductance	µS/cm	-	-	-	-	-	-	353.6	-	-	J
Conductivity	umho/cm	-	-	-	-	-	-	330.0	1	-	J
Field Turbidity	NTU	-	-	-	-	-	-	12	0.1	-	J
Turbidity	NTU	-	-	-	-	-	-	5.4	0.1	-	J
Alkalinity (Total as CaCO ₃)	mg/L	-	-	-	-	-	-	99.0	1	-	J
Total Hardness (CaCO ₃)	mg/L	-	-	-	-	-	-	122.7	0.5 - 1	-	J
Total Suspended Solids	mg/L	5 mg/L above the background value ^c	-	-	-	-	-	9.3	1 - 10	8.35	(1)
Total Residual Chlorine	mg/L	0.0005	-	0.002	-	-	-	0.01	0.0012	0.002 ^j	(2)
Nutrients											
Dissolved Organic Carbon	mg/L	-	-	-	-	-	-	2.1	0.5	-	J
Total Kjeldahl Nitrogen (TKN)	mg/L	-	-	-	-	-	-	0.3	0.1	-	J
Total Ammonia-N	mg/L	0.044 ^d	-	-	-	-	-	0.2	0.01 - 1	0.044	(1)
Total Un-ionized Ammonia	mg/L	0.019	-	0.02	-	-	-	0.01	0.00051 - 0.044	0.019	(1)
Total BOD	mg/L	-	-	-	-	-	-	2.0	2	-	J
Total Chemical Oxygen Demand (CO ₂)	mg/L	-	-	-	-	-	-	7.4	4	-	J
Orthophosphate (P)	mg/L	-	-	-	-	-	-	0.01	0.01	-	J
Total Phosphorus	mg/L	-	-	-	0.02	-	-	0.02	0.02 - 2.51	0.02	(2)
Anion											
Fluoride (F)	mg/L	0.12	-	-	-	-	-	-	-	0.12	(1)
Chloride (Cl)	mg/L	640	-	-	-	-	-	-	-	640	(1)
Nitrate (N)	mg/L	13	-	-	-	-	-	0.36	0.1	13	(1)
Nitrite (N)	mg/L	0.06	-	-	-	-	-	0.006	0.01	0.06	(1)
Hydrocarbons											
Benzene	µg/L	370	-	-	100	-	-	0.0	0.1 - 0.5	370	(1)
Ethylbenzene	µg/L	90	-	-	8	-	-	0.0	0.1 - 0.5	90	(1)
Toluene	µg/L	2	-	-	0.8	-	-	-	-	2	(1)
m,p-xylene	µg/L	-	-	-	2 ^j	-	-	-	-	2	(2)
o-xylene	µg/L	-	-	-	40	-	-	-	-	40	(2)
Xylene, Total	µg/L	-	-	-	2 ^j	-	-	-	-	2	(2)
F1 (C6-C10)	µg/L	167	-	-	-	-	-	0.0	25	167	(1)
F1 (C6-C10) - BTEX	µg/L	167	-	-	-	-	-	0.0	25	167	(1)
F2 (C10-C16 Hydrocarbons)	µg/L	42	-	-	-	-	-	0.0	100	42	(1)
F3 (C16-C34 Hydrocarbons)	µg/L	-	-	-	-	-	-	147	200	200	(5) ^g
F4 (C34-C50 Hydrocarbons)	µg/L	-	-	-	-	-	-	0.0	200	200	(5) ^g
Ethylene Glycol	mg/L	192	-	-	2	-	-	-	5	192	(1)
Propylene Glycol	mg/L	500	-	-	10 ^j	-	-	-	5	500	(1)
Biological											
Chlorophyll	µg/L	-	-	-	-	-	-	1.6	0.1 - 0.2	-	J
Background	CFU/100mL	-	-	-	-	-	-	480	10	-	J

Table A-10: Ecological Screening Criteria for Surface Water COPCs

Analyte	Units	CCME CWQG (1)	FEQG (6-9)	PWQO (2)	Interim PWQO (2)	Suter and Tsao, 1996 (3) ^a	Borgmann et al. 2005 (4) ^b	95 th Percentile Background, 2019 Environmental Study (5)	Detection Limit (5)	Selected Ecological Screening Criteria	Reference
Total Coliforms	CFU/100mL	-	-	100	-	-	-	62.5	10	100	(2) ^h
Fecal coliform	CFU/100mL	-	-	100	-	-	-	10.0	10	100	(2) ^h
Escherichia coli	CFU/100mL	-	-	100	-	-	-	10.0	10	100	(2)
Metals											
Total Aluminum (Al)	µg/L	100	-	-	-	-	-	4.4	0.5 - 5	100	(1)
Dissolved (0.2u) Aluminum (Al)	µg/L	-	-	-	75	-	-	5.0	5	75	(2)
Total Antimony (Sb)	µg/L	-	-	20	-	-	-	0.1	0.02 - 0.5	20	(2)
Total Arsenic (As)	µg/L	5	-	100	5	-	-	0.8	0.02 - 1	5	(1)
Total Barium (Ba)	µg/L	-	-	-	-	4	315	23.2	0.02 - 2	4	(3)
Total Beryllium (Be)	µg/L	-	-	1100	-	-	-	0.0	0.01 - 0.5	1100	(2)
Total Bismuth (Bi)	µg/L	-	-	-	-	-	2.5	0.0	0.005 - 1	2.5	(4)
Total Boron (B)	µg/L	1500	-	-	200	-	-	23.4	10 - 50	1500	(1)
Total Cadmium (Cd)	µg/L	0.17 ^e	-	0.2	0.5	-	-	0.0	0.005 - 0.1	0.17	(1)
Total Calcium (Ca)	µg/L	-	-	-	-	11600	-	34860	0.05 - 250	11600	(3)
Total Cesium (Cs)	µg/L	-	-	-	-	-	315	0.0	0.05 - 0.2	315	(4)
Total Chromium (Cr)	µg/L	8.9	-	8.9	-	-	-	0.4	0.1 - 5	8.9	(1)
Chromium (+3)	µg/L	8.9	-	8.9	-	-	-	0.1	0.5 - 5	8.9	(1)
Chromium (VI)	µg/L	1	-	1	-	-	-	0.3	0.5	1	(1)
Total Cobalt (Co)	µg/L	-	1	-	0.9	-	-	0.0	0.005 - 0.5	1	(6)
Total Copper (Cu)	µg/L	2.57 ^e	-	5	5	-	-	0.6	0.05 - 1	5	(1)
Gadolinium (Gd)	µg/L	-	-	-	-	-	15	-	2	15	(4)
Total Iron (Fe)	µg/L	300	-	300	-	-	-	1.5	1 - 100	300	(1)
Total Lead (Pb)	µg/L	3.59 ^e	-	25	5	-	-	0.0	0.005 - 0.5	3.59	(1)
Total Lithium (Li)	µg/L	-	-	-	-	14	65	2.0	0.5 - 5	14	(3)
Total Magnesium (Mg)	µg/L	-	-	-	-	8200	-	8718	0.05 - 250	8200	(3)
Total Manganese (Mn)	µg/L	120 ^{d,e}	-	-	-	-	-	0.3	0.05 - 2	220	(1)
Mercury (Hg)	µg/L	0.026	-	0.2	-	-	-	0.0007	0.01	0.026	(1)
Total Molybdenum (Mo)	µg/L	73.000	-	-	40	-	-	1.2	0.05 - 1	40	(2)
Total Nickel (Ni)	µg/L	103 ^e	-	25	-	-	-	0.5	0.02 - 1	25	(2)
Total Potassium (K)	µg/L	-	-	-	-	5300	-	1667	0.05 - 1000	5300	(3)
Total Selenium (Se)	µg/L	1	-	100	-	-	-	0.1	0.04 - 2	1	(1)
Total Silicon (Si)	µg/L	-	-	-	-	-	-	608.8	50	-	J
Total Silver (Ag)	µg/L	0.25	-	0.1	-	-	-	0.0	0.005 - 0.1	0.1	(2)
Total Sodium (Na)	µg/L	-	-	-	-	68000	-	14860	0.05 - 250	68000	(3)
Total Strontium (Sr)	µg/L	-	2500	-	-	-	-	195	0.05 - 1	2500	(7)
Total Tellurium (Te)	µg/L	-	-	-	-	-	151.9	-	0.5-1	151.9	(4)
Total Thallium (Tl)	µg/L	0.8	-	-	0.3	-	-	0.006	0.002 - 0.05	0.8	(1)
Total Thorium (Th)	µg/L	-	-	-	-	-	0.52	0.002	0.005 - 1	0.52	(4)
Total Tin (Sn)	µg/L	-	-	-	-	73	315	0.030	0.2 - 5	73	(3)
Total Titanium (Ti)	µg/L	-	-	-	-	-	27.2	0.493	0.5 - 5	27.2	(4)
Total Tungsten (W)	µg/L	-	-	-	30	-	-	0.125	0.01 - 1	30	(2)
Total Uranium (U)	µg/L	15	-	-	5	-	-	0.388	0.002 - 0.1	15	(1)
Total Vanadium (V)	µg/L	-	120	-	6	-	-	0.182	0.2 - 5	120	(8)
Total Zinc (Zn)	µg/L	7 ^k	-	30	20	-	-	1.095	0.1 - 5	7	(1)
Dissolved Zinc (Zn)	µg/L	7	-	-	-	-	-	3.606	5	7	(1)

Table A-10: Ecological Screening Criteria for Surface Water COPCs

Analyte	Units	CCME CWQG (1)	FEQG (6-9)	PWQO (2)	Interim PWQO (2)	Suter and Tsao, 1996 (3) ^a	Borgmann et al. 2005 (4) ^b	95 th Percentile Background, 2019 Environmental Study (5)	Detection Limit (5)	Selected Ecological Screening Criteria	Reference
Total Zirconium (Zr)	µg/L	-	-	-	4	-	-	0.014	0.1 - 1	4	(2)
Other											
Hydrazine	µg/L		2.6	-	-	-	-	0.1	0.1	2.6	(9)
Morpholine	µg/L	-	-	-	4	-	-	0.6	4	4	(2)
Bromoform	µg/L	-	-	-	60	-	-	0.0	0.2 - 1	60	(2)
Chloroform	µg/L	1.8	-	-	-	-	-	0.0	0.1 - 0.5	1.8	(1)
Bromodichloromethane	µg/L	-	-	-	200	-	-	0.0	0.1 - 0.5	200	(2)
Alcohol ethoxylates	µg/L	See Table A.12b	See Table A.12b,c	-	-	-	-	-	-	- ^m	-
bis(2-Ethylhexyl)phthalate	µg/L	-	-	60	-	-	-	-	-	60	(2)

References:

1. CCME Canadian Water Quality Guidelines for Protection of Aquatic Life. Accessed in July 2020.
2. MOECC: Water management: policies, guidelines, provincial water quality objectives (1994).
3. Suter and Tsao, (1996). Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision.
4. Borgmann et al., (2005). Toxicity of Sixty-Three Metals and Metalloids to *Hyalella Azteca* at Two Levels of Water Hardness.
5. Ecometrix. (2020). Darlington New Nuclear Project Supporting Environmental Studies – Environment. Report prepared for OPG. Report No. NK054-REP-01210-0001. May.
6. Environment Canada (2017). Canadian Environmental Quality Guidelines, Cobalt, May.
7. ECCC (2020). Federal Environmental Quality Guidelines - Strontium. July.
8. ECCC (2006). Federal Environmental Quality Guidelines, Vanadium. May.
9. Environment Canada (2013). Federal Environmental Quality Guidelines, Hydrazine. May.

Notes:

- ^a Secondary Chronic Values (SCV) were selected for COPCs. If the SCV was not available, the lowest LC50 value was modified by a safety factor of 10.
- ^b To be conservative, the measured LC50 values of *H. Azteca* (software or hardware) was divided by a safety factor of 10. If there is no measured value, the tap water LC50 (nominal) values were adjusted by a safety factor of 10, considering the water in Lake Ontario is similar to tap water used in this study.
- ^c 5 mg/L above the mean background value was used according to the CCME CWQG "narrative" for clear flow.
- ^d pH 9 assumed to determine CWQG value for all pH dependent parameters.
- ^e Hardness of 110 mg/L CaCO₃ was used to calculate hardness dependent CWQG values.
- ^f PWQO is selected as the benchmark for TRC, as there is no current methodology to reach the CCME guideline of 0.0005 mg/L.
- ^g If the 95th percentile background value is less than the detection limit (as uncensored data was used in the 2019 study), the detection limit was selected as the selected criteria. Otherwise, the 95 percentile value was used as the screening criteria.
- ^h The PWQO value for *E.coli* is used to screen total and fecal coliforms
- ⁱ To be conservative, the lowest iPWQO value for xylene isomer, m-xylene, is represented as the iPWQO value for m,p-xylene and total xylene.
- ^j The Analyte is not considered of ecological health concern, and therefore no screening criteria are necessary.
- ^k The CCME CWQG value is for dissolved zinc. This value is also applied to screen the total zinc concentration.
- ^l iPWQO values for both 1,2- and 1,3- propylene glycol was available. The lower value for 1,3-propylene glycol is illustrated here for conservative approach.
- ^m Screening criteria selection for alcohol ethoxylates is detailed in Table A.14b, c.

Table A-11: Screening of Lake Water Quality for Ecological Health

Analyte	Units	Ecological Screening Criteria	Reference	2019 Study Max	COPC in the 2016 ERA?	Carried Forward as COPC?
Physical/Conventional Characteristics						
Field Temperature	Celsius	-	-	22.67	-	-
Field pH	pH	6.5-8.5	(2)	6.69-9.21	No	Yes
pH	pH	6.5-8.5	(2)	8.02-8.44	No	No
Field Sp. Conductance	µS/cm	-	-	860	-	-
Conductivity	umho/cm	-	-	570	-	-
Field Turbidity	NTU	-	-	26.1	-	-
Turbidity	NTU	-	-	11	-	-
Alkalinity (Total as CaCO ₃)	mg/L	-	-	150	-	-
Total Hardness (CaCO ₃)	mg/L	-	-	270	-	-
Total Suspended Solids	mg/L	8.35	(1)	33	No	Yes
Total Residual Chlorine	mg/L	0.002	(2)	<0.0012 ^a	No	No
Nutrients						
Dissolved Organic Carbon	mg/L	-	-	6	-	-
Total Kjeldahl Nitrogen (TKN)	mg/L	-	-	0.48	-	-
Total Ammonia-N	mg/L	0.044	(1)	0.26^b	No	Yes
Total Un-ionized Ammonia	mg/L	0.019	(1)	0.051^c	No	Yes
Nitrate (N)	mg/L	13	(1)	2.2	Yes	No
Nitrite (N)	mg/L	0.06	(1)	0.013	No	No
Total BOD	mg/L	-	-	2	-	-
Total Chemical Oxygen Demand (COD)	mg/L	-	-	13	-	-
Orthophosphate (P)	mg/L	-	-	0.013	No	No
Total Phosphorus	mg/L	0.02	(2)	0.059	No	No ^d
Hydrocarbons						
Benzene	µg/L	370	(1)	0.14	No	No
Ethylbenzene	µg/L	90	(1)	0	No	No
F1 (C6-C10)	µg/L	167	(1)	0	No	No
F1 (C6-C10) - BTEX	µg/L	167	(1)	0	No	No
F2 (C10-C16 Hydrocarbons)	µg/L	42	(1)	0	No	No
F3 (C16-C34 Hydrocarbons)	µg/L	200	(5)	170	No	No
F4 (C34-C50 Hydrocarbons)	µg/L	200	(5)	0	No	No
Biological						
Chlorophyll	µg/L	-	-	9.08	-	-
Background	CFU/100mL	-	-	9600	-	-
Total Coliforms	CFU/100mL	100	(2)	2100	No	No ^e
Fecal coliform	CFU/100mL	100	(2)	2000	No	No ^e
Escherichia coli	CFU/100mL	100	(2)	2000	No	No ^e
Metals						
Total Aluminum (Al)	µg/L	100	(1)	142	Yes	No ^f
Dissolved (0.2µ) Aluminum (Al)	µg/L	75	(2)	21	No	No
Total Antimony (Sb)	µg/L	20	(2)	0.176	No	No
Total Arsenic (As)	µg/L	5	(1)	0.841	No	No
Total Barium (Ba)	µg/L	4	(3)	32.3	No	Yes
Total Beryllium (Be)	µg/L	1100	(2)	0.007	No	No
Total Bismuth (Bi)	µg/L	2.5	(4)	0.027	No	No
Total Boron (B)	µg/L	1500	(1)	27	No	No
Total Cadmium (Cd)	µg/L	0.17	(1)	0.016	No	No
Total Calcium (Ca)	µg/L	11600	(3)	62100	-	No ^g
Total Cesium (Cs)	µg/L	315	(4)	0.087	No	No
Total Chromium (Cr)	µg/L	8.9	(1)	1.346	No	No
Chromium (+3)	µg/L	8.9	(1)	0	No	No
Chromium (VI)	µg/L	1	(1)	0.34	No	No
Total Cobalt (Co)	µg/L	1	(6)	0.091	No	No
Total Copper (Cu)	µg/L	5	(1)	1	No	No
Total Iron (Fe)	µg/L	300	(1)	178	No	No
Total Lead (Pb)	µg/L	3.59	(1)	0.157	No	No
Total Lithium (Li)	µg/L	14	(3)	10.2	No	No
Total Magnesium (Mg)	µg/L	8200	(3)	11400	No	No ^g
Total Manganese (Mn)	µg/L	220	(1)	18.1	No	No
Mercury (Hg)	µg/L	0.026	(1)	0.0031	No	No

Table A-11: Screening of Lake Water Quality for Ecological Health

Analyte	Units	Ecological Screening Criteria	Reference	2019 Study Max	COPC in the 2016 ERA?	Carried Forward as COPC?
Total Molybdenum (Mo)	µg/L	40	(2)	1.35	No	No
Total Nickel (Ni)	µg/L	25	(2)	0.703	No	No
Total Potassium (K)	µg/L	5300	(3)	6500	No	No ⁹
Total Selenium (Se)	µg/L	1	(1)	0.189	No	No
Total Silicon (Si)	µg/L	-	-	932	-	-
Total Silver (Ag)	µg/L	0.1	(2)	0.006	No	No
Total Sodium (Na)	µg/L	68000	(3)	39600	No	No
Total Strontium (Sr)	µg/L	2500	(6)	625	No	No
Total Thallium (Tl)	µg/L	0.8	(1)	0.014	No	No
Total Thorium (Th)	µg/L	0.52	(4)	0.014	No	No
Total Tin (Sn)	µg/L	73	(3)	0.405	No	No
Total Titanium (Ti)	µg/L	27.2	(4)	5.2	No	No
Total Tungsten (W)	µg/L	30	(2)	0.134	No	No
Total Uranium (U)	µg/L	15	(1)	0.61	No	No
Total Vanadium (V)	µg/L	120	(8)	0.64	No	No
Total Zinc (Zn)	µg/L	7	(1)	3.138	No	No
Dissolved Zinc (Zn)	µg/L	7	(1)	13	No	Yes
Total Zirconium (Zr)	µg/L	4	(2)	0.34	No	No
Other						
Hydrazine	µg/L	2.6	(7)	0.11	No	No
Morpholine	µg/L	4	(2)	2	No	No
Bromoform	µg/L	60	(2)	0	No	No
Chloroform	µg/L	1.8	(1)	0	No	No
Bromodichloromethane	µg/L	200	(2)	0	No	No

References:

1. CCME Canadian Water Quality Guidelines for Protection of Aquatic Life. Accessed in July 2020.
2. MOECC: Water management: policies, guidelines, provincial water quality objectives (1994).
3. Suter and Tsao, (1996). Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision.
4. Borgmann et al., (2005). Toxicity of Sixty-Three Metals and Metalloids to *Hyalella Azteca* at Two Levels of Water Hardness.
5. Ecometrix. (2020). Darlington New Nuclear Project Supporting Environment Studies – Environment. Report prepared for OPG. Report No. NK054-REP-01210-0001. May.
6. ECCC (2020). Federal Environmental Quality Guidelines - Strontium. July.
7. Environment Canada (2013). Federal Environmental Quality Guidelines, Vanadium. May.

Notes:

- ^a Due to machine calibration issues in the summer, the maximum observed concentration for TRC was 0.028 mg/L. The problematic results were removed from the screening dataset.
- ^b The maximum observed concentration during the 2019 study was 0.40 mg/L due to the lab contamination during the spring sampling season. Problematic results were removed from the screening dataset.
- ^c The maximum observed concentration during the 2019 study was 0.081 mg/L due to the lab contamination during the spring sampling season. Problematic results were removed from the screening dataset.
- ^d Phosphorus is a nutrient and not a toxicant. Therefore it was not carried forward as a COPC. See Section 4.1.4.2.1.
- ^e E.coli and other coliforms are not of concern for ecological health. They are not carried forward as COPCs. See Section 4.1.4.2.1.
- ^f Although the concentration of total aluminum exceeded the selected screening criteria, its more bioavailable form, dissolved aluminum, did not exceed. Therefore, aluminum was not carried forward as a COPC. See Section 4.1.4.2.1.
- ^g Major ions (Ca, Mg, K) are not considered toxic at environmental concentrations. They are not carried forward as COPCs. See Section 4.1.4.2.1 for more discussion.

Table A-12: Screening of CCW Effluent (ECA Data) for Ecological Health

Analyte	Units	Ecological Surface Water Screening Criteria ^a	Measured Maximum Concentrations from ECAs				Max Concentrations in CCW	Estimated Max Mixing Zone Concentrations	Carried forward as COPC?
			2016	2017	2018	2019			
Unionized Ammonia	mg/L	0.019	0.01	0.01	0.01	0.01	0.01	0.0014	No
Hydrazine	mg/L	0.0026	0.006	0.005	0.0051	0.005	0.006	0.0009	No
Morpholine	mg/L	0.004	0.005	0.003	0.0011	0.006	0.006	0.0009	No
pH	pH units	6.5 - 8.5	8.0-8.6	7.9-8.5	7.7-8.3	7.9-8.4	8.6	8.6 ^b	No ^c
TRC	mg/L	0.002	<0.001	<0.001	0.006	0.01	0.01	0.0014	No

Notes:

^a See Table A.10 for references of selected screening criteria.

^b The maximum pH in the CCW was directly carried forward to represent the possible maximum mixing zone pH value.

^c See discussion in Section 4.1.4.2.2.1

Table A-13: Screening of MISA Control Point Effluents for Ecological Health

Analyte	Units	Intake Concentrations (Golder, 2011a)	MISA Limit at Station Discharge	Estimated Maximum Concentration in Station Discharge (Section 4.1.4.2.2.2)	Estimated Max Mixing Zone Concentrations	Selected Surface Water Screening Criteria ^a	Carried Forward as COPC?
RLWMS							
Phosphorus	mg/L	0.0154	1	0.015	0.002	0.02	No
TSS	mg/L	5.175	73	5.176	0.739	8.35	No
Zinc	mg/L	0.0019	1	0.002	0.0003	5	No
Iron	mg/L	0.0282	9	0.028	0.004	0.3	No
Oil and Grease	mg/L	0	36	0.00038	0.0001	-	No
WTP							
Aluminum	mg/L	0.0377	13	0.038	0.005	0.1	No
TSS	mg/L	5.175	70	5.179	0.740	8.35	No
Iron	mg/L	0.0282	2.5	0.028	0.004	0.3	No

Notes:
^a See Table A.10 for references of selected screening criteria.

Table A-14a: Screening of 2016 CCW Effluent for Ecological Health

Analyte	Units	Selected Surface Water Screening Criteria ^a	Measured Stream Concentrations					Estimated Max Mixing Zone Concentrations	Carried Forward as a COPC?
			RLW	BB	IAD	WTP	CCW		
			Max_Value	Max_Value	Max_Value	Max_Value	Max_Value		
Morpholine	µg/L	4	6					-	No ^b
Gadolinium (Gd)	µg/L	15	46				9.6	1.37	No
Mercury (Hg)	µg/L	0.026	<0.1				<0.1	<0.014	No ^b
Total Aluminum (Al)	µg/L	100	59.9		19.2	0.012	150	21.43	No ^b
Total Cadmium (Cd)	µg/L	0.17	0.257	0.013	0.008	4.76	0.015	0.002	No ^b
Total Chromium (Cr)	µg/L	8.9	6.97	0.44	0.64	9.91	0.79	0.11	No ^b
Total Copper (Cu)	µg/L	2.57	15.5	0.914	3.25	13.8	1.92	0.27	No ^b
Total Iron (Fe)	µg/L	300	32	13.1	37.7		250	35.71	No
Total Lead (Pb)	µg/L	3.59	19.8	0.213	0.086	0.199	0.335	0.05	No ^b
Total Lithium (Li)	µg/L	14	330				3.82	0.55	No ^b
Total Molybdenum (Mo)	µg/L	40	7.78			65.6	1.59	0.23	No ^b
Total Nickel (Ni)	µg/L	25	50.6	0.087	0.752	1.83	0.932	0.13	No ^b
Total Selenium (Se)	µg/L	1	1	0.04	0.141	2.05	0.199	0.03	No ^b
Total Zinc (Zn)	µg/L	7	25.5	2.95		21.2	8.79	1.26	No ^b
Nitrate (N)	mg/L	13				4.88	0.44	0.06	No
Total Phosphorus	mg/L	0.02	0.177				0.029	0.004	No ^b
Ethylene Glycol	mg/L	192	<20		<5		<5	<0.71	No
Propylene Glycol	mg/L	500	<20		<5		<5	<0.71	No
F1 (C6-C10)	µg/L	167	<25			<25	<25	<3.57	No
F1 (C6-C10) - BTEX	µg/L	167	<25			<25	<25	<3.57	No
F2 (C10-C16 Hydrocarbons)	µg/L	42	<100			<100	<100	<14.29	No ^b
F3 (C16-C34 Hydrocarbons)	µg/L	200	<200			<200	<200	<28.57	No
Total Residual Chlorine (TRC)	µg/L	2				4		-	No ^b

Notes:
^a See Table A.10 for references for these selected screening benchmarks.

^b See discussion in Section 4.1.4.2.2.3.

RLW - Radioactive Liquid Waste
 BB - Boiler Blowdown
 IAD - Inactive Drainage
 WTP - Water Treatment Plant
 CCW - Condenser Cooling Water

Table A-14b: Screening of 2016 CCW Effluent for Ecological Health

Analyte	Units	Detection Limit	FEQG (1)	CWQG (2)	HERA (3)	Selected Surface Water Screening Criteria	Reference	Maximum Concentration in CCW (EcoMetrix, 2016)	Estimated Max Mixing Zone Concentrations	Carried forward to detailed screening?
Alcohol Ethoxylates C8-9	µg/L	0.03	179	-	-	179	(1)	ND ^a	ND	No
Alcohol Ethoxylates C10-11	µg/L	0.03	80	-	-	80	(1)	ND	ND	No
Alcohol Ethoxylates C12 -13	µg/L	0.03	32	-	-	32	(1)	108.7	15.5	No ^b
Alcohol Ethoxylates C14-15	µg/L	0.03	11	-	-	11	(1)	16	2.3	No ^b
Alcohol Ethoxylates C16-18	µg/L	0.03	2	-	-	2	(1)	1	0.1	No
Total Alcohol Ethoxylates	µg/L	0.03	-	-	-	None	-	121	17.3	No ^b
Nonylphenol Ethoxycarboxylate	µg/L	0.01	-	1	-	1	(2)	ND	ND	No
Linear Alkylbenzene Sulphonates C10	µg/L	0.06	-	-	1700	1700	(3)	1.1	0.2	No
Linear Alkylbenzene Sulphonates C12	µg/L	0.06	-	-	320	320	(3)	15.3	2.2	No
Total Linear Alkylbenzene Sulphonates	µg/L	0.06	-	-	-	None	-	15.3	2.2	No ^b

References:

1. Federal Environmental Quality Guidelines - Alcohol Ethoxylates, n = 0 (EC, 2013b)
2. Canadian Water Quality Guideline for the Protection of Aquatic Life (CCME, 2002)
3. Revised Human and Environmental Risk Assessment (HERA) Report - Linear Alkylbenzene Sulphonate, Table 10 (HERA, 2013)

Notes:
^a ND = non-detect

^b See discussion in Section 4.1.4.2.2.3.

Table A-14c: Screening of 2016 CCW Effluent for Ecological Health

AEO Fraction	Ethoxylate Number	FWQG (1)	Maximum Concentration in CCW (EcoMetrix, 2016)	Estimated Max Mixing Zone Concentrations	Carried forward as COPC?
		(ng/L)			
C12 (ng/L)	E4	128000	80253	11465	No
	E5	158000	5136	734	No
	E6	193000	5164	738	No
	E7	233000	4847	692	No
	E8	279000	5568	795	No
	E9	332000	4268	610	No
	E10	392000	3375	482	No
C13 (ng/L)	E3	62000	1674	239	No
	E4	78000	1762	252	No
	E5	96000	224	32	No
	E6	118000	93	13	No
	E7	142000	14	2	No
	E8	170000	32	5	No
	E9	203000	14	2	No
	E10	240000	39	6	No
C14 (ng/L)	E3	37000	11832	1690	No
	E4	46000	2692	385	No
	E5	57000	2278	325	No
	E6	70000	2094	299	No
	E7	84000	1601	229	No
	E8	102000	1257	180	No
	E9	121000	1377	197	No
	E10	144000	829	118	No
C15 (ng/L)	E3	21000	202	29	No
	E4	26000	2176	311	No
	E5	33000	943	135	No
	E6	40000	830	119	No
	E7	49000	461	66	No
	E8	59000	752	107	No
	E9	71000	625	89	No
	E10	84000	128	18	No

References:

1. Federal Environmental Quality Guidelines - Alcohol Ethoxylates (EC, 2013b)

Table A-15: Screening of Stormwater Quality for Ecological Health

Analyte	Maximum Stormwater Loading		Estimated Diluted Concentration in Lake Water		Selected Surface Water Screening	Carried Forward as COPC?
	Value	Units	Value	Units		
Physical/Conventional Characteristics						
Alkalinity, Bicarbonate (HCO3)	54010	mg/s	5.56	mg/L	- ^b	-
Alkalinity, Carbonate (CO3)	1015.388	mg/s	0.10	mg/L	- ^b	-
Alkalinity, Hydroxide (OH)	423.66	mg/s	0.04	mg/L	- ^b	-
Alkalinity, Total	54010	mg/s	5.56	mg/L	- ^b	-
Conductivity	7.64	mS/cm	7.64	mS/cm	- ^b	-
Hardness, Calcium Carbonate, Total	147184800	µg/s	15142	µg/L	- ^b	-
pH	8.36	pH	8.36	pH	6.5-8.5	No
pH, field measured	8.97	pH	8.97	pH	6.5-8.5	No ^e
Temperature, field measured	25.3	Celsius	25.30	Celsius	- ^b	-
Total Dissolved Solids	1080231.3	mg/s	111.1	mg/L	- ^b	-
Total Suspended Solids	68868.8	mg/s	7.09	mg/L	8.35	No
Nutrient						
Ammonia Nitrogen	757.77	mg/s	0.08	mg/L	0.44	No
Unionized Ammonia, calculated	57.486	mg/s	0.0059	mg/L	0.019	No
Biochemical Oxygen Demand, 5 Day	1270.98	mg/s	0.13	mg/L	- ^b	-
Biological						
Background Colonies	300380	CFU/s	3.09	CFU/100 ml	- ^b	-
Escherichia coli	80972	CFU/s	0.83	CFU/100 ml	100	No
Fecal Coliform	2746200	CFU/s	28.25	CFU/100 ml	100	No
Total Coliform	120152	CFU/s	1.24	CFU/100 ml	100	No
Anions						
Chloride	630792	mg/s	64.90	mg/L	640	No
Nitrate as N	188.838	mg/s	0.02	mg/L	13	No
Nitrite as N	7.32036	mg/s	0.0008	mg/L	0.06	No
Nitrogen, Nitrate-Nitrite	190.2906	mg/s	0.02	mg/L	-	-
Total Phosphorus	60.8192	mg/s	0.0063	mg/L	0.02	No
Dissolved Phosphorus	31.2144	mg/s	0.0032	mg/L	0.02	No
Metals and Inorganics						
Total Aluminum (Al)	765085.14	µg/s	78.71	µg/L	100	No
Dissolved Aluminum (Al)	24208.22944	µg/s	2.49	µg/L	75	No
Dissolved (0.2u) Aluminum (Al)	8896.86	µg/s	0.92	µg/L	75	No
Total Antimony (Sb)	211.83	µg/s	0.022	µg/L	20	No
Dissolved Antimony (Sb)	211.83	µg/s	0.022	µg/L	20	No
Total Arsenic (As)	423.66	µg/s	0.044	µg/L	5	No
Dissolved Arsenic (As)	423.66	µg/s	0.044	µg/L	5	No
Total Barium (Ba)	42052.8	µg/s	4.3264	µg/L	4	Yes
Dissolved Barium (Ba)	39424.5	µg/s	4.0560	µg/L	4	Yes
Total Beryllium (Be)	<211.83	µg/s	<0.022	µg/L	1100	No
Dissolved Beryllium (Be)	<211.83	µg/s	<0.022	µg/L	1100	No
Total Bismuth (Bi)	<423.66	µg/s	<0.044	µg/L	2.5	No
Dissolved Bismuth (Bi)	423.66	µg/s	0.044	µg/L	2.5	No
Total Boron (B)	31214.4	µg/s	3.21	µg/L	1500	No
Dissolved Boron (B)	26755.2	µg/s	2.75	µg/L	1500	No
Total Cadmium (Cd)	85.8624	µg/s	0.0088	µg/L	0.17	No
Dissolved Cadmium (Cd)	42.366	µg/s	0.0044	µg/L	0.17	No
Total Calcium (Ca)	38129400	µg/s	3923	µg/L	11600	No
Dissolved Calcium (Ca)	42052800	µg/s	4326	µg/L	11600	No
Total Chromium (Cr)	2540.096	µg/s	0.26	µg/L	8.9	No
Dissolved Chromium (Cr)	2118.3	µg/s	0.22	µg/L	8.9	No
Total Cobalt (Co)	465.088	µg/s	0.048	µg/L	1	No
Dissolved Cobalt (Co)	211.83	µg/s	0.022	µg/L	1	No
Total Copper (Cu)	5276.96	µg/s	0.54	µg/L	5	No
Dissolved Copper (Cu)	1694.64	µg/s	0.17	µg/L	5	No
Hexavalent Chromium	416.546354	µg/s	0.043	µg/L	1	No
Total Iron (Fe)	1144832	µg/s	117.8	µg/L	300	No
Dissolved Iron (Fe)	42366	µg/s	4.4	µg/L	300	No
Total Lead (Pb)	2879.968	µg/s	0.30	µg/L	3.59	No
Dissolved Lead (Pb)	211.83	µg/s	0.022	µg/L	3.59	No
Total Lithium (Li)	2499.594	µg/s	0.26	µg/L	14	No
Dissolved Lithium (Li)	2118.3	µg/s	0.22	µg/L	14	No
Total Magnesium (Mg)	9987540	µg/s	1028	µg/L	8200	No
Dissolved Magnesium	9987540	µg/s	1028	µg/L	8200	No
Total Manganese (Mn)	45435.52	µg/s	4.67	µg/L	220	No
Dissolved Manganese (Mn)	30245.6	µg/s	3.11	µg/L	220	No
Total Mercury (Hg)	4.2366	µg/s	0.00044	µg/L	0.026	No
Total Molybdenum (Mo)	402.477	µg/s	0.041	µg/L	40	No
Dissolved Molybdenum (Mo)	377.0574	µg/s	0.039	µg/L	40	No

Table A-15: Screening of Stormwater Quality for Ecological Health

Analyte	Maximum Stormwater Loading		Estimated Diluted Concentration in Lake Water		Selected Surface Water Screening	Carried Forward as COPC?
	Value	Units	Value	Units		
Total Nickel (Ni)	1252.16	µg/s	0.13	µg/L	25	No
Dissolved Nickel (Ni)	423.66	µg/s	0.044	µg/L	25	No
Total Potassium (K)	1355712	µg/s	139.48	µg/L	5300	No
Dissolved Potassium (K)	1182735	µg/s	121.68	µg/L	5300	No
Total Selenium (Se)	847.32	µg/s	0.087	µg/L	1	No
Dissolved Selenium (Se)	137.31	µg/s	0.014	µg/L	1	No
Total Silicon (Si)	1275141.9	µg/s	131.2	µg/L	^b	-
Dissolved Silicon (Si)	630792	µg/s	64.9	µg/L	^b	-
Total Silver (Ag)	42.366	µg/s	0.0044	µg/L	0.1	No
Dissolved Silver (Ag)	42.366	µg/s	0.0044	µg/L	0.1	No
Total Sodium (Na)	367962000	µg/s	37856	µg/L	68000	No
Dissolved Sodium (Na)	341679000	µg/s	35152	µg/L	68000	No
Total Strontium (Sr)	473094	µg/s	48.67	µg/L	2500	No
Dissolved Strontium (Sr)	473094	µg/s	48.67	µg/L	2500	No
Total Thallium (Tl)	21.183	µg/s	0.0022	µg/L	0.8	No
Dissolved Thallium (Tl)	21.183	µg/s	0.0022	µg/L	0.8	No
Dissolved Tellurium (Te)	<423.66	µg/s	<0.044	µg/L	151.9	No
Total Tellurium (Te)	<423.66	µg/s	<0.044	µg/L	151.9	No
Dissolved Thorium (Th)	<137.31	µg/s	<0.014	µg/L	0.52	No
Total Thorium (Th)	847.32	µg/s	0.087	µg/L	0.52	No
Total Tin (Sn)	423.66	µg/s	0.044	µg/L	73	No
Dissolved Tin (Sn)	423.66	µg/s	0.044	µg/L	73	No
Total Titanium (Ti)	22952.5542	µg/s	2.36	µg/L	27.2	No
Dissolved Titanium (Ti)	2118.3	µg/s	0.218	µg/L	27.2	No
Dissolved Tungsten (W)	423.66	µg/s	0.044	µg/L	30	No
Total Tungsten (W)	438.048	µg/s	0.045	µg/L	30	No
Total Vanadium (Va)	1341.6	µg/s	0.138	µg/L	120	No
Dissolved Vanadium (Va)	353.217	µg/s	0.036	µg/L	120	No
Total Uranium (U)	237.644	µg/s	0.024	µg/L	15	No
Dissolved Uranium (U)	233.9187	µg/s	0.024	µg/L	15	No
Total Zinc (Zn)	134160	µg/s	13.80	µg/L	7	No ^f
Dissolved Zinc (Zn)	23654.7	µg/s	2.43	µg/L	7	No
Dissolved Zirconium (Zr)	423.66	µg/s	0.044	µg/L	4	No
Total Zirconium (Zr)	423.66	µg/s	0.044	µg/L	4	No
PCB						
Aroclor 1016	<21.183	µg/s	<0.0022	µg/L	^d	-
Aroclor 1221	<21.183	µg/s	<0.0022	µg/L	^d	-
Aroclor 1232	<21.183	µg/s	<0.0022	µg/L	^d	-
Aroclor 1242	<21.183	µg/s	<0.0022	µg/L	^d	-
Aroclor 1248	<21.183	µg/s	<0.0022	µg/L	^d	-
Aroclor 1254	<21.183	µg/s	<0.0022	µg/L	^d	-
Aroclor 1260	<21.183	µg/s	<0.0022	µg/L	^d	-
Aroclor 1262	<21.183	µg/s	<0.0022	µg/L	^d	-
Aroclor 1268	<21.183	µg/s	<0.0022	µg/L	^d	-
Polychlorinated Biphenyls	<21.183	µg/s	<0.0022	µg/L	^d	-
PHC						
Petroleum Hydrocarbons - F1 (C6-C10)-BTX	<10591.5	µg/s	<1.09	µg/L	167	No
Petroleum Hydrocarbons - F1 (C6-C10)	<10591.5	µg/s	<1.09	µg/L	167	No
Petroleum Hydrocarbons - F2 (C10-C16)	<42366	µg/s	<4.36	µg/L	42	No
Petroleum Hydrocarbons - F3 (C16-C34)	84732	µg/s	8.72	µg/L	200	No
Petroleum Hydrocarbons - F4 (C34-C50)	<84732	µg/s	<8.72	µg/L	200	No
Reached Baseline at C50	NA			-		-
Oil & Grease, Total Rec	445.92	mg/s	0.05	mg/L	^c	-
Benzene	<84.732	µg/s	<0.0087	µg/L	370	No
Ethylbenzene	<84.732	µg/s	<0.0087	µg/L	90	No
m,p-Xylenes	231.2904	µg/s	0.024	µg/L	2	No
o-Xylene	84.732	µg/s	0.009	µg/L	40	No
Toluene	420.368	µg/s	0.043	µg/L	0.8	No
Xylenes, Total	289.113	µg/s	0.030	µg/L	2	No

Notes:

^a See Table A.10 for references for these selected screening criteria. For all metals, the screening criteria for total metal and inorganics were also used to screen concentration of the dissolved metal ions.

^b Analytes not of ecological health concern. Screening was considered not necessary.

^c PCBs do not partition in water, and they are not COPCs from nuclear stations. Therefore these parameters were not screened.

^d The pH value was exceeding the PWQO guideline, but within the range of the CCME guideline. The range from 6.5-9.0 was considered not harmful to fish and benthic invertebrates. Not carried forward.

^e The selected benchmark was defined for dissolved zinc. As the estimated concentration of dissolved zinc concentration did not exceed the guideline, total zinc was not carried forward.

Table A-16: Screening of Pond Water Quality for Ecological Health

Analyte	Unit	Selected Screening Criteria	Reference	Coot's Pond			Treefrog Pond		
				2019 Study Max	COPC in the 2016 ERA?	Carried Forward as COPC?	2019 Study Max	COPC in the 2016 ERA?	Carried Forward as COPC?
Physical/Conventional Characteristics									
Field Temperature	Celsius	-	-	22.95	-	-	21.63	-	-
Field pH	pH	6.5-8.5	(2)	7.39-9.62	No	Yes	6.88-8.26	No	No
pH	pH	6.5-8.5	(2)	8.18-9.4	No	Yes	7.55-7.99	No	No
Field Sp. Conductance	µS/cm	-	-	583	-	-	528	-	-
Conductivity	umho/cm	-	-	650	-	-	580	-	-
Field Turbidity	NTU	-	-	15.2	-	-	3.6	-	-
Alkalinity (Total as CaCO3)	mg/L	-	-	200	-	-	270	-	-
Total Hardness (CaCO3)	mg/L	-	-	297	-	-	285	-	-
Nutrients									
Dissolved Organic Carbon	mg/L	-	-	9.8	-	-	11	-	-
Total Kjeldahl Nitrogen (TKN)	mg/L	-	-	0.72	-	-	1.1	-	-
Total Ammonia-N	mg/L	0.044	(1)	0.18	No	Yes	0.21	No	Yes
Total Un-ionized Ammonia	mg/L	0.019	(1)	0.048	Yes	Yes	0.005	No	No
Nitrate (N)	mg/L	13	(1)	0	Yes	No	0	Yes	No
Nitrite (N)	mg/L	0.06	(1)	0.003	No	No	0.004	No	No
Total BOD	mg/L	-	-	5	-	-	2	-	-
Total Chemical Oxygen Demand (COD)	mg/L	-	-	48	-	-	34	-	-
Orthophosphate (P)	mg/L	-	-	0.011	No	-	0.066	No	No
Total Phosphorus	mg/L	0.02	(2)	0.099	No	No ^a	0.18	No	No ^a
Hydrocarbons									
Benzene	µg/L	370	(1)	0	No	No	0	No	No
Ethylbenzene	µg/L	90	(1)	0	No	No	0	No	No
F1 (C6-C10)	µg/L	167	(1)	0	No	No	0	No	No
F1 (C6-C10) - BTEX	µg/L	167	(1)	0	No	No	0	No	No
F2 (C10-C16 Hydrocarbons)	µg/L	42	(1)	0	No	No	0	No	No
F3 (C16-C34 Hydrocarbons)	µg/L	200	(5)	160	No	No	89	No	No
F4 (C34-C50 Hydrocarbons)	µg/L	200	(5)	0	No	No	0	No	No
Biological									
Chlorophyll	µg/L	-	-	26.4	-	-	6.94	-	-
Background	CFU/100mL	-	-	12000	-	-	8400	-	-
Total Coliforms	CFU/100mL	100	(2)	280	No	No ^b	640	No	No ^b
Fecal coliform	CFU/100mL	100	(2)	40	No	No ^b	350	No	No ^b
Escherichia coli	CFU/100mL	100	(2)	40	No	No ^a	340	No	No ^b
Metals									
Total Aluminum (Al)	µg/L	100	(1)	369	Yes	No ^c	18.2	No	No
Dissolved (0.2u) Aluminum (Al)	µg/L	75	(2)	25	No	No	11	No	No
Total Antimony (Sb)	µg/L	20	(2)	0.268	No	No	0.063	No	No
Total Arsenic (As)	µg/L	5	(1)	1.32	No	No	0.298	No	No
Total Barium (Ba)	µg/L	4	(3)	56.5	Yes	Yes	39.8	Yes	Yes
Total Beryllium (Be)	µg/L	1100	(2)	0.017	No	No	0.003	No	No
Total Bismuth (Bi)	µg/L	2.5	(4)	0.006	No	No	0.003	No	No
Total Boron (B)	µg/L	1500	(1)	230	No	No	21	Yes	No
Total Cadmium (Cd)	µg/L	0.17	(1)	0.0095	No	No	0.005	No	No
Total Calcium (Ca)	µg/L	11600	(3)	74500	Yes	No ^d	97900	Yes	No ^d
Total Cesium (Cs)	µg/L	315	(4)	0.018	No	No	0.011	No	No
Total Chromium (Cr)	µg/L	8.9	(1)	1.58	No	No	1.2	No	No
Chromium (+3)	µg/L	8.9	(1)	0	No	No	0	No	No
Chromium (VI)	µg/L	1	(1)	0.31	No	No	0.24	No	No
Total Cobalt (Co)	µg/L	1	(6)	0.235	Yes	No	0.24	Yes	No
Total Copper (Cu)	µg/L	5	(1)	1.72	No	No	0.388	No	No
Total Iron (Fe)	µg/L	300	(1)	433	No	Yes	520	Yes	Yes
Total Lead (Pb)	µg/L	3.59	(1)	0.614	No	No	0.07	No	No
Total Lithium (Li)	µg/L	14	(3)	5.92	No	No	0.4046	No	No
Total Magnesium (Mg)	µg/L	8200	(3)	30000	Yes	No ^d	9900	Yes	No ^d
Total Manganese (Mn)	µg/L	220	(1)	68.5	No	No	310	Yes	No
Mercury (Hg)	µg/L	0.026	(1)	0.0029	No	No	0.0038	No	No
Total Molybdenum (Mo)	µg/L	40	(2)	1.04	No	No	0.15	No	No
Total Nickel (Ni)	µg/L	25	(2)	0.88	No	No	0.271	No	No
Total Potassium (K)	µg/L	5300	(3)	7030	Yes	No ^d	5870	Yes	No ^d
Total Selenium (Se)	µg/L	1	(1)	0.079	No	No	0.114	No	No
Total Silicon (Si)	µg/L	-	-	2270	-	-	4440	-	-
Total Silver (Ag)	µg/L	0.1	(2)	0.003	No	No	0.002	No	No
Total Sodium (Na)	µg/L	68000	(3)	21400	No	No	4860	No	No
Total Strontium (Sr)	µg/L	2500	(6)	506	No	No	225	No	No
Total Thallium (Tl)	µg/L	0.8	(1)	0.0058	No	No	0.01	No	No
Total Thorium (Th)	µg/L	0.52	(4)	0.013	No	No	0.002	No	No
Total Tin (Sn)	µg/L	73	(3)	0.52	No	No	0.0361	No	No
Total Titanium (Ti)	µg/L	27.2	(4)	19	No	No	1.592	No	No
Total Tungsten (W)	µg/L	30	(2)	0.06	No	No	0.007	No	No
Total Uranium (U)	µg/L	15	(1)	1.48	No	No	0.672	No	No
Total Vanadium (V)	µg/L	120	(8)	2.53	No	No	0.4	No	No
Total Zinc (Zn)	µg/L	7	(1)	3.75	No	No	3.1	No	No
Dissolved Zinc (Zn)	µg/L	7	(1)	2.615	No	No	3.502	No	No
Total Zirconium (Zr)	µg/L	4	(2)	0.19	No	No	0.065	Yes	No
Other									
Morpholine	µg/L	4	(2)	1	No	No	0	No	No
Bromoform	µg/L	60	(2)	0	No	No	0	No	No
Chloroform	µg/L	1.8	(1)	0	No	No	0	No	No
Bromodichloromethane	µg/L	200	(2)	0	No	No	0	No	No

References:

1. CCME Canadian Water Quality Guidelines for Protection of Aquatic Life. Accessed in July 2020.
2. MOECC: Water management: policies, guidelines, provincial water quality objectives (1994).
3. Suter and Tsao, (1996). Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision.
4. Borgmann et al., (2005). Toxicity of Sixty-Three Metals and Metalloids to Hyalella Azteca at Two Levels of Water Hardness.
5. Ecometrix. (2020). Darlington New Nuclear Project Supporting Environment Studies – Environment. Report prepared for OPG. Report No. NK054-REP-01210-0001. May.
6. ECCC (2020). Federal Environmental Quality Guidelines - Strontium. July.
7. Environment Canada (2013). Federal Environmental Quality Guidelines, Vanadium. May.

Notes:

- ^a Phosphorus is a nutrient and not a toxicant. Therefore it was not carried forward as a COPC. See Section 4.1.4.2.4.
- ^b E. coli and other coliforms are not of concern of ecological health. They are not carried forward as COPCs. See Section 4.1.4.2.4.
- ^c Although the concentration of total aluminum exceeded the selected screening criteria, its more bioavailable form, dissolved aluminum, did not exceed. Therefore, aluminum was not carried forward as a COPC. See Section 4.1.4.2.4.
- ^d Major ions (Ca, Mg, K) are not considered toxic at environmental concentrations. They are not carried forward as COPCs. See Section 4.1.4.2.4 for more discussion.

Table A-17: Ecological Screening Criteria for Sediment COPCs

Analyte	Units	Sediment Quality Guidelines				Background Values		Lake Ontario Sediment		Pond Sediment	
		PSQG (LEL) (1)	CSQG (2)	Toxicity/Other Benchmark (3-6)	Toxicity/other Benchmark Reference for Sediment	95th Percentile Background Value, Lake Ontario (7)	Dragun & Chiasson (1991, 8)	Selected Screening Criteria, Lake Ontario	Reference	Selected Screening Criteria, Pond ^c	Reference
Physical/Conventional Parameters											
Moisture	%	-	-	-	-	-	-	-	- ^d	-	- ^d
Nutrients											
Calculated Total Kjeldahl Nitrogen	µg/g	550	550	-	-	-	-	550	(1)	550	(1)
Total Organic Carbon	mg/kg	10000	-	-	-	-	-	10000	(1)	10000	(1)
Total Phosphorus (P)	mg/kg	600	-	-	-	-	-	600	(1)	600	(1)
Metals											
Total Aluminum (Al)	mg/kg	-	-	58030	(3)	-	-	58030	(3)	58030	(3)
Total Antimony (Sb)	mg/kg	-	-	2	(6)	-	-	2	(6)	2	(6)
Total Arsenic (As)	mg/kg	6	5.9	-	-	-	-	5.9	(2)	5.9	(2)
Total Barium (Ba)	mg/kg	-	-	-	-	264.3	10-5000	264.3	(7) ^a	10-5000	(8)
Total Beryllium (Be)	mg/kg	-	-	-	-	1.17	<1.0-15	1.17	(7) ^a	<1.0-15	(8)
Total Bismuth (Bi)	mg/kg	-	-	-	-	<0.5	<10-15	0.5	(7) ^a	<10-15	(8)
Total Boron (B)	mg/kg	-	-	-	-	7.1	<20-300	7.1	(7) ^a	<20-300	(8)
Hot Water Ext. Boron (B)	µg/g	-	-	-	-	0.5	-	0.5	(7) ^b	-	-
Total Cadmium (Cd)	mg/kg	0.6	0.6	-	-	-	-	0.6	(1)	0.6	(1)
Total Calcium (Ca)	mg/kg	-	-	-	-	107576	100-320,000	107576	(7) ^a	100-320,000	(8)
Total Cesium (Cs)	mg/kg	-	-	-	-	0.21	0.25-25	0.21	(7) ^a	0.25-25	(8)
Total Chromium (Cr)	mg/kg	26	37.3	-	-	-	-	26	(1)	26	(1)
Total Cobalt (Co)	mg/kg	-	-	50	(4)	-	-	50	(4)	50	(4)
Total Copper (Cu)	mg/kg	16	35.7	-	-	-	-	16	(1)	16	(1)
Total Iron (Fe)	mg/kg	20000	-	-	-	-	-	20000	(1)	20000	(1)
Total Lead (Pb)	mg/kg	31	35	-	-	-	-	31	(1)	31	(1)
Total Lithium (Li)	mg/kg	-	-	-	-	7.2	<5.0-140	7.2	(7) ^a	<5.0-140	(8)
Total Magnesium (Mg)	mg/kg	-	-	-	-	10501	50->100,000	10501	(7) ^a	50->100,000	(8)
Total Manganese (Mn)	mg/kg	460	-	-	-	-	-	460	(1)	460	(1)
Total Mercury (Hg)	mg/kg	0.2	0.17	-	-	-	-	0.17	(2)	0.17	(2)
Total Molybdenum (Mo)	mg/kg	-	-	13.8	(5)	-	-	13.8	(5)	13.8	(5)
Total Nickel (Ni)	mg/kg	16	-	-	-	-	-	16	(1)	16	(1)
Total Potassium (K)	mg/kg	-	-	-	-	8494	50-63,000	8494	(7) ^a	50-63,000	(8)

Table A-17: Ecological Screening Criteria for Sediment COPCs

Analyte	Units	Sediment Quality Guidelines				Background Values		Lake Ontario Sediment		Pond Sediment	
		PSQG (LEL) (1)	CSQG (2)	Toxicity/Other Benchmark (3-6)	Toxicity/other Benchmark Reference for Sediment	95th Percentile Background Value, Lake Ontario (7)	Dragun & Chiasson (1991, 8)	Selected Screening Criteria, Lake Ontario	Reference	Selected Screening Criteria, Pond ^c	Reference
Total Selenium (Se)	mg/kg	-	-	1.9	(5)	-	-	1.9	(5)	1.9	(5)
Total Silver (Ag)	mg/kg	-	-	0.5	(4)	-	-	0.5	(4)	0.5	(4)
Total Sodium (Na)	mg/kg	-	-	-	-	9154	<500-100,000	9154	(7) ^a	<500-100,000	(8)
Total Strontium (Sr)	mg/kg	-	-	-	-	270	<5-3000	270	(7) ^a	<5-3000	(8)
Total Thallium (Tl)	mg/kg	-	-	-	-	0.17	<0.25-10	0.17	(7) ^a	<0.25-10	(8)
Total Thorium (Th)	mg/kg	-	-	-	-	4.34	2.2-31	4.34	(7) ^a	2.2-31	(8)
Total Tin (Sn)	mg/kg	-	-	-	-	3.01	<0.1-10	3.01	(7) ^a	<0.1-10	(8)
Total Titanium (Ti)	mg/kg	-	-	-	-	3534	70-20,000	3534	(7) ^a	70-20,000	(8)
Total Tungsten (W)	mg/kg	-	-	-	-	0.58	<100-1000	0.58	(7) ^a	<100-1000	(8)
Total Uranium (U)	mg/kg	-	-	104.4	(5)	-	-	104.4	(5)	104.4	(5)
Total Vanadium (V)	mg/kg	-	-	35.2	(5)	-	-	35.2	(5)	35.2	(5)
Total Zinc (Zn)	mg/kg	120	123	-	-	-	-	120	(1)	120	(1)
Total Zirconium (Zr)	mg/kg	-	-	-	-	122.2	<20-2000	85.68	(7) ^a	<20-2000	(8)
PHCs											
F1 (C6-C10)	µg/g	-	-	-	-	10	-	10	(7) ^a	-	-
F1 (C6-C10) - BTEX	µg/g	-	-	-	-	10	-	10	(7) ^a	-	-
F2 (C10-C16 Hydrocarbons)	µg/g	-	-	-	-	10	-	10	(7) ^a	-	-
F3 (C16-C34 Hydrocarbons)	µg/g	-	-	-	-	10	-	10	(7) ^a	-	-
F4 (C34-C50 Hydrocarbons)	µg/g	-	-	-	-	10	-	10	(7) ^a	-	-
F4G-sg (Grav. Heavy Hydrocarbons)	µg/g	-	-	-	-	10	-	10	(7) ^a	-	-
PAHs											
Anthracene	µg/g	0.22	0.0469	-	-	-	-	0.0469	(2)	0.0469	(2)
Benzo(a)anthracene	µg/g	0.32	0.317	-	-	-	-	0.317	(2)	0.317	(2)
Benzo(a)pyrene	µg/g	0.37	0.0319	-	-	-	-	0.0319	(2)	0.0319	(2)
Benzo(g,h,i)perylene	µg/g	0.17	-	-	-	-	-	0.17	(1)	0.17	(1)
Benzo(k)fluoranthene	µg/g	0.24	-	-	-	-	-	0.24	(1)	0.24	(1)
Chrysene	µg/g	0.34	0.0571	-	-	-	-	0.0571	(2)	0.0571	(2)
Dibenzo(a,h)anthracene	µg/g	0.06	0.00622	-	-	-	-	0.00622	(2)	0.00622	(2)
Fluoranthene	µg/g	0.75	0.111	-	-	-	-	0.111	(2)	0.111	(2)
Fluorene	µg/g	0.19	0.0212	-	-	-	-	0.0212	(2)	0.0212	(2)
Indeno(1,2,3-cd)pyrene	µg/g	0.2	-	-	-	-	-	0.2	(1)	0.2	(1)
Phenanthrene	µg/g	0.56	0.0419	-	-	-	-	0.0419	(2)	0.0419	(2)
Pyrene	µg/g	0.49	0.053	-	-	-	-	0.053	(2)	0.053	(2)
Total PAHs	µg/g	4	-	-	-	-	-	4	(1)	4	(1)

Table A-17: Ecological Screening Criteria for Sediment COPCs

Analyte	Units	Sediment Quality Guidelines				Background Values		Lake Ontario Sediment		Pond Sediment	
		PSQG (LEL) (1)	CSQG (2)	Toxicity/Other Benchmark (3-6)	Toxicity/other Benchmark Reference for Sediment	95th Percentile Background Value, Lake Ontario (7)	Dragun & Chiasson (1991, 8)	Selected Screening Criteria, Lake Ontario	Reference	Selected Screening Criteria, Pond ^c	Reference
Pesticides and PCBs											
Chlordane (Total)	µg/g	0.007	0.0045	-	-	-	-	0.0045	(2)	0.0045	(2)
Aldrin	µg/g	0.0020	-	-	-	-	-	0.002	(1)	0.002	(1)
Total (α-, β-, γ-) BHC	µg/g	0.003	-	-	-	-	-	0.003	(1)	0.003	(1)
alpha-BHC	µg/g	0.006	-	-	-	-	-	0.006	(1)	0.006	(1)
beta-BHC	µg/g	0.005	-	-	-	-	-	0.005	(1)	0.005	(1)
gamma-BHC (Lindane)	µg/g	0.003	-	-	-	-	-	0.003	(1)	0.003	(1)
Dieldrin	µg/g	0.002	0.00285	-	-	-	-	0.002	(1)	0.002	(1)
Endrin	µg/g	0.003	0.00267	-	-	-	-	0.00267	(2)	0.00267	(2)
Hexachlorobenzene	µg/g	0.02	-	-	-	-	-	0.02	(1)	0.02	(1)
Heptachlor	µg/g	0.0003	0.0006	-	-	-	-	0.0003	(1)	0.0003	(1)
Heptachlor epoxide	µg/g	0.005	0.003	-	-	-	-	0.003	(2)	0.003	(2)
Mirex	µg/g	0.007	-	-	-	-	-	0.007	(1)	0.007	(1)
o,p-DDT + p,p-DDT	µg/g	0.008	-	-	-	-	-	0.008	(1)	0.008	(1)
p,p-DDD	µg/g	0.008	-	-	-	-	-	0.008	(1)	0.008	(1)
p,p-DDE	µg/g	0.005	-	-	-	-	-	0.005	(1)	0.005	(1)
Aroclor 1016	µg/g	0.007	-	-	-	-	-	0.007	(1)	0.007	(1)
Aroclor 1248	µg/g	0.03	-	-	-	-	-	0.03	(1)	0.03	(1)
Aroclor 1254	µg/g	0.06	-	-	-	-	-	0.06	(1)	0.06	(1)
Aroclor 1260	µg/g	0.005	-	-	-	-	-	0.005	(1)	0.005	(1)
Total PCB	µg/g	0.07	0.0341	-	-	-	-	0.0341	(2)	0.0341	(2)

References:

1. Ministry of the Environment, Conservation and Parks (2019). Guidelines for identifying, assessing and managing contaminated sediments in Ontario.
2. CCME (1999). Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. Updated 2001.
3. Jones, Suter, (1997). Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment - Associated Biota: 1997 Revision. The probable effect concentration was adopted.
4. MOEE (1993). Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Benchmarks were carried forward from the Open Water Disposal Guideline published in 1976.
5. P. A. Thompson, J. Kurias and S. Mihok. 2005. Derivation and use of sediment quality guidelines for ecological risk assessment of metals and radionuclides released to the environment from uranium mining and milling activities in Canada. Environmental Monitoring and Assessment (110): 71-85. Weighted method was adopted in the table.
6. Long, E. R. and Morgan L. G. (1991). The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA. August.
7. OPG (2009). Ecological Risk Assessment and Assessment of Effects on Non-Human Biota Technical Support Document New Nuclear - Darlington Environmental Assessment. Report No. NK054-REP-07730-00022-R000. September.

Notes:

- ^a If the 95th percentile of the background value is greater than the detection limit, the background value is selected as the screening criteria. Otherwise, detection limit was selected as the screening criteria.
- ^b The concentration of hot water extracted boron collected in the local study area (off-site) in the 2009 ERA was used to screen this parameter.
- ^c As the aquatic environment in ponds are very different from Lake Ontario, it is considered not appropriate to use the lake sediment background value to screen pond parameters. For pond sediment, the upper crustal values in the continental USA was used as the background concentration.
- ^d The Analyte is not considered of ecological health concern, and therefore no screening benchmark is necessary.

Table A-18: Screening of Lake Ontario Sediment Quality for Ecological Health

Analyte	Units	Selected Ecological Screening Criteria	Reference	2018 Study Max	2019 Study Max	Overall Max	Carried Forward as COPC?
Physical/Conventional Parameters							
Moisture	%	-	-	23	37	37	-
Nutrients							
Calculated Total Kjeldahl Nitrogen	µg/g	550	(1)	600	944	944	Yes
Total Organic Carbon	mg/kg	10000	(1)	3300	9100	9100	No
Total Phosphorus (P)	mg/kg	600	(1)	850	1010	1010	Yes
Metals							
Total Aluminum (Al)	mg/kg	58030	(3)	-	4860	4860	No
Total Antimony (Sb)	mg/kg	2	(6)	-	0.15	0.15	No
Total Arsenic (As)	mg/kg	5.9	(2)	-	1.86	1.86	No
Total Barium (Ba)	mg/kg	264.3	(7) ^a	-	42.2	42.2	No
Total Beryllium (Be)	mg/kg	1.17	(7)	-	0.24	0.24	No
Total Bismuth (Bi)	mg/kg	0.5	(7)	-	0.04438	0.04438	No
Total Boron (B)	mg/kg	7.1	(7)	-	5.4	5.4	No
Hot Water Ext. Boron (B)	µg/g	0.5	(7)	-	0.46	0.46	No
Total Cadmium (Cd)	mg/kg	0.6	(1)	-	0.149	0.149	No
Total Calcium (Ca)	mg/kg	107576	(7)	-	173000	173000	No ^a
Total Cesium (Cs)	mg/kg	0.21	(7)	-	0.39409	0.39409	Yes
Total Chromium (Cr)	mg/kg	26	(1)	-	9.5	9.5	No
Total Cobalt (Co)	mg/kg	50	(4)	-	2.91	2.91	No
Total Copper (Cu)	mg/kg	16	(1)	-	6.31	6.31	No
Total Iron (Fe)	mg/kg	20000	(1)	-	18100	18100	No
Total Lead (Pb)	mg/kg	31	(1)	-	23.6	23.6	No
Total Lithium (Li)	mg/kg	7.2	(7)	-	5.3	5.3	No
Total Magnesium (Mg)	mg/kg	10501	(7)	-	6950	6950	No
Total Manganese (Mn)	mg/kg	460	(1)	-	296	296	No
Total Mercury (Hg)	mg/kg	0.17	(2)	-	0.01488	0.01488	No
Total Molybdenum (Mo)	mg/kg	13.8	(5)	-	0.19	0.19	No
Total Nickel (Ni)	mg/kg	16	(1)	-	6.24	6.24	No
Total Potassium (K)	mg/kg	8494	(7)	-	1010	1010	No
Total Selenium (Se)	mg/kg	1.9	(5)	-	0.24486	0.24486	No
Total Silver (Ag)	mg/kg	0.5	(4)	-	0.02449	0.02449	No
Total Sodium (Na)	mg/kg	9154	(7)	-	211	211	No
Total Strontium (Sr)	mg/kg	270	(7)	-	276	276	Yes
Total Thallium (Tl)	mg/kg	0.17	(7)	-	0.064	0.064	No
Total Thorium (Th)	mg/kg	4.34	(7)	-	3.67	3.67	No
Total Tin (Sn)	mg/kg	3.01	(7)	-	0.68	0.68	No
Total Titanium (Ti)	mg/kg	3534	(7)	-	469	469	No
Total Tungsten (W)	mg/kg	0.58	(7)	-	0.13889	0.13889	No
Total Uranium (U)	mg/kg	104.4	(5)	-	1.05	1.05	No
Total Vanadium (V)	mg/kg	35.2	(5)	-	33.9	33.9	No
Total Zinc (Zn)	mg/kg	120	(1)	-	25.9	25.9	No
Total Zirconium (Zr)	mg/kg	85.68	(7)	-	2.27	2.27	No
PHCs							
F1 (C6-C10)	µg/g	10	(7)	-	0	0	No
F1 (C6-C10) - BTEX	µg/g	10	(7)	-	0	0	No
F2 (C10-C16 Hydrocarbons)	µg/g	10	(7)	-	0	0	No
F3 (C16-C34 Hydrocarbons)	µg/g	10	(7)	-	64	64	Yes
F4 (C34-C50 Hydrocarbons)	µg/g	10	(7)	-	0	0	No
PAHs							
Anthracene	µg/g	0.0469	(2)	0.03	0	0.03	No
Benzo(a)anthracene	µg/g	0.317	(2)	0.07	0.008597	0.07	No
Benzo(a)pyrene	µg/g	0.0319	(2)	0.06	0.011	0.06	Yes
Benzo(g,h,i)perylene	µg/g	0.17	(1)	0.03	0.011	0.03	No
Benzo(k)fluoranthene	µg/g	0.24	(1)	0.03	0.006074	0.03	No
Chrysene	µg/g	0.0571	(2)	0.06	0.011	0.06	Yes
Dibenzo(a,h)anthracene	µg/g	0.00622	(2)	0.007	0	0.007	Yes
Fluoranthene	µg/g	0.111	(2)	0.1	0.026	0.1	No
Fluorene	µg/g	0.0212	(2)	0.02	0	0.02	No
Indeno(1,2,3-cd)pyrene	µg/g	0.2	(1)	0.04	0.011	0.04	No
Phenanthrene	µg/g	0.0419	(2)	0.1	0.013	0.1	Yes
Pyrene	µg/g	0.053	(2)	0.09	0.02	0.09	Yes
Total PAHs	µg/g	4	(1)	0.7	0	0.7	No
Pesticides and PCBs							
Chlordane (Total)	µg/g	0.0045	(2)	<0.002	0	<0.002	No
Aldrin	µg/g	0.002	(1)	<0.002	0	<0.002	No
Total (α-, β-, γ-) BHC	µg/g	0.003	(1)	<0.002	0	<0.002	No
alpha-BHC	µg/g	0.006	(1)	<0.002	0	<0.002	No
beta-BHC	µg/g	0.005	(1)	<0.002	0	<0.002	No
gamma-BHC (Lindane)	µg/g	0.003	(1)	<0.002	0	<0.002	No
Dieldrin	µg/g	0.002	(1)	<0.002	0	<0.002	No

Table A-18: Screening of Lake Ontario Sediment Quality for Ecological Health

Analyte	Units	Selected Ecological Screening Criteria	Reference	2018 Study Max	2019 Study Max	Overall Max	Carried Forward as COPC?
Endrin	µg/g	0.00267	(2)	<0.002	0	<0.002	No
Hexachlorobenzene	µg/g	0.02	(1)	<0.002	0	<0.002	No
Heptachlor	µg/g	0.0003	(1)	<0.002	0.000233	<0.002	No ^b
Heptachlor epoxide	µg/g	0.003	(2)	<0.002	0	<0.002	No
Mirex	µg/g	0.007	(1)	<0.002	0	<0.002	No
o,p-DDT + p,p-DDT	µg/g	0.008	(1)	<0.002	0	<0.002	No
p,p-DDD	µg/g	0.008	(1)	<0.002	0	<0.002	No
p,p-DDE	µg/g	0.005	(1)	<0.002	0	<0.002	No
Aroclor 1016	µg/g	0.007	(1)	<0.05	0	<0.05	No ^b
Aroclor 1248	µg/g	0.03	(1)	<0.05	0	<0.05	No ^b
Aroclor 1254	µg/g	0.06	(1)	<0.02	0	<0.02	No
Aroclor 1260	µg/g	0.005	(1)	<0.02	0	<0.02	No ^b
Total PCB	µg/g	0.0341	(2)	<0.05	0	<0.05	No ^b

References:

1. Ministry of the Environment, Conservation and Parks (2019). Guidelines for identifying, assessing and managing contaminated sediments in Ontario.
2. CCME (1999), Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. Updated 2001.
3. Jones, Suter, (1997). Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment - Associated Biota: 1997 Revision. The probable effect concentration was adopted.
4. MOEE (1993). Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Benchmarks were carried forward from the Open Water Disposal Guideline published in 1976.
5. P. A. Thompson, J. Kurias and S. Mihok. 2005. Derivation and use of sediment quality guidelines for ecological risk assessment of metals and radionuclides released to the environment from uranium mining and milling activities in Canada. Environmental Monitoring and Assessment (110): 71-85. Weighted method was
6. Long, E. R. and Morgan L. G. (1991), The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA. August.
7. OPG (2009). Ecological Risk Assessment and Assessment of Effects on Non-Human Biota Technical Support Document New Nuclear - Darlington Environmental Assessment. Report No. NK054-REP-07730-00022-R000. September.

Notes:

^a Calcium is a natural component in soil, and is an essential nutrient for life. It is not a toxicant for ecological receptors and therefore is not carried forward as a

^b All PCB concentrations in the 2018-2019 sampling events were below detection. Also, there is no known source of PCBs at the Darlington site. Therefore, PCBs were not carried forward as COPCs for sediment.

Table A-19: Screening of Pond Sediment Quality for Ecological Health

Analyte	Units	Selected Screening Criteria	Reference	Coot's Pond			Treefrog Pond		
				2019 Study Max	COPC in the 2016 ERA?	Carried Forward as COPC?	2019 Study Max	COPC in the 2016 ERA?	Carried Forward as COPC?
Physical/Conventional Parameters									
Moisture	%	-	-	68	-	-	85	-	-
Nutrients									
Calculated Total Kjeldahl Nitrogen	µg/g	550	(1)	3780	No	Yes	21200	No	Yes
Total Organic Carbon	mg/kg	10000	(1)	31000	No	Yes	260000	No	Yes
Total Phosphorus (P)	mg/kg	600	(1)	812	Yes	Yes	1420	Yes	Yes
Metals									
Total Aluminum (Al)	mg/kg	58030	(3)	20300	No	No	17900	No	No
Total Antimony (Sb)	mg/kg	2	(6)	0.64	No	No	0.4	No	No
Total Arsenic (As)	mg/kg	5.9	(2)	2.74	No	No	2.46	No	No
Total Beryllium (Be)	mg/kg	<1.0-15	(8)	0.81	No	No	0.77	No	No
Total Bismuth (Bi)	mg/kg	<10-15	(8)	0.15	No	No	0.2	No	No
Total Boron (B)	mg/kg	<20-300	(8)	18.3	No	No	10	No	No
Hot Water Ext. Boron (B)	µg/g	-	-	1.6	-	-	2.4	-	-
Total Cadmium (Cd)	mg/kg	0.6	(1)	1.6	No	Yes	1.21	No	Yes
Total Calcium (Ca)	mg/kg	100-320,000	(8)	186000	No	No	21800	No	No
Total Cesium (Cs)	mg/kg	0.25-25	(8)	1.4	No	No	0.90	No	No
Total Chromium (Cr)	mg/kg	26	(1)	30.7	No	Yes	25.7	Yes	No
Total Cobalt (Co)	mg/kg	50	(4)	17.3	No	No	6.02	No	No
Total Copper (Cu)	mg/kg	16	(1)	40.5	Yes	Yes	54.8	Yes	Yes
Total Iron (Fe)	mg/kg	20000	(1)	23700	No	Yes	17300	Yes	No
Total Lead (Pb)	mg/kg	31	(1)	13.2	No	No	30	No	No
Total Lithium (Li)	mg/kg	<5.0-140	(8)	21.8	No	No	15.8	No	No
Total Magnesium (Mg)	mg/kg	50->100,000	(8)	12400	No	No	4550	Yes	No
Total Manganese (Mn)	mg/kg	460	(1)	540	Yes	Yes	181	No	No
Total Mercury (Hg)	mg/kg	0.17	(2)	0.065	No	No	0.17	No	No
Total Molybdenum (Mo)	mg/kg	13.8	(5)	5.96	No	No	1.43	No	No
Total Nickel (Ni)	mg/kg	16	(1)	20.2	No	Yes	14.2	Yes	No
Total Potassium (K)	mg/kg	50-63,000	(8)	3940	No	No	1980	No	-
Total Selenium (Se)	mg/kg	1.9	(5)	0.36	No	No	3.07	No	Yes
Total Silver (Ag)	mg/kg	0.5	(4)	0.06	No	No	0.15	No	No
Total Sodium (Na)	mg/kg	<500-100,000	(8)	550	No	No	167	No	No
Total Strontium (Sr)	mg/kg	<5-3000	(8)	453	No	No	53.5	No	No
Total Thallium (Tl)	mg/kg	<0.25-10	(8)	0.23	No	No	0.16	No	No
Total Thorium (Th)	mg/kg	2.2-31	(8)	3.68	No	No	2.3	No	No
Total Tin (Sn)	mg/kg	<0.1-10	(8)	1.25	No	No	1.31	No	No
Total Titanium (Ti)	mg/kg	70-20,000	(8)	795	No	No	591	No	No
Total Tungsten (W)	mg/kg	<100-1000	(8)	0.23	No	No	0.12	No	No
Total Uranium (U)	mg/kg	104.4	(5)	1.34	No	No	6.96	No	No
Total Vanadium (V)	mg/kg	35.2	(5)	59.6	Yes	Yes	37.5	Yes	Yes
Total Zinc (Zn)	mg/kg	120	(1)	170	No	Yes	119	No	No
Total Zirconium (Zr)	mg/kg	<20-2000	(8)	2.11	No	No	3.56	No	No
PHCs									
F1 (C6-C10)	µg/g	-	-	0	-	-	0	-	-
F1 (C6-C10) - BTEX	µg/g	-	-	0	-	-	0	-	-
F2 (C10-C16 Hydrocarbons)	µg/g	-	-	46	-	-	34.07	-	-
F3 (C16-C34 Hydrocarbons)	µg/g	-	-	460	-	-	410	-	-
F4 (C34-C50 Hydrocarbons)	µg/g	-	-	160	-	-	147.95	-	-
PAHs									
Anthracene	µg/g	0.0469	(2)	0	No	No	0	No	No
Benzo(a)anthracene	µg/g	0.317	(2)	0	No	No	0.018	No	No
Benzo(a)pyrene	µg/g	0.0319	(2)	0	No	No	0.025	No	No
Benzo(g,h,i)perylene	µg/g	0.17	(1)	0.014	No	No	0.035	No	No
Benzo(k)fluoranthene	µg/g	0.24	(1)	0.0040	No	No	0.010	No	No
Chrysene	µg/g	0.0571	(2)	0.0073	No	No	0.022	No	No
Dibenzo(a,h)anthracene	µg/g	0.00622	(2)	0	No	No	0	No	No
Fluoranthene	µg/g	0.111	(2)	0.015	No	No	0.037	No	No
Fluorene	µg/g	0.0212	(2)	0	No	No	0	No	No
Indeno(1,2,3-cd)pyrene	µg/g	0.2	(1)	0.0088	No	No	0.027	No	No
Phenanthrene	µg/g	0.0419	(2)	0.0071	No	No	0.023	No	No
Pyrene	µg/g	0.053	(2)	0.014	No	No	0.034	No	No

References:

1. Ministry of the Environment, Conservation and Parks (2019). Guidelines for identifying, assessing and managing contaminated sediments in Ontario.
2. CCME (1999), Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. Updated 2001.
3. Jones, Suter, (1997). Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment - Associated Biota: 1997 Revision. The probable effect concentration was adopted.
4. MOEE (1993). Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Benchmarks were carried forward from the Open Water Disposal Guideline published in 1976.
5. P. A. Thompson, J. Kurias and S. Mihok. 2005. Derivation and use of sediment quality guidelines for ecological risk assessment of metals and radionuclides released to the environment from uranium mining and milling activities in Canada. Environmental Monitoring and Assessment (110): 71-85. Weighted method was adopted in the table.
6. Long, E. R. and Morgan L. G. (1991), The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA. August.

Table A-20: Ecological Screening Criteria for Soil COPCs

Analyte	Units	PSO Component Value (1) ^a	BM Component Value (1) ^b	CCME SQG Agricultural (2)	Interim CSQG (3)	MOE Table 1 (Residential/Park land, 1)	Rural Parkland OTR ₉₅ (1) ^c	Dragun & Chiasson (1991, 4)	Selected Screening Criteria, Plants and Soil Invertebrates	PSO Reference	Selected Screening Criteria, Birds and Mammals	BM Reference
Physical/Conventional Parameters												
Conductivity	µmho/cm	700	-	2000	-	0.57	-	-	700	(1)	2000	(2)
pH	pH	-	-	5-9	6-8	-	-	-	5-9	(2)	5-9	(2)
TOC	%	-	-	-	-	-	-	-	-			
Moisture	%	-	-	-	-	-	-	-	-			
Sodium Adsorption Ratio	N/A	5	-	5	-	2.4	-	-	5	(2)	5	(2)
Metals												
Hot Water Ext. Boron (B)	µg/g	1.5	-	2	1	-	-	-	1.5	(1)	2	(2)
Total Aluminum (Al)	µg/g	-	-	-	-	-	30000	-	30000	(1)	30000	(1)
Total Antimony (Sb)	µg/g	20	25	20	20	1.3	-	-	20	(2)	20	(2)
Total Arsenic (As)	µg/g	20	51	12	5	18	-	-	12	(2)	12	(2)
Total Barium (Ba)	µg/g	750	390	750	200	220	-	-	750	(1)	390	(1)
Total Beryllium (Be)	µg/g	4	13	4	4	2.5	-	-	4	(2)	4	(2)
Total Bismuth (Bi)	µg/g	-	-	-	-	-	-	<10-15	<10-15	(4)	<10-15	(4)
Total Boron (B)	µg/g	-	120	-	-	36	-	-	36	(1)	120	(1)
Total Cadmium (Cd)	µg/g	12	1.9	1.4	0.5	1.2	-	-	1.4	(2)	1.4	(2)
Total Calcium (Ca)	µg/g	-	-	-	-	-	54000	-	54000	(1)	54000	(1)
Total Cesium (Cs)	µg/g	-	-	-	-	-	-	0.25-25	0.25-25	(4)	0.25-25	(4)
Total Chromium (Cr)	µg/g	310	160	64	2.5	70	-	-	64	(2)	64	(2)
Total Cobalt (Co)	µg/g	40	180	40	10	21	-	-	40	(2)	40	(2)
Total Copper (Cu)	µg/g	140	770	63	30	92	-	-	63	(2)	63	(2)
Total Iron (Fe)	µg/g	-	-	-	-	-	36000	-	36000	(2)	36000	(2)
Total Lead (Pb)	µg/g	250	32	70	25	120	-	-	70	(2)	32	(1)
Total Lithium (Li)	µg/g	-	-	-	-	-	-	<5.0-140	<5.0-140	(4)	<5.0-140	(4)
Total Magnesium (Mg)	µg/g	-	-	-	-	-	19000	-	19000	(1)	19000	(1)
Total Manganese (Mn)	µg/g	-	-	-	-	-	1900	-	1900	(1)	1900	(1)
Total Mercury (Hg)	µg/g	10	20	6.6	0.1	0.27	-	-	6.6	(2)	6.6	(2)
Total Molybdenum (Mo)	µg/g	40	6.9	5	2	2	-	-	5	(2)	5	(2)
Total Nickel (Ni)	µg/g	100	5000	45	20	82	-	-	45	(2)	45	(2)
Total Potassium (K)	µg/g	-	-	-	-	-	6500	-	6500	(1)	6500	(1)
Total Selenium (Se)	µg/g	10	2.4	1	1	1.5	-	-	1	(2)	1	(2)
Total Silver (Ag)	µg/g	20	-	20	2	0.5	-	-	20	(2)	20	(2)
Total Sodium (Na)	µg/g	-	-	-	-	-	690	-	690	(1)	690	(1)
Total Strontium (Sr)	µg/g	-	-	-	-	-	63	-	63	(1)	63	(1)
Total Thallium (Tl)	µg/g	1.4	3.9	1	0.5	1	-	-	1	(1)	1	(1)
Total Thorium (Th)	µg/g	-	-	-	-	-	-	2.2-31	2.2-31	(4)	2.2-31	(4)
Total Tin (Sn)	µg/g	-	-	5	5	-	-	-	5	(2)	5	(2)
Total Titanium (Ti)	µg/g	-	-	-	-	-	5500	-	5500	(1)	5500	(1)
Total Tungsten (W)	µg/g	-	-	-	-	-	-	<100-1000	<100-1000	(4)	<100-1000	(4)
Total Uranium (U)	µg/g	500	33	23	-	2.5	-	-	23	(2)	23	(2)
Total Vanadium (V)	µg/g	200	18	130	25	86	86	-	130	(2)	86	(1) ^e
Total Zinc (Zn)	µg/g	400	340	250	60	290	-	-	250	(2)	250	(2)
Total Zirconium (Zr)	µg/g	-	-	-	-	-	-	<20-2000	<20-2000	(4)	<20-2000	(4)

Table A-20: Ecological Screening Criteria for Soil COPCs

Analyte	Units	PSO Component Value (1) ^a	BM Component Value (1) ^b	CCME SQG Agricultural (2)	Interim CSQG (3)	MOE Table 1 (Residential/Park land, 1)	Rural Parkland OTR ₉₅ (1) ^c	Dragun & Chiasson (1991, 4)	Selected Screening Criteria, Plants and Soil Invertebrates	PSO Reference	Selected Screening Criteria, Birds and Mammals	BM Reference
PHC												
F1 (C6-C10) - BTEX	µg/g	210	-	210	-	25	-	-	210	(2)	210	(2)
F1 (C6-C10)	µg/g	210	-	210	-	25	-	-	210	(2)	210	(2)
F2 (C10-C16 Hydrocarbons)	µg/g	150	-	150	-	10	-	-	150	(2)	150	(2)
F3 (C16-C34 Hydrocarbons)	µg/g	300	-	300	-	240	-	-	300	(2)	300	(2)
F4 (C34-C50 Hydrocarbons)	µg/g	2800	-	2800	-	120	-	-	2800	(2)	2800	(2)
F4G-sg (Grav. Heavy Hydrocarbons)	µg/g	2800	-	2800	-	120	-	-	2800	(2)	2800	(2)
VOC												
1,1,1,2-Tetrachloroethane	µg/g	-	-	-	-	0.05	-	-	0.05	(1)	0.05	(1)
1,1-Dichloroethane	µg/g	8.4	-	0.1	-	0.05	-	-	0.1	(2)	0.1	(2)
1,1-Dichloroethylene	µg/g	50	-	0.1	-	0.05	-	-	0.1	(2)	0.1	(2)
1,2-Dibromoethane (ethylene dibromide)	µg/g	-	-	-	-	0.05	-	-	0.05	(1)	0.05	(1)
1,2-Dichlorobenzene	µg/g	3.4	-	0.1	0.1	0.05	-	-	0.1	(2)	0.1	(2)
1,2-Dichloroethane	µg/g	48	-	0.1	-	0.05	-	-	0.1	(2)	0.1	(2)
1,2-Dichloropropane	µg/g	25	-	0.1	-	0.05	-	-	0.1	(2)	0.1	(2)
1,3-Dichlorobenzene	µg/g	4.8	-	0.1	0.1	0.05	-	-	0.1	(2)	0.1	(2)
1,3-Dichloropropene (cis+trans)	µg/g	25	-	-	-	0.05	-	-	25	(1)	0.05	(1)
1,4-Dichlorobenzene	µg/g	3.6	-	0.1	0.1	0.05	-	-	0.1	(2)	0.1	(2)
2-Butanone (Methyl Ethyl Ketone)	µg/g	35	9900	-	-	0.5	-	-	35	(1)	9900	(1)
Methyl Isobutyl Ketone	µg/g	-	-	-	-	0.5	-	-	0.5	(1)	0.5	(1)
Acetone (2-Propanone)	µg/g	-	56	-	-	0.5	-	-	0.5	(1)	56	(1)
Benzene	µg/g	25	370	0.03	0.05	0.02	-	-	0.03	(2)	0.03	(2)
Bromodichloromethane	µg/g	-	-	-	-	0.05	-	-	0.05	(1)	0.05	(1)
Bromoform	µg/g	-	-	-	-	0.05	0.00027	-	0.05	(1)	0.05	(1)
Bromomethane	µg/g	-	-	-	-	0.05	0.0011	-	0.05	(1)	0.05	(1)
Carbon Tetrachloride	µg/g	5.8	7.6	0.1	-	0.05	-	-	0.1	(2)	0.1	(2)
Chlorobenzene	µg/g	6	-	0.1	0.1	0.05	-	-	0.1	(2)	0.1	(2)
Chloroform	µg/g	34	81	0.1	-	0.05	-	-	0.1	(2)	0.1	(2)
cis-1,2-Dichloroethylene	µg/g	-	84	-	-	0.05	-	-	0.05	(1)	84	(1)
cis-1,3-Dichloropropene ^d	µg/g	25	-	-	-	0.05	-	-	25	(1)	0.05	(1)
Dibromochloromethane	µg/g	-	-	-	-	0.05	0.00019	-	0.05	(1)	0.05	(1)
Dichlorodifluoromethane (FREON 12)	µg/g	40	-	-	-	0.05	-	-	40	(1)	0.05	(1)
Ethylbenzene	µg/g	55	90	0.082	0.1	0.05	-	-	0.082	(2)	0.082	(2)
p+m-Xylene	µg/g	-	-	-	0.1	-	-	-	0.1	(3)	0.1	(3)
Methyl t-butyl ether (MTBE)	µg/g	25	-	-	-	0.05	-	-	25	(1)	0.05	(1)
Methylene Chloride(Dichloromethane)	µg/g	0.78	350	0.1	-	-	-	-	0.1	(2)	0.1	(2)
o-Xylene	µg/g	-	-	-	0.1	-	-	-	0.1	(3)	0.1	(3)
Styrene	µg/g	17	-	0.1	0.1	0.05	-	-	0.1	(2)	0.1	(2)
trans-1,2-Dichloroethylene	µg/g	-	84	-	-	0.05	-	-	0.05	(1)	84	(1)
trans-1,3-Dichloropropene ^d	µg/g	25	-	-	-	0.05	-	-	25	(1)	0.05	(1)
Trichloroethylene	µg/g	100	8.1	-	-	0.05	-	-	100	(1)	8.1	(1)
Trichlorofluoromethane (FREON 11)	µg/g	16	-	-	-	0.25	-	-	16	(1)	0.25	(1)
Vinyl Chloride	µg/g	3.4	12	-	-	0.25	-	-	3.4	(1)	12	(1)

Table A-20: Ecological Screening Criteria for Soil COPCs

Analyte	Units	PSO Component Value (1) ^a	BM Component Value (1) ^b	CCME SQG Agricultural (2)	Interim CSQG (3)	MOE Table 1 (Residential/Park land, 1)	Rural Parkland OTR ₉₅ (1) ^c	Dragun & Chiasson (1991, 4)	Selected Screening Criteria, Plants and Soil Invertebrates	PSO Reference	Selected Screening Criteria, Birds and Mammals	BM Reference
Total Xylenes	µg/g	95	96	11	0.1	0.05	-	-	11	(2)	11	(2)
Hexane	µg/g	-	-	0.49	-	0.05	-	-	0.49	(2)	0.49	(2)
PAHs												
1-Methylnaphthalene	µg/g	-	-	-	-	0.59	0.006	-	0.59	(1)	0.59	(1)
2-Methylnaphthalene	µg/g	-	-	-	-	0.59	0.006	-	0.59	(1)	0.59	(1)
Acenaphthene	µg/g	-	6600	-	-	0.072	-	-	0.072	(1)	6600	(1)
Acenaphthylene	µg/g	-	-	-	-	0.093	0.093	-	0.093	(1)	0.093	(1)
Anthracene	µg/g	2.5	38000	2.5	-	0.16	-	-	2.5	(2)	2.5	(2)
Benzo(b,j)fluoranthene	µg/g	-	-	0.1 ^f	-	0.47	-	-	0.1	(2)	0.1	(2)
Benzo(a)anthracene	µg/g	0.5	-	0.1 ^f	-	0.36	-	-	0.5	(1)	0.1	(2)
Benzo(a)pyrene	µg/g	20	1600	20	-	0.3	-	-	20	(2)	20	(2)
Benzo(g,h,i)perylene	µg/g	6.6	-	-	-	0.68	-	-	6.6	(1)	0.68	(1)
Benzo(k)fluoranthene	µg/g	7.6	-	0.1 ^f	-	0.48	-	-	7.6	(1)	0.48	(2)
Chrysene	µg/g	7	-	-	-	2.8	-	-	7	(1)	2.8	(1)
Dibenzo(a,h)anthracene	µg/g	-	-	0.1 ^f	-	0.1	-	-	0.1	(2)	0.1	(2)
Fluoranthene	µg/g	50	0.69	50	-	0.56	-	-	50	(1)	0.69	(1)
Fluorene	µg/g	-	-	-	-	0.12	0.0094	-	0.12	(1)	0.12	(1)
Indeno(1,2,3-cd)pyrene	µg/g	0.38	-	0.1 ^f	-	0.23	-	-	0.38	(1)	0.23	(2)
Naphthalene	µg/g	0.6	380	0.6	-	0.09	-	-	0.6	(1)	380	(1)
Phenanthrene	µg/g	6.2	2700	0.1 ^f	-	0.69	-	-	6.2	(1)	2700	(1)
Pyrene	µg/g	-	4700	0.1 ^f	-	1	-	-	1	(2)	4700	(1)
Other												
Cyanide (free)	µg/g	0.9	0.11	0.9	0.25	0.051	-	-	0.9	(2)	0.11	(1)
Total Phosphorus	µg/g	-	-	-	-	-	1100	-	1100	(1)	1100	(1)

Reference:

- Standards Development Branch, Ontario Ministry of the Environment, 2011. Rationale for the Development of Soil and Ground Water Standards for Use at contaminated Sites in Ontario. April.
- CCME. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health. Accessed on July 2020.
- CCME (1991). Interim Canadian Environmental Quality Criteria for Contaminated Sites. September.
- Dragun and Chiasson (1991). Elements in North American Soils.

Notes:
^a Plant and Soil component values for agricultural/other land use was adopted in this table.

^b Bird and mammal component values derived for residential/parkland were adopted in this table.

^c If there are multiple OTR₉₅ values in different sampling regions, values from region 3 (central) was selected considering the DN facility resides in region 3.

^d Screening Criteria selected to screen 1,3-dichloropropene was also applied to screen cis- and trans-1,3-dichloropropene.

^e OTR₉₅ was selected for vanadium for protection of mammal and birds, considering the background concentration in Ontario is more elevated than the component value. See discussion in Section 4.1.4.3.

^f Insufficient direct soil contact data available. This value is based on the interim CSQG. Ontario component value, if available, is selected prior to this value.

Table A-21: Screening of Soil Quality for Ecological Health

		Selected Screening Criteria, Plants and Soil Invertebrates		Selected Screening Criteria, Birds and Mammals		Measured 2019 Max Concentrations				Plants and Soil		Birds and Mammals	
Analyte	Units	Screening Criteria	Reference	Screening Criteria	Reference	AB	C	D	E	COPC in the 2016 ERA?	Carried Forward as COPC?	COPC in the 2016 ERA?	Carried Forward as COPC?
Physical/Conventional Parameters													
Conductivity	µmho/cm	700	(1)	2000	(2)	265	230	256	407				
pH	pH	5-9	(2)	5-9	(2)	7.55	7.59	7.55	8.12	No	No	No	No
TOC	%	-		-		2.57	2.43	3.41	2.12	No	No	No	No
Moisture	%	-		-		33	24	26	42	No	No	No	No
Sodium Adsorption Ratio	N/A	5	(2)	5	(2)	0.24	0.3	0.19	0.51	No	No	No	No
Metals													
Hot Water Ext. Boron (B)	µg/g	1.5	(1)	2	(2)	0.65	0.29	0.44	0.75	Yes (AB)	No	No	No
Total Aluminum (Al)	µg/g	30000	(1)	30000	(1)	13900	12800	11800	13600	No	No	No	No
Total Antimony (Sb)	µg/g	20	(2)	20	(2)	0.18	0.06972	0.13	15.4	No	No	No	No
Total Arsenic (As)	µg/g	12	(2)	12	(2)	6.77	1.8	2	133	No	Yes (E)	No	Yes (E)
Total Barium (Ba)	µg/g	750	(1)	390	(1)	104	92.9	107	110	No	No	Yes (AB, C, D, E)	No
Total Beryllium (Be)	µg/g	4	(2)	4	(2)	0.55	0.55	0.48	0.68	No	No	No	No
Total Bismuth (Bi)	µg/g	<10-15	(4)	<10-15	(4)	0.075	0.07324	0.0747	0.73	No	No	No	No
Total Boron (B)	µg/g	36	(1)	120	(1)	6.9	6.5	7.7	13.2	No	No	No	No
Total Cadmium (Cd)	µg/g	1.4	(2)	1.4	(2)	0.285	0.129	0.274	3.75	No	Yes (E)	No	Yes (E)
Total Calcium (Ca)	µg/g	54000	(1)	54000	(1)	106000	74500	86000	277000	No	No ^a	No	No ^a
Total Cesium (Cs)	µg/g	0.25-25	(4)	0.25-25	(4)	0.72709	0.64941	0.76087	0.96806	No	No	No	No
Total Chromium (Cr)	µg/g	64	(2)	64	(2)	22.2	20.9	20.8	74.8	No	Yes (E)	No	Yes (E)
Total Cobalt (Co)	µg/g	40	(2)	40	(2)	7.06	7.1	6.98	159	No	Yes (E)	No	Yes (E)
Total Copper (Cu)	µg/g	63	(2)	63	(2)	16.8	15.2	15.1	2230	No	Yes (E)	No	Yes (E)
Total Iron (Fe)	µg/g	36000	(2)	36000	(2)	18500	17800	17300	94900	No	Yes (E)	No	Yes (E)
Total Lead (Pb)	µg/g	70	(2)	32	(1)	23.6	8.14	9.83	589	No	Yes (E)	Yes (AB)	Yes (E)
Total Lithium (Li)	µg/g	<5.0-140	(4)	<5.0-140	(4)	11	12.6	10.5	11.3	No	No	No	No
Total Magnesium (Mg)	µg/g	19000	(1)	19000	(1)	7660	6060	7740	15900	No	No	No	No
Total Manganese (Mn)	µg/g	1900	(1)	1900	(1)	443	408	446	572	No	No	No	No
Total Mercury (Hg)	µg/g	6.6	(2)	6.6	(2)	0.045	0.02441	0.04482	0.03497	No	No	No	No
Total Molybdenum (Mo)	µg/g	5	(2)	5	(2)	0.39	0.24	0.95	42.3	No	Yes (E)	No	Yes (E)
Total Nickel (Ni)	µg/g	45	(2)	45	(2)	13	15.1	13.7	129	No	Yes (E)	No	Yes (E)
Total Potassium (K)	µg/g	6500	(1)	6500	(1)	2010	2310	2770	2400	No	No	No	No
Total Selenium (Se)	µg/g	1	(2)	1	(2)	0.334	0.12695	0.29382	6.12	No	Yes (E)	No	Yes (E)
Total Silver (Ag)	µg/g	20	(2)	20	(2)	0.055	0.03906	0.553	1.85	No	No	No	No
Total Sodium (Na)	µg/g	690	(1)	690	(1)	205	168	266	1920	No	Yes (E)	No	Yes (E)
Total Strontium (Sr)	µg/g	63	(1)	63	(1)	174	122	142	755	Yes (AB, C, D, E)	Yes (AB, C, D, E)	Yes (AB, C, D, E)	Yes (AB, C, D, E)
Total Thallium (Tl)	µg/g	1	(1)	1	(1)	0.144	0.137	0.148	0.139	No	No	No	No
Total Thorium (Th)	µg/g	2.2-31	(4)	2.2-31	(4)	3.78	3.87	3.56	4.01	No	No	No	No
Total Tin (Sn)	µg/g	5	(2)	5	(2)	0.91	0.58	0.69	108	Yes (C, D)	Yes (E)	Yes (C, D)	Yes (E)
Total Titanium (Ti)	µg/g	5500	(1)	5500	(1)	874	434	639	719	No	No	No	No
Total Tungsten (W)	µg/g	<100-1000	(4)	<100-1000	(4)	0.095	0.08789	7.04	1.91	No	No	No	No
Total Uranium (U)	µg/g	23	(2)	23	(2)	0.642	0.454	0.583	1.16	No	No	No	No
Total Vanadium (V)	µg/g	130	(2)	86	(1)	36.7	27.5	30.2	31.2	No	No	No	No
Total Zinc (Zn)	µg/g	250	(2)	250	(2)	63	44	53.5	9320	No	Yes (E)	No	Yes (E)
Total Zirconium (Zr)	µg/g	<20-2000	(4)	<20-2000	(4)	1.85	2.12	1.81	14.5	No	No	No	No

Table A-21: Screening of Soil Quality for Ecological Health

		Selected Screening Criteria, Plants and Soil Invertebrates		Selected Screening Criteria, Birds and Mammals		Measured 2019 Max Concentrations				Plants and Soil		Birds and Mammals	
Analyte	Units	Screening Criteria	Reference	Screening Criteria	Reference	AB	C	D	E	COPC in the 2016 ERA?	Carried Forward as COPC?	COPC in the 2016 ERA?	Carried Forward as COPC?
PHCs													
F1 (C6-C10) - BTEX	µg/g	210	(2)	210	(2)	0	0	0	0	No	No	No	No
F1 (C6-C10)	µg/g	210	(2)	210	(2)	0	0	0	0	No	No	No	No
F2 (C10-C16 Hydrocarbons)	µg/g	150	(2)	150	(2)	0	0	0	12	No	No	No	No
F3 (C16-C34 Hydrocarbons)	µg/g	300	(2)	300	(2)	30.09146	62	44.34857	250	No	No	No	No
F4 (C34-C50 Hydrocarbons)	µg/g	2800	(2)	2800	(2)	0	0	0	750	No	No	No	No
F4G-sg (Grav. Heavy Hydrocarbons)	µg/g	2800	(2)	2800	(2)	0	0	0	3900	No	Yes (E)	No	Yes (E)
VOCs													
1,1,1,2-Tetrachloroethane	µg/g	0.05	(1)	0.05	(1)	0	0	0	0	No	No	No	No
1,1-Dichloroethane	µg/g	0.1	(2)	0.1	(2)	0	0	0	0	No	No	No	No
1,1-Dichloroethylene	µg/g	0.1	(2)	0.1	(2)	0	0	0	0	No	No	No	No
1,2-Dibromoethane (ethylene dibromide)	µg/g	0.05	(1)	0.05	(1)	0	0	0	0	No	No	No	No
1,2-Dichlorobenzene	µg/g	0.1	(2)	0.1	(2)	0	0	0	0	No	No	No	No
1,2-Dichloroethane	µg/g	0.1	(2)	0.1	(2)	0	0	0	0	No	No	No	No
1,2-Dichloropropane	µg/g	0.1	(2)	0.1	(2)	0	0	0	0	No	No	No	No
1,3-Dichlorobenzene	µg/g	0.1	(2)	0.1	(2)	0	0	0	0	No	No	No	No
1,3-Dichloropropene (cis+trans)	µg/g	25	(1)	0.05	(1)	0	0	0	0	No	No	No	No
1,4-Dichlorobenzene	µg/g	0.1	(2)	0.1	(2)	0	0	0	0	No	No	No	No
2-Butanone (Methyl Ethyl Ketone)	µg/g	35	(1)	9900	(1)	0	0	0	0	No	No	No	No
Methyl Isobutyl Ketone	µg/g	0.5	(1)	0.5	(1)	0	0	0	0	No	No	No	No
Acetone (2-Propanone)	µg/g	0.5	(1)	56	(1)	0	0	0	0	No	No	No	No
Benzene	µg/g	0.03	(2)	0.03	(2)	0	0	0	0	No	No	No	No
Bromodichloromethane	µg/g	0.05	(1)	0.05	(1)	0	0	0	0	No	No	No	No
Bromoforn	µg/g	0.05	(1)	0.05	(1)	0	0	0	0	No	No	No	No
Bromomethane	µg/g	0.05	(1)	0.05	(1)	0	0	0	0	No	No	No	No
Carbon Tetrachloride	µg/g	0.1	(2)	0.1	(2)	0	0	0	0	No	No	No	No
Chlorobenzene	µg/g	0.1	(2)	0.1	(2)	0	0	0	0	No	No	No	No
Chloroform	µg/g	0.1	(2)	0.1	(2)	0	0	0	0	No	No	No	No
cis-1,2-Dichloroethylene	µg/g	0.05	(1)	84	(1)	0	0	0	0	No	No	No	No
cis-1,3-Dichloropropene	µg/g	25	(1)	0.05	(1)	0	0	0	0	No	No	No	No
Dibromochloromethane	µg/g	0.05	(1)	0.05	(1)	0	0	0	0	No	No	No	No
Dichlorodifluoromethane (FREON 12)	µg/g	40	(1)	0.05	(1)	0	0	0	0	No	No	No	No
Ethylbenzene	µg/g	0.082	(2)	0.082	(2)	0	0	0	0	No	No	No	No
p+m-Xylene	µg/g	0.1	(3)	0.1	(3)	0	0	0	0	No	No	No	No
Methyl t-butyl ether (MTBE)	µg/g	25	(1)	0.05	(1)	0	0	0	0	No	No	No	No
Methylene Chloride(Dichloromethane)	µg/g	0.1	(2)	0.1	(2)	0	0	0	0	No	No	No	No
o-Xylene	µg/g	0.1	(3)	0.1	(3)	0	0	0	0	No	No	No	No
Styrene	µg/g	0.1	(2)	0.1	(2)	0	0	0	0	No	No	No	No
trans-1,2-Dichloroethylene	µg/g	0.05	(1)	84	(1)	0	0	0	0	No	No	No	No
trans-1,3-Dichloropropene	µg/g	25	(1)	0.05	(1)	0	0	0	0	No	No	No	No
Trichloroethylene	µg/g	100	(1)	8.1	(1)	0	0	0	0	No	No	No	No
Trichlorofluoromethane (FREON 11)	µg/g	16	(1)	0.25	(1)	0	0	0	0	No	No	No	No
Vinyl Chloride	µg/g	3.4	(1)	12	(1)	0	0	0	0	No	No	No	No
Total Xylenes	µg/g	11	(2)	11	(2)	0	0	0	0	No	No	No	No
Hexane	µg/g	0.49	(2)	0.49	(2)	0	0	0	0	No	No	No	No

Table A-21: Screening of Soil Quality for Ecological Health

		Selected Screening Criteria, Plants and Soil Invertebrates		Selected Screening Criteria, Birds and Mammals		Measured 2019 Max Concentrations				Plants and Soil		Birds and Mammals	
Analyte	Units	Screening Criteria	Reference	Screening Criteria	Reference	AB	C	D	E	COPC in the 2016 ERA?	Carried Forward as COPC?	COPC in the 2016 ERA?	Carried Forward as COPC?
PAHs													
1-Methylnaphthalene	µg/g	0.59	(1)	0.59	(1)	0	0	0.0091	0.0056	No	No	No	No
2-Methylnaphthalene	µg/g	0.59	(1)	0.59	(1)	0	0	0.0092	0.0058	No	No	No	No
Acenaphthene	µg/g	0.072	(1)	6600	(1)	0	0	0	0.041823	No	No	No	No
Acenaphthylene	µg/g	0.093	(1)	0.093	(1)	0	0	0	0	No	No	No	No
Anthracene	µg/g	2.5	(2)	2.5	(2)	0	0	0	0.048847	No	No	No	No
Benzo(b)fluoranthene	µg/g	0.1	(2)	0.1	(2)	0.01	0.004163	0.0089	0.1	No	No	No	No
Benzo(a)anthracene	µg/g	0.5	(1)	0.1	(2)	0.0052	0	0.004761	0.086	No	No	No	No
Benzo(a)pyrene	µg/g	20	(2)	20	(2)	0.0067	0	0.0064	0.081	No	No	No	No
Benzo(g,h,i)perylene	µg/g	6.6	(1)	0.68	(1)	0.0071	0.0058	0.0075	0.083	No	No	No	No
Benzo(k)fluoranthene	µg/g	7.6	(1)	0.48	(1)	0.002909	0	0	0.034582	No	No	No	No
Chrysene	µg/g	7	(1)	2.8	(1)	0.0054	0	0.0061	0.077	No	No	No	No
Dibenz(a,h)anthracene	µg/g	0.1	(2)	0.1	(2)	0	0	0	0.01	No	No	No	No
Fluoranthene	µg/g	50	(1)	0.69	(1)	0.011	0.003637	0.0092	0.26	No	No	No	No
Fluorene	µg/g	0.12	(1)	0.12	(1)	0	0	0	0.041499	No	No	No	No
Indeno(1,2,3-cd)pyrene	µg/g	0.38	(1)	0.23	(1)	0.0064	0	0.004912	0.061	No	No	No	No
Naphthalene	µg/g	0.6	(1)	380	(1)	0	0	0.004408	0.007	No	No	No	No
Phenanthrene	µg/g	6.2	(1)	2700	(1)	0.0057	0	0.0082	0.26	No	No	No	No
Pyrene	µg/g	1	(1)	4700	(1)	0.02	0	0.0086	0.18	No	No	No	No
Other													
Cyanide (free)	µg/g	0.9	(2)	0.11	(1)	0.07	0.05	0.01	0.33	No	No	No	Yes (E)
Total Phosphorus	µg/g	1100	(1)	1100	(1)	751	661	782	672	No	No	No	No

Reference:

- Standards Development Branch, Ontario Ministry of the Environment, 2011. Rationale for the Development of Soil and Ground Water Standards for Use at contaminated Sites in Ontario. April.
- CCME. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health. Accessed on July 2020.
- CCME (1991). Interim Canadian Environmental Quality Criteria for Contaminated Sites. September.
- Dragun and Chiasson (1991). Elements in North American Soils.

Notes

^a Calcium is a natural component in soil, and is an essential nutrient for life. It is not a toxicant for ecological receptors and therefore is not carried forward as a COPC.

Table A-22: Screening of Groundwater Quality for Ecological Health

Analyte	Units	MOE GW3 Value ¹	Maximum Analyzed Concentration, All Wells				Estimated Maximum Concentration in Lake Ontario ^a	Selected Surface Water Screening Criteria ^b	Carried Forward as COPC?
			2016	2017	2018	2019			
F1 (C6-C10)	µg/L	750	25	25	110	180	0.070	167	No
F1 (C6-C10) - BTEX	µg/L	750	25	25	110	170	0.067	167	No
F2 (C10-C16 Hydrocarbons)	µg/L	970	240	100	100	100	0.094	42	No
F3 (C16-C34 Hydrocarbons)	µg/L	- ^c	200	200	200	200	0.078	200	No
F4 (C34-C50 Hydrocarbons)	µg/L	- ^c	200	200	200	200	0.078	200	No
Benzene	µg/L	5,800	18	1.3	2	5.2	0.007	370	No
Ethylbenzene	µg/L	2300	0.54	0.22	0.2	0.2	0.00021	8	No
o-Xylene	µg/L	- ^d	0.7	0.2	0.2	0.2	0.00027	2	No
p+m-Xylene	µg/L	- ^d	1.3	0.46	0.44	3.7	0.0014	2	No
Toluene	µg/L	18000	0.74	0.22	0.4	0.59	0.00029	4	No
Total Xylenes	µg/L	4200	2	0.46	0.44	3.7	0.00145	2	No

Reference:

- Standards Development Branch, Ontario Ministry of the Environment, 2011. Rationale for the Development of Soil and Ground Water Standards for Use at contaminated Sites in Ontario. April.
- OPG 2018. Review of the Darlington Nuclear Site Specific Survey. Report No. NK38-REP-03443-10004-R0000. December

Notes:
^a Maximum in groundwater times nearshore dilution factor (DF); DF = groundwater flow / alongshore flow.

Groundwater flow = 3.17E-8 m/s (CSA N288.1-14) x seepage area (120m offshore x1000m alongshore).

Alongshore flow = 0.081 m/s (OPG, 2018)² x wave zone cross-sectional area (120m offshore x 2m water depth / 2).

^b See Table A.8 for references for these selected screening criteria. For all metals, the screening criteria for total metal and inorganics were also used to screen concentration of the dissolved metal ions.

^c There is no MOE GW3 values for F3 and F4 of PHCs. However, these heavy fractions do not travel along the groundwater flow to the mixing zone in Lake Ontario. Therefore, no screening is considered necessary.

^d There is no MOE GW3 values for o-xylene and p+m-xylenes. Total xylenes were screened instead.

Appendix B Sampling Locations for 2018 to 2019 Environmental Studies



Figure B-1: Location of Surface Water Sampling in Lake Ontario, 2019 Environmental Studies (Ecometrix, 2020)



Figure B-2: Location of Surface Water and Sediment Sampling in On-Site Ponds, 2019 Environmental Studies (Ecometrix, 2020)

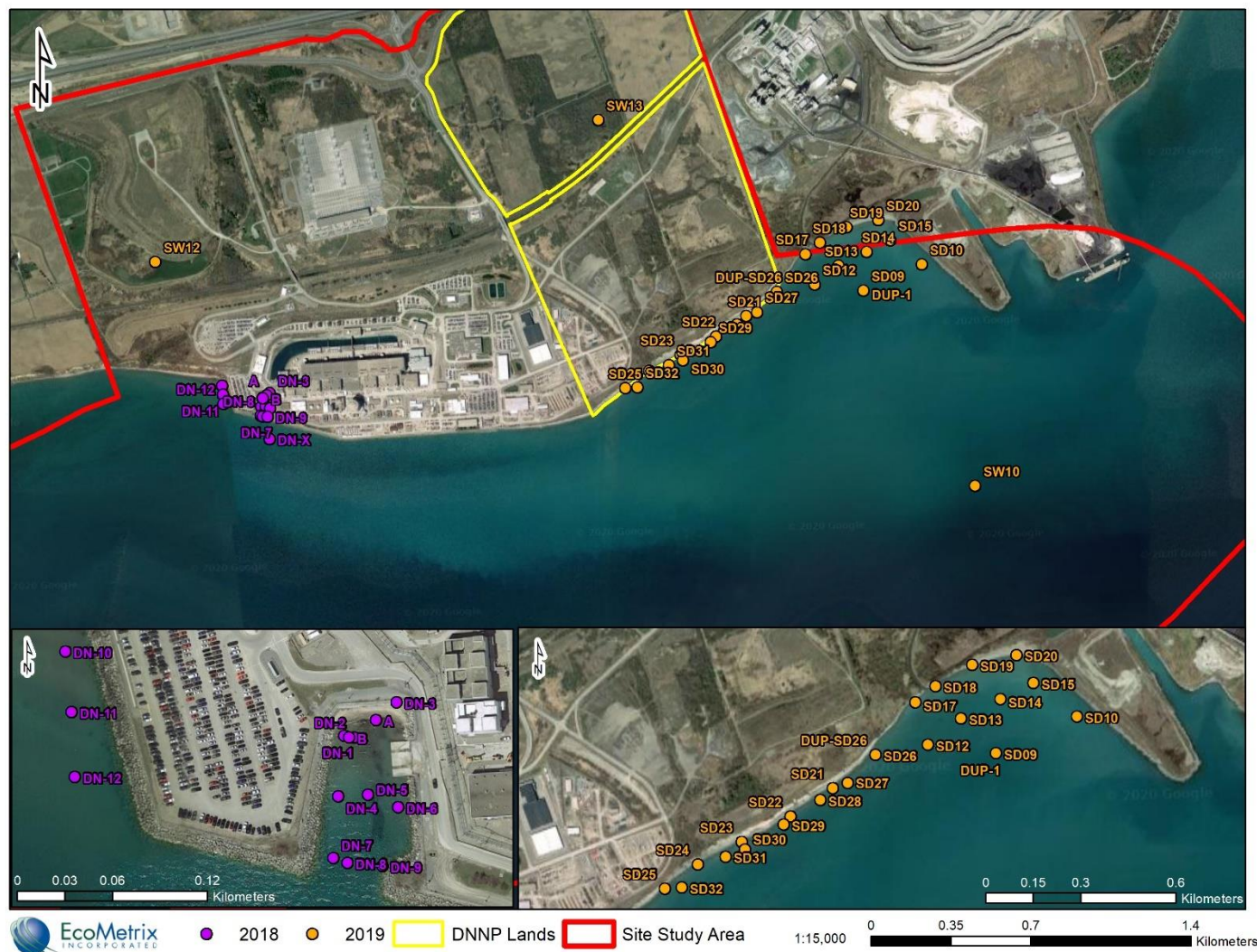


Figure B-3: Location of Sediment Sampling in Lake Ontario, 2018-2019 Environmental Studies (Ecometrix, 2018, 2019, 2020)



Figure B-4: Locations of Soil Sampling on the DN Site, 2019 Environmental Studies (Ecometrix, 2020)

Appendix C Ecological Receptor Profiles

One of the key considerations, which defines the scope of a risk assessment, is the selection of ecological receptors. In selecting ecological receptors, it is important to identify plants and animals that are likely to be most exposed to the effects of the project. As it is not possible to evaluate all ecological species at a site, representative VECs are generally selected based on several criteria as discussed in Section 4.1.2 of the main report.

This appendix details the aquatic and terrestrial ecological receptors (groups or species) selected for the assessment.

C.1 Aquatic Biota

C.1.1 Fish

C.1.1.1 Northern Redbelly Dace

The Northern Redbelly Dace (*Chrosomus eos*) is a cool water forage fish that inhabits lakes, bogs, ponds, and creeks across Canada and the northern areas of the St. Lawrence (Ontario Freshwater Fishes Life History Database, n.d; Stasiak, 2006). Spawning events typically take place in the late spring (May) and early summer (July) with five to 30 fertilized eggs being produced per event (Ontario Freshwater Fishes Life History Database, n.d; Stasiak, 2006). Eggs hatch about eight to 10 days later (Stasiak, 2006). The Northern Redbelly Dace is an invertivore and planktivore fish that primarily feeds on plant material (detritus, macrophytes and filamentous algae) (Stasiak, 2006). Predators of the Northern Redbelly Dace include fish such as trout, birds such as the kingfishers and mergansers, and aquatic invertebrates such as beetles and giant water bugs (Scott and Crossman, 1973; Stasiak, 2006).

C.1.1.2 Round Whitefish

The Round Whitefish (*Prosopium cylindraceum*) is a cold water lake fish. Spawning migrations may be undertaken by some Round Whitefish populations. Adults typically weigh between 454 g and 1360 g. Spawning occurs along lake and stream shorelines in late fall or early winter in southern Canada over gravel shoals or river mouths. Round whitefish are shallow water bottom feeders. Females lay an average of 5,000 to 12,000 eggs. Round whitefish hatch as sac fry in March to May and remain on the bottom, seeking shelter in rubble and boulders. Older juveniles, age 1 and 2, live in the same areas as adults but in shallower water and tend to move into deeper and faster water as they grow. Round whitefish eat a variety of invertebrates including mayfly larvae, chironomid larvae, small mollusks, crustaceans, fish, and fish eggs. Fish in lakes may eat more molluscs and small crustaceans than those in rivers (DFO, 2007; IF&W, 2001).

C.1.1.3 White Sucker

White Sucker (*Catostomus commersonni*) is a freshwater fish found in lakes and streams across North America. It is a bottom feeding fish that resides mainly in shallow, warm waters. The White Sucker spawns in spring, April or May, in moderate to swift riffles, in gravelly and stony areas, when the water temperature is above 4°C. Spawning may also take place in the shallow water of lakes. Females randomly scatter 30,000 to 130,000 eggs over the spawning grounds. Fry (1.2 cm in length) feed primarily on plankton and other small free-floating invertebrates. When the White Sucker reaches a length of about 1.6 to 1.8 cm, it begins bottom feeding. White suckers are preyed upon by birds, fishes, lamprey and mammals. In this assessment, White Suckers are assumed to spend half of their time at the sediment surface and the other half immersed in the water (Ontario Fish Species, n.d.).

C.1.1.4 Alewife

Alewife (*Alosa pseudoharengus*) is a member of the herring family. Alewife are found in Lake Ontario, although there is debate as to whether the Alewife population found in Lake Ontario is native or introduced. In its native range, alewives are anadromous, they are quite capable of completing its life cycle in freshwater environments. Adult Alewife average about 6 to 7 inches in length in the freshwater variety. Alewives live for about 6 to 7 years and usually begin to reproduce around two years of age. Alewife spawn once a year from late April to early June. Females randomly deposit 10,000 to 12,000 eggs. In less than a week, the young alewives hatch and begin feeding primarily on zooplankton. In the fall, the young alewives make their way back to the sea or into the deep waters of freshwater lakes or rivers. Adult alewives feed on zooplankton, aquatic insects, and small fish (Indiana DNR, n.d.).

C.1.1.5 Lake Trout

Lake Trout (*Salvelinus namaycush*) is a freshwater char. Lake trout mainly reside in deep lakes in northern North America where the water is cold and oxygen-rich. In spring, Lake Trout are widely dispersed in the shallow waters of their habitat but, as soon as the water warms they migrate to deeper and colder water. Adults are generally 38 to 52 cm in length and have an average weight of 4.5 kg. In general, Lake Trout spawn on rocky reefs or shoals in the fall. Spawning takes place at night during which the eggs are scattered over the rocky bottom. The eggs remain among the rocks for weeks and hatch the following spring. Within a month or so after hatching, the young Lake Trout usually seek deeper water and are thought to be reclusive, plankton feeders during their first few years of life. The Lake Trout's diet varies depending on the season; in the summer months they become more planktivorous and during the cooler months, they become piscivorous (DFO, 2013).

C.1.1.6 American Eel

The American Eel (*Anguilla rostrata*) is a freshwater species found on the eastern coast of North America, and enter Ontario through the St. Lawrence River and Lake Ontario. The eel has a snake-like body and a dorsal fin that extends from half-way down the length of its back to the underside of its body. At maturity, eel range from 75 to 100 centimetres (cm) in length and weigh one to three kilograms. American Eel have a complex life cycle, which begins with breeding in the Sargasso Sea in the Atlantic Ocean (OMNR, 2007). Young eels migrate to inland streams where they proceed to feed and mature in freshwater bodies for 10 to 25 years, before returning to the Sargasso Sea to spawn (OMNR, 2007). The majority of American Eel found in Ontario are large, highly fecund (egg-laden) females. The eel is an important indicator of ecosystem health, and is a top predator. The American Eel is designated an endangered species and is protected under the Provincial *Endangered Species Act*, 2007. The American Eel is designated as “threatened” under COSEWIC and “endangered” under SARO.

C.1.2 Reptiles and amphibians

Reptiles (class: Reptilia) are cold blooded animals with scales or scutes rather than fur and feathers like mammals and birds. Common animals within the class include turtles, snakes and lizards. Most reptiles are oviparous (egg-laying) but do not require water bodies in which to breed.

Amphibians (class: Amphibia) typically inhabit a wide variety of habitats with most species bridging terrestrial and aquatic ecosystems during their life cycle. Common animals within the class include frogs and salamanders. Amphibians rely on surface water for reproduction as larvae are typically born in water. The young generally undergo metamorphosis from larva with gills to an adult air-breathing form with lungs. With their complex reproductive needs and permeable skins, amphibians are often used as ecological indicators.

Reptiles represented by turtles and amphibians represented by frogs are being model for Treefrog Pond, Polliwog Pond and Dragonfly Pond because these ponds provide a habitat for reptiles and amphibians.

C.1.3 Aquatic Plants

C.1.3.1 Macrophytes

Macrophytes are aquatic plants growing in or near water and can be either emergent, submergent or floating. Macrophytes are primary producers that provide food, cover and shelter for wildlife, such as spawning and nursery habitats for fish and nesting habitats for waterfowl, improve water quality and clarity, and help to stabilize shorelines and bottom sediments. Emergent aquatic plants such as cattails and bur-reed are found along the edges of on-site ponds at DN (Golder and SENES, 2009). Macrophytes such as cattails provide food for Muskrats.

Because of the waves and/or unsuitable substrates along the nearshores of Lake Ontario, rooted aquatic plants are not found along the shores of Lake Ontario near the DN.

Photosynthetic organisms are limited to attach algae.

Macrophytes are aquatic plants in the ecological model for Coot's Pond and Treefrog Pond, which includes Dragonfly and Polliwog ponds.

C.1.4 Benthic Invertebrates

Benthic invertebrates or "benthos" live and feed within sediments. Benthic invertebrates include, among others, amphipods, bivalves, shrimps, crabs, snails, worms, and aquatic insects. They play an integral role in the integrity of the freshwater ecosystem through their role in nutrient cycling and function as an important food source for wildlife such as the diving (e.g. Bufflehead) and dabbling (e.g. Mallard) ducks and fish (e.g. White Sucker). Benthic invertebrates provide a sediment to fish pathway link and a link between aquatic and terrestrial ecosystems. Many species feed on decaying organic matter and thereby form an important link between the decomposer and primary consumer levels.

The Lake Ontario nearshore benthic community is limited to species such as the zebra mussels and quagga mussels, which can withstand the abrasive wave actions and coarse substrates of the nearshore environment, whereas the habitat of Coot's Pond is favourable to support a diverse benthic community (Golder and SENES, 2009).

Benthic invertebrates are being model for Lake Ontario and Coot's Pond.

C.2 Riparian Birds

Birds are mobile receptors that will forage from a large home range. During breeding and rearing of young, the home range is often reduced.

C.2.1.1 Bufflehead

The Bufflehead (*Bucephala albeola*) is Canada's smallest diving duck. Males average 450 g in weight and females about 340 g. During migration they may carry up to an additional 115 g of fat. Their breeding habitat is small ponds, usually in wooded areas. They are not gregarious and typically occur in groups of 10 birds or fewer. Their summer breeding range is north and west of the Great Lakes. Their Canadian overwinter range includes the west coast and favoured spots around Lake Ontario and the southern coasts of New Brunswick and Nova Scotia. Buffleheads nest in tree cavities. The female lays a clutch of 7 to 11 eggs. Hatching occurs about 30 days later and ducklings remain in the nest only 24 to 36 hours before being led to the nearest waterbody. The young may be eaten by pike or other predators. The Buffleheads' main foods are arthropods, mostly insect larvae in freshwater and small crustaceans, such as shrimps, crabs, amphipods, in salt water. In fall they eat many seeds of aquatic plants, and in winter they take small marine snails or freshwater clams in their respective habitats (EC & CWF, 2013).

The average territory size of the Bufflehead in ponds in British Columbia was measured to be 0.56 hectares (Gauthier, 1993).

For the ecological model it is assumed that the Bufflehead diet consists of benthic invertebrates (90%) and aquatic plants (10%). It is also assumed that the Bufflehead spends 50% of its time at DN.

C.2.1.2 Mallard

The Mallard (*Anas platyrhynchos*) is an omnivorous migratory duck that may breed over winter in Canada (U.S. EPA, 1993; FCSAP, 2012). Males average 1.1 kg in weight and females about 1.2 kg in weight (FCSAP, 2012). The general habitat of the Mallard is wetlands. Mallard typically nest on the ground in thick vegetation away from a waterbody. The female lays a clutch of 1 to 13 eggs with hatching occurring about 23 to 30 days later (Drilling, et al., 2002). Ducklings remain in the nest only 13 to 16 hours before leaving the nest (Drilling, et al., 2002).

The bulk of the Mallard's diet is plant material (mostly aquatic plants and seeds) with the remaining portions of the diet consisting of aquatic invertebrates, especially in the breeding season (FCSAP, 2012). The Mallard forages by dabbling and filtering through sediment (U.S. EPA, 1993).

The mean home range of a Mallard is between 111 and 620 hectares in spring (U.S. EPA, 1993).

For the ecological model it is assumed that the Mallard diet, based on breeding, consists of benthic invertebrates (75%) and aquatic plants (25%). It is also assumed that the Mallard spends 50% of its time at DN.

C.2.1.3 Green Heron

The Green Heron (*Butorides virescens*) is a riparian piscivore that breeds in southern Ontario, southwestern BC, and southern Quebec, and migrates for winter to the southern US and northern South America (David and Kushlan, 1994). Green Heron is a small member of the Heron family, with an average weight of 175 g (Animal Diversity Web. Accessed on Oct 25, 2020). Green Heron generally prefers wetland habitats, and nests in forest and swamp patches. It breeds once annually, and the female Green Heron lays a clutch of 2-4 eggs per breeding season. Incubation usually lasts for 19-21 days. Fledging occurs when chicks are 16-17 days old, and independence is gained between 30-35 days (Hancock, 1999).

At the DN Site, Green Heron is known to breed at the Coot's Pond area (Beacon 2019). For the ecological model it is assumed that the diet of Green Heron consists of 100% fish from Coot's Pond. It is also assumed that the Green Heron spends 50% of its time at DN.

C.3 Riparian Mammals

C.3.1 Muskrat

The Muskrat (*Ondatra zibethicus*) is a large rodent, measuring approximately 50 cm from tip of the nose to tail, and weighing on average 1 kg. Muskrats exist all over North America, from the Arctic Ocean in the north to the Gulf of Mexico in the south, from the Pacific Ocean in the west to the Atlantic Ocean in the east. Muskrats prefer freshwater marshes, marshy areas of lakes, and slow-moving streams. The preferred water depth in these areas is 1 to 2 m, deep enough not to freeze fully during the winter but shallow enough to allow aquatic vegetation to grow. Muskrats nest in compact mounds of partially dried and decayed plant material such as cattails and bulrushes. In winter, Muskrats generally occupy lodges that they build through burrowing underneath their mounds (EC & CWF, 2013).

Muskrats mainly feed on aquatic plants such as cattails, bulrushes, horsetails, or pondweeds; however, they prefer cattails. When aquatic plants are unavailable, Muskrats are also known to feed on fish, frogs, and clams. Breeding generally occurs in March, April, or May. Birth of the litter usually occurs within 1 month of mating and usually contains 5 to 10 young. Breeding can occur multiple times throughout the season (EC & CWF, 2013).

The mean home range size of a Muskrat in the summer ranges between 0.048 to 0.17 hectares (U.S. EPA, 1993).

For the ecological model it is assumed that the Muskrat's diet consists of aquatic plants (100%) and that it spends 100% of its time at DN.

C.4 Terrestrial Biota

C.4.1 Earthworms

Earthworms live in soil, and depending on the species they either move vertically or horizontally in different soil layers. Earthworms acquire their nutrition through the organic matter in soil as well as the decomposing remains of other animals. They can devour one third of their own body weight per day.

C.4.2 Terrestrial Birds

C.4.2.1 American Robin

The American Robin (*Turdus migratorius*) is a migratory thrush that may breed and over winter in Canada (FCSAP, 2012). During the breeding season, the American Robin is found across the continental United States and Canada (U.S., 1993). The average breeding male weight is 77.4 g and the average breeding female weight is 80.6 g (Wheelright, 1986 as cited in U.S. EPA, 1993). American Robins make use of a wide variety of habitats with open areas. American Robins typically nest in trees, but may also nest in gutters, eaves, external light fixtures and structures (Sallabanks and James, 1999). Females lay a clutch of 3 to 5 eggs. Eggs hatch within 12 to 14 days and the nestling

period lasts approximately 13 days (Sallabanks and James, 1999). The American Robin forages on the ground for invertebrates and in shrubs and low tree branches for fruit and foliage-dwelling insects (U.S. EPA, 1993). Earthworms and insects account for most (71%) of the nestlings and fledglings diet with the remainder of the diet consisting of vegetation, seeds and fruit (29%). Before and during the breeding season, robins predominately feed on invertebrates (between 80 to 90% volume), with fruits making up the bulk of the robin's diet for the remainder of the year (between 60 to 90% volume) (Wheelright, 1986 as cited in U.S. EPA, 1993).

The mean territory size of the American Robin ranges between 0.11 and 0.42 hectares in the spring with a mean foraging home range between 0.15 and 0.81 in the summer (U.S. EPA, 1993).

For the ecological model it is assumed that the American Robin's diet consists of 60% fruits represented by berries and 40% invertebrates, represented as Earthworms (FCSAP, 2012). It is also assumed that the American Robin spends 50% of its time at DN.

C.4.2.2 Bank Swallow

The Bank Swallow (*Riparia riparia*) nest in colonies along cliffs and the banks of streams and rivers, but can also be found in anthropogenic habitats such as gravel pits and roadcuts across much of North America (COSEWIC, 2013). The Bank Swallow weighs between 10 and 19 g. In Ontario, the breeding season spans between early May to mid- August (MNRF, 2016). Females lay a clutch of 3 to 6 eggs. Eggs hatch within 13 to 16 days and the nestling period lasts between 18 to 24 days (Garrison, 1999). Young are tended by both parents. Bank Swallows are aerial insectivores, feeding primarily while flying above clearings or open water (COSEWIC, 2013). Predators of the Bank Swallow include raptors, snakes, rats, chipmunks, Raccoons, badgers, skunks, weasels, foxes, and coyotes, among others (COSEWIC, 2013). The Bank Swallow is designated threatened and is protected under the Provincial *Endangered Species Act*, 2007. The Bank Swallow is also designated as "threatened" federally (SARA Schedule 1, as well as COSEWIC).

In the United Kingdom, mean foraging ranges from Bank Swallow colonies have been reported to be within 0.26 km when adults were providing for nestlings and within 0.69 km when building nests (MNRF, 2016).

For the ecological model it is assumed that the Bank Swallow's diet consists of 100% insects represented by the caterpillar. It is also assumed that the Bank Swallow spends 50% of its time at DN.

C.4.2.3 Song Sparrow

The Song Sparrow (*Melospiza melodia*) is the most widespread sparrow found throughout most of North America with most of the populations of the Song Sparrow being migratory. The Song Sparrow weighs between 12 and 53 g. They breed in brushy areas along streamside thickets or the edges of marshes. Nests sites may include the ground under

grass or shrubs or in shrubs and low lying trees. Song Sparrows typically lay two or more clutches of eggs per breeding season with clutch size ranging between 1 and 6 eggs. Eggs hatch within 12 to 15 days and the nestling period lasts between 9 to 12 days. The Song Sparrow forages on the ground feeding primarily on fruits and seeds, with insects being eaten mostly in the summer (Arcese et al., 2002).

The breeding territory of the Song Sparrow is typically less than 0.4 hectares (NatureServe 2015).

For the ecological model it is assumed that the Song Sparrow's diet consists of 90% grains and seeds represented by berries and 10% insects represented by the caterpillar. It is also assumed that the Song Sparrow spends 80% of its time at DN.

C.4.2.4 Yellow Warbler

The migratory Yellow Warbler (*Dendroica petechia*) is widespread throughout North America. They weigh between 9 and 11 g. They breed in streamside thickets and early successional areas typically dominated by willows. Nests are usually placed in the vertical fork of a bush or small tree. Females lay a clutch of 1 to 7 eggs. Incubation by the female lasts within 10 to 13 days and the nestling period lasts between 9 to 12 days. Young are tended by both parents. Yellow Warbler forages along the branches of shrubs, small trees and foliage gleaning off insects (Lowther et al., 1999). The Yellow Warbler may eat fruit and probe in flowers (NatureServe, 2015).

The breeding territory of the Yellow Warbler can be as small as 0.16 hectares (NatureServe, 2015).

For the ecological model it is assumed that the Yellow Warbler's diet consists of 90% insects represented by caterpillar and 10% fruits represented by berries. It is also assumed that the Yellow Warbler spends 50% of its time at DN.

C.4.3 Terrestrial Plants

C.4.3.1 Grass

Cultural meadow and thicket ecosystems make up a large portion of the terrestrial environment at DN. For the ecological model, grasses were used as a food source for the American Robin, Song Sparrow, Yellow Warbler, Eastern cottontail, Meadow Vole, White-tailed Deer, Raccoon, and Red Fox.

C.4.3.2 Sugar Maple

Four primary ecosystems have been identified for the DN: cultural meadow and thickets, shrub bluff, wetland and woodlands (Beacon, 2009). The Sugar Maple, which is found at the DN, has been identified as an indicator species for the woodland ecosystems because it is used by wildlife. For the ecological model, the Sugar Maple is used as a food source for the White-tailed Deer and Raccoon.

C.4.4 Terrestrial Mammals

C.4.4.1 Eastern Cottontail

The Eastern cottontail (*Sylvilagus floridanus*) is a medium sized rabbit, measuring 35 to 43 cm in length, and weighing between 0.7 to 1.8 kg (U.S. EPA, 1993). Females are typically 1 to 2% larger than males (Naughton, 2012). The Eastern cottontail is found in southern Canada and the eastern and western United States (U.S. EPA, 1993). Although the Eastern cottontail may be found in swamps, woodlands and grasslands, they prefer mixed farmland and hedgerow habitats (Naughton, 2012). The mean home range of the Eastern cottontail is between 0.8 and 7.8 hectares (U.S. EPA, 1993).

The Eastern Cottontail breeds throughout the year, with peak mating between January and April. Gestation lasts approximately 28 days, with females producing five to seven litters per year and 25 to 35 young per year. Although not fully weaned, young leave the litter after 14 to 16 days (U.S. EPA, 1993; Naughton, 2012).

The Eastern cottontail forages throughout the night and feeds on herbaceous vegetation such as grasses and forbs in the summer and woody vegetation such as twigs and bark in the winter (U.S. EPA, 1993). Predators of the Eastern cottontail include raptors, owls, Red Foxes and coyotes (U.S. EPA, 1993; Naughton, 2012).

For the ecological model it is assumed that the Eastern cottontail's diet consists of 100% grass and that the Eastern cottontail spends 100% of its time at DN.

C.4.4.2 Meadow Vole

The Meadow Vole (*Microtus pennsylvanicus*) is a small herbivorous rodent, measuring 8.9 to 13 cm from head to tail, and weighing between 0.02 to 0.04 kg. The Meadow Vole is found across Canada, Alaska and the northern United States. They can be found mainly in meadows, lowland fields, grassy marshes, and along rivers and lakes. They are also occasionally found in flooded marshes, high grasslands near water, and orchards or open woodland if grassy (US EPA, 1993). The Meadow Vole has a small home range size with a mean home range between 0.0069 and 0.083 hectares in the summer (U.S. EPA, 1993).

The Meadow Vole breeds throughout the year, but breeding peaks from April to October. Gestation lasts approximately 21 days, with litter sizes ranging from 1 to 9 (NatureServe, 2012). Meadow voles mainly feed on shoots, grass, and bark. Voles are prey for hawks and owls as well as several mammalian predators such as short-tailed shrews, badgers, and foxes (US EPA, 1993).

For the ecological model it is assumed that the Meadow Vole's diet consists of 100% grass and spends 100% of its time at DN.

C.4.4.3 White-tailed Deer

The White-tailed Deer (*Odocoileus virginianus*) is the smallest of the native Canadian deer, measuring 151 to 240 cm in total length, and weighing between 50 to 135 kg (adult). Males are typically 20 to 55% larger than females (Naughton, 2012).

The White-tailed Deer is widespread throughout North America. They prefer open forests intermixed with “*meadows, clearings, grasslands, and riparian flatlands*”. The White-tailed Deer home range size ranges between 60 to 500 hectares (Naughton, 2012).

The White-tailed Deer diet consists mainly of terrestrial vegetation such as fresh grasses, forbs, fruits, nuts, browse, as well as mushrooms. In areas near the Great Lakes, White-tailed Deer are known to consume alewives that have washed ashore after spawning. Predators of the white-tail deer include wolves, coyotes, cougars, and black bears (Naughton, 2012).

If a female White-tailed Deer is well nourished, it breeds yearly. Mating season for Canadian deer typically take place between late October and mid-December, with a breeding peak in mid-November. Gestation lasts approximately 200 days with first time mothers typically producing one off-spring and repeat, larger, well-nourished mothers producing two or three off-springs. Fawns are fully weaned by four months (Naughton, 2012).

For the ecological model it is assumed that the White-tailed Deer’s diet consists of 100% terrestrial vegetation (e.g. grass and/or Sugar Maple) and that the White-tailed Deer spends 100% of its time at DN.

C.4.4.4 Common (Masked) Shrew

The common (masked) shrew (*Sorex cinereus*) is the most widespread and adaptable of the North American shrews with reproductive age Canadian shrews measuring 7.5 to 12.5 cm in total length, and weighing on average between 0.0036 and 0.0046 kg. Although the Common Shrew may occupy a wide variety of habitats they are most abundant in damp and mossy woodlands. Shrews build hollow nests of grass and leaves in stumps, logs, debris or burrows, and forage under leaf litter in tunnels or runways created by other animals (Naughton, 2012).

The Common Shrew is an insectivore that eats a variety of invertebrates. During the winter, the diet of the shrew consists mostly of dormant insects and pupae with truffles and seeds being consumed when food is limited. Shrews may also eat carrion, salamanders and bird eggs. Shrews are prey for hawks and owls, herons, shrikes, snakes as well as several carnivorous mammals such as weasels, foxes, and larger shrews (Naughton, 2012). The average foraging range size of the shrew is 0.6 hectares (Nagorsen, 1996 as cited in FSCAP, 2012).

Shrews typically breed between May and September, with most females producing one to three litters annually and an average litter size of five to seven. The gestation period of the

Common Shrew is not known. Young shrews leave the nest after approximately 27 days (Naughton, 2012).

For the ecological model it is assumed that the Common Shrew's diet consists of 100% insects (e.g., Caterpillars or Earthworms) and that they spend 100% of its time at DN.

C.4.4.5 Raccoon

The Raccoon (*Procyon lotor*) is a medium sized generalist nocturnal omnivore. An adult Raccoon measures 74 to 105 cm in total length and weighs between 3.9 and 13.5 kg. Adult male Raccoons are on average 10 to 15% heavier than female Raccoons (Naughton, 2012).

The Raccoon is very adaptable and widespread throughout southern Canada. They are abundant in urban, riparian, and wetland areas (Naughton, 2012). Tree cavities, spaces in rocks, caves, brush, uninhabited fox dens, Muskrat houses, squirrel and bird nests, buildings such as attics, basements and barns are used as Raccoon dens. The Raccoon has a mean home range between 39 and 2560 hectares, with male Raccoons occupying larger home ranges than female Raccoons (U.S. EPA, 1993; Naughton, 2012).

The Raccoon eats masts, grains, insects, aquatic invertebrates, fish, reptiles and amphibians, reptile eggs, small mammals, small birds and eggs, carrion, and human garbage. Animal matter makes up a good portion of the Raccoon's diet in the spring and early summer, while fruits make up the bulk of the Raccoon's diet in the late summer and fall. In the winter, acorns are typically consumed, however if available, grains and masts may also be consumed. Predators of the Raccoon include owls, coyotes, wolves, cougars, fishers, and foxes (U.S. EPA, 1993; Naughton, 2012).

Breeding season for the Raccoon typically begins in early February and ends in June, with peak breeding taking place in March. Gestation lasts approximately 63 days, with a mean litter size between 2 and 4 cubs. A female typically produces one litter per year. Cubs begin to forage on their own at approximately 18 months of age (U.S. EPA, 1993; Naughton, 2012).

For the ecological model it is assumed that the Raccoon's diet consists of 10% benthic invertebrates (for polygon AB); 15% fruits; 25% terrestrial vegetation (represented by grass for polygon AB and C, and grass and Sugar Maple in equal portion for polygons D and E); 10% small mammals (represented by the Meadow Vole), and 40 or 50% invertebrates (represented by caterpillars for polygons AB, C and D, and represented by Earthworms for polygon E). The Raccoon is assumed to spend 100% of its time at DN.

C.4.4.6 Red Fox

The Red Fox (*Vulpes vulpes*) is a small mammal that ranges in length between 90 and 112 cm, and weighs approximately 4.54 kg (US EPA, 1993). Red foxes are found throughout Canada in all provinces and territories. They generally occupy a home range between 4 to 8 km² and reside in a main underground den and one or more other burrows

within their home range. The tunnels are up to 10 m long and lead to a chamber 1 to 3 m below surface. Foxes breed between late December and mid-March, and pups are born from March through May, with litter sizes ranging from 1 to 10. Pup-rearing is the primary focus of the Red Fox during spring and early summer. Their diet is predominantly small mammals such as mice and voles, but they also eat insects, fruits, berries, seeds and nuts. Their diet varies with the seasons, eating mainly small mammals in fall and winter, nesting waterfowl in the spring, and insects and berries in the summer (EC & CWF, 2013).

For the ecological model it is assumed that the Red Fox's diet consists of 70% small mammals (48% Eastern cottontails and 32% Meadow Voles) and 30% terrestrial plants represented by grass for polygons C, D and E, and 50% small mammals (30% Eastern cottontails and 20% Meadow Voles), 30% aquatic birds (15% Bufflehead and 15% Mallard), and 20% terrestrial plants represented by grass for polygon AB. The Red Fox is assumed to spend 100% of its time at DN.

C.4.4.7 Short-tailed Weasel

The Short-tailed Weasel (*Mustela erminea*) or the ermine is a small mammal. A Canadian adult weasel ranges in total length between 22 and 36 cm, and weighs between 0.05 and 0.24 kg, with males being up to 80% heavier than female weasels (Naughton, 2012).

The Short-tailed Weasel is found throughout Canada in all provinces and territories. They inhabit successional forests, woodlands, parklands, edges of forests, wetlands such as marshes, riverbanks, and farmlands. The weasel uses trees cavities, rock openings, prey burrows, and subnivean runways or areas as their dens, while the fur and feathers of their prey are used to line their nests. The home range of a Canadian male weasel ranges between 1 and 205 hectares, whereas the home range of a Canadian female weasel ranges between 4 and 95 hectares. Weasels found in western Canada occupying larger home ranges than weasels found in eastern Canada (Naughton, 2012).

The diet of the Short-tailed Weasel is predominantly small mammals such as mice and voles, but they also eat lemmings, rabbits and hares, squirrels, shrews, chipmunks, birds, bird eggs, reptiles, amphibians, fish, and invertebrates. Short-tailed weasels are prey for raptors and owls, foxes, coyotes, snakes and larger weasels. Because of their high metabolism, starvation is the primary cause of death for the Short-tailed Weasel. Missing two or three consecutive meals is enough to cause death (Naughton, 2012).

Breeding season for the Short-tailed Weasel takes place between April and June. Gestation lasts approximately 11 to 12 months, with females producing a mean litter size of 4 and 8 kits. Young are weaned after approximately 12 weeks of age (Naughton, 2012).

For the ecological model it is assumed that the Short-tailed Weasel's diet consists of 100% Meadow Voles. It is also assumed that the Short-tailed Weasel spends 100% of its time at DN.

C.5 References

- Arcese, Peter, Mark K. Sogge, Amy B. Marr and Michael A. Patten. 2002. Song Sparrow (*Melospiza melodia*). In The Birds of North America, No. 704 (A. Poole, Ed.). The Birds of North America Online, Ithaca, New York.
- Beacon Environmental (Beacon). 2019. Darlington New Nuclear Project Terrestrial Environmental Existing Conditions. 2010-2019 Baseline Update. NK054-REP-07730-0801575. December.
- Beacon Environmental (Beacon). 2009. Terrestrial Environment Existing Environmental Conditions Technical Support Document, New Nuclear- Darlington Environmental Assessment. Submitted to: Ontario Power Generation Inc., Prepared by: Beacon Environmental, September 2009.
- Covich, A.P., Palmer, M.A., Crowl, T.A. 1999. The Role of Benthic Invertebrates Species in Freshwater Ecosystems: Zoobenthic species influence energy flows and nutrient cycling. BioScience, 49: 119-127.
- COSEWIC. 2013. COSEWIC assessment and status report on the Bank Swallow *Riparia riparia* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 48 pp.
- Davis, W., Kushlan J., 1994. The Green Heron. The Bird of North America.
- Drilling, N., R. Titman, and F. McKinney. 2002. Mallard (*Anas platyrhynchos*). In The Birds of North America, No. 658 (A. Poole and F. Gill, eds.). The Birds of North America Online, Ithaca, New York.
- Environment Canada and Canadian Wildlife Federation (EC & CWF). 2013. Hinterland Who's Who. Retrieved from, <http://www.hww.ca/en/species/>.
- FCSAP. 2012. Ecological Risk Assessment Guidance, Module 3: Standardization of Wildlife Receptor Characteristics. Prepared for: Environment Canada (Government of Canada), Vancouver, B.C. Prepared by Azimuth Consulting Group, Vancouver, B.C., March 2012.
- Fisheries and Oceans Canada (DFO). 2013. Ontario Great Lakes Fact Sheets. Lake Trout. Retrieved from, <http://www.dfo-mpo.gc.ca/regions/central/pub/factsheets-feuilletsinfos-ogla-rglo/laketrou-touladi-eng.htm>
- Fisheries and Oceans Canada (DFO). 2007. Fish life history and habitat use in the Northwest Territories: Round Whitefish (*Prosopium cylindraceum*). Retrieved from, <http://www.dfo-mpo.gc.ca/Library/332060.pdf>

- Garrison, B. A. 1999. Bank Swallow (*Riparia riparia*). In The Birds of North America, No. 414 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Gauthier, Gilles. 1993. Bufflehead (*Bucephala albeola*). In The Birds of North America, No. 67 (A. Poole and F. Gill, eds.). The Birds of North America Online, Ithaca, New York.
- Golder Associates and SENES Consultants Limited. 2009. Aquatic Environment Existing Environmental Conditions Technical Support Document New Nuclear- Darlington Environmental Assessment. Submitted to: Ontario Power Generation Inc., Prepared by: Golder Associates and SENES Consultants Limited, September 2009.
- Hancock, J., 1999. Herons and Egrets of the World. London, UK: Academic Press.
- International Programme on Chemical Safety (IPCS) INCHEM. 1998. Zirconium. Harrison, W.N., Bradberry, S.M., Vale, J.A., National Poisons Information Service, Birmingham, U.K. Available at:
<http://www.inchem.org/documents/ukpids/ukpids/ukpid90.htm>
- Indiana Department of Natural Resources. n.d. Aquatic Invasive Species. Retrieved from, <http://www.in.gov/dnr/files/ALEWIFE.pdf>
- Inland Fisheries and Wildlife (IF&W). 2001. Whitefish Management Plan. Retrieved from, <http://www.maine.gov/tools/whatsnew/attach.php?id=442566&an=1>
- Lowther, P. E., C. Celada, N. K. Klein, C. C. Rimner, and D. A. Spector. 1999. Yellow Warbler (*Dendroica petechia*). In The Birds of North America, No. 454 (A. Poole and F. Gill, eds.). The Birds of North America Online, Ithaca, New York.
- NatureServe. 2012. An Online Encyclopedia of Life. Version 7.1. Retrieved from, <http://www.natureserve.org/explorer/>
- NatureServe. 2015. An Online Encyclopedia of Life. Version 7.1 (2 February 2009). Retrieved from, <http://www.natureserve.org/explorer/>
- Naughton, D. 2012. The Natural History of Canadian Mammals. Canadian Museum of Nature and University of Toronto Press, Toronto, Ontario.
- Ontario Fish Species. n.d. White Sucker. Retrieved from, <http://www.ontariofishspecies.com/white-sucker.html>
- Ontario Freshwater Fishes Life History Database. n.d. Northern Redbelly Dace. Retrieved from, http://www.ontariofishes.ca/fish_detail.php?FID=19 Ontario Ministry of Natural Resources (OMNR). 2007. State of resources reporting: American eel in Ontario. February. Available at:

http://www.mnr.gov.on.ca/stdprodconsume/groups/lr/@mnr/@sorr/documents/document/stel02_166010.pdf

Ontario Ministry of Natural Resources and Forestry (MNRF). 2016. Bank Swallow (*Riparia riparia*) in Ontario. Ontario Recovery Strategy Series. Available at: https://files.ontario.ca/mnrf_bans_rs_final-accsbl.pdf

Sallabanks, Rex and Frances C. James. 1999. American Robin (*Turdus migratorius*). In The Birds of North America, No. 462 (A. Poole, Ed.). The Birds of North America Online, Ithaca, New York.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Bull. Fish. Res. Board Can. 184. [1998 Reprint] Galt House Publications Ltd. Oakville, ON. xx + 966 pp.

Stasiak, R. 2006. Northern Redbelly Dace (*Phoxinus eos*): A Technical Conservation Assessment. Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project. Prepared by Richard Stasiak, Department of Biology, University of Nebraska at Omaha, Omaha, NE, February, 2006.

United States Environmental Protection Agency (U.S. EPA). 1993. Wildlife Exposure Factors Handbook. Document No. EPA/600/R-93/187. December.

Wheelwright, N.T. 1986. The diet of American robins: an analysis of U.S. Biological Survey records. Auk 103:710-725 (as cited in the U.S. EPA, 1993).

Appendix D Modelled Concentrations for Ecological Receptors

Table D.1: Modelled Radiation Concentration for Aquatic Biota for Polygon Lake Ontario

Receptor	Unit	Carbon-14		Cobalt-60		Cesium-134		Cesium-137		Tritium		Iodine-131	
		Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Lake Trout	Bq/kg (fw)	1.31E+03	1.78E+02	1.70E+01	1.87E+00	2.01E+03	3.29E+02	2.54E+03	4.97E+02	1.16E+01	1.29E+00	6.60E+00	2.46E+00
American Eel	Bq/kg (fw)	1.31E+03	1.78E+02	1.70E+01	1.87E+00	2.01E+03	3.29E+02	2.54E+03	4.97E+02	1.16E+01	1.29E+00	6.60E+00	2.46E+00
Bufflehead	Bq/kg (fw)	4.23E+01	3.89E+01	2.21E-01	2.06E-01	6.52E-01	5.83E-01	6.75E-01	5.90E-01	1.63E+01	1.52E+01	1.91E-01	1.91E-01
Mallard	Bq/kg (fw)	4.23E+01	3.89E+01	2.08E-01	1.94E-01	6.14E-01	5.48E-01	6.36E-01	5.55E-01	1.63E+01	1.52E+01	1.80E-01	1.79E-01

Table D.2: Modelled Radiation Concentration for Media and VECs for Polygon AB

Receptor	Unit	Carbon-14		Cobalt-60		Cesium-134		Cesium-137		Tritium		Iodine-131	
		Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Loam Pore Water	Bq/L	1.17E-01	1.17E-01	0.00E+00	0.00E+00	5.40E-04	5.40E-04	1.49E-02	1.49E-02	7.79E+02	7.79E+02	1.22E-01	1.22E-01
Turtles	Bq/kg (fw)	3.99E+02	3.51E+02	6.43E+00	4.88E+00	5.11E+02	5.11E+02	7.32E+02	6.83E+02	3.51E+01	3.04E+01	2.31E+01	1.39E+01
Frogs	Bq/kg (fw)	3.99E+02	3.51E+02	6.43E+00	4.88E+00	5.11E+02	5.11E+02	7.32E+02	6.83E+02	3.51E+01	3.04E+01	2.31E+01	13.86
Aquatic Plants	Bq/kg (fw)	3.89E+01	3.51E+01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	4.30E+01	4.16E+01	2.00E+00	2.00E+00
Benthic Invertebrates	Bq/kg (fw)	3.64E+02	3.20E+02	1.31E+01	9.93E+00	1.45E+01	1.45E+01	2.07E+01	1.93E+01	3.51E+01	3.04E+01	3.70E+01	2.22E+01
Bufflehead	Bq/kg (fw)	3.64E+02	3.20E+02	2.44E+00	1.86E+00	7.50E+00	7.50E+00	1.07E+01	1.00E+01	2.26E+01	0.00E+00	6.33E-02	3.81E-02
Mallard	Bq/kg (fw)	3.10E+02	2.73E+02	1.95E+00	1.49E+00	5.97E+00	5.97E+00	8.49E+00	7.93E+00	2.30E+01	0.00E+00	5.04E-02	3.06E-02
Muskrat	Bq/kg (fw)	6.25E+01	5.64E+01	1.69E-02	1.67E-02	8.73E-01	8.73E-01	8.99E-01	8.95E-01	4.59E+01	4.34E+01	8.26E-01	6.99E-01
Green Heron	Bq/kg (fw)	3.50E+01	3.19E+01	2.33E-01	2.31E-01	6.53E-01	6.53E-01	6.66E-01	6.64E-01	3.50E+01	3.31E+01	6.47E-01	6.46E-01
American Robin	Bq/kg (fw)	3.14E+01	3.06E+01	5.26E-01	5.24E-01	1.47E+00	1.47E+00	1.58E+00	1.58E+00	2.41E+01	2.36E+01	2.44E-02	2.36E-02
Bank Swallow	Bq/kg (fw)	3.39E+01	2.95E+01	4.32E-01	4.30E-01	1.21E+00	1.21E+00	1.28E+00	1.27E+00	2.62E+01	2.53E+01	2.36E-02	2.25E-02
Song Sparrow	Bq/kg (fw)	4.74E+01	4.62E+01	1.05E+00	1.05E+00	2.94E+00	2.94E+00	3.04E+00	3.03E+00	5.16E+01	5.07E+01	2.42E-02	2.28E-02
Yellow Warbler	Bq/kg (fw)	3.36E+01	2.94E+01	4.67E-01	4.65E-01	1.31E+00	1.31E+00	1.37E+00	1.37E+00	2.66E+01	2.58E+01	2.36E-02	2.27E-02
Eastern Cottontail	Bq/kg (fw)	5.79E+01	5.63E+01	1.88E-02	1.86E-02	9.71E-01	9.71E-01	1.05E+00	1.05E+00	2.38E+02	1.59E+02	4.74E+00	4.61E+00
Meadow Vole	Bq/kg (fw)	5.79E+01	5.63E+01	7.61E-03	7.52E-03	3.94E-01	3.94E-01	4.13E-01	4.11E-01	2.38E+02	1.59E+02	1.95E+00	1.87E+00
White-tailed Deer	Bq/kg (fw)	5.79E+01	5.63E+01	2.64E-02	2.61E-02	1.36E+00	1.36E+00	1.43E+00	1.42E+00	2.65E+02	1.76E+02	6.73E+00	6.48E+00
Common Shrew	Bq/kg (fw)	5.59E+01	4.85E+01	2.64E-02	2.63E-02	1.35E+00	1.35E+00	1.39E+00	1.38E+00	4.81E+01	4.57E+01	2.38E+00	2.32E+00
Raccoon	Bq/kg (fw)	4.67E+01	4.28E+01	4.55E-02	3.87E-02	2.53E+00	2.53E+00	3.34E+00	3.18E+00	9.52E+01	0.00E+00	3.81E+00	3.16E+00
Red Fox	Bq/kg (fw)	1.20E+02	1.09E+02	5.34E-03	4.34E-03	7.45E-01	7.45E-01	1.02E+00	9.59E-01	1.18E+02	0.00E+00	8.03E-01	6.43E-01
Short-tailed Weasel	Bq/kg (fw)	5.79E+01	5.63E+01	5.55E-04	4.40E-04	2.44E-01	2.44E-01	3.08E-01	3.04E-01	1.42E+02	1.02E+02	5.64E-01	4.56E-01

Table D.3: Modelled Radiation Concentration for Media and VECs for Polygon C

Receptor	Unit	Carbon-14		Cobalt-60		Cesium-134		Cesium-137		Tritium		Iodine-131	
		Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Loam Pore Water	Bq/L	3.33E-02	3.33E-02	0.00E+00	0.00E+00	2.70E-04	2.70E-04	1.89E-03	1.89E-03	5.48E+02	5.48E+02	1.33E-01	1.33E-01
American Robin	Bq/kg (fw)	3.49E+01	3.49E+01	5.19E-01	5.19E-01	1.45E+00	1.45E+00	1.46E+00	1.46E+00	7.11E+01	7.11E+01	2.07E-02	2.07E-02
Song Sparrow	Bq/kg (fw)	5.50E+01	5.50E+01	1.04E+00	1.04E+00	2.89E+00	2.89E+00	2.90E+00	2.90E+00	1.41E+02	1.41E+02	2.25E-02	2.25E-02
Yellow Warbler	Bq/kg (fw)	5.17E+01	5.17E+01	4.58E-01	4.58E-01	1.28E+00	1.28E+00	1.28E+00	1.28E+00	9.76E+01	9.76E+01	2.81E-02	2.81E-02
Eastern Cottontail	Bq/kg (fw)	1.16E+02	1.16E+02	1.82E-02	1.82E-02	9.30E-01	9.30E-01	9.38E-01	9.38E-01	2.81E+02	2.81E+02	3.65E+00	3.65E+00
Meadow Vole	Bq/kg (fw)	1.16E+02	1.16E+02	7.24E-03	7.24E-03	3.70E-01	3.70E-01	3.72E-01	3.72E-01	2.81E+02	2.81E+02	1.46E+00	1.46E+00
White-tailed Deer	Bq/kg (fw)	1.16E+02	1.16E+02	2.51E-02	2.51E-02	1.28E+00	1.28E+00	1.29E+00	1.29E+00	2.66E+02	2.66E+02	5.05E+00	5.05E+00
Common Shrew	Bq/kg (fw)	8.74E+01	8.74E+01	2.61E-02	2.61E-02	1.34E+00	1.34E+00	1.34E+00	1.34E+00	2.44E+02	2.44E+02	2.99E+00	2.99E+00
Raccoon	Bq/kg (fw)	8.92E+01	8.92E+01	2.04E-02	2.04E-02	1.09E+00	1.09E+00	1.10E+00	1.10E+00	2.53E+02	2.53E+02	2.60E+00	2.60E+00
Red Fox	Bq/kg (fw)	1.09E+02	1.09E+02	1.15E-03	1.15E-03	2.07E-01	2.07E-01	2.10E-01	2.10E-01	2.94E+02	2.94E+02	4.14E-01	4.14E-01
Short-tailed Weasel	Bq/kg (fw)	1.16E+02	1.16E+02	7.64E-05	7.64E-05	2.01E-01	2.01E-01	2.06E-01	2.06E-01	3.05E+02	3.05E+02	2.53E-01	2.53E-01

Table D.4: Modelled Radiation Concentration for Media and VECs for Polygon D

Receptor	Unit	Carbon-14		Cobalt-60		Cesium-134		Cesium-137		Tritium		Iodine-131	
		Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Loam Pore Water	Bq/L	3.57E-01	3.57E-01	0.00E+00	0.00E+00	5.40E-04	5.40E-04	1.70E-02	1.70E-02	4.92E+02	4.92E+02	1.66E-02	1.66E-02
Turtles	Bq/kg (fw)	5.07E+02	5.07E+02	3.00E+00	3.00E+00	2.49E+02	2.49E+02	2.34E+02	2.34E+02	4.35E+01	4.35E+01	1.33E+00	1.33E+00
Aquatic Plants	Bq/kg (fw)	5.75E+01	5.75E+01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	5.80E+01	5.80E+01	3.00E+00	3.00E+00
American Robin	Bq/kg (fw)	3.74E+01	3.70E+01	5.22E-01	5.22E-01	1.46E+00	1.46E+00	1.57E+00	1.57E+00	2.33E+01	2.28E+01	2.57E-02	2.57E-02
Song Sparrow	Bq/kg (fw)	5.69E+01	5.57E+01	1.04E+00	1.04E+00	2.91E+00	2.91E+00	3.01E+00	3.01E+00	5.32E+01	5.15E+01	1.90E-02	1.90E-02
Yellow Warbler	Bq/kg (fw)	3.58E+01	3.58E+01	4.62E-01	4.62E-01	1.29E+00	1.29E+00	1.35E+00	1.35E+00	3.46E+01	3.45E+01	1.45E-02	1.45E-02
Eastern Cottontail	Bq/kg (fw)	1.14E+02	9.79E+01	1.85E-02	1.85E-02	9.50E-01	9.50E-01	1.02E+00	1.02E+00	4.83E+01	4.30E+01	5.99E+00	5.99E+00
Meadow Vole	Bq/kg (fw)	1.14E+02	9.79E+01	7.41E-03	7.41E-03	3.82E-01	3.82E-01	3.92E-01	3.92E-01	4.83E+01	4.30E+01	2.39E+00	2.39E+00
White-tailed Deer	Bq/kg (fw)	1.14E+02	9.79E+01	2.57E-02	2.57E-02	1.32E+00	1.32E+00	1.35E+00	1.35E+00	4.83E+01	4.22E+01	8.29E+00	8.29E+00
Common Shrew	Bq/kg (fw)	5.91E+01	5.91E+01	2.62E-02	2.62E-02	1.34E+00	1.34E+00	1.37E+00	1.37E+00	6.27E+01	6.27E+01	1.50E+00	1.50E+00
Raccoon	Bq/kg (fw)	7.58E+01	6.95E+01	2.07E-02	2.07E-02	1.11E+00	1.11E+00	1.23E+00	6.95E+01	5.44E+01	5.25E+01	2.71E+00	2.71E+00
Red Fox	Bq/kg (fw)	1.08E+02	9.23E+01	1.51E-03	1.51E-03	2.35E-01	2.35E-01	2.56E-01	9.23E+01	3.03E+01	2.74E+01	6.78E-01	6.78E-01
Short-tailed Weasel	Bq/kg (fw)	1.14E+02	3.00E-04	3.00E-04	3.00E-04	2.22E-01	2.22E-01	2.74E-01	4.84E+01	4.84E+01	4.07E-01	4.07E-01	4.07E-01

Table D.5: Modelled Radiation Concentration for Media and VECs for Polygon E

Receptor	Unit	Carbon-14		Cobalt-60		Cesium-134		Cesium-137		Tritium		Iodine-131	
		Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM	Maximum	UCLM
Loam Pore Water	Bq/L	9.26E-02	2.22E-02	9.37E-04	1.33E-04	1.08E-03	4.92E-04	1.24E-02	2.43E-03	8.90E+02	8.90E+02	1.22E-01	3.13E-02
Earthworm	Bq/kg (fw)	3.95E+01	3.95E+01	5.54E-03	2.41E-03	3.58E-02	1.63E-02	4.11E-01	8.05E-02	1.23E+03	1.23E+03	3.49E-01	9.39E-02
American Robin	Bq/kg (fw)	4.01E+01	4.01E+01	3.36E-01	3.15E-01	9.94E-01	8.97E-01	1.31E+00	9.56E-01	2.09E+02	2.08E+02	6.46E-03	5.55E-03
Bank Swallow	Bq/kg (fw)	4.34E+01	4.34E+01	2.84E-02	3.96E-03	1.68E-01	4.09E-02	6.84E-01	1.34E-01	3.44E+02	3.43E+02	2.04E-03	6.25E-04
Song Sparrow	Bq/kg (fw)	5.98E+01	5.98E+01	9.72E-01	9.39E-01	2.79E+00	2.64E+00	3.01E+00	2.68E+00	1.64E+02	1.63E+02	1.68E-02	1.59E-02
Yellow Warbler	Bq/kg (fw)	4.30E+01	4.30E+01	7.13E-02	4.86E-02	2.82E-01	1.64E-01	7.87E-01	2.54E-01	3.27E+02	3.26E+02	2.69E-03	1.33E-03
Terrestrial Plants (Grass)	Bq/kg (fw)	5.09E+01	5.09E+01	2.46E-02	1.98E-02	4.24E-03	1.93E-03	4.88E-02	9.54E-03	1.18E+03	1.18E+03	7.96E-02	6.32E-02
Terrestrial Plants (Sugar maple)	Bq/kg (fw)	5.09E+01	5.09E+01	7.54E-03	2.70E-03	4.24E-03	1.93E-03	4.88E-02	9.54E-03	1.18E+03	1.18E+03	2.78E-02	1.14E-02
Eastern Cottontail	Bq/kg (fw)	1.02E+02	1.02E+02	2.25E-03	5.62E-04	1.65E-01	2.95E-02	2.96E-01	5.80E-02	5.24E+02	5.20E+02	1.20E-01	5.24E-02
Meadow Vole	Bq/kg (fw)	1.02E+02	1.02E+02	1.17E-03	2.54E-04	9.37E-02	1.60E-02	1.41E-01	2.76E-02	5.24E+02	5.20E+02	6.26E-02	2.67E-02
White-tailed Deer	Bq/kg (fw)	1.02E+02	1.02E+02	3.74E-03	6.52E-04	3.15E-01	5.37E-02	4.73E-01	9.27E-02	5.95E+02	5.92E+02	2.02E-01	8.10E-02
Common Shrew	Bq/kg (fw)	7.16E+01	7.16E+01	9.05E-04	1.49E-04	1.16E-01	3.34E-02	6.54E-01	1.28E-01	5.24E+02	5.20E+02	1.72E-01	5.02E-02
Raccoon	Bq/kg (fw)	7.73E+01	7.73E+01	5.86E-03	3.74E-03	4.09E-01	2.21E-01	7.78E-01	2.92E-01	4.29E+02	4.25E+02	2.87E-01	1.62E-01
Red Fox	Bq/kg (fw)	9.64E+01	9.64E+01	2.09E-03	2.51E-04	2.21E-01	3.68E-02	3.03E-01	5.93E-02	2.96E+02	2.90E+02	1.20E-01	4.54E-02
Short-tailed Weasel	Bq/kg (fw)	1.02E+02	1.02E+02	1.36E-03	1.54E-04	1.71E-01	2.92E-02	2.60E-01	5.08E-02	2.75E+02	2.69E+02	8.38E-02	3.12E-02

Notes:

For C-14 and HTO, earthworm concentrations were estimated using the specific activity model

NA- Not applicable because air emissions data was not inputted for these parameters.

Table D.6: Modelled Non-Radiation Concentration for VECs that are prey for other VECs for Polygon AB (mg/kg fw)

COPCs	Unit	Aquatic Plants		Benthic Invertebrates		Northern Redbelly Dac		Bufflehead		Mallard		Eastern Cottontail		Meadow Vole	
		Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM
Barium	mg/kg (fw)	3.50E+00	3.24E+00	9.99E+00	9.25E+00	4.13E+01	3.70E+01	3.92E-02	3.64E-02	3.65E-02	3.41E-02	1.93E-01	1.27E-01	7.52E-02	4.86E-02
Cadmium	mg/kg (fw)	1.41E-01	1.20E-01	7.40E-04	6.29E-04	2.00E-02	2.00E-02	6.82E-03	5.71E-03	1.65E-02	1.37E-02	7.25E-03	4.20E-03	2.67E-03	1.46E-03
Chromium	mg/kg (fw)	1.58E-02	9.92E-03	6.16E-01	3.87E-01	2.17E+00	2.11E+00	1.24E-01	8.29E-02	1.31E-01	9.71E-02	3.70E-01	2.84E-01	1.15E-01	8.12E-02
Copper	mg/kg (fw)	5.16E+00	3.40E+00	7.22E-02	4.76E-02	4.59E+00	4.28E+00	4.07E-02	2.84E-02	9.31E-02	6.59E-02	1.19E+00	7.01E-01	4.57E-01	2.63E-01
Manganese	mg/kg (fw)	3.01E+02	2.09E+02	4.73E+01	3.27E+01	5.72E+01	5.18E+01	2.97E-02	2.07E-02	4.34E-02	3.06E-02	4.83E-01	3.46E-01	1.58E-01	1.03E-01
Nickel	mg/kg (fw)	4.58E-02	3.92E-02	8.80E-02	7.54E-02	1.79E+00	1.64E+00	9.05E-03	8.26E-03	1.50E-02	1.43E-02	1.41E-01	8.66E-02	4.77E-02	2.60E-02
Strontium	mg/kg (fw)	1.85E+02	1.79E+02	1.35E+02	1.31E+02	1.86E+02	1.68E+02	5.97E-01	5.76E-01	6.01E-01	5.81E-01	1.83E+00	1.54E+00	7.01E-01	5.83E-01
Vanadium	mg/kg (fw)	4.05E-01	3.41E-01	9.87E-01	8.31E-01	1.50E+00	1.25E+00	6.43E-03	5.49E-03	7.40E-03	6.45E-03	6.52E-02	4.43E-02	1.92E-02	1.09E-02
Zinc	mg/kg (fw)	3.66E+00	2.69E+00	4.71E+00	3.45E+00	3.52E+02	3.41E+02	5.01E-01	3.76E-01	5.45E-01	4.23E-01	1.82E+02	1.22E+02	7.11E+01	4.73E+01

Notes

Estimates for TKN, TOC, ammonia (un-ionized; as NH₃), iron, and phosphorus were not provided because these COPCs were assessed qualitatively for mammals and birds

Table D.7: Modelled Non-Radiation Concentration for VECs that are prey for other VECs for Polygon C (mg/kg fw)

COPCs	Unit	Eastern Cottontail		Meadow Vole	
		Max	UCLM	Max	UCLM
Strontium	mg/kg (fw)	6.50E-01	5.87E-01	2.40E-01	2.15E-01

Table D.8: Modelled Non-Radiation Concentration for VECs that are prey for other VECs for Polygon D (mg/kg fw)

COPCs	Unit	Eastern Cottontail		Meadow Vole	
		Max	UCLM	Max	UCLM
Barium	mg/kg (fw)	5.81E-02	4.19E-02	2.12E-02	1.47E-02
Cadmium	mg/kg (fw)	3.64E-03	2.49E-03	1.24E-03	7.83E-04
Copper	mg/kg (fw)	9.62E-01	7.60E-01	3.69E-01	2.88E-01
Selenium	mg/kg (fw)	6.30E-02	5.79E-02	2.12E-02	1.92E-02
Strontium	mg/kg (fw)	1.01E+00	7.06E-01	3.78E-01	2.57E-01
Vanadium	mg/kg (fw)	2.55E-02	2.48E-02	4.61E-03	4.35E-03

Table D.9: Modelled Non-Radiation Concentration for VECs that are prey for other VECs for Polygon E (mg/kg fw)

COPCs	Unit	Terrestrial Plants		Fruits		Earthworm		Eastern Cottontail		Meadow Vole	
		Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM	Max	UCLM
Arsenic	mg/kg (fw)	6.65E+00	7.68E-01	3.33E+00	3.84E-01	4.97E+00	5.75E-01	7.03E+00	8.13E-01	2.46E+00	2.84E-01
Cadmium	mg/kg (fw)	1.58E+00	2.06E-01	7.88E-01	1.03E-01	7.88E+00	1.03E+00	3.97E-01	5.19E-02	1.56E-01	2.03E-02
Chromium	mg/kg (fw)	1.23E-01	3.05E-02	6.13E-02	1.52E-02	3.94E+00	9.79E-01	4.95E-01	1.23E-01	8.92E-02	2.22E-02
Cobalt	mg/kg (fw)	1.49E+00	1.85E-01	7.47E-01	9.24E-02	9.67E-01	1.20E-01	6.35E-02	7.86E-03	1.64E-02	2.02E-03
Copper	mg/kg (fw)	3.57E+02	3.85E+01	1.78E+02	1.93E+01	1.97E+02	2.13E+01	1.19E+02	1.28E+01	4.52E+01	4.88E+00
Iron	mg/kg (fw)	9.49E+01	2.02E+01	4.75E+01	1.01E+01	5.81E+02	1.23E+02	7.63E+02	1.62E+02	1.30E+02	2.76E+01
Lead	mg/kg (fw)	3.65E+01	4.24E+00	1.83E+01	2.12E+00	1.68E+01	1.95E+00	1.30E+00	1.51E-01	4.64E-01	5.39E-02
Molybdenum	mg/kg (fw)	3.05E+00	3.44E-01	1.52E+00	1.72E-01	6.85E+00	7.73E-01	1.51E-01	1.71E-02	5.47E-02	6.17E-03
Nickel	mg/kg (fw)	1.21E+01	2.00E+00	6.06E+00	1.00E+00	8.41E+00	1.39E+00	2.90E+00	4.79E-01	1.07E+00	1.77E-01
Selenium	mg/kg (fw)	5.51E-01	6.89E-02	2.75E-01	3.44E-02	9.06E+00	1.13E+00	2.65E+00	3.32E-01	9.77E-01	1.22E-01
Sodium	mg/kg (fw)	4.61E+01	9.02E+00	2.30E+01	4.51E+00	1.41E+03	2.76E+02	4.45E+01	8.71E+00	1.40E+01	2.73E+00
Strontium	mg/kg (fw)	1.31E+02	5.59E+01	6.57E+01	2.79E+01	6.77E+00	2.88E+00	7.74E+00	3.29E+00	2.96E+00	1.26E+00
Tin	mg/kg (fw)	8.86E+00	9.64E-01	4.43E+00	4.82E-01	3.08E+00	3.35E-01	4.75E+00	5.17E-01	1.74E+00	1.89E-01
Zinc	mg/kg (fw)	2.42E+03	2.63E+02	1.21E+03	1.31E+02	5.07E+03	5.50E+02	1.72E+04	1.86E+03	6.65E+03	7.22E+02

Notes

Estimates for PHC F4 and Cyanide were not provided because they do not accumulate along the food chain.

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
Lake Ontario	Round Whitefish	C-14	mGy/d	0.00E+00	0.00E+00	2.31E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.13E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.31E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	5.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.22E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.32E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.90E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.17E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.32E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.77E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-06
		HTO	mGy/d	0.00E+00	0.00E+00	6.91E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.91E-07
		I-131	mGy/d	0.00E+00	0.00E+00	2.64E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.04E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.67E-05
		OBT	mGy/d	0.00E+00	0.00E+00	2.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.98E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	5.28E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.43E-05
Lake Ontario	White Sucker	C-14	mGy/d	0.00E+00	0.00E+00	2.31E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.13E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.31E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	5.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.22E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.32E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.90E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.17E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	7.48E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.77E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-06
		HTO	mGy/d	0.00E+00	0.00E+00	2.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-06
		I-131	mGy/d	0.00E+00	0.00E+00	9.90E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.04E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E-05
		OBT	mGy/d	0.00E+00	0.00E+00	2.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.98E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	3.72E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.87E-05
Lake Ontario	Alewife	C-14	mGy/d	0.00E+00	0.00E+00	2.35E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.35E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	5.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.10E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.90E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.90E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	4.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.40E-06
		HTO	mGy/d	0.00E+00	0.00E+00	3.18E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.18E-06
		I-131	mGy/d	0.00E+00	0.00E+00	4.29E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.29E-05
		OBT	mGy/d	0.00E+00	0.00E+00	2.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.98E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	8.43E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.43E-05
Lake Ontario	Lake Trout	C-14	mGy/d	0.00E+00	0.00E+00	8.91E-04	9.89E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.91E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	8.65E-05	9.73E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.62E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	9.86E-03	1.09E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.87E-03
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.12E-02	4.93E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-02
		HTO	mGy/d	0.00E+00	0.00E+00	1.60E-06	1.31E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-06
		I-131	mGy/d	0.00E+00	0.00E+00	2.18E-05	5.06E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.68E-05
		OBT	mGy/d	0.00E+00	0.00E+00	2.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.98E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	2.20E-02	3.06E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.21E-02
Lake Ontario	American Eel	C-14	mGy/d	0.00E+00	0.00E+00	8.91E-04	7.42E-11	0.00E+00	0.00E+00	0.00E+00	2.13E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.91E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	8.65E-05	7.30E-06	0.00E+00	0.00E+00	0.00E+00	3.22E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.41E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	9.86E-03	8.19E-06	0.00E+00	0.00E+00	0.00E+00	5.17E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.87E-03
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.12E-02	3.70E-06	0.00E+00	0.00E+00	0.00E+00	3.77E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-02
		HTO	mGy/d	0.00E+00	0.00E+00	1.60E-06	9.82E-14	0.00E+00	0.00E+00	0.00E+00	5.74E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-06
		I-131	mGy/d	0.00E+00	0.00E+00	2.18E-05	3.80E-06	0.00E+00	0.00E+00	0.00E+00	3.04E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.59E-05
		OBT	mGy/d	0.00E+00	0.00E+00	2.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.98E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	2.20E-02	2.30E-05	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.21E-02
Lake Ontario	Benthic Invertebrates	C-14	mGy/d	0.00E+00	0.00E+00	2.59E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.89E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.59E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	1.25E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.65E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.73E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.13E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.35E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.97E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.32E-06
		HTO	mGy/d	0.00E+00	0.00E+00	1.39E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.56E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.39E-06
		I-131	mGy/d	0.00E+00	0.00E+00	2.17E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.19E-04

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
		OBT	mGy/d	0.00E+00	0.00E+00	2.99E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.99E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	2.50E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.30E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-04
Lake Ontario Shore	Bufflehead	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-05	0.00E+00	0.00E+00	2.88E-05
		Co-60	mGy/d	1.01E-11	0.00E+00	9.21E-08	0.00E+00	0.00E+00	0.00E+00	6.54E-10	1.87E-07	0.00E+00	1.17E-06	0.00E+00	0.00E+00	1.45E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.37E-07	0.00E+00	0.00E+00	0.00E+00	4.43E-09	3.26E-07	0.00E+00	3.02E-06	0.00E+00	0.00E+00	3.78E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	4.68E-07	0.00E+00	0.00E+00	0.00E+00	7.68E-09	2.39E-07	0.00E+00	2.56E-06	0.00E+00	0.00E+00	3.28E-06
		HTO	mGy/d	1.67E-06	0.00E+00	1.64E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-07	0.00E+00	0.00E+00	2.25E-06
		I-131	mGy/d	3.90E-14	4.61E-19	1.73E-09	0.00E+00	0.00E+00	0.00E+00	2.22E-11	1.91E-07	0.00E+00	6.49E-07	0.00E+00	0.00E+00	8.42E-07
		OBT	mGy/d	1.83E-07	0.00E+00	1.80E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.01E-07
		Total Dose	mGy/d	1.85E-06	4.61E-19	1.18E-06	0.00E+00	0.00E+00	0.00E+00	1.28E-08	9.44E-07	0.00E+00	3.66E-05	0.00E+00	0.00E+00	4.06E-05
Lake Ontario Shore	Mallard	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-05	0.00E+00	0.00E+00	2.88E-05
		Co-60	mGy/d	1.06E-11	0.00E+00	8.56E-08	0.00E+00	0.00E+00	0.00E+00	1.88E-09	1.87E-07	0.00E+00	1.10E-06	0.00E+00	0.00E+00	1.37E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.06E-07	0.00E+00	0.00E+00	0.00E+00	1.27E-08	3.26E-07	0.00E+00	2.84E-06	0.00E+00	0.00E+00	3.58E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	4.34E-07	0.00E+00	0.00E+00	0.00E+00	2.20E-08	2.39E-07	0.00E+00	2.41E-06	0.00E+00	0.00E+00	3.10E-06
		HTO	mGy/d	1.67E-06	0.00E+00	1.64E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-07	0.00E+00	0.00E+00	2.25E-06
		I-131	mGy/d	4.10E-14	4.61E-19	1.60E-09	0.00E+00	0.00E+00	0.00E+00	6.38E-11	1.91E-07	0.00E+00	6.10E-07	0.00E+00	0.00E+00	8.03E-07
		OBT	mGy/d	1.83E-07	0.00E+00	1.80E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.01E-07
		Total Dose	mGy/d	1.85E-06	4.61E-19	1.11E-06	0.00E+00	0.00E+00	0.00E+00	3.67E-08	9.44E-07	0.00E+00	3.61E-05	0.00E+00	0.00E+00	4.01E-05
Coot's Pond	Dace	C-14	mGy/d	0.00E+00	0.00E+00	2.38E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	5.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.88E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.29E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.90E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.21E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.22E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	4.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.13E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.91E-06
		HTO	mGy/d	0.00E+00	0.00E+00	1.06E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.82E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.06E-05
		I-131	mGy/d	0.00E+00	0.00E+00	1.05E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-03
		OBT	mGy/d	0.00E+00	0.00E+00	9.06E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.06E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	1.10E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-03
Coot's Pond	Turtles	C-14	mGy/d	0.00E+00	0.00E+00	2.71E-04	2.89E-10	0.00E+00	0.00E+00	0.00E+00	1.95E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.71E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	9.64E-06	3.04E-06	0.00E+00	0.00E+00	0.00E+00	2.06E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.29E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.18E-03	2.41E-06	0.00E+00	0.00E+00	0.00E+00	3.72E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-03
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.34E-03	1.27E-06	0.00E+00	0.00E+00	0.00E+00	6.12E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.34E-03
		HTO	mGy/d	0.00E+00	0.00E+00	4.85E-06	1.12E-11	0.00E+00	0.00E+00	0.00E+00	6.86E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.85E-06
		I-131	mGy/d	0.00E+00	0.00E+00	5.78E-05	1.56E-05	0.00E+00	0.00E+00	0.00E+00	2.34E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.36E-05
		OBT	mGy/d	0.00E+00	0.00E+00	9.06E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.06E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	3.86E-03	2.23E-05	0.00E+00	0.00E+00	0.00E+00	1.43E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.88E-03
Coot's Pond	Frogs	C-14	mGy/d	0.00E+00	0.00E+00	2.71E-04	2.89E-10	0.00E+00	0.00E+00	0.00E+00	1.95E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.71E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	9.64E-06	3.04E-06	0.00E+00	0.00E+00	0.00E+00	2.06E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.29E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.18E-03	2.41E-06	0.00E+00	0.00E+00	0.00E+00	3.72E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-03
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.34E-03	1.27E-06	0.00E+00	0.00E+00	0.00E+00	6.12E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.34E-03
		HTO	mGy/d	0.00E+00	0.00E+00	4.85E-06	1.12E-11	0.00E+00	0.00E+00	0.00E+00	6.86E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.85E-06
		I-131	mGy/d	0.00E+00	0.00E+00	5.78E-05	1.56E-05	0.00E+00	0.00E+00	0.00E+00	2.34E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.36E-05
		OBT	mGy/d	0.00E+00	0.00E+00	9.06E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.06E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	3.86E-03	2.23E-05	0.00E+00	0.00E+00	0.00E+00	1.43E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.88E-03
Coot's Pond	Aquatic Plants	C-14	mGy/d	0.00E+00	0.00E+00	2.64E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.64E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	2.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.70E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	3.30E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.30E-06

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
		HTO	mGy/d	0.00E+00	0.00E+00	5.94E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.94E-06
		I-131	mGy/d	0.00E+00	0.00E+00	5.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.40E-06
		OBT	mGy/d	0.00E+00	0.00E+00	7.12E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.12E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	4.66E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.66E-05
Coot's Pond	Benthic Invertebrates	C-14	mGy/d	0.00E+00	0.00E+00	2.45E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.79E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.45E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	1.63E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.13E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.71E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.65E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	4.87E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.68E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.13E-05
		HTO	mGy/d	0.00E+00	0.00E+00	4.86E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.94E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.86E-06
		I-131	mGy/d	0.00E+00	0.00E+00	7.72E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.82E-05
		OBT	mGy/d	0.00E+00	0.00E+00	9.08E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.08E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	4.18E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.02E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.24E-04
AB	Bufflehead AB	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.58E-06	2.45E-04	0.00E+00	0.00E+00	2.47E-04
		Co-60	mGy/d	6.85E-12	0.00E+00	3.49E-08	0.00E+00	0.00E+00	0.00E+00	3.81E-10	1.09E-07	1.14E-07	1.38E-05	0.00E+00	0.00E+00	1.40E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.11E-07	0.00E+00	0.00E+00	0.00E+00	2.75E-09	2.03E-07	2.95E-07	3.93E-05	0.00E+00	0.00E+00	3.99E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.35E-07	0.00E+00	0.00E+00	0.00E+00	1.04E-08	3.25E-07	2.51E-07	4.78E-05	0.00E+00	0.00E+00	4.85E-05
		HTO	mGy/d	1.13E-06	0.00E+00	4.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.79E-07	1.32E-06	0.00E+00	0.00E+00	3.12E-06
		I-131	mGy/d	2.65E-14	4.35E-19	6.05E-09	0.00E+00	0.00E+00	0.00E+00	1.46E-11	1.26E-07	1.22E-09	2.08E-07	0.00E+00	0.00E+00	3.41E-07
		OBT	mGy/d	1.24E-07	0.00E+00	5.48E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.79E-07
		Total Dose	mGy/d	1.26E-06	4.35E-19	8.40E-07	0.00E+00	0.00E+00	0.00E+00	1.36E-08	7.62E-07	3.42E-06	3.47E-04	0.00E+00	0.00E+00	3.54E-04
AB	Mallard AB	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.45E-06	2.04E-04	0.00E+00	0.00E+00	2.10E-04
		Co-60	mGy/d	7.20E-12	0.00E+00	3.24E-08	0.00E+00	0.00E+00	0.00E+00	1.09E-09	1.09E-07	2.76E-07	1.08E-05	0.00E+00	0.00E+00	1.12E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.03E-07	0.00E+00	0.00E+00	0.00E+00	7.90E-09	2.03E-07	7.14E-07	3.08E-05	0.00E+00	0.00E+00	3.18E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.25E-07	0.00E+00	0.00E+00	0.00E+00	3.00E-08	3.25E-07	6.07E-07	3.75E-05	0.00E+00	0.00E+00	3.85E-05
		HTO	mGy/d	1.13E-06	0.00E+00	4.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.48E-07	1.10E-06	0.00E+00	0.00E+00	3.17E-06
		I-131	mGy/d	2.78E-14	4.35E-19	5.62E-09	0.00E+00	0.00E+00	0.00E+00	4.19E-11	1.26E-07	2.95E-09	1.63E-07	0.00E+00	0.00E+00	2.97E-07
		OBT	mGy/d	1.24E-07	0.00E+00	5.48E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.79E-07
		Total Dose	mGy/d	1.26E-06	4.35E-19	8.19E-07	0.00E+00	0.00E+00	0.00E+00	3.90E-08	7.62E-07	8.50E-06	2.84E-04	0.00E+00	0.00E+00	2.96E-04
AB	Muskrat	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.25E-05	0.00E+00	0.00E+00	0.00E+00	4.25E-05
		Co-60	mGy/d	3.97E-13	0.00E+00	2.52E-09	0.00E+00	0.00E+00	0.00E+00	6.49E-11	2.30E-07	6.50E-08	0.00E+00	0.00E+00	0.00E+00	2.98E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.62E-07	0.00E+00	0.00E+00	0.00E+00	9.50E-09	4.06E-07	3.41E-06	0.00E+00	0.00E+00	0.00E+00	3.99E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.32E-07	0.00E+00	0.00E+00	0.00E+00	4.24E-08	6.80E-07	3.41E-06	0.00E+00	0.00E+00	0.00E+00	4.36E-06
		HTO	mGy/d	1.76E-06	0.00E+00	1.87E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.71E-06	0.00E+00	0.00E+00	0.00E+00	6.34E-06
		I-131	mGy/d	3.46E-12	8.71E-19	9.85E-07	0.00E+00	0.00E+00	0.00E+00	5.62E-09	2.69E-07	1.57E-06	0.00E+00	0.00E+00	0.00E+00	2.83E-06
		OBT	mGy/d	2.11E-07	0.00E+00	2.24E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.36E-07
		Total Dose	mGy/d	1.97E-06	8.71E-19	3.48E-06	0.00E+00	0.00E+00	0.00E+00	5.76E-08	1.58E-06	5.37E-05	0.00E+00	0.00E+00	0.00E+00	6.08E-05
AB	Earthworm	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-06
		I-131	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-05
		OBT	mGy/d	1.49E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-05
		Total Dose	mGy/d	1.49E-05	0.00E+00	0.00E+00	0.00E+00	5.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.26E-05
AB	American Robin	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.13E-05	0.00E+00	2.13E-05
		Co-60	mGy/d	6.62E-12	0.00E+00	4.16E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-06	0.00E+00	3.00E-06

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.32E-07	0.00E+00	1.94E-08	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.65E-06	0.00E+00	1.09E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.61E-07	0.00E+00	4.54E-07	3.08E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-06	0.00E+00	3.79E-05
		HTO	mGy/d	1.13E-06	0.00E+00	4.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-06	0.00E+00	3.33E-06
		I-131	mGy/d	2.56E-14	4.35E-19	7.21E-09	0.00E+00	4.42E-10	8.29E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.54E-08	0.00E+00	8.37E-06
		OBT	mGy/d	1.24E-07	0.00E+00	5.48E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.94E-08	0.00E+00	2.59E-07
		Total Dose	mGy/d	1.26E-06	4.35E-19	8.95E-07	0.00E+00	4.73E-07	4.22E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.03E-05	0.00E+00	8.51E-05
AB	Bank Swallow	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.31E-05	0.00E+00	2.31E-05
		Co-60	mGy/d	6.34E-12	0.00E+00	5.16E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.41E-06	0.00E+00	2.46E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.64E-07	0.00E+00	1.06E-08	1.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E-06	0.00E+00	7.97E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.99E-07	0.00E+00	2.48E-07	1.54E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.30E-06	0.00E+00	2.11E-05
		HTO	mGy/d	1.13E-06	0.00E+00	4.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E-06	0.00E+00	3.62E-06
		I-131	mGy/d	2.45E-14	4.35E-19	8.94E-09	0.00E+00	2.41E-10	4.15E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.10E-08	0.00E+00	4.23E-06
		OBT	mGy/d	1.24E-07	0.00E+00	5.48E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.31E-08	0.00E+00	2.72E-07
		Total Dose	mGy/d	1.26E-06	4.35E-19	9.77E-07	0.00E+00	2.59E-07	2.11E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-05	0.00E+00	6.27E-05
AB	Song Sparrow	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.22E-05	0.00E+00	3.22E-05
		Co-60	mGy/d	1.03E-11	0.00E+00	7.11E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.92E-06	0.00E+00	5.99E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.26E-07	0.00E+00	1.64E-08	4.99E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-05	0.00E+00	2.05E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.74E-07	0.00E+00	3.83E-07	4.92E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-05	0.00E+00	6.29E-05
		HTO	mGy/d	1.81E-06	0.00E+00	7.97E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.52E-06	0.00E+00	7.13E-06
		I-131	mGy/d	4.00E-14	6.97E-19	1.23E-08	0.00E+00	3.73E-10	1.33E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.98E-08	0.00E+00	1.33E-05
		OBT	mGy/d	1.99E-07	0.00E+00	8.77E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.11E-07	0.00E+00	4.98E-07
		Total Dose	mGy/d	2.01E-06	6.97E-19	1.47E-06	0.00E+00	4.00E-07	6.75E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.13E-05	0.00E+00	1.43E-04
AB	Yellow Warbler	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.29E-05	0.00E+00	2.29E-05
		Co-60	mGy/d	6.44E-12	0.00E+00	4.72E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-06	0.00E+00	2.66E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.50E-07	0.00E+00	1.10E-08	1.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-06	0.00E+00	8.48E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.82E-07	0.00E+00	2.58E-07	1.54E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-06	0.00E+00	2.16E-05
		HTO	mGy/d	1.13E-06	0.00E+00	4.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.05E-06	0.00E+00	3.68E-06
		I-131	mGy/d	2.49E-14	4.35E-19	8.18E-09	0.00E+00	2.51E-10	4.15E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.19E-08	0.00E+00	4.23E-06
		OBT	mGy/d	1.24E-07	0.00E+00	5.48E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.58E-08	0.00E+00	2.75E-07
		Total Dose	mGy/d	1.26E-06	4.35E-19	9.41E-07	0.00E+00	2.69E-07	2.11E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.02E-05	0.00E+00	6.37E-05
AB	Green Heron	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E-05	0.00E+00	0.00E+00	2.38E-05
		Co-60	mGy/d	6.72E-12	0.00E+00	3.76E-08	0.00E+00	0.00E+00	0.00E+00	7.69E-10	1.09E-07	0.00E+00	1.29E-06	0.00E+00	0.00E+00	1.44E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.19E-07	0.00E+00	0.00E+00	0.00E+00	5.56E-09	2.03E-07	0.00E+00	3.34E-06	0.00E+00	0.00E+00	3.66E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.45E-07	0.00E+00	0.00E+00	0.00E+00	2.11E-08	3.25E-07	0.00E+00	2.83E-06	0.00E+00	0.00E+00	3.32E-06
		HTO	mGy/d	1.13E-06	0.00E+00	4.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.21E-06	0.00E+00	0.00E+00	4.84E-06
		I-131	mGy/d	2.59E-14	4.35E-19	6.51E-09	0.00E+00	0.00E+00	0.00E+00	2.95E-11	1.26E-07	0.00E+00	2.19E-06	0.00E+00	0.00E+00	2.33E-06
		OBT	mGy/d	1.24E-07	0.00E+00	5.48E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.79E-07
		Total Dose	mGy/d	1.26E-06	4.35E-19	8.62E-07	0.00E+00	0.00E+00	0.00E+00	2.75E-08	7.62E-07	0.00E+00	3.67E-05	0.00E+00	0.00E+00	3.96E-05
AB	Grass	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.96E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.96E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.84E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.84E-05
		I-131	mGy/d	0.00E+00	8.71E-19	0.00E+00	0.00E+00	4.42E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.42E-05
		OBT	mGy/d	1.40E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-09
		Total Dose	mGy/d	1.40E-09	8.71E-19	0.00E+00	0.00E+00	1.40E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-04

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
AB	Eastern Cottontail	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.94E-05	0.00E+00	3.94E-05
		Co-60	mGy/d	4.14E-13	0.00E+00	2.53E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.26E-08	0.00E+00	7.52E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.63E-07	0.00E+00	9.59E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06	0.00E+00	1.02E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.33E-07	0.00E+00	2.64E-07	6.44E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06	0.00E+00	6.87E-05
		HTO	mGy/d	1.76E-06	0.00E+00	1.87E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.92E-05	0.00E+00	3.29E-05
		I-131	mGy/d	3.61E-12	8.71E-19	9.88E-07	0.00E+00	2.43E-08	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E-05	0.00E+00	3.24E-05
		OBT	mGy/d	2.11E-07	0.00E+00	2.24E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.31E-06	0.00E+00	1.75E-06
		Total Dose	mGy/d	1.97E-06	8.71E-19	3.48E-06	0.00E+00	2.98E-07	8.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.13E-05	0.00E+00	1.85E-04
AB	Meadow Vole	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.94E-05	0.00E+00	3.94E-05
		Co-60	mGy/d	4.62E-13	0.00E+00	1.48E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-08	0.00E+00	3.04E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	9.52E-08	0.00E+00	1.39E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	7.85E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.36E-07	0.00E+00	3.82E-08	6.44E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	6.60E-05
		HTO	mGy/d	1.76E-06	0.00E+00	1.87E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.92E-05	0.00E+00	3.29E-05
		I-131	mGy/d	4.03E-12	8.71E-19	5.78E-07	0.00E+00	3.52E-09	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.46E-06	0.00E+00	2.38E-05
		OBT	mGy/d	2.11E-07	0.00E+00	2.24E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.31E-06	0.00E+00	1.75E-06
		Total Dose	mGy/d	1.97E-06	8.71E-19	2.91E-06	0.00E+00	4.31E-08	8.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.84E-05	0.00E+00	1.72E-04
AB	White-tailed Deer	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.94E-05	0.00E+00	3.94E-05
		Co-60	mGy/d	2.63E-12	0.00E+00	2.48E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.02E-07	0.00E+00	5.27E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.17E-06	0.00E+00	1.54E-08	3.17E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.93E-05	0.00E+00	2.36E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	9.15E-07	0.00E+00	2.32E-07	3.15E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-05	0.00E+00	4.31E-05
		HTO	mGy/d	1.76E-06	0.00E+00	1.49E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.34E-05	0.00E+00	3.67E-05
		I-131	mGy/d	8.89E-12	8.71E-19	3.76E-06	0.00E+00	2.07E-08	8.58E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.66E-05	0.00E+00	4.90E-05
		OBT	mGy/d	2.11E-07	0.00E+00	1.79E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-06	0.00E+00	1.89E-06
		Total Dose	mGy/d	1.97E-06	8.71E-19	7.54E-06	0.00E+00	2.68E-07	4.32E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.41E-04	0.00E+00	1.94E-04
AB	Common Shrew	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E-05	0.00E+00	3.80E-05
		Co-60	mGy/d	3.15E-13	0.00E+00	1.07E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-07	0.00E+00	1.06E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	6.90E-08	0.00E+00	3.71E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E-06	0.00E+00	1.18E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	9.87E-08	0.00E+00	1.02E-07	6.44E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.48E-06	0.00E+00	7.00E-05
		HTO	mGy/d	1.76E-06	0.00E+00	1.87E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.02E-06	0.00E+00	6.65E-06
		I-131	mGy/d	2.75E-12	8.71E-19	4.19E-07	0.00E+00	9.40E-09	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.94E-06	0.00E+00	2.51E-05
		OBT	mGy/d	2.11E-07	0.00E+00	2.24E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E-07	0.00E+00	5.71E-07
		Total Dose	mGy/d	1.97E-06	8.71E-19	2.68E-06	0.00E+00	1.15E-07	8.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.91E-05	0.00E+00	1.52E-04
AB	Raccoon Poly AB	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.48E-06	2.69E-05	3.94E-07	3.18E-05
		Co-60	mGy/d	4.79E-13	0.00E+00	3.16E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-07	6.80E-08	6.45E-11	1.82E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.03E-07	0.00E+00	1.60E-08	6.24E-06	0.00E+00	0.00E+00	0.00E+00	6.43E-06	3.56E-06	1.75E-07	1.66E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.91E-07	0.00E+00	4.40E-07	6.44E-05	0.00E+00	0.00E+00	0.00E+00	9.20E-06	3.57E-06	1.84E-07	7.80E-05
		HTO	mGy/d	1.76E-06	0.00E+00	1.87E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.21E-08	9.35E-06	1.61E-07	1.32E-05
		I-131	mGy/d	4.18E-12	8.71E-19	1.24E-06	0.00E+00	4.06E-08	1.77E-05	0.00E+00	0.00E+00	0.00E+00	3.79E-06	6.54E-06	1.99E-07	2.95E-05
		OBT	mGy/d	2.11E-07	0.00E+00	2.24E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.20E-07	1.60E-09	8.57E-07
		Total Dose	mGy/d	1.97E-06	8.71E-19	3.83E-06	0.00E+00	4.97E-07	8.83E-05	0.00E+00	0.00E+00	0.00E+00	2.40E-05	5.04E-05	1.11E-06	1.70E-04
AB	Red Fox AB	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.63E-06	7.63E-05	8.19E-05
		Co-60	mGy/d	4.53E-13	0.00E+00	3.08E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.36E-09	1.39E-08	2.14E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.98E-07	0.00E+00	1.73E-09	5.75E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	2.63E-06	8.81E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.84E-07	0.00E+00	4.74E-08	1.26E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	3.60E-06	1.30E-04
		HTO	mGy/d	1.76E-06	0.00E+00	1.87E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.18E-06	8.49E-06	1.63E-05
		I-131	mGy/d	3.95E-12	8.71E-19	1.20E-06	0.00E+00	4.37E-09	1.61E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.21E-07	4.63E-07	1.86E-05

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
		OBT	mGy/d	2.11E-07	0.00E+00	2.24E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.88E-07	8.50E-08	7.09E-07
		Total Dose	mGy/d	1.97E-06	8.71E-19	3.78E-06	0.00E+00	5.35E-08	1.48E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-05	9.15E-05	2.57E-04
AB	Short-tailed Weasel	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.94E-05	3.94E-05
		Co-60	mGy/d	3.80E-13	0.00E+00	1.90E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.21E-10	2.22E-09
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.22E-07	0.00E+00	6.33E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.71E-07	7.24E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.75E-07	0.00E+00	1.74E-07	6.44E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.13E-07	6.56E-05
		HTO	mGy/d	1.76E-06	0.00E+00	1.87E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.61E-05	1.97E-05
		I-131	mGy/d	3.32E-12	8.71E-19	7.42E-07	0.00E+00	1.60E-08	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.92E-07	1.95E-05
		OBT	mGy/d	2.11E-07	0.00E+00	2.24E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-07	5.96E-07
		Total Dose	mGy/d	1.97E-06	8.71E-19	3.14E-06	0.00E+00	1.96E-07	8.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.84E-05	1.52E-04
C	Earthworm	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.39E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.39E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.11E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.11E-06
		I-131	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-05
		OBT	mGy/d	1.05E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-05
		Total Dose	mGy/d	1.05E-05	0.00E+00	0.00E+00	0.00E+00	6.11E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.15E-05
C	American Robin	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E-05	0.00E+00	2.38E-05
		Co-60	mGy/d	4.66E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-06	0.00E+00	2.96E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.45E-10	0.00E+00	9.71E-09	1.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.65E-06	0.00E+00	9.22E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.45E-09	0.00E+00	5.77E-08	3.91E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-06	0.00E+00	1.05E-05
		HTO	mGy/d	7.96E-07	0.00E+00	5.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E-06	0.00E+00	9.83E-06
		I-131	mGy/d	1.80E-14	2.71E-19	2.49E-10	0.00E+00	4.82E-10	9.05E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.96E-08	0.00E+00	9.12E-06
		OBT	mGy/d	8.75E-08	0.00E+00	6.42E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-07	0.00E+00	8.79E-07
		Total Dose	mGy/d	8.83E-07	2.71E-19	6.48E-06	0.00E+00	6.79E-08	1.45E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.43E-05	0.00E+00	6.62E-05
C	Song Sparrow	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.74E-05	0.00E+00	3.74E-05
		Co-60	mGy/d	7.28E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.92E-06	0.00E+00	5.92E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.18E-10	0.00E+00	8.20E-09	2.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-05	0.00E+00	1.78E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.48E-09	0.00E+00	4.87E-08	6.26E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-05	0.00E+00	1.93E-05
		HTO	mGy/d	1.27E-06	0.00E+00	9.34E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.82E-06	0.00E+00	1.94E-05
		I-131	mGy/d	2.81E-14	4.33E-19	4.24E-10	0.00E+00	4.07E-10	1.45E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.56E-08	0.00E+00	1.45E-05
		OBT	mGy/d	1.40E-07	0.00E+00	1.03E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.12E-07	0.00E+00	1.58E-06
		Total Dose	mGy/d	1.41E-06	4.33E-19	1.04E-05	0.00E+00	5.74E-08	2.32E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.10E-05	0.00E+00	1.16E-04
C	Yellow Warbler	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.52E-05	0.00E+00	3.52E-05
		Co-60	mGy/d	4.53E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-06	0.00E+00	2.61E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.78E-10	0.00E+00	5.52E-09	7.80E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-06	0.00E+00	7.54E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.65E-09	0.00E+00	3.28E-08	1.96E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-06	0.00E+00	7.73E-06
		HTO	mGy/d	7.96E-07	0.00E+00	5.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.86E-06	0.00E+00	1.35E-05
		I-131	mGy/d	1.75E-14	2.71E-19	2.82E-10	0.00E+00	2.74E-10	4.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.51E-08	0.00E+00	4.62E-06
		OBT	mGy/d	8.75E-08	0.00E+00	6.42E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E-07	0.00E+00	1.05E-06
		Total Dose	mGy/d	8.83E-07	2.71E-19	6.48E-06	0.00E+00	3.86E-08	7.26E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.76E-05	0.00E+00	7.22E-05
C	Grass	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.68E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.68E-05
		I-131	mGy/d	0.00E+00	5.41E-19	0.00E+00	0.00E+00	3.64E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.64E-05
		OBT	mGy/d	9.85E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.85E-10
		Total Dose	mGy/d	9.85E-10	5.41E-19	0.00E+00	0.00E+00	1.20E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-04
C	Eastern Cottontail	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.89E-05	0.00E+00	7.89E-05
		Co-60	mGy/d	2.92E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.26E-08	0.00E+00	7.26E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	3.01E-10	0.00E+00	4.80E-09	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06	0.00E+00	6.93E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.11E-09	0.00E+00	3.36E-08	8.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06	0.00E+00	1.20E-05
		HTO	mGy/d	1.24E-06	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.57E-05	0.00E+00	3.89E-05
		I-131	mGy/d	2.54E-12	5.41E-19	3.41E-08	0.00E+00	2.65E-08	1.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-05	0.00E+00	3.07E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.06E-07	0.00E+00	3.48E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	2.46E-05	0.00E+00	6.49E-08	3.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-04	0.00E+00	1.71E-04
C	Meadow Vole	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.89E-05	0.00E+00	7.89E-05
		Co-60	mGy/d	3.25E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-08	0.00E+00	2.90E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.76E-10	0.00E+00	6.94E-10	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	4.64E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.23E-09	0.00E+00	4.86E-09	8.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	9.71E-06
		HTO	mGy/d	1.24E-06	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.57E-05	0.00E+00	3.89E-05
		I-131	mGy/d	2.83E-12	5.41E-19	1.99E-08	0.00E+00	3.84E-09	1.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.49E-06	0.00E+00	2.39E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.06E-07	0.00E+00	3.48E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	2.46E-05	0.00E+00	9.39E-09	3.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.03E-04	0.00E+00	1.59E-04
C	White-tailed Deer	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.89E-05	0.00E+00	7.89E-05
		Co-60	mGy/d	1.85E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.02E-07	0.00E+00	5.02E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.16E-09	0.00E+00	7.71E-09	1.59E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.93E-05	0.00E+00	2.09E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	8.28E-09	0.00E+00	2.95E-08	4.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-05	0.00E+00	1.46E-05
		HTO	mGy/d	1.24E-06	0.00E+00	1.75E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-05	0.00E+00	3.67E-05
		I-131	mGy/d	6.26E-12	5.41E-19	1.30E-07	0.00E+00	2.26E-08	9.36E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.02E-05	0.00E+00	3.97E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.07E-07	0.00E+00	3.06E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	1.97E-05	0.00E+00	5.98E-08	1.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.58E-04	0.00E+00	1.94E-04
C	Common Shrew	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.95E-05	0.00E+00	5.95E-05
		Co-60	mGy/d	2.22E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-07	0.00E+00	1.04E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.28E-10	0.00E+00	1.86E-09	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E-06	0.00E+00	8.59E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	8.93E-10	0.00E+00	1.30E-08	8.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.48E-06	0.00E+00	1.37E-05
		HTO	mGy/d	1.24E-06	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-05	0.00E+00	3.37E-05
		I-131	mGy/d	1.93E-12	5.41E-19	1.44E-08	0.00E+00	1.03E-08	1.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.26E-06	0.00E+00	2.86E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.74E-07	0.00E+00	3.25E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	2.46E-05	0.00E+00	2.51E-08	3.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.08E-05	0.00E+00	1.47E-04
C	Raccoon	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.28E-05	7.89E-06	6.07E-05
		Co-60	mGy/d	3.37E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.14E-08	6.55E-11	8.15E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	3.76E-10	0.00E+00	8.00E-09	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.26E-06	1.76E-07	7.57E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.63E-09	0.00E+00	5.60E-08	8.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.27E-06	1.76E-07	1.27E-05
		HTO	mGy/d	1.24E-06	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.99E-06	1.90E-06	3.50E-05
		I-131	mGy/d	2.94E-12	5.41E-19	4.26E-08	0.00E+00	4.42E-08	1.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.81E-06	1.59E-07	2.74E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.49E-07	3.19E-08	3.26E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	2.46E-05	0.00E+00	1.08E-07	3.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.97E-05	1.03E-05	1.47E-04
C	Red Fox	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-05	6.31E-05	7.44E-05
		Co-60	mGy/d	3.19E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.36E-09	2.31E-10	4.59E-09

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
		Cs-134	mGy/d	0.00E+00	0.00E+00	3.67E-10	0.00E+00	8.63E-10	2.88E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	6.20E-07	3.73E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.57E-09	0.00E+00	6.04E-09	1.61E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	6.25E-07	1.69E-05
		HTO	mGy/d	1.24E-06	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E-06	1.52E-05	4.06E-05
		I-131	mGy/d	2.78E-12	5.41E-19	4.15E-08	0.00E+00	4.77E-09	1.75E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-07	5.62E-07	1.88E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-07	2.55E-07	3.13E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	2.46E-05	0.00E+00	1.17E-08	3.65E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.48E-05	8.03E-05	1.58E-04
C	Short-tailed Weasel	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.89E-05	7.89E-05
		Co-60	mGy/d	2.68E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.05E-10	3.06E-10
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.26E-10	0.00E+00	3.16E-09	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.19E-07	3.94E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.58E-09	0.00E+00	2.22E-08	8.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.23E-07	9.04E-06
		HTO	mGy/d	1.24E-06	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-05	4.21E-05
		I-131	mGy/d	2.33E-12	5.41E-19	2.56E-08	0.00E+00	1.75E-08	1.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.42E-07	2.01E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.19E-07	3.10E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	2.46E-05	0.00E+00	4.28E-08	3.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-04	1.57E-04
Dragonfly Pond	Turtles	C-14	mGy/d	0.00E+00	0.00E+00	3.45E-04	3.67E-10	0.00E+00	0.00E+00	0.00E+00	1.86E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	4.50E-06	1.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.91E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	5.72E-04	1.17E-06	0.00E+00	0.00E+00	0.00E+00	3.69E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-04
		Cs-137	mGy/d	0.00E+00	0.00E+00	7.49E-04	4.06E-07	0.00E+00	0.00E+00	0.00E+00	2.85E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.52E-04
		HTO	mGy/d	0.00E+00	0.00E+00	6.01E-06	1.39E-11	0.00E+00	0.00E+00	0.00E+00	8.01E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.01E-06
		I-131	mGy/d	0.00E+00	0.00E+00	3.32E-06	8.95E-07	0.00E+00	0.00E+00	0.00E+00	1.43E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E-06
		OBT	mGy/d	0.00E+00	0.00E+00	1.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-06
		Total Dose	mGy/d	0.00E+00	0.00E+00	1.68E-03	3.89E-06	0.00E+00	0.00E+00	0.00E+00	3.38E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-03
Polliwog Pond	Turtles	C-14	mGy/d	0.00E+00	0.00E+00	3.45E-04	3.67E-10	0.00E+00	0.00E+00	0.00E+00	1.86E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	4.50E-06	1.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.91E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	5.72E-04	1.17E-06	0.00E+00	0.00E+00	0.00E+00	3.69E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-04
		Cs-137	mGy/d	0.00E+00	0.00E+00	7.49E-04	4.06E-07	0.00E+00	0.00E+00	0.00E+00	2.85E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.52E-04
		HTO	mGy/d	0.00E+00	0.00E+00	6.01E-06	1.39E-11	0.00E+00	0.00E+00	0.00E+00	8.01E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.01E-06
		I-131	mGy/d	0.00E+00	0.00E+00	3.32E-06	8.95E-07	0.00E+00	0.00E+00	0.00E+00	1.43E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E-06
		OBT	mGy/d	0.00E+00	0.00E+00	1.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-06
		Total Dose	mGy/d	0.00E+00	0.00E+00	1.68E-03	3.89E-06	0.00E+00	0.00E+00	0.00E+00	3.38E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-03
Treefrog Pond	Turtles	C-14	mGy/d	0.00E+00	0.00E+00	3.45E-04	3.67E-10	0.00E+00	0.00E+00	0.00E+00	1.86E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	4.50E-06	1.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.91E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	5.72E-04	1.17E-06	0.00E+00	0.00E+00	0.00E+00	3.69E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-04
		Cs-137	mGy/d	0.00E+00	0.00E+00	7.49E-04	4.06E-07	0.00E+00	0.00E+00	0.00E+00	2.85E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.52E-04
		HTO	mGy/d	0.00E+00	0.00E+00	6.01E-06	1.39E-11	0.00E+00	0.00E+00	0.00E+00	8.01E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.01E-06
		I-131	mGy/d	0.00E+00	0.00E+00	3.32E-06	8.95E-07	0.00E+00	0.00E+00	0.00E+00	1.43E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E-06
		OBT	mGy/d	0.00E+00	0.00E+00	1.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-06
		Total Dose	mGy/d	0.00E+00	0.00E+00	1.68E-03	3.89E-06	0.00E+00	0.00E+00	0.00E+00	3.38E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-03
Dragonfly Pond	Frogs	C-14	mGy/d	0.00E+00	0.00E+00	2.30E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.86E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	1.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.30E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.69E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.67E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	3.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.85E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.05E-06
		HTO	mGy/d	0.00E+00	0.00E+00	5.25E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.01E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.25E-06
		I-131	mGy/d	0.00E+00	0.00E+00	5.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.52E-05
		OBT	mGy/d	0.00E+00	0.00E+00	1.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-06
		Total Dose	mGy/d	0.00E+00	0.00E+00	9.14E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.38E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.48E-05

Table D.10: Maximum Dose for Radiological COPCs

[illegible]

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
		OBT	mGy/d	9.39E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.39E-06
		Total Dose	mGy/d	9.39E-06	0.00E+00	0.00E+00	0.00E+00	6.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.64E-05
D	American Robin	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.54E-05	0.00E+00	2.54E-05
		Co-60	mGy/d	4.18E-12	0.00E+00	1.94E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-06	0.00E+00	2.98E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	6.44E-08	0.00E+00	1.94E-08	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.65E-06	0.00E+00	1.09E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	5.14E-08	0.00E+00	5.20E-07	3.52E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-06	0.00E+00	4.23E-05
		HTO	mGy/d	7.14E-07	0.00E+00	6.17E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-06	0.00E+00	3.23E-06
		I-131	mGy/d	1.62E-14	2.16E-19	4.14E-10	0.00E+00	6.03E-11	1.13E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.70E-08	0.00E+00	1.22E-06
		OBT	mGy/d	7.85E-08	0.00E+00	6.79E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.85E-08	0.00E+00	2.35E-07
		Total Dose	mGy/d	7.92E-07	2.16E-19	8.21E-07	0.00E+00	5.39E-07	3.95E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.46E-05	0.00E+00	8.62E-05
D	Song Sparrow	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.87E-05	0.00E+00	3.87E-05
		Co-60	mGy/d	6.53E-12	0.00E+00	3.32E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.92E-06	0.00E+00	5.95E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.10E-07	0.00E+00	1.64E-08	4.99E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-05	0.00E+00	2.04E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	8.78E-08	0.00E+00	4.39E-07	5.64E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-05	0.00E+00	6.99E-05
		HTO	mGy/d	1.14E-06	0.00E+00	9.88E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.22E-06	0.00E+00	7.35E-06
		I-131	mGy/d	2.52E-14	3.46E-19	7.06E-10	0.00E+00	5.09E-11	1.81E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.40E-08	0.00E+00	1.87E-06
		OBT	mGy/d	1.26E-07	0.00E+00	1.09E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.44E-07	0.00E+00	4.78E-07
		Total Dose	mGy/d	1.27E-06	3.46E-19	1.33E-06	0.00E+00	4.55E-07	6.32E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.85E-05	0.00E+00	1.45E-04
D	Yellow Warbler	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.44E-05	0.00E+00	2.44E-05
		Co-60	mGy/d	4.07E-12	0.00E+00	2.20E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-06	0.00E+00	2.63E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	7.30E-08	0.00E+00	1.10E-08	1.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-06	0.00E+00	8.40E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	5.84E-08	0.00E+00	2.95E-07	1.76E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-06	0.00E+00	2.37E-05
		HTO	mGy/d	7.14E-07	0.00E+00	6.17E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-06	0.00E+00	4.78E-06
		I-131	mGy/d	1.57E-14	2.16E-19	4.69E-10	0.00E+00	3.42E-11	5.65E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.88E-08	0.00E+00	6.15E-07
		OBT	mGy/d	7.85E-08	0.00E+00	6.79E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.61E-07	0.00E+00	3.07E-07
		Total Dose	mGy/d	7.92E-07	2.16E-19	8.39E-07	0.00E+00	3.06E-07	1.97E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.31E-05	0.00E+00	6.48E-05
D	Grass	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.86E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.86E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.60E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.60E-06
		I-131	mGy/d	0.00E+00	4.33E-19	0.00E+00	0.00E+00	5.98E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.98E-05
		OBT	mGy/d	8.84E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.84E-10
		Total Dose	mGy/d	8.84E-10	4.33E-19	0.00E+00	0.00E+00	1.14E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-04
D	Sugar Maple	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.86E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.86E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.80E-06
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.60E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.60E-06
		I-131	mGy/d	0.00E+00	4.33E-19	0.00E+00	0.00E+00	1.36E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E-04
		OBT	mGy/d	8.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.84E-06
		Total Dose	mGy/d	8.84E-06	4.33E-19	0.00E+00	0.00E+00	2.22E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.31E-04
D	Eastern Cottontail	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.76E-05	0.00E+00	7.76E-05
		Co-60	mGy/d	2.62E-13	0.00E+00	1.18E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.26E-08	0.00E+00	7.38E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	7.92E-08	0.00E+00	9.59E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06	0.00E+00	1.01E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	7.45E-08	0.00E+00	3.02E-07	7.37E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06	0.00E+00	7.79E-05

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
		HTO	mGy/d	1.11E-06	0.00E+00	2.32E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.25E-06	0.00E+00	6.68E-06
		I-131	mGy/d	2.28E-12	4.33E-19	5.67E-08	0.00E+00	3.31E-09	2.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-05	0.00E+00	2.10E-05
		OBT	mGy/d	1.33E-07	0.00E+00	2.78E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E-07	0.00E+00	5.58E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	2.81E-06	0.00E+00	3.15E-07	8.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E-04	0.00E+00	1.94E-04
D	Meadow Vole	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.76E-05	0.00E+00	7.76E-05
		Co-60	mGy/d	2.92E-13	0.00E+00	6.90E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-08	0.00E+00	2.97E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.63E-08	0.00E+00	1.39E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	7.81E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	4.36E-08	0.00E+00	4.37E-08	7.37E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	7.53E-05
		HTO	mGy/d	1.11E-06	0.00E+00	2.32E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.25E-06	0.00E+00	6.68E-06
		I-131	mGy/d	2.54E-12	4.33E-19	3.32E-08	0.00E+00	4.80E-10	2.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.38E-06	0.00E+00	9.83E-06
		OBT	mGy/d	1.33E-07	0.00E+00	2.78E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E-07	0.00E+00	5.58E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	2.72E-06	0.00E+00	4.56E-08	8.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.15E-05	0.00E+00	1.78E-04
D	White-tailed Deer	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.76E-05	0.00E+00	7.76E-05
		Co-60	mGy/d	1.66E-12	0.00E+00	1.16E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.02E-07	0.00E+00	5.14E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	5.69E-07	0.00E+00	1.54E-08	3.17E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.93E-05	0.00E+00	2.30E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.93E-07	0.00E+00	2.66E-07	3.60E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-05	0.00E+00	4.71E-05
		HTO	mGy/d	1.11E-06	0.00E+00	1.85E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.72E-06	0.00E+00	6.68E-06
		I-131	mGy/d	5.62E-12	4.33E-19	2.16E-07	0.00E+00	2.82E-09	1.17E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.95E-05	0.00E+00	5.09E-05
		OBT	mGy/d	1.33E-07	0.00E+00	2.22E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.67E-07	0.00E+00	5.22E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	3.16E-06	0.00E+00	2.84E-07	4.04E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.61E-04	0.00E+00	2.06E-04
D	Common Shrew	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.02E-05	0.00E+00	4.02E-05
		Co-60	mGy/d	1.99E-13	0.00E+00	5.00E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-07	0.00E+00	1.05E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	3.36E-08	0.00E+00	3.71E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E-06	0.00E+00	1.17E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	3.16E-08	0.00E+00	1.17E-07	7.37E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.48E-06	0.00E+00	7.93E-05
		HTO	mGy/d	1.11E-06	0.00E+00	2.32E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.24E-06	0.00E+00	8.67E-06
		I-131	mGy/d	1.73E-12	4.33E-19	2.40E-08	0.00E+00	1.28E-09	2.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.63E-06	0.00E+00	7.07E-06
		OBT	mGy/d	1.33E-07	0.00E+00	2.78E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.36E-07	0.00E+00	6.47E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	2.69E-06	0.00E+00	1.22E-07	8.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.13E-05	0.00E+00	1.48E-04
D	Raccoon	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.38E-05	7.76E-06	5.16E-05
		Co-60	mGy/d	3.02E-13	0.00E+00	1.47E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.15E-08	6.70E-11	8.30E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	9.90E-08	0.00E+00	1.60E-08	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.27E-06	1.81E-07	1.08E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	9.32E-08	0.00E+00	5.04E-07	7.37E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.27E-06	1.86E-07	7.88E-05
		HTO	mGy/d	1.11E-06	0.00E+00	2.32E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.76E-06	3.26E-07	7.52E-06
		I-131	mGy/d	2.64E-12	4.33E-19	7.09E-08	0.00E+00	5.53E-09	2.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.08E-06	2.61E-07	1.08E-05
		OBT	mGy/d	1.33E-07	0.00E+00	2.78E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-07	5.10E-09	5.86E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	2.86E-06	0.00E+00	5.26E-07	8.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.44E-05	8.72E-06	1.60E-04
D	Red Fox	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-05	6.21E-05	7.32E-05
		Co-60	mGy/d	2.86E-13	0.00E+00	1.44E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.36E-09	2.35E-10	6.03E-09
		Cs-134	mGy/d	0.00E+00	0.00E+00	9.65E-08	0.00E+00	1.73E-09	5.75E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	6.35E-07	6.71E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	9.08E-08	0.00E+00	5.43E-08	1.45E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	6.76E-07	1.46E-04
		HTO	mGy/d	1.11E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.65E-07	2.61E-06	4.19E-06
		I-131	mGy/d	2.49E-12	4.33E-19	6.91E-08	0.00E+00	5.96E-10	2.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-06	9.21E-07	4.29E-06
		OBT	mGy/d	1.33E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.09E-08	4.08E-08	1.95E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	2.58E-07	0.00E+00	5.67E-08	1.53E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E-05	6.70E-05	2.34E-04
D	Short-tailed Weasel	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.76E-05	7.76E-05
		Co-60	mGy/d	2.40E-13	0.00E+00	8.86E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.13E-10	1.20E-09

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
		Cs-134	mGy/d	0.00E+00	0.00E+00	5.95E-08	0.00E+00	6.33E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.44E-07	7.15E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	5.60E-08	0.00E+00	1.99E-07	7.37E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.66E-07	7.48E-05
		HTO	mGy/d	1.11E-06	0.00E+00	2.32E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.26E-06	6.69E-06
		I-131	mGy/d	2.09E-12	4.33E-19	4.26E-08	0.00E+00	2.19E-09	2.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-06	3.68E-06
		OBT	mGy/d	1.33E-07	0.00E+00	2.78E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.10E-08	4.62E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	2.76E-06	0.00E+00	2.08E-07	8.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.39E-05	1.70E-04
E	Earthworm	C-14	mGy/d	2.69E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.69E-05
		Co-60	mGy/d	3.41E-09	0.00E+00	0.00E+00	0.00E+00	6.57E-09	1.86E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.86E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.30E-08	8.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.09E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-06	3.36E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.50E-05
		HTO	mGy/d	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-04
		I-131	mGy/d	1.56E-08	0.00E+00	0.00E+00	0.00E+00	9.27E-07	1.01E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-05
		OBT	mGy/d	1.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-05
		Total Dose	mGy/d	2.13E-04	0.00E+00	0.00E+00	0.00E+00	2.42E-06	7.03E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.86E-04
E	American Robin	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.72E-05	2.72E-05
		Co-60	mGy/d	7.57E-12	0.00E+00	1.10E-07	0.00E+00	2.25E-08	1.40E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.78E-06	0.00E+00	1.60E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	5.21E-07	0.00E+00	3.89E-08	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.71E-06	0.00E+00	1.15E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	5.57E-07	0.00E+00	3.79E-07	2.57E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.98E-06	0.00E+00	3.16E-05
		HTO	mGy/d	1.29E-06	0.00E+00	1.64E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.75E-05	0.00E+00	2.89E-05
		I-131	mGy/d	2.93E-14	2.30E-19	2.06E-09	0.00E+00	4.42E-10	8.29E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.95E-08	0.00E+00	8.31E-06
		OBT	mGy/d	1.42E-07	0.00E+00	1.80E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.28E-06	0.00E+00	1.44E-06
		Total Dose	mGy/d	1.43E-06	2.30E-19	1.37E-06	0.00E+00	4.41E-07	5.43E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.75E-05	0.00E+00	1.25E-04
E	Bank Swallow	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.95E-05	0.00E+00	2.95E-05
		Co-60	mGy/d	7.25E-12	0.00E+00	1.36E-07	0.00E+00	1.23E-08	7.02E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E-08	0.00E+00	7.18E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	6.46E-07	0.00E+00	2.12E-08	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.23E-07	0.00E+00	4.01E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	6.91E-07	0.00E+00	2.07E-07	1.29E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E-06	0.00E+00	1.59E-05
		HTO	mGy/d	1.29E-06	0.00E+00	1.64E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.61E-05	0.00E+00	4.76E-05
		I-131	mGy/d	2.80E-14	2.30E-19	2.55E-09	0.00E+00	2.41E-10	4.15E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.13E-09	0.00E+00	4.15E-06
		OBT	mGy/d	1.42E-07	0.00E+00	1.80E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.15E-06	0.00E+00	2.31E-06
		Total Dose	mGy/d	1.43E-06	2.30E-19	1.66E-06	0.00E+00	2.41E-07	2.71E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.02E-05	0.00E+00	1.11E-04
E	Song Sparrow	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.07E-05	0.00E+00	4.07E-05
		Co-60	mGy/d	1.18E-11	0.00E+00	1.88E-07	0.00E+00	1.90E-08	2.25E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.33E-06	0.00E+00	2.80E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	8.89E-07	0.00E+00	3.28E-08	9.98E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E-05	0.00E+00	2.47E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	9.52E-07	0.00E+00	3.20E-07	4.12E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.23E-05	0.00E+00	5.47E-05
		HTO	mGy/d	2.07E-06	0.00E+00	2.62E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.04E-05	0.00E+00	2.27E-05
		I-131	mGy/d	4.57E-14	3.69E-19	3.52E-09	0.00E+00	3.73E-10	1.33E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.34E-08	0.00E+00	1.33E-05
		OBT	mGy/d	2.27E-07	0.00E+00	2.89E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.52E-07	0.00E+00	1.21E-06
		Total Dose	mGy/d	2.30E-06	3.69E-19	2.32E-06	0.00E+00	3.73E-07	8.69E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.35E-05	0.00E+00	1.85E-04
E	Yellow Warbler	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.92E-05	0.00E+00	2.92E-05
		Co-60	mGy/d	7.37E-12	0.00E+00	1.25E-07	0.00E+00	1.28E-08	7.02E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.69E-07	0.00E+00	7.43E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	5.91E-07	0.00E+00	2.21E-08	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.79E-07	0.00E+00	4.61E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	6.32E-07	0.00E+00	2.15E-07	1.29E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.69E-06	0.00E+00	1.64E-05
		HTO	mGy/d	1.29E-06	0.00E+00	1.64E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.37E-05	0.00E+00	4.52E-05
		I-131	mGy/d	2.85E-14	2.30E-19	2.34E-09	0.00E+00	2.51E-10	4.15E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.55E-09	0.00E+00	4.15E-06
		OBT	mGy/d	1.42E-07	0.00E+00	1.80E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.04E-06	0.00E+00	2.20E-06
		Total Dose	mGy/d	1.43E-06	2.30E-19	1.53E-06	0.00E+00	2.51E-07	2.71E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.89E-05	0.00E+00	1.09E-04

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
E	Grass	C-14	mGy/d	3.46E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.46E-05
		Co-60	mGy/d	3.41E-08	0.00E+00	0.00E+00	0.00E+00	1.02E-08	6.71E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.71E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.06E-08	3.02E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.02E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.66E-07	1.32E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E-04
		HTO	mGy/d	1.63E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.63E-04
		I-131	mGy/d	1.50E-07	4.61E-19	0.00E+00	0.00E+00	5.72E-08	4.23E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.25E-05
		OBT	mGy/d	1.60E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-09
		Total Dose	mGy/d	1.98E-04	4.61E-19	0.00E+00	0.00E+00	2.44E-07	2.71E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.69E-04
E	Sugar Maple	C-14	mGy/d	3.46E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.46E-05
		Co-60	mGy/d	3.41E-08	0.00E+00	0.00E+00	0.00E+00	1.02E-07	2.03E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.04E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.94E-08	8.94E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.00E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E-07	3.71E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.75E-05
		HTO	mGy/d	1.63E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.63E-04
		I-131	mGy/d	3.40E-08	4.61E-19	0.00E+00	0.00E+00	1.30E-07	1.26E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-05
		OBT	mGy/d	1.60E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-05
		Total Dose	mGy/d	2.14E-04	4.61E-19	0.00E+00	0.00E+00	6.71E-07	7.89E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.94E-04
E	Eastern Cottontail	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E-05	0.00E+00	6.95E-05
		Co-60	mGy/d	4.74E-13	0.00E+00	6.67E-09	0.00E+00	5.49E-10	2.96E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.79E-09	0.00E+00	2.97E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	6.41E-07	0.00E+00	1.92E-08	1.25E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.61E-08	0.00E+00	1.32E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	8.08E-07	0.00E+00	2.21E-07	5.38E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.86E-07	0.00E+00	5.50E-05
		HTO	mGy/d	2.01E-06	0.00E+00	6.15E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.98E-05	0.00E+00	7.24E-05
		I-131	mGy/d	4.13E-12	4.61E-19	2.82E-07	0.00E+00	2.43E-08	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.41E-08	0.00E+00	1.81E-05
		OBT	mGy/d	2.41E-07	0.00E+00	7.39E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-06	0.00E+00	3.45E-06
		Total Dose	mGy/d	2.25E-06	4.61E-19	2.43E-06	0.00E+00	2.65E-07	1.14E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-04	0.00E+00	2.61E-04
E	Meadow Vole	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E-05	0.00E+00	6.95E-05
		Co-60	mGy/d	5.28E-13	0.00E+00	3.90E-09	0.00E+00	7.95E-11	2.96E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.13E-10	0.00E+00	2.96E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	3.75E-07	0.00E+00	2.78E-09	1.25E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.43E-09	0.00E+00	1.29E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	4.73E-07	0.00E+00	3.19E-08	5.38E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.41E-08	0.00E+00	5.44E-05
		HTO	mGy/d	2.01E-06	0.00E+00	6.15E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.98E-05	0.00E+00	7.24E-05
		I-131	mGy/d	4.60E-12	4.61E-19	1.65E-07	0.00E+00	3.52E-09	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.55E-08	0.00E+00	1.79E-05
		OBT	mGy/d	2.41E-07	0.00E+00	7.39E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-06	0.00E+00	3.45E-06
		Total Dose	mGy/d	2.25E-06	4.61E-19	1.71E-06	0.00E+00	3.83E-08	1.14E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-04	0.00E+00	2.60E-04
E	White-tailed Deer	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E-05	0.00E+00	6.95E-05
		Co-60	mGy/d	3.01E-12	0.00E+00	6.55E-08	0.00E+00	1.21E-09	1.51E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.07E-09	0.00E+00	1.52E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.61E-06	0.00E+00	3.09E-08	6.34E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.17E-08	0.00E+00	1.11E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	3.17E-06	0.00E+00	1.94E-07	2.63E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.14E-07	0.00E+00	3.02E-05
		HTO	mGy/d	2.01E-06	0.00E+00	4.92E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.98E-05	0.00E+00	8.23E-05
		I-131	mGy/d	1.02E-11	4.61E-19	1.07E-06	0.00E+00	2.07E-08	8.58E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.16E-07	0.00E+00	9.79E-06
		OBT	mGy/d	2.41E-07	0.00E+00	5.90E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.58E-06	0.00E+00	3.88E-06
		Total Dose	mGy/d	2.25E-06	4.61E-19	9.47E-06	0.00E+00	2.47E-07	5.64E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.54E-04	0.00E+00	2.22E-04
E	Common Shrew	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.87E-05	0.00E+00	4.87E-05
		Co-60	mGy/d	3.60E-13	0.00E+00	2.83E-09	0.00E+00	2.12E-10	2.96E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.79E-10	0.00E+00	2.96E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.72E-07	0.00E+00	7.42E-09	1.25E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.96E-07	0.00E+00	1.30E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	3.42E-07	0.00E+00	8.54E-08	5.38E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E-06	0.00E+00	5.65E-05
		HTO	mGy/d	2.01E-06	0.00E+00	6.15E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.98E-05	0.00E+00	7.24E-05
		I-131	mGy/d	3.14E-12	4.61E-19	1.20E-07	0.00E+00	9.40E-09	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.04E-07	0.00E+00	1.83E-05

Table D.10: Maximum Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
		OBT	mGy/d	2.41E-07	0.00E+00	7.39E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-06	0.00E+00	3.45E-06
		Total Dose	mGy/d	2.25E-06	4.61E-19	1.43E-06	0.00E+00	1.02E-07	1.14E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.24E-04	0.00E+00	2.42E-04
E	Raccoon	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.56E-05	6.95E-06	5.25E-05
		Co-60	mGy/d	5.48E-13	0.00E+00	8.34E-09	0.00E+00	9.16E-10	2.96E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.42E-08	1.06E-11	2.97E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	8.01E-07	0.00E+00	3.20E-08	1.25E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.00E-07	4.44E-08	1.42E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.01E-06	0.00E+00	3.68E-07	5.38E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.74E-06	6.69E-08	5.70E-05
		HTO	mGy/d	2.01E-06	0.00E+00	6.15E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.31E-05	3.54E-06	5.93E-05
		I-131	mGy/d	4.78E-12	4.61E-19	3.53E-07	0.00E+00	4.06E-08	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.89E-07	6.84E-09	1.86E-05
		OBT	mGy/d	2.41E-07	0.00E+00	7.39E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.39E-06	3.16E-08	2.73E-06
		Total Dose	mGy/d	2.25E-06	4.61E-19	2.86E-06	0.00E+00	4.42E-07	1.14E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-04	1.06E-05	2.34E-04
E	Red Fox	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.94E-06	5.56E-05	6.55E-05
		Co-60	mGy/d	5.18E-13	0.00E+00	8.13E-09	0.00E+00	9.87E-11	2.72E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E-10	3.05E-11	2.72E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	7.80E-07	0.00E+00	3.45E-09	1.15E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.68E-10	1.20E-07	1.24E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	9.84E-07	0.00E+00	3.97E-08	1.06E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-08	2.06E-07	1.07E-04
		HTO	mGy/d	2.01E-06	0.00E+00	6.15E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.98E-06	2.83E-05	4.09E-05
		I-131	mGy/d	4.52E-12	4.61E-19	3.44E-07	0.00E+00	4.37E-09	1.61E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.84E-09	1.96E-08	1.65E-05
		OBT	mGy/d	2.41E-07	0.00E+00	7.39E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.49E-07	2.53E-07	1.02E-06
		Total Dose	mGy/d	2.25E-06	4.61E-19	2.81E-06	0.00E+00	4.76E-08	1.60E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.04E-05	8.45E-05	2.70E-04
E	Short-tailed Weasel	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E-05	6.95E-05
		Co-60	mGy/d	4.35E-13	0.00E+00	5.01E-09	0.00E+00	3.62E-10	2.96E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.95E-11	2.96E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.81E-07	0.00E+00	1.27E-08	1.25E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-07	1.32E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	6.07E-07	0.00E+00	1.46E-07	5.38E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.12E-07	5.49E-05
		HTO	mGy/d	2.01E-06	0.00E+00	6.15E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.54E-05	3.80E-05
		I-131	mGy/d	3.79E-12	4.61E-19	2.12E-07	0.00E+00	1.60E-08	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.19E-08	1.80E-05
		OBT	mGy/d	2.41E-07	0.00E+00	7.39E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.16E-07	6.31E-07
		Total Dose	mGy/d	2.25E-06	4.61E-19	1.99E-06	0.00E+00	1.75E-07	1.14E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.06E-04	2.24E-04

Table D.11: UCLM Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
Lake Ontario	Round Whitefish	C-14	mGy/d	0.00E+00	0.00E+00	2.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.31E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.20E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	5.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.24E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.34E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.90E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.77E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.67E-07
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.06E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-06
		HTO	mGy/d	0.00E+00	0.00E+00	6.80E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.53E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.80E-07
		I-131	mGy/d	0.00E+00	0.00E+00	2.64E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.65E-05
		OBT	mGy/d	0.00E+00	0.00E+00	3.33E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.33E-08
		Total Dose	mGy/d	0.00E+00	0.00E+00	5.12E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.58E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.18E-05
Lake Ontario	White Sucker	C-14	mGy/d	0.00E+00	0.00E+00	2.09E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.31E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.09E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	5.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.24E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.34E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.90E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.77E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.67E-07
		Cs-137	mGy/d	0.00E+00	0.00E+00	5.85E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.94E-07
		HTO	mGy/d	0.00E+00	0.00E+00	9.17E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.53E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.17E-07
		I-131	mGy/d	0.00E+00	0.00E+00	9.90E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-05
		OBT	mGy/d	0.00E+00	0.00E+00	3.33E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.33E-08
		Total Dose	mGy/d	0.00E+00	0.00E+00	3.33E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.58E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.39E-05
Lake Ontario	Alewife	C-14	mGy/d	0.00E+00	0.00E+00	2.29E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.29E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	5.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.10E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.90E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.90E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	4.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.40E-06
		HTO	mGy/d	0.00E+00	0.00E+00	3.03E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.03E-06
		I-131	mGy/d	0.00E+00	0.00E+00	4.29E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.29E-05
		OBT	mGy/d	0.00E+00	0.00E+00	3.33E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.33E-08
		Total Dose	mGy/d	0.00E+00	0.00E+00	8.33E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.33E-05
Lake Ontario	Lake Trout	C-14	mGy/d	0.00E+00	0.00E+00	1.21E-04	1.35E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	9.53E-06	1.07E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.06E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.61E-03	1.79E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.62E-03
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.19E-03	9.66E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.19E-03
		HTO	mGy/d	0.00E+00	0.00E+00	1.78E-07	1.46E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.78E-07
		I-131	mGy/d	0.00E+00	0.00E+00	8.12E-06	1.89E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-05
		OBT	mGy/d	0.00E+00	0.00E+00	3.33E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.33E-08
		Total Dose	mGy/d	0.00E+00	0.00E+00	3.94E-03	5.71E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.95E-03
Lake Ontario	American Eel	C-14	mGy/d	0.00E+00	0.00E+00	1.21E-04	1.01E-11	0.00E+00	0.00E+00	0.00E+00	5.31E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	9.53E-06	8.04E-07	0.00E+00	0.00E+00	0.00E+00	1.24E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.61E-03	1.34E-06	0.00E+00	0.00E+00	0.00E+00	1.77E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.62E-03
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.19E-03	7.24E-07	0.00E+00	0.00E+00	0.00E+00	1.08E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.19E-03
		HTO	mGy/d	0.00E+00	0.00E+00	1.78E-07	1.10E-14	0.00E+00	0.00E+00	0.00E+00	2.53E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.78E-07
		I-131	mGy/d	0.00E+00	0.00E+00	8.12E-06	1.41E-06	0.00E+00	0.00E+00	0.00E+00	1.49E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.68E-06
		OBT	mGy/d	0.00E+00	0.00E+00	3.33E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.33E-08
		Total Dose	mGy/d	0.00E+00	0.00E+00	3.94E-03	4.28E-06	0.00E+00	0.00E+00	0.00E+00	5.58E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.94E-03
Lake Ontario	Benthic Invertebrates	C-14	mGy/d	0.00E+00	0.00E+00	2.38E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.72E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	1.25E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.38E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.79E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.73E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.21E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.55E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.35E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.67E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.92E-06
		HTO	mGy/d	0.00E+00	0.00E+00	1.39E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.87E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.39E-06
		I-131	mGy/d	0.00E+00	0.00E+00	2.17E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.46E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E-04
		OBT	mGy/d	0.00E+00	0.00E+00	3.34E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.34E-08
		Total Dose	mGy/d	0.00E+00	0.00E+00	2.48E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.67E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-04

Table D.11: UCLM Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
Lake Ontario Shore	Bufflehead	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.65E-05	0.00E+00	0.00E+00	2.65E-05
		Co-60	mGy/d	1.01E-11	0.00E+00	1.02E-08	0.00E+00	0.00E+00	0.00E+00	2.52E-10	7.21E-08	0.00E+00	1.17E-06	0.00E+00	0.00E+00	1.25E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	7.15E-08	0.00E+00	0.00E+00	0.00E+00	1.51E-09	1.12E-07	0.00E+00	3.02E-06	0.00E+00	0.00E+00	3.20E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	9.16E-08	0.00E+00	0.00E+00	0.00E+00	2.21E-09	6.86E-08	0.00E+00	2.56E-06	0.00E+00	0.00E+00	2.72E-06
		HTO	mGy/d	1.67E-06	0.00E+00	1.83E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-07	0.00E+00	0.00E+00	2.10E-06
		I-131	mGy/d	3.90E-14	4.61E-19	6.44E-10	0.00E+00	0.00E+00	0.00E+00	1.09E-11	9.39E-08	0.00E+00	6.49E-07	0.00E+00	0.00E+00	7.43E-07
		OBT	mGy/d	1.83E-07	0.00E+00	2.01E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-07
		Total Dose	mGy/d	1.85E-06	4.61E-19	1.94E-07	0.00E+00	0.00E+00	0.00E+00	3.98E-09	3.46E-07	0.00E+00	3.43E-05	0.00E+00	0.00E+00	3.67E-05
Lake Ontario Shore	Mallard	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.65E-05	0.00E+00	0.00E+00	2.65E-05
		Co-60	mGy/d	1.06E-11	0.00E+00	9.43E-09	0.00E+00	0.00E+00	0.00E+00	7.23E-10	7.21E-08	0.00E+00	1.10E-06	0.00E+00	0.00E+00	1.18E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	6.64E-08	0.00E+00	0.00E+00	0.00E+00	4.35E-09	1.12E-07	0.00E+00	2.84E-06	0.00E+00	0.00E+00	3.02E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	8.51E-08	0.00E+00	0.00E+00	0.00E+00	6.33E-09	6.86E-08	0.00E+00	2.41E-06	0.00E+00	0.00E+00	2.57E-06
		HTO	mGy/d	1.67E-06	0.00E+00	1.83E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-07	0.00E+00	0.00E+00	2.10E-06
		I-131	mGy/d	4.10E-14	4.61E-19	5.98E-10	0.00E+00	0.00E+00	0.00E+00	3.13E-11	9.39E-08	0.00E+00	6.10E-07	0.00E+00	0.00E+00	7.04E-07
		OBT	mGy/d	1.83E-07	0.00E+00	2.01E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-07
		Total Dose	mGy/d	1.85E-06	4.61E-19	1.82E-07	0.00E+00	0.00E+00	0.00E+00	1.14E-08	3.46E-07	0.00E+00	3.38E-05	0.00E+00	0.00E+00	3.62E-05
Coot's Pond	Dace	C-14	mGy/d	0.00E+00	0.00E+00	2.16E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.16E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	5.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.27E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.90E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.21E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.22E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	4.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.91E-06
		HTO	mGy/d	0.00E+00	0.00E+00	1.00E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.76E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-05
		I-131	mGy/d	0.00E+00	0.00E+00	1.05E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.92E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-03
		OBT	mGy/d	0.00E+00	0.00E+00	7.84E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.84E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	1.10E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-03
Coot's Pond	Turtles	C-14	mGy/d	0.00E+00	0.00E+00	2.39E-04	2.54E-10	0.00E+00	0.00E+00	0.00E+00	1.95E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.39E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	7.31E-06	2.30E-06	0.00E+00	0.00E+00	0.00E+00	1.85E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.18E-03	2.41E-06	0.00E+00	0.00E+00	0.00E+00	3.72E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-03
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.18E-03	1.18E-06	0.00E+00	0.00E+00	0.00E+00	6.08E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.19E-03
		HTO	mGy/d	0.00E+00	0.00E+00	4.20E-06	9.72E-12	0.00E+00	0.00E+00	0.00E+00	6.61E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.20E-06
		I-131	mGy/d	0.00E+00	0.00E+00	3.47E-05	9.36E-06	0.00E+00	0.00E+00	0.00E+00	2.26E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.42E-05
		OBT	mGy/d	0.00E+00	0.00E+00	7.84E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.84E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	3.64E-03	1.53E-05	0.00E+00	0.00E+00	0.00E+00	1.39E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.66E-03
Coot's Pond	Frogs	C-14	mGy/d	0.00E+00	0.00E+00	2.39E-04	2.54E-10	0.00E+00	0.00E+00	0.00E+00	1.95E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.39E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	7.31E-06	2.30E-06	0.00E+00	0.00E+00	0.00E+00	1.85E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.18E-03	2.41E-06	0.00E+00	0.00E+00	0.00E+00	3.72E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-03
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.18E-03	1.18E-06	0.00E+00	0.00E+00	0.00E+00	6.08E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.19E-03
		HTO	mGy/d	0.00E+00	0.00E+00	4.20E-06	9.72E-12	0.00E+00	0.00E+00	0.00E+00	6.61E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.20E-06
		I-131	mGy/d	0.00E+00	0.00E+00	3.47E-05	9.36E-06	0.00E+00	0.00E+00	0.00E+00	2.26E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.42E-05
		OBT	mGy/d	0.00E+00	0.00E+00	7.84E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.84E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	3.64E-03	1.53E-05	0.00E+00	0.00E+00	0.00E+00	1.39E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.66E-03
Coot's Pond	Aquatic Plants	C-14	mGy/d	0.00E+00	0.00E+00	2.39E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.39E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	2.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.70E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	3.30E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.30E-06
		HTO	mGy/d	0.00E+00	0.00E+00	5.75E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.75E-06
		I-131	mGy/d	0.00E+00	0.00E+00	5.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.40E-06
		OBT	mGy/d	0.00E+00	0.00E+00	6.16E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.16E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	4.37E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.37E-05

Table D.11: UCLM Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
Cool's Pond	Benthic Invertebrates	C-14	mGy/d	0.00E+00	0.00E+00	2.15E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.79E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.15E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	1.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.32E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.31E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.65E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	4.54E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.66E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.81E-05
		HTO	mGy/d	0.00E+00	0.00E+00	4.21E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.76E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.21E-06
		I-131	mGy/d	0.00E+00	0.00E+00	4.63E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.63E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.73E-05
		OBT	mGy/d	0.00E+00	0.00E+00	7.86E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.86E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	3.49E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.88E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.55E-04
AB	Bufflehead AB	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.33E-06	2.15E-04	0.00E+00	0.00E+00	2.18E-04
		Co-60	mGy/d	6.85E-12	0.00E+00	2.65E-08	0.00E+00	0.00E+00	0.00E+00	3.43E-10	9.81E-08	1.14E-07	1.04E-05	0.00E+00	0.00E+00	1.07E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.11E-07	0.00E+00	0.00E+00	0.00E+00	2.75E-09	2.03E-07	2.95E-07	3.93E-05	0.00E+00	0.00E+00	3.99E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.26E-07	0.00E+00	0.00E+00	0.00E+00	1.04E-08	3.23E-07	2.51E-07	4.46E-05	0.00E+00	0.00E+00	4.53E-05
		HTO	mGy/d	1.13E-06	0.00E+00	4.31E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.73E-07	1.14E-06	0.00E+00	0.00E+00	2.87E-06
		I-131	mGy/d	2.65E-14	4.35E-19	3.63E-09	0.00E+00	0.00E+00	0.00E+00	1.41E-11	1.21E-07	1.22E-09	1.25E-07	0.00E+00	0.00E+00	2.51E-07
		OBT	mGy/d	1.24E-07	0.00E+00	4.74E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.72E-07
		Total Dose	mGy/d	1.26E-06	4.35E-19	7.45E-07	0.00E+00	0.00E+00	0.00E+00	1.35E-08	7.45E-07	3.16E-06	3.11E-04	0.00E+00	0.00E+00	3.17E-04
AB	Mallard AB	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.82E-06	1.80E-04	0.00E+00	0.00E+00	1.85E-04
		Co-60	mGy/d	7.20E-12	0.00E+00	2.46E-08	0.00E+00	0.00E+00	0.00E+00	9.84E-10	9.81E-08	2.76E-07	8.18E-06	0.00E+00	0.00E+00	8.58E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.03E-07	0.00E+00	0.00E+00	0.00E+00	7.90E-09	2.03E-07	7.14E-07	3.08E-05	0.00E+00	0.00E+00	3.18E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.17E-07	0.00E+00	0.00E+00	0.00E+00	2.98E-08	3.23E-07	6.07E-07	3.50E-05	0.00E+00	0.00E+00	3.60E-05
		HTO	mGy/d	1.13E-06	0.00E+00	4.31E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.33E-07	9.49E-07	0.00E+00	0.00E+00	2.94E-06
		I-131	mGy/d	2.78E-14	4.35E-19	3.37E-09	0.00E+00	0.00E+00	0.00E+00	4.04E-11	1.21E-07	2.95E-09	9.78E-08	0.00E+00	0.00E+00	2.25E-07
		OBT	mGy/d	1.24E-07	0.00E+00	4.74E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.72E-07
		Total Dose	mGy/d	1.26E-06	4.35E-19	7.26E-07	0.00E+00	0.00E+00	0.00E+00	3.87E-08	7.45E-07	7.86E-06	2.55E-04	0.00E+00	0.00E+00	2.65E-04
AB	Muskrat	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.84E-05	0.00E+00	0.00E+00	0.00E+00	3.84E-05
		Co-60	mGy/d	3.97E-13	0.00E+00	1.91E-09	0.00E+00	0.00E+00	0.00E+00	5.84E-11	2.07E-07	6.50E-08	0.00E+00	0.00E+00	0.00E+00	2.74E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.62E-07	0.00E+00	0.00E+00	0.00E+00	9.50E-09	4.06E-07	3.41E-06	0.00E+00	0.00E+00	0.00E+00	3.99E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.17E-07	0.00E+00	0.00E+00	0.00E+00	4.22E-08	6.75E-07	3.41E-06	0.00E+00	0.00E+00	0.00E+00	4.34E-06
		HTO	mGy/d	1.76E-06	0.00E+00	1.62E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.62E-06	0.00E+00	0.00E+00	0.00E+00	6.00E-06
		I-131	mGy/d	3.46E-12	8.71E-19	5.91E-07	0.00E+00	0.00E+00	0.00E+00	5.41E-09	2.59E-07	1.57E-06	0.00E+00	0.00E+00	0.00E+00	2.43E-06
		OBT	mGy/d	2.11E-07	0.00E+00	1.94E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.05E-07
		Total Dose	mGy/d	1.97E-06	8.71E-19	2.78E-06	0.00E+00	0.00E+00	0.00E+00	5.71E-08	1.55E-06	4.95E-05	0.00E+00	0.00E+00	0.00E+00	5.58E-05
AB	Earthworm	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-06
		I-131	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-05
		OBT	mGy/d	1.49E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-05
		Total Dose	mGy/d	1.49E-05	0.00E+00	0.00E+00	0.00E+00	5.68E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.17E-05
AB	American Robin	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-05	0.00E+00	2.08E-05
		Co-60	mGy/d	6.62E-12	0.00E+00	3.16E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-06	0.00E+00	2.99E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.32E-07	0.00E+00	1.94E-08	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.65E-06	0.00E+00	1.09E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.50E-07	0.00E+00	4.54E-07	3.08E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-06	0.00E+00	3.79E-05
		HTO	mGy/d	1.13E-06	0.00E+00	4.31E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-06	0.00E+00	3.26E-06
		I-131	mGy/d	2.56E-14	4.35E-19	4.32E-09	0.00E+00	4.42E-10	8.29E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.54E-08	0.00E+00	8.37E-06
		OBT	mGy/d	1.24E-07	0.00E+00	4.74E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.94E-08	0.00E+00	2.51E-07
		Total Dose	mGy/d	1.26E-06	4.35E-19	7.97E-07	0.00E+00	4.73E-07	4.22E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.98E-05	0.00E+00	8.45E-05

Table D.11: UCLM Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
AB	Bank Swallow	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-05	0.00E+00	2.00E-05
		Co-60	mGy/d	6.34E-12	0.00E+00	3.92E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.41E-06	0.00E+00	2.45E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.64E-07	0.00E+00	1.06E-08	1.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E-06	0.00E+00	7.97E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.86E-07	0.00E+00	2.48E-07	1.54E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.30E-06	0.00E+00	2.11E-05
		HTO	mGy/d	1.13E-06	0.00E+00	4.31E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.94E-06	0.00E+00	3.50E-06
		I-131	mGy/d	2.45E-14	4.35E-19	5.36E-09	0.00E+00	2.41E-10	4.15E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.10E-08	0.00E+00	4.22E-06
		OBT	mGy/d	1.24E-07	0.00E+00	4.74E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.04E-08	0.00E+00	2.62E-07
		Total Dose	mGy/d	1.26E-06	4.35E-19	8.73E-07	0.00E+00	2.59E-07	2.11E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.61E-05	0.00E+00	5.95E-05
AB	Song Sparrow	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-05	0.00E+00	3.14E-05
		Co-60	mGy/d	1.03E-11	0.00E+00	5.39E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.92E-06	0.00E+00	5.98E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.26E-07	0.00E+00	1.64E-08	4.99E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-05	0.00E+00	2.05E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.56E-07	0.00E+00	3.83E-07	4.92E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-05	0.00E+00	6.29E-05
		HTO	mGy/d	1.81E-06	0.00E+00	6.90E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.51E-06	0.00E+00	7.01E-06
		I-131	mGy/d	4.00E-14	6.97E-19	7.38E-09	0.00E+00	3.73E-10	1.33E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.98E-08	0.00E+00	1.33E-05
		OBT	mGy/d	1.99E-07	0.00E+00	7.59E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-07	0.00E+00	4.85E-07
		Total Dose	mGy/d	2.01E-06	6.97E-19	1.31E-06	0.00E+00	4.00E-07	6.75E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.05E-05	0.00E+00	1.42E-04
AB	Yellow Warbler	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-05	0.00E+00	2.00E-05
		Co-60	mGy/d	6.44E-12	0.00E+00	3.58E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-06	0.00E+00	2.65E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.50E-07	0.00E+00	1.10E-08	1.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-06	0.00E+00	8.48E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.70E-07	0.00E+00	2.58E-07	1.54E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-06	0.00E+00	2.15E-05
		HTO	mGy/d	1.13E-06	0.00E+00	4.31E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-06	0.00E+00	3.56E-06
		I-131	mGy/d	2.49E-14	4.35E-19	4.91E-09	0.00E+00	2.51E-10	4.15E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.19E-08	0.00E+00	4.22E-06
		OBT	mGy/d	1.24E-07	0.00E+00	4.74E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.34E-08	0.00E+00	2.65E-07
		Total Dose	mGy/d	1.26E-06	4.35E-19	8.39E-07	0.00E+00	2.69E-07	2.11E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.73E-05	0.00E+00	6.07E-05
AB	Green Heron	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.17E-05	0.00E+00	0.00E+00	2.17E-05
		Co-60	mGy/d	6.72E-12	0.00E+00	2.86E-08	0.00E+00	0.00E+00	0.00E+00	6.93E-10	9.81E-08	0.00E+00	1.29E-06	0.00E+00	0.00E+00	1.42E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.19E-07	0.00E+00	0.00E+00	0.00E+00	5.56E-09	2.03E-07	0.00E+00	3.34E-06	0.00E+00	0.00E+00	3.66E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.35E-07	0.00E+00	0.00E+00	0.00E+00	2.10E-08	3.23E-07	0.00E+00	2.83E-06	0.00E+00	0.00E+00	3.31E-06
		HTO	mGy/d	1.13E-06	0.00E+00	4.31E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.02E-06	0.00E+00	0.00E+00	4.58E-06
		I-131	mGy/d	2.59E-14	4.35E-19	3.91E-09	0.00E+00	0.00E+00	0.00E+00	2.84E-11	1.21E-07	0.00E+00	2.19E-06	0.00E+00	0.00E+00	2.32E-06
		OBT	mGy/d	1.24E-07	0.00E+00	4.74E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.72E-07
		Total Dose	mGy/d	1.26E-06	4.35E-19	7.66E-07	0.00E+00	0.00E+00	0.00E+00	2.72E-08	7.45E-07	0.00E+00	3.43E-05	0.00E+00	0.00E+00	3.71E-05
AB	Grass	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E-05
		I-131	mGy/d	0.00E+00	8.71E-19	0.00E+00	0.00E+00	4.42E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.42E-05
		OBT	mGy/d	1.40E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-09
		Total Dose	mGy/d	1.40E-09	8.71E-19	0.00E+00	0.00E+00	1.14E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-04
AB	Eastern Cottontail	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.83E-05	0.00E+00	3.83E-05
		Co-60	mGy/d	4.14E-13	0.00E+00	1.92E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.26E-08	0.00E+00	7.46E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.63E-07	0.00E+00	9.59E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06	0.00E+00	1.02E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.17E-07	0.00E+00	2.64E-07	6.44E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06	0.00E+00	6.86E-05
		HTO	mGy/d	1.76E-06	0.00E+00	1.62E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.86E-05	0.00E+00	2.20E-05
		I-131	mGy/d	3.61E-12	8.71E-19	5.93E-07	0.00E+00	2.43E-08	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E-05	0.00E+00	3.20E-05
		OBT	mGy/d	2.11E-07	0.00E+00	1.94E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.37E-07	0.00E+00	1.24E-06
		Total Dose	mGy/d	1.97E-06	8.71E-19	2.79E-06	0.00E+00	2.98E-07	8.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.91E-05	0.00E+00	1.72E-04

Table D.11: UCLM Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
AB	Meadow Vole	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.83E-05	0.00E+00	3.83E-05
		Co-60	mGy/d	4.62E-13	0.00E+00	1.12E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-08	0.00E+00	3.01E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	9.52E-08	0.00E+00	1.39E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	7.85E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.27E-07	0.00E+00	3.82E-08	6.44E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	6.60E-05
		HTO	mGy/d	1.76E-06	0.00E+00	1.62E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.86E-05	0.00E+00	2.20E-05
		I-131	mGy/d	4.03E-12	8.71E-19	3.47E-07	0.00E+00	3.52E-09	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.46E-06	0.00E+00	2.35E-05
		OBT	mGy/d	2.11E-07	0.00E+00	1.94E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.37E-07	0.00E+00	1.24E-06
		Total Dose	mGy/d	1.97E-06	8.71E-19	2.38E-06	0.00E+00	4.31E-08	8.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.62E-05	0.00E+00	1.59E-04
AB	White-tailed Deer	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.83E-05	0.00E+00	3.83E-05
		Co-60	mGy/d	2.63E-12	0.00E+00	1.88E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.02E-07	0.00E+00	5.21E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.17E-06	0.00E+00	1.54E-08	3.17E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.93E-05	0.00E+00	2.36E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	8.54E-07	0.00E+00	2.32E-07	3.15E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-05	0.00E+00	4.31E-05
		HTO	mGy/d	1.76E-06	0.00E+00	1.29E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.13E-05	0.00E+00	2.43E-05
		I-131	mGy/d	8.89E-12	8.71E-19	2.25E-06	0.00E+00	2.07E-08	8.58E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.66E-05	0.00E+00	4.75E-05
		OBT	mGy/d	2.11E-07	0.00E+00	1.55E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.56E-07	0.00E+00	1.32E-06
		Total Dose	mGy/d	1.97E-06	8.71E-19	5.74E-06	0.00E+00	2.68E-07	4.32E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-04	0.00E+00	1.79E-04
AB	Common Shrew	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.30E-05	0.00E+00	3.30E-05
		Co-60	mGy/d	3.15E-13	0.00E+00	8.14E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-07	0.00E+00	1.05E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	6.90E-08	0.00E+00	3.71E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E-06	0.00E+00	1.18E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	9.21E-08	0.00E+00	1.02E-07	6.44E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.48E-06	0.00E+00	7.00E-05
		HTO	mGy/d	1.76E-06	0.00E+00	1.62E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.93E-06	0.00E+00	6.31E-06
		I-131	mGy/d	2.75E-12	8.71E-19	2.51E-07	0.00E+00	9.40E-09	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.94E-06	0.00E+00	2.49E-05
		OBT	mGy/d	2.11E-07	0.00E+00	1.94E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E-07	0.00E+00	5.37E-07
		Total Dose	mGy/d	1.97E-06	8.71E-19	2.23E-06	0.00E+00	1.15E-07	8.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.41E-05	0.00E+00	1.47E-04
AB	Raccoon Poly AB	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.94E-06	2.48E-05	3.83E-07	2.91E-05
		Co-60	mGy/d	4.79E-13	0.00E+00	2.40E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.42E-08	6.80E-08	6.38E-11	1.55E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.03E-07	0.00E+00	1.60E-08	6.24E-06	0.00E+00	0.00E+00	0.00E+00	6.43E-06	3.56E-06	1.75E-07	1.66E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.72E-07	0.00E+00	4.40E-07	6.44E-05	0.00E+00	0.00E+00	0.00E+00	8.58E-06	3.57E-06	1.83E-07	7.74E-05
		HTO	mGy/d	1.76E-06	0.00E+00	1.62E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.91E-08	6.44E-06	1.07E-07	9.95E-06
		I-131	mGy/d	4.18E-12	8.71E-19	7.41E-07	0.00E+00	4.06E-08	1.77E-05	0.00E+00	0.00E+00	0.00E+00	2.27E-06	6.54E-06	1.92E-07	2.75E-05
		OBT	mGy/d	2.11E-07	0.00E+00	1.94E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-07	1.14E-09	6.96E-07
		Total Dose	mGy/d	1.97E-06	8.71E-19	3.03E-06	0.00E+00	4.97E-07	8.83E-05	0.00E+00	0.00E+00	0.00E+00	2.13E-05	4.53E-05	1.04E-06	1.61E-04
AB	Red Fox AB	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E-06	6.89E-05	7.44E-05
		Co-60	mGy/d	4.53E-13	0.00E+00	2.34E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.36E-09	1.07E-08	1.74E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.98E-07	0.00E+00	1.73E-09	5.75E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	2.63E-06	8.81E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.65E-07	0.00E+00	4.74E-08	1.26E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	3.39E-06	1.30E-04
		HTO	mGy/d	1.76E-06	0.00E+00	1.62E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.66E-06	5.80E-06	1.18E-05
		I-131	mGy/d	3.95E-12	8.71E-19	7.22E-07	0.00E+00	4.37E-09	1.61E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.21E-07	4.48E-07	1.81E-05
		OBT	mGy/d	2.11E-07	0.00E+00	1.94E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-07	6.15E-08	5.87E-07
		Total Dose	mGy/d	1.97E-06	8.71E-19	3.00E-06	0.00E+00	5.35E-08	1.48E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.54E-06	8.13E-05	2.44E-04
AB	Short-tailed Weasel	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.83E-05	3.83E-05
		Co-60	mGy/d	3.80E-13	0.00E+00	1.44E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.17E-10	1.76E-09
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.22E-07	0.00E+00	6.33E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.71E-07	7.24E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.63E-07	0.00E+00	1.74E-07	6.44E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.09E-07	6.56E-05
		HTO	mGy/d	1.76E-06	0.00E+00	1.62E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E-05	1.41E-05
		I-131	mGy/d	3.32E-12	8.71E-19	4.45E-07	0.00E+00	1.60E-08	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.54E-07	1.92E-05
		OBT	mGy/d	2.11E-07	0.00E+00	1.94E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-07	5.19E-07
		Total Dose	mGy/d	1.97E-06	8.71E-19	2.54E-06	0.00E+00	1.96E-07	8.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.19E-05	1.45E-04

Table D.11: UCLM Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
C	Earthworm	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.39E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.39E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.11E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.11E-06
		I-131	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-05
		OBT	mGy/d	1.05E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-05
		Total Dose	mGy/d	1.05E-05	0.00E+00	0.00E+00	0.00E+00	6.11E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.15E-05
C	American Robin	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E-05	0.00E+00	2.38E-05
		Co-60	mGy/d	4.66E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-06	0.00E+00	2.96E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.45E-10	0.00E+00	9.71E-09	1.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.65E-06	0.00E+00	9.22E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.45E-09	0.00E+00	5.77E-08	3.91E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-06	0.00E+00	1.05E-05
		HTO	mGy/d	7.96E-07	0.00E+00	5.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E-06	0.00E+00	9.83E-06
		I-131	mGy/d	1.80E-14	2.71E-19	2.49E-10	0.00E+00	4.82E-10	9.05E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.96E-08	0.00E+00	9.12E-06
		OBT	mGy/d	8.75E-08	0.00E+00	6.42E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-07	0.00E+00	8.79E-07
		Total Dose	mGy/d	8.83E-07	2.71E-19	6.48E-06	0.00E+00	6.79E-08	1.45E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.43E-05	0.00E+00	6.62E-05
C	Song Sparrow	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.74E-05	0.00E+00	3.74E-05
		Co-60	mGy/d	7.28E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.92E-06	0.00E+00	5.92E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.18E-10	0.00E+00	8.20E-09	2.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-05	0.00E+00	1.78E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.48E-09	0.00E+00	4.87E-08	6.26E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-05	0.00E+00	1.93E-05
		HTO	mGy/d	1.27E-06	0.00E+00	9.34E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.82E-06	0.00E+00	1.94E-05
		I-131	mGy/d	2.81E-14	4.33E-19	4.24E-10	0.00E+00	4.07E-10	1.45E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.56E-08	0.00E+00	1.45E-05
		OBT	mGy/d	1.40E-07	0.00E+00	1.03E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.12E-07	0.00E+00	1.58E-06
		Total Dose	mGy/d	1.41E-06	4.33E-19	1.04E-05	0.00E+00	5.74E-08	2.32E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.10E-05	0.00E+00	1.16E-04
C	Yellow Warbler	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.52E-05	0.00E+00	3.52E-05
		Co-60	mGy/d	4.53E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-06	0.00E+00	2.61E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.78E-10	0.00E+00	5.52E-09	7.80E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-06	0.00E+00	7.54E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.65E-09	0.00E+00	3.28E-08	1.96E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-06	0.00E+00	7.73E-06
		HTO	mGy/d	7.96E-07	0.00E+00	5.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.86E-06	0.00E+00	1.35E-05
		I-131	mGy/d	1.75E-14	2.71E-19	2.82E-10	0.00E+00	2.74E-10	4.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.51E-08	0.00E+00	4.62E-06
		OBT	mGy/d	8.75E-08	0.00E+00	6.42E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E-07	0.00E+00	1.05E-06
		Total Dose	mGy/d	8.83E-07	2.71E-19	6.48E-06	0.00E+00	3.86E-08	7.26E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.76E-05	0.00E+00	7.22E-05
C	Grass	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.68E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.68E-05
		I-131	mGy/d	0.00E+00	5.41E-19	0.00E+00	0.00E+00	3.64E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.64E-05
		OBT	mGy/d	9.85E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.85E-10
		Total Dose	mGy/d	9.85E-10	5.41E-19	0.00E+00	0.00E+00	1.20E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-04
C	Eastern Cottontail	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.89E-05	0.00E+00	7.89E-05
		Co-60	mGy/d	2.92E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.26E-08	0.00E+00	7.26E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	3.01E-10	0.00E+00	4.80E-09	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06	0.00E+00	6.93E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.11E-09	0.00E+00	3.36E-08	8.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06	0.00E+00	1.20E-05
		HTO	mGy/d	1.24E-06	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.57E-05	0.00E+00	3.89E-05
		I-131	mGy/d	2.54E-12	5.41E-19	3.41E-08	0.00E+00	2.65E-08	1.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-05	0.00E+00	3.07E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.06E-07	0.00E+00	3.48E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	2.46E-05	0.00E+00	6.49E-08	3.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-04	0.00E+00	1.71E-04

Table D.11: UCLM Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
C	Meadow Vole	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.89E-05	0.00E+00	7.89E-05
		Co-60	mGy/d	3.25E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-08	0.00E+00	2.90E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.76E-10	0.00E+00	6.94E-10	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	4.64E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.23E-09	0.00E+00	4.86E-09	8.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	9.71E-06
		HTO	mGy/d	1.24E-06	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.57E-05	0.00E+00	3.89E-05
		I-131	mGy/d	2.83E-12	5.41E-19	1.99E-08	0.00E+00	3.84E-09	1.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.49E-06	0.00E+00	2.39E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.06E-07	0.00E+00	3.48E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	2.46E-05	0.00E+00	9.39E-09	3.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.03E-04	0.00E+00	1.59E-04
C	White-tailed Deer	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.89E-05	0.00E+00	7.89E-05
		Co-60	mGy/d	1.85E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.02E-07	0.00E+00	5.02E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.16E-09	0.00E+00	7.71E-09	1.59E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.93E-05	0.00E+00	2.09E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	8.28E-09	0.00E+00	2.95E-08	4.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-05	0.00E+00	1.46E-05
		HTO	mGy/d	1.24E-06	0.00E+00	1.75E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-05	0.00E+00	3.67E-05
		I-131	mGy/d	6.26E-12	5.41E-19	1.30E-07	0.00E+00	2.26E-08	9.36E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.02E-05	0.00E+00	3.97E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.07E-07	0.00E+00	3.06E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	1.97E-05	0.00E+00	5.98E-08	1.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.58E-04	0.00E+00	1.94E-04
C	Common Shrew	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.95E-05	0.00E+00	5.95E-05
		Co-60	mGy/d	2.22E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-07	0.00E+00	1.04E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.28E-10	0.00E+00	1.86E-09	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E-06	0.00E+00	8.59E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	8.93E-10	0.00E+00	1.30E-08	8.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.48E-06	0.00E+00	1.37E-05
		HTO	mGy/d	1.24E-06	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-05	0.00E+00	3.37E-05
		I-131	mGy/d	1.93E-12	5.41E-19	1.44E-08	0.00E+00	1.03E-08	1.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.26E-06	0.00E+00	2.86E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.74E-07	0.00E+00	3.25E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	2.46E-05	0.00E+00	2.51E-08	3.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.08E-05	0.00E+00	1.47E-04
C	Raccoon	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.28E-05	7.89E-06	6.07E-05
		Co-60	mGy/d	3.37E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.14E-08	6.55E-11	8.15E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	3.76E-10	0.00E+00	8.00E-09	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.26E-06	1.76E-07	7.57E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.63E-09	0.00E+00	5.60E-08	8.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.27E-06	1.76E-07	1.27E-05
		HTO	mGy/d	1.24E-06	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.99E-06	1.90E-06	3.50E-05
		I-131	mGy/d	2.94E-12	5.41E-19	4.26E-08	0.00E+00	4.42E-08	1.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.81E-06	1.59E-07	2.74E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.49E-07	3.19E-08	3.26E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	2.46E-05	0.00E+00	1.08E-07	3.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.97E-05	1.03E-05	1.47E-04
C	Red Fox	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-05	6.31E-05	7.44E-05
		Co-60	mGy/d	3.19E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.36E-09	2.31E-10	4.59E-09
		Cs-134	mGy/d	0.00E+00	0.00E+00	3.67E-10	0.00E+00	8.63E-10	2.88E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	6.20E-07	3.73E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.57E-09	0.00E+00	6.04E-09	1.61E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	6.25E-07	1.69E-05
		HTO	mGy/d	1.24E-06	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E-06	1.52E-05	4.06E-05
		I-131	mGy/d	2.78E-12	5.41E-19	4.15E-08	0.00E+00	4.77E-09	1.75E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-07	5.62E-07	1.88E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-07	2.55E-07	3.13E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	2.46E-05	0.00E+00	1.17E-08	3.65E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.48E-05	8.03E-05	1.58E-04
C	Short-tailed Weasel	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.89E-05	7.89E-05
		Co-60	mGy/d	2.68E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.05E-10	3.06E-10
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.26E-10	0.00E+00	3.16E-09	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.19E-07	3.94E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.58E-09	0.00E+00	2.22E-08	8.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.23E-07	9.04E-06
		HTO	mGy/d	1.24E-06	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-05	4.21E-05
		I-131	mGy/d	2.33E-12	5.41E-19	2.56E-08	0.00E+00	1.75E-08	1.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.42E-07	2.01E-05
		OBT	mGy/d	1.49E-07	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.19E-07	3.10E-06
		Total Dose	mGy/d	1.39E-06	5.41E-19	2.46E-05	0.00E+00	4.28E-08	3.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-04	1.57E-04

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
Dragonfly Pond	Turtles	C-14	mGy/d	0.00E+00	0.00E+00	3.45E-04	3.67E-10	0.00E+00	0.00E+00	0.00E+00	1.86E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	4.50E-06	1.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.91E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	5.72E-04	1.17E-06	0.00E+00	0.00E+00	0.00E+00	3.69E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-04
		Cs-137	mGy/d	0.00E+00	0.00E+00	7.49E-04	4.06E-07	0.00E+00	0.00E+00	0.00E+00	2.72E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.52E-04
		HTO	mGy/d	0.00E+00	0.00E+00	6.01E-06	1.39E-11	0.00E+00	0.00E+00	0.00E+00	7.63E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.01E-06
		I-131	mGy/d	0.00E+00	0.00E+00	3.32E-06	8.95E-07	0.00E+00	0.00E+00	0.00E+00	1.42E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E-06
		OBT	mGy/d	0.00E+00	0.00E+00	1.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-06
		Total Dose	mGy/d	0.00E+00	0.00E+00	1.68E-03	3.89E-06	0.00E+00	0.00E+00	0.00E+00	3.25E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-03
Polliwog Pond	Turtles	C-14	mGy/d	0.00E+00	0.00E+00	3.45E-04	3.67E-10	0.00E+00	0.00E+00	0.00E+00	1.86E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	4.50E-06	1.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.91E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	5.72E-04	1.17E-06	0.00E+00	0.00E+00	0.00E+00	3.69E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-04
		Cs-137	mGy/d	0.00E+00	0.00E+00	7.49E-04	4.06E-07	0.00E+00	0.00E+00	0.00E+00	2.72E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.52E-04
		HTO	mGy/d	0.00E+00	0.00E+00	6.01E-06	1.39E-11	0.00E+00	0.00E+00	0.00E+00	7.63E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.01E-06
		I-131	mGy/d	0.00E+00	0.00E+00	3.32E-06	8.95E-07	0.00E+00	0.00E+00	0.00E+00	1.42E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E-06
		OBT	mGy/d	0.00E+00	0.00E+00	1.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-06
		Total Dose	mGy/d	0.00E+00	0.00E+00	1.68E-03	3.89E-06	0.00E+00	0.00E+00	0.00E+00	3.25E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-03
Treefrog Pond	Turtles	C-14	mGy/d	0.00E+00	0.00E+00	3.45E-04	3.67E-10	0.00E+00	0.00E+00	0.00E+00	1.86E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-04
		Co-60	mGy/d	0.00E+00	0.00E+00	4.50E-06	1.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.91E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	5.72E-04	1.17E-06	0.00E+00	0.00E+00	0.00E+00	3.69E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-04
		Cs-137	mGy/d	0.00E+00	0.00E+00	7.49E-04	4.06E-07	0.00E+00	0.00E+00	0.00E+00	2.72E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	

Table D.11: UCLM Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
Dragonfly Pond	Aquatic Plants	C-14	mGy/d	0.00E+00	0.00E+00	3.91E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.91E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	2.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.70E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	3.30E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.30E-06
		HTO	mGy/d	0.00E+00	0.00E+00	8.02E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.02E-06
		I-131	mGy/d	0.00E+00	0.00E+00	8.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.10E-06
		OBT	mGy/d	0.00E+00	0.00E+00	8.82E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.82E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	6.42E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.42E-05
Polliwog Pond	Aquatic Plants	C-14	mGy/d	0.00E+00	0.00E+00	3.91E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.91E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	2.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.70E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	3.30E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.30E-06
		HTO	mGy/d	0.00E+00	0.00E+00	8.02E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.02E-06
		I-131	mGy/d	0.00E+00	0.00E+00	8.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.10E-06
		OBT	mGy/d	0.00E+00	0.00E+00	8.82E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.82E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	6.42E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.42E-05
Treefrog Pond	Aquatic Plants	C-14	mGy/d	0.00E+00	0.00E+00	3.91E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.91E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	2.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	2.70E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	3.30E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.30E-06
		HTO	mGy/d	0.00E+00	0.00E+00	8.02E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.02E-06
		I-131	mGy/d	0.00E+00	0.00E+00	8.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.10E-06
		OBT	mGy/d	0.00E+00	0.00E+00	8.82E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.82E-07
		Total Dose	mGy/d	0.00E+00	0.00E+00	6.42E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.42E-05
D	Earthworm	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.42E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.42E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.63E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.63E-06
		I-131	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.24E-05
		OBT	mGy/d	9.39E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.39E-06
		Total Dose	mGy/d	9.39E-06	0.00E+00	0.00E+00	0.00E+00	6.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.64E-05
D	American Robin	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.51E-05	0.00E+00	2.51E-05
		Co-60	mGy/d	4.18E-12	0.00E+00	1.94E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-06	0.00E+00	2.98E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	6.44E-08	0.00E+00	1.94E-08	3.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.65E-06	0.00E+00	1.09E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	5.14E-08	0.00E+00	5.20E-07	3.52E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-06	0.00E+00	4.23E-05
		HTO	mGy/d	7.14E-07	0.00E+00	6.17E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.81E-06	0.00E+00	3.15E-06
		I-131	mGy/d	1.62E-14	2.16E-19	4.14E-10	0.00E+00	6.03E-11	1.13E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.70E-08	0.00E+00	1.22E-06
		OBT	mGy/d	7.85E-08	0.00E+00	6.79E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.47E-08	0.00E+00	2.31E-07
		Total Dose	mGy/d	7.92E-07	2.16E-19	8.21E-07	0.00E+00	5.39E-07	3.95E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.42E-05	0.00E+00	8.59E-05
D	Song Sparrow	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.79E-05	0.00E+00	3.79E-05
		Co-60	mGy/d	6.53E-12	0.00E+00	3.32E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.92E-06	0.00E+00	5.95E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.10E-07	0.00E+00	1.64E-08	4.99E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-05	0.00E+00	2.04E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	8.78E-08	0.00E+00	4.39E-07	5.64E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-05	0.00E+00	6.99E-05
		HTO	mGy/d	1.14E-06	0.00E+00	9.88E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.99E-06	0.00E+00	7.12E-06
		I-131	mGy/d	2.52E-14	3.46E-19	7.06E-10	0.00E+00	5.09E-11	1.81E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.40E-08	0.00E+00	1.87E-06
		OBT	mGy/d	1.26E-07	0.00E+00	1.09E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.33E-07	0.00E+00	4.67E-07
		Total Dose	mGy/d	1.27E-06	3.46E-19	1.33E-06	0.00E+00	4.55E-07	6.32E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.74E-05	0.00E+00	1.44E-04

Table D.11: UCLM Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
D	Yellow Warbler	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-05	0.00E+00	2.43E-05
		Co-60	mGy/d	4.07E-12	0.00E+00	2.20E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-06	0.00E+00	2.63E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	7.30E-08	0.00E+00	1.10E-08	1.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-06	0.00E+00	8.40E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	5.84E-08	0.00E+00	2.95E-07	1.76E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.74E-06	0.00E+00	2.37E-05
		HTO	mGy/d	7.14E-07	0.00E+00	6.17E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.44E-06	0.00E+00	4.77E-06
		I-131	mGy/d	1.57E-14	2.16E-19	4.69E-10	0.00E+00	3.42E-11	5.65E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.88E-08	0.00E+00	6.15E-07
		OBT	mGy/d	7.85E-08	0.00E+00	6.79E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-07	0.00E+00	3.07E-07
		Total Dose	mGy/d	7.92E-07	2.16E-19	8.39E-07	0.00E+00	3.06E-07	1.97E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.31E-05	0.00E+00	6.48E-05
D	Grass	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.31E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.31E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-06
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.88E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.88E-06
		I-131	mGy/d	0.00E+00	4.33E-19	0.00E+00	0.00E+00	5.98E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.98E-05
		OBT	mGy/d	8.84E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.84E-10
		Total Dose	mGy/d	8.84E-10	4.33E-19	0.00E+00	0.00E+00	1.06E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.06E-04
D	Sugar Maple	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.31E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.31E-05
		Co-60	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-05
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.80E-06
		HTO	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.88E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.88E-06
		I-131	mGy/d	0.00E+00	4.33E-19	0.00E+00	0.00E+00	1.36E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E-04
		OBT	mGy/d	8.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.84E-06
		Total Dose	mGy/d	8.84E-06	4.33E-19	0.00E+00	0.00E+00	2.14E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.23E-04
D	Eastern Cottontail	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.66E-05	0.00E+00	6.66E-05
		Co-60	mGy/d	2.62E-13	0.00E+00	1.18E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.26E-08	0.00E+00	7.38E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	7.92E-08	0.00E+00	9.59E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06	0.00E+00	1.01E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	7.45E-08	0.00E+00	3.02E-07	7.37E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-06	0.00E+00	7.79E-05
		HTO	mGy/d	1.11E-06	0.00E+00	2.32E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.51E-06	0.00E+00	5.94E-06
		I-131	mGy/d	2.28E-12	4.33E-19	5.67E-08	0.00E+00	3.31E-09	2.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-05	0.00E+00	2.10E-05
		OBT	mGy/d	1.33E-07	0.00E+00	2.78E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-07	0.00E+00	5.24E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	2.81E-06	0.00E+00	3.15E-07	8.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.54E-05	0.00E+00	1.82E-04
D	Meadow Vole	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.66E-05	0.00E+00	6.66E-05
		Co-60	mGy/d	2.92E-13	0.00E+00	6.90E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-08	0.00E+00	2.97E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.63E-08	0.00E+00	1.39E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	7.81E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	4.36E-08	0.00E+00	4.37E-08	7.37E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	7.53E-05
		HTO	mGy/d	1.11E-06	0.00E+00	2.32E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.51E-06	0.00E+00	5.94E-06
		I-131	mGy/d	2.54E-12	4.33E-19	3.32E-08	0.00E+00	4.80E-10	2.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.38E-06	0.00E+00	9.83E-06
		OBT	mGy/d	1.33E-07	0.00E+00	2.78E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-07	0.00E+00	5.24E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	2.72E-06	0.00E+00	4.56E-08	8.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.96E-05	0.00E+00	1.66E-04
D	White-tailed Deer	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.66E-05	0.00E+00	6.66E-05
		Co-60	mGy/d	1.66E-12	0.00E+00	1.16E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.02E-07	0.00E+00	5.14E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	5.69E-07	0.00E+00	1.54E-08	3.17E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.93E-05	0.00E+00	2.30E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	2.93E-07	0.00E+00	2.66E-07	3.60E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-05	0.00E+00	4.71E-05
		HTO	mGy/d	1.11E-06	0.00E+00	1.85E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.87E-06	0.00E+00	5.83E-06
		I-131	mGy/d	5.62E-12	4.33E-19	2.16E-07	0.00E+00	2.82E-09	1.17E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.95E-05	0.00E+00	5.09E-05
		OBT	mGy/d	1.33E-07	0.00E+00	2.22E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.29E-07	0.00E+00	4.84E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	3.16E-06	0.00E+00	2.84E-07	4.04E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.49E-04	0.00E+00	1.94E-04

Table D.11: UCLM Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
D	Common Shrew	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.02E-05	0.00E+00	4.02E-05
		Co-60	mGy/d	1.99E-13	0.00E+00	5.00E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-07	0.00E+00	1.05E-07
		Cs-134	mGy/d	0.00E+00	0.00E+00	3.36E-08	0.00E+00	3.71E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.47E-06	0.00E+00	1.17E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	3.16E-08	0.00E+00	1.17E-07	7.37E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.48E-06	0.00E+00	7.93E-05
		HTO	mGy/d	1.11E-06	0.00E+00	2.32E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.24E-06	0.00E+00	8.67E-06
		I-131	mGy/d	1.73E-12	4.33E-19	2.40E-08	0.00E+00	1.28E-09	2.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.63E-06	0.00E+00	7.07E-06
		OBT	mGy/d	1.33E-07	0.00E+00	2.78E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.36E-07	0.00E+00	6.47E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	2.69E-06	0.00E+00	1.22E-07	8.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.13E-05	0.00E+00	1.48E-04
D	Raccoon	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.06E-05	6.66E-06	4.73E-05
		Co-60	mGy/d	3.02E-13	0.00E+00	1.47E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.15E-08	6.70E-11	8.30E-08
		Cs-134	mGy/d	0.00E+00	0.00E+00	9.90E-08	0.00E+00	1.60E-08	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.27E-06	1.81E-07	1.08E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	9.32E-08	0.00E+00	5.04E-07	7.37E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.27E-06	1.86E-07	7.88E-05
		HTO	mGy/d	1.11E-06	0.00E+00	2.32E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.54E-06	2.90E-07	7.25E-06
		I-131	mGy/d	2.64E-12	4.33E-19	7.09E-08	0.00E+00	5.53E-09	2.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.08E-06	2.61E-07	1.08E-05
		OBT	mGy/d	1.33E-07	0.00E+00	2.78E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.59E-07	4.80E-09	5.75E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	2.86E-06	0.00E+00	5.26E-07	8.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.10E-05	7.58E-06	1.56E-04
D	Red Fox	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.52E-06	5.32E-05	6.28E-05
		Co-60	mGy/d	2.86E-13	0.00E+00	1.44E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.36E-09	2.35E-10	6.03E-09
		Cs-134	mGy/d	0.00E+00	0.00E+00	9.65E-08	0.00E+00	1.73E-09	5.75E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	6.35E-07	6.71E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	9.08E-08	0.00E+00	5.43E-08	1.45E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	6.76E-07	1.46E-04
		HTO	mGy/d	1.11E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.59E-07	2.32E-06	3.79E-06
		I-131	mGy/d	2.49E-12	4.33E-19	6.91E-08	0.00E+00	5.96E-10	2.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-06	9.21E-07	4.29E-06
		OBT	mGy/d	1.33E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.61E-08	3.84E-08	1.88E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	2.58E-07	0.00E+00	5.67E-08	1.53E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E-05	5.78E-05	2.23E-04
D	Short-tailed Weasel	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.66E-05	6.66E-05
		Co-60	mGy/d	2.40E-13	0.00E+00	8.86E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.13E-10	1.20E-09
		Cs-134	mGy/d	0.00E+00	0.00E+00	5.95E-08	0.00E+00	6.33E-09	6.24E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.44E-07	7.15E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	5.60E-08	0.00E+00	1.99E-07	7.37E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.66E-07	7.48E-05
		HTO	mGy/d	1.11E-06	0.00E+00	2.32E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-06	6.33E-06
		I-131	mGy/d	2.09E-12	4.33E-19	4.26E-08	0.00E+00	2.19E-09	2.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-06	3.68E-06
		OBT	mGy/d	1.33E-07	0.00E+00	2.78E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.80E-08	4.59E-07
		Total Dose	mGy/d	1.24E-06	4.33E-19	2.76E-06	0.00E+00	2.08E-07	8.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.24E-05	1.59E-04
E	Earthworm	C-14	mGy/d	2.69E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.69E-05
		Co-60	mGy/d	3.41E-09	0.00E+00	0.00E+00	0.00E+00	9.30E-10	2.64E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.64E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.23E-08	3.64E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.68E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.74E-07	6.57E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.84E-06
		HTO	mGy/d	1.69E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-04
		I-131	mGy/d	1.56E-08	0.00E+00	0.00E+00	0.00E+00	2.38E-07	2.60E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.85E-06
		OBT	mGy/d	1.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-05
		Total Dose	mGy/d	2.13E-04	0.00E+00	0.00E+00	0.00E+00	5.55E-07	1.54E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.29E-04
E	American Robin	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.72E-05	0.00E+00	2.72E-05
		Co-60	mGy/d	7.57E-12	0.00E+00	1.21E-08	0.00E+00	3.19E-09	1.99E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.78E-06	0.00E+00	3.79E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	8.52E-08	0.00E+00	1.77E-08	2.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.65E-06	0.00E+00	7.59E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.09E-07	0.00E+00	7.42E-08	5.03E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.12E-06	0.00E+00	9.33E-06
		HTO	mGy/d	1.29E-06	0.00E+00	1.83E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.75E-05	0.00E+00	2.88E-05
		I-131	mGy/d	2.93E-14	2.30E-19	7.68E-10	0.00E+00	1.13E-10	2.13E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-08	0.00E+00	2.15E-06
		OBT	mGy/d	1.42E-07	0.00E+00	2.01E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.28E-06	0.00E+00	1.43E-06
		Total Dose	mGy/d	1.43E-06	2.30E-19	2.28E-07	0.00E+00	9.52E-08	1.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.66E-05	0.00E+00	8.03E-05

Table D.11: UCLM Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
E	Bank Swallow	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.95E-05	0.00E+00	2.95E-05
		Co-60	mGy/d	7.25E-12	0.00E+00	1.50E-08	0.00E+00	1.74E-09	9.95E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.82E-09	0.00E+00	1.02E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.06E-07	0.00E+00	9.66E-09	1.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-07	0.00E+00	1.64E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.35E-07	0.00E+00	4.05E-08	2.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.26E-07	0.00E+00	3.12E-06
		HTO	mGy/d	1.29E-06	0.00E+00	1.83E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.61E-05	0.00E+00	4.74E-05
		I-131	mGy/d	2.80E-14	2.30E-19	9.52E-10	0.00E+00	6.20E-11	1.06E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-09	0.00E+00	1.07E-06
		OBT	mGy/d	1.42E-07	0.00E+00	2.01E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.15E-06	0.00E+00	2.30E-06
		Total Dose	mGy/d	1.43E-06	2.30E-19	2.77E-07	0.00E+00	5.20E-08	5.99E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.83E-05	0.00E+00	8.61E-05
E	Song Sparrow	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.07E-05	0.00E+00	4.07E-05
		Co-60	mGy/d	1.18E-11	0.00E+00	2.07E-08	0.00E+00	2.69E-09	3.18E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.33E-06	0.00E+00	8.54E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.45E-07	0.00E+00	1.49E-08	4.54E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E-05	0.00E+00	1.85E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.86E-07	0.00E+00	6.27E-08	8.05E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-05	0.00E+00	2.01E-05
		HTO	mGy/d	2.07E-06	0.00E+00	2.93E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.04E-05	0.00E+00	2.25E-05
		I-131	mGy/d	4.57E-14	3.69E-19	1.31E-09	0.00E+00	9.58E-11	3.41E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.26E-08	0.00E+00	3.46E-06
		OBT	mGy/d	2.27E-07	0.00E+00	3.22E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.52E-07	0.00E+00	1.18E-06
		Total Dose	mGy/d	2.30E-06	3.69E-19	3.86E-07	0.00E+00	8.04E-08	1.92E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.30E-05	0.00E+00	1.15E-04
E	Yellow Warbler	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.92E-05	0.00E+00	2.92E-05
		Co-60	mGy/d	7.37E-12	0.00E+00	1.37E-08	0.00E+00	1.81E-09	9.95E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-07	0.00E+00	1.27E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	9.67E-08	0.00E+00	1.00E-08	1.42E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.61E-07	0.00E+00	2.29E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.24E-07	0.00E+00	4.22E-08	2.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.79E-07	0.00E+00	3.66E-06
		HTO	mGy/d	1.29E-06	0.00E+00	1.83E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.37E-05	0.00E+00	4.50E-05
		I-131	mGy/d	2.85E-14	2.30E-19	8.71E-10	0.00E+00	6.45E-11	1.06E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.60E-09	0.00E+00	1.07E-06
		OBT	mGy/d	1.42E-07	0.00E+00	2.01E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.04E-06	0.00E+00	2.18E-06
		Total Dose	mGy/d	1.43E-06	2.30E-19	2.55E-07	0.00E+00	5.41E-08	5.99E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.70E-05	0.00E+00	8.48E-05
E	Grass	C-14	mGy/d	3.46E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.46E-05
		Co-60	mGy/d	3.41E-08	0.00E+00	0.00E+00	0.00E+00	1.44E-09	9.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.54E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.82E-09	1.37E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E-05
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.24E-08	2.57E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.58E-05
		HTO	mGy/d	1.63E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.63E-04
		I-131	mGy/d	1.50E-07	4.61E-19	0.00E+00	0.00E+00	1.47E-08	1.09E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-05
		OBT	mGy/d	1.60E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-09
		Total Dose	mGy/d	1.98E-04	4.61E-19	0.00E+00	0.00E+00	5.34E-08	5.98E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.58E-04
E	Sugar Maple	C-14	mGy/d	3.46E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.46E-05
		Co-60	mGy/d	3.41E-08	0.00E+00	0.00E+00	0.00E+00	1.44E-08	2.87E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.92E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-08	4.07E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.10E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.44E-08	7.26E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.33E-06
		HTO	mGy/d	1.63E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.63E-04
		I-131	mGy/d	3.40E-08	4.61E-19	0.00E+00	0.00E+00	3.33E-08	3.23E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.30E-06
		OBT	mGy/d	1.60E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-05
		Total Dose	mGy/d	2.14E-04	4.61E-19	0.00E+00	0.00E+00	1.49E-07	1.74E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.32E-04
E	Eastern Cottontail	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E-05	0.00E+00	6.95E-05
		Co-60	mGy/d	4.74E-13	0.00E+00	7.35E-10	0.00E+00	7.78E-11	4.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.44E-09	0.00E+00	4.20E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.05E-07	0.00E+00	8.73E-09	5.68E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.34E-09	0.00E+00	5.80E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.58E-07	0.00E+00	4.32E-08	1.05E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.63E-08	0.00E+00	1.08E-05
		HTO	mGy/d	2.01E-06	0.00E+00	6.87E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.98E-05	0.00E+00	7.19E-05
		I-131	mGy/d	4.13E-12	4.61E-19	1.05E-07	0.00E+00	6.24E-09	4.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.09E-08	0.00E+00	4.72E-06
		OBT	mGy/d	2.41E-07	0.00E+00	8.25E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-06	0.00E+00	3.39E-06
		Total Dose	mGy/d	2.25E-06	4.61E-19	4.46E-07	0.00E+00	5.82E-08	2.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-04	0.00E+00	1.70E-04

Table D.11: UCLM Dose for Radiological COPCs

Location	Receptor	Radionuclide	Unit	Air (internal)	Air (external)	Water (internal)	Water (external)	Soil (internal)	Soil (external)	Sediment (internal)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Sum
E	Meadow Vole	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E-05	0.00E+00	6.95E-05
		Co-60	mGy/d	5.28E-13	0.00E+00	4.30E-10	0.00E+00	1.13E-11	4.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.72E-10	0.00E+00	4.20E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	6.13E-08	0.00E+00	1.26E-09	5.68E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.93E-09	0.00E+00	5.74E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	9.25E-08	0.00E+00	6.25E-09	1.05E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.45E-08	0.00E+00	1.06E-05
		HTO	mGy/d	2.01E-06	0.00E+00	6.87E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.98E-05	0.00E+00	7.19E-05
		I-131	mGy/d	4.60E-12	4.61E-19	6.16E-08	0.00E+00	9.04E-10	4.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.03E-08	0.00E+00	4.64E-06
		OBT	mGy/d	2.41E-07	0.00E+00	8.25E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-06	0.00E+00	3.39E-06
		Total Dose	mGy/d	2.25E-06	4.61E-19	2.93E-07	0.00E+00	8.43E-09	2.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.42E-04	0.00E+00	1.70E-04
E	White-tailed Deer	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E-05	0.00E+00	6.95E-05
		Co-60	mGy/d	3.01E-12	0.00E+00	7.22E-09	0.00E+00	1.71E-10	2.14E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.64E-09	0.00E+00	2.16E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	7.54E-07	0.00E+00	1.40E-08	2.89E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.72E-08	0.00E+00	3.69E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	6.22E-07	0.00E+00	3.80E-08	5.15E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-07	0.00E+00	5.91E-06
		HTO	mGy/d	2.01E-06	0.00E+00	5.49E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.98E-05	0.00E+00	8.19E-05
		I-131	mGy/d	1.02E-11	4.61E-19	4.00E-07	0.00E+00	5.31E-09	2.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.04E-08	0.00E+00	2.69E-06
		OBT	mGy/d	2.41E-07	0.00E+00	6.59E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.58E-06	0.00E+00	3.83E-06
		Total Dose	mGy/d	2.25E-06	4.61E-19	1.84E-06	0.00E+00	5.75E-08	1.24E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-04	0.00E+00	1.70E-04
E	Common Shrew	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.87E-05	0.00E+00	4.87E-05
		Co-60	mGy/d	3.60E-13	0.00E+00	3.12E-10	0.00E+00	3.01E-11	4.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.52E-10	0.00E+00	4.20E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	4.44E-08	0.00E+00	3.38E-09	5.68E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.90E-08	0.00E+00	5.82E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	6.71E-08	0.00E+00	1.67E-08	1.05E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.41E-07	0.00E+00	1.11E-05
		HTO	mGy/d	2.01E-06	0.00E+00	6.87E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.98E-05	0.00E+00	7.19E-05
		I-131	mGy/d	3.14E-12	4.61E-19	4.46E-08	0.00E+00	2.42E-09	4.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-07	0.00E+00	4.71E-06
		OBT	mGy/d	2.41E-07	0.00E+00	8.25E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-06	0.00E+00	3.39E-06
		Total Dose	mGy/d	2.25E-06	4.61E-19	2.33E-07	0.00E+00	2.25E-08	2.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-04	0.00E+00	1.50E-04
E	Raccoon	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.56E-05	6.95E-06	5.25E-05
		Co-60	mGy/d	5.48E-13	0.00E+00	9.19E-10	0.00E+00	1.30E-10	4.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.39E-08	2.29E-12	4.21E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.31E-07	0.00E+00	1.46E-08	5.68E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.51E-07	7.58E-09	6.58E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.98E-07	0.00E+00	7.20E-08	1.05E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.13E-07	1.31E-08	1.17E-05
		HTO	mGy/d	2.01E-06	0.00E+00	6.87E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.31E-05	3.51E-06	5.87E-05
		I-131	mGy/d	4.78E-12	4.61E-19	1.32E-07	0.00E+00	1.04E-08	4.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.57E-07	2.92E-09	5.06E-06
		OBT	mGy/d	2.41E-07	0.00E+00	8.25E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.39E-06	3.10E-08	2.67E-06
		Total Dose	mGy/d	2.25E-06	4.61E-19	5.38E-07	0.00E+00	9.71E-08	2.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.03E-04	1.05E-05	1.41E-04
E	Red Fox	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.94E-06	5.56E-05	6.55E-05
		Co-60	mGy/d	5.18E-13	0.00E+00	8.96E-10	0.00E+00	1.40E-11	3.85E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.61E-11	7.36E-12	3.85E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	1.28E-07	0.00E+00	1.57E-09	5.23E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.40E-10	2.12E-08	5.39E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.93E-07	0.00E+00	7.76E-09	2.07E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E-09	4.03E-08	2.09E-05
		HTO	mGy/d	2.01E-06	0.00E+00	6.87E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.98E-06	2.81E-05	4.02E-05
		I-131	mGy/d	4.52E-12	4.61E-19	1.28E-07	0.00E+00	1.12E-09	4.13E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.05E-09	8.52E-09	4.27E-06
		OBT	mGy/d	2.41E-07	0.00E+00	8.25E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.49E-07	2.48E-07	9.46E-07
		Total Dose	mGy/d	2.25E-06	4.61E-19	5.26E-07	0.00E+00	1.05E-08	3.39E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.04E-05	8.40E-05	1.41E-04
E	Short-tailed Weasel	C-14	mGy/d	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.95E-05	6.95E-05
		Co-60	mGy/d	4.35E-13	0.00E+00	5.52E-10	0.00E+00	5.13E-11	4.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E-11	4.20E-06
		Cs-134	mGy/d	0.00E+00	0.00E+00	7.87E-08	0.00E+00	5.76E-09	5.68E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.53E-08	5.80E-06
		Cs-137	mGy/d	0.00E+00	0.00E+00	1.19E-07	0.00E+00	2.85E-08	1.05E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.11E-08	1.07E-05
		HTO	mGy/d	2.01E-06	0.00E+00	6.87E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.51E-05	3.72E-05
		I-131	mGy/d	3.79E-12	4.61E-19	7.90E-08	0.00E+00	4.12E-09	4.56E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E-08	4.65E-06
		OBT	mGy/d	2.41E-07	0.00E+00	8.25E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.10E-07	5.59E-07
		Total Dose	mGy/d	2.25E-06	4.61E-19	3.54E-07	0.00E+00	3.84E-08	2.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-04	1.33E-04

Table D.12: Exposure Dose for Bufflehead

Parameter	Bufflehead									
	Maximum Dose					UCLM Dose				
	Exposure via Water mg/kg bw/day	Exposure via Sediment mg/kg bw/day	Exposure via Aquatic Invertebrates (mussels) mg/kg bw/day	Exposure Via Aquatic Plants mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Sediment mg/kg bw/day	Exposure via Aquatic Invertebrates (mussels) mg/kg bw/day	Exposure Via Aquatic Plants mg/kg bw/day	Total Exposure mg/kg bw/day
Lake Ontario										
Barium	1.23E-03	1.72E-02	8.06E+00	0.00E+00	8.08E+00	8.87E-04	6.24E-03	5.82E+00	0.00E+00	5.83E+00
Cesium	3.31E-06	1.61E-04	4.68E-03	0.00E+00	4.85E-03	2.41E-07	5.61E-05	3.57E-03	0.00E+00	3.63E-03
Strontium	2.38E-02	1.13E-01	5.80E+01	0.00E+00	5.81E+01	8.37E-03	6.80E-02	4.05E+01	0.00E+00	4.05E+01
Zinc	4.95E-04	1.06E-02	5.69E-01	0.00E+00	5.80E-01	5.58E-05	5.05E-03	4.26E-01	0.00E+00	4.31E-01
PHC F3	6.47E-03	2.53E-02	1.82E+01	0.00E+00	1.82E+01	2.82E-03	9.56E-03	7.93E+00	0.00E+00	7.94E+00
Benzo(a)pyrene	6.04E-07	1.63E-05	1.13E-02	0.00E+00	1.13E-02	1.15E-07	3.10E-06	2.14E-03	0.00E+00	2.14E-03
Chrysene	4.04E-08	2.04E-05	1.57E-04	0.00E+00	1.78E-04	1.29E-08	3.70E-06	5.00E-05	0.00E+00	5.37E-05
Dibenzo(a,h)anthracene	4.29E-06	2.04E-06	1.21E-02	0.00E+00	1.21E-02	7.78E-07	6.49E-07	2.19E-03	0.00E+00	2.19E-03
Phenanthrene	8.53E-06	5.30E-06	1.09E-02	0.00E+00	1.09E-02	1.99E-06	8.01E-07	2.54E-03	0.00E+00	2.54E-03
Pyrene	3.70E-06	1.22E-05	1.04E-02	0.00E+00	1.04E-02	5.59E-07	2.86E-06	1.57E-03	0.00E+00	1.58E-03
Polygon AB										
Barium	2.11E-03	6.48E-02	1.36E+00	5.28E-02	1.48E+00	1.96E-03	6.40E-02	1.26E+00	4.89E-02	1.37E+00
Cadmium	2.82E-07	6.52E-04	1.01E-04	2.12E-03	2.88E-03	2.39E-07	5.14E-04	8.55E-05	1.81E-03	2.41E-03
Chromium	6.01E-05	1.25E-02	8.38E-02	2.39E-04	9.66E-02	3.78E-05	1.19E-02	5.26E-02	1.50E-04	6.46E-02
Copper	6.55E-05	1.65E-02	9.82E-03	7.79E-02	1.04E-01	4.31E-05	1.49E-02	6.47E-03	5.14E-02	7.28E-02
Manganese	2.61E-03	2.20E-01	6.42E+00	4.55E+00	1.12E+01	1.81E-03	2.20E-01	4.45E+00	3.15E+00	7.82E+00
Nickel	3.35E-05	8.24E-03	1.20E-02	6.91E-04	2.09E-02	2.87E-05	8.24E-03	1.02E-02	5.92E-04	1.91E-02
Strontium	1.91E-02	1.80E-01	1.84E+01	2.80E+00	2.14E+01	1.84E-02	1.80E-01	1.78E+01	2.70E+00	2.07E+01
Vanadium	9.63E-05	2.43E-02	1.34E-01	6.11E-03	1.65E-01	8.11E-05	2.25E-02	1.13E-01	5.15E-03	1.41E-01
Zinc	9.95E-05	6.93E-02	6.40E-01	5.53E-02	7.65E-01	7.30E-05	6.33E-02	4.70E-01	4.06E-02	5.74E-01

Table D.13: Exposure Dose for Mallard

Parameter	Mallard									
	Maximum Dose					UCLM Dose				
	Exposure via Water mg/kg bw/day	Exposure via Sediment mg/kg bw/day	Exposure via Aquatic Invertebrates (mussels) mg/kg bw/day	Exposure Via Aquatic Plants mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Sediment mg/kg bw/day	Exposure via Aquatic Invertebrates (mussels) mg/kg bw/day	Exposure Via Aquatic Plants mg/kg bw/day	Total Exposure mg/kg bw/day
Lake Ontario										
Barium	9.28E-04	4.02E-02	6.16E+00	0.00E+00	6.21E+00	6.70E-04	1.46E-02	4.45E+00	0.00E+00	4.47E+00
Cesium	2.50E-06	3.76E-04	3.58E-03	0.00E+00	3.96E-03	1.82E-07	1.31E-04	2.73E-03	0.00E+00	2.87E-03
Strontium	1.80E-02	2.63E-01	4.44E+01	0.00E+00	4.46E+01	6.32E-03	1.59E-01	3.09E+01	0.00E+00	3.11E+01
Zinc	3.74E-04	2.47E-02	4.36E-01	0.00E+00	4.61E-01	4.21E-05	1.18E-02	3.26E-01	0.00E+00	3.38E-01
PHC F3	4.89E-03	5.91E-02	1.39E+01	0.00E+00	1.40E+01	2.13E-03	2.23E-02	6.06E+00	0.00E+00	6.09E+00
Benzo(a)pyrene	4.56E-07	3.81E-05	8.61E-03	0.00E+00	8.65E-03	8.66E-08	7.24E-06	1.64E-03	0.00E+00	1.64E-03
Chrysene	3.05E-08	4.77E-05	1.20E-04	0.00E+00	1.68E-04	9.72E-09	8.64E-06	3.83E-05	0.00E+00	4.69E-05
Dibenzo(a,h)anthracene	3.24E-06	4.77E-06	9.25E-03	0.00E+00	9.26E-03	5.88E-07	1.52E-06	1.68E-03	0.00E+00	1.68E-03
Phenanthrene	6.45E-06	1.24E-05	8.32E-03	0.00E+00	8.33E-03	1.50E-06	1.87E-06	1.94E-03	0.00E+00	1.95E-03
Pyrene	2.79E-06	2.86E-05	7.96E-03	0.00E+00	7.99E-03	4.22E-07	6.68E-06	1.20E-03	0.00E+00	1.21E-03
Polygon AB										
Barium	1.60E-03	1.52E-01	8.66E-01	1.01E-01	1.12E+00	1.48E-03	1.50E-01	8.01E-01	9.35E-02	1.05E+00
Cadmium	2.13E-07	1.52E-03	6.41E-05	4.06E-03	5.65E-03	1.81E-07	1.20E-03	5.45E-05	3.45E-03	4.71E-03
Chromium	4.54E-05	2.93E-02	5.34E-02	4.56E-04	8.32E-02	2.85E-05	2.77E-02	3.35E-02	2.87E-04	6.16E-02
Copper	4.94E-05	3.86E-02	6.26E-03	1.49E-01	1.94E-01	3.26E-05	3.49E-02	4.13E-03	9.82E-02	1.37E-01
Manganese	1.97E-03	5.15E-01	4.10E+00	8.70E+00	1.33E+01	1.36E-03	5.15E-01	2.84E+00	6.03E+00	9.38E+00
Nickel	2.53E-05	1.93E-02	7.62E-03	1.32E-03	2.82E-02	2.17E-05	1.93E-02	6.53E-03	1.13E-03	2.69E-02
Strontium	1.44E-02	4.21E-01	1.17E+01	5.35E+00	1.75E+01	1.39E-02	4.21E-01	1.13E+01	5.17E+00	1.69E+01
Vanadium	7.27E-05	5.68E-02	8.55E-02	1.17E-02	1.54E-01	6.12E-05	5.25E-02	7.20E-02	9.84E-03	1.34E-01
Zinc	7.52E-05	1.62E-01	4.08E-01	1.06E-01	6.76E-01	5.52E-05	1.48E-01	2.99E-01	7.76E-02	5.25E-01

Table D.14: Exposure Dose for Green Heron

Parameter	Green Heron											
	Maximum Dose						UCLM Dose					
	Exposure via Water mg/kg bw/day	Exposure via Sediment mg/kg bw/day	Exposure via Aquatic Invertebrates (mussels) mg/kg bw/day	Exposure Via Aquatic Plants mg/kg bw/day	Exposure Via Fish (Northern Redbelly Dace) mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Sediment mg/kg bw/day	Exposure via Aquatic Invertebrates (mussels) mg/kg bw/day	Exposure Via Aquatic Plants mg/kg bw/day	Exposure Via Fish (Northern Redbelly Dace) mg/kg bw/day	Total Exposure mg/kg bw/day
Polygon AB												
Barium	2.92E-03	1.68E-01	0.00E+00	0.00E+00	8.85E+00	9.02E+00	2.70E-03	1.66E-01	0.00E+00	0.00E+00	7.93E+00	8.09E+00
Cadmium	3.89E-07	1.69E-03	0.00E+00	1.00E+00	4.29E-03	1.01E+00	3.31E-07	1.33E-03	0.00E+00	1.00E+00	4.29E-03	1.01E+00
Chromium	8.31E-05	3.25E-02	0.00E+00	2.00E+00	4.65E-01	2.50E+00	5.22E-05	3.07E-02	0.00E+00	2.00E+00	4.51E-01	2.48E+00
Copper	9.04E-05	4.28E-02	0.00E+00	3.00E+00	9.84E-01	4.03E+00	5.96E-05	3.87E-02	0.00E+00	3.00E+00	9.16E-01	3.95E+00
Manganese	3.60E-03	5.71E-01	0.00E+00	4.00E+00	1.23E+01	1.68E+01	2.49E-03	5.71E-01	0.00E+00	4.00E+00	1.11E+01	1.57E+01
Nickel	4.63E-05	2.14E-02	0.00E+00	5.00E+00	3.84E-01	5.40E+00	3.96E-05	2.14E-02	0.00E+00	5.00E+00	3.50E-01	5.37E+00
Strontium	2.63E-02	4.67E-01	0.00E+00	6.00E+00	3.99E+01	4.64E+01	2.54E-02	4.67E-01	0.00E+00	6.00E+00	3.60E+01	4.25E+01
Vanadium	1.33E-04	6.30E-02	0.00E+00	7.00E+00	3.21E-01	7.38E+00	1.12E-04	5.82E-02	0.00E+00	7.00E+00	2.68E-01	7.33E+00
Zinc	1.37E-04	1.80E-01	0.00E+00	8.00E+00	7.55E+01	8.37E+01	1.01E-04	1.64E-01	0.00E+00	8.00E+00	7.31E+01	8.13E+01

Table D.15: Exposure Dose for American Robin

Parameter	American Robin									
	Maximum Dose					UCLM Dose				
	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Fruit (Berries) mg/kg bw/day	Exposure via Invertebrates (Earthworm) mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Fruit (Berries) mg/kg bw/day	Exposure via Invertebrates (Earthworm) mg/kg bw/day	Total Exposure mg/kg bw/day
Polygon AB										
Barium	7.93E-03	7.96E-01	5.69E+00	7.54E+00	1.40E+01	7.34E-03	7.96E-01	3.65E+00	5.41E+00	9.86E+00
Cadmium	1.06E-06	2.18E-03	4.71E-03	1.85E+00	1.86E+00	8.99E-07	2.18E-03	2.45E-03	1.03E+00	1.04E+00
Chromium	2.26E-04	1.70E-01	9.35E-02	1.73E+00	1.99E+00	1.42E-04	1.70E-01	6.01E-02	1.41E+00	1.64E+00
Copper	2.46E-04	1.29E-01	6.59E-01	1.89E+00	2.68E+00	1.62E-04	1.29E-01	3.73E-01	1.68E+00	2.18E+00
Manganese	9.79E-03	3.39E+00	2.44E+00	3.64E+01	4.22E+01	6.78E-03	3.39E+00	1.46E+00	3.00E+01	3.48E+01
Nickel	1.26E-04	9.95E-02	9.13E-02	1.07E+00	1.26E+00	1.08E-04	9.95E-02	4.46E-02	8.53E-01	9.97E-01
Strontium	7.16E-02	1.33E+00	5.65E+00	2.52E+01	3.22E+01	6.91E-02	1.33E+00	4.67E+00	1.90E+01	2.51E+01
Vanadium	3.61E-04	2.81E-01	1.16E-01	2.45E+00	2.85E+00	3.04E-04	2.81E-01	5.18E-02	1.97E+00	2.31E+00
Zinc	3.74E-04	4.82E-01	4.73E+00	7.82E+01	8.35E+01	2.74E-04	4.82E-01	3.12E+00	6.80E+01	7.16E+01
Polygon C										
Strontium	NA	8.57E-01	1.89E+00	6.28E+00	9.03E+00	NA	8.57E-01	1.68E+00	6.28E+00	8.82E+00
Polygon D										
Barium	5.69E-03	8.19E-01	1.54E+00	1.72E+01	1.96E+01	5.69E-03	8.19E-01	1.04E+00	1.13E+01	1.32E+01
Cadmium	7.14E-07	2.10E-03	2.07E-03	4.28E-01	4.32E-01	7.14E-07	2.10E-03	1.21E-03	3.56E-01	3.60E-01
Copper	5.54E-05	1.16E-01	5.31E-01	1.72E+00	2.36E+00	5.54E-05	1.16E-01	4.12E-01	1.56E+00	2.09E+00
Strontium	3.21E-02	1.09E+00	3.01E+00	1.35E+01	1.76E+01	3.21E-02	1.09E+00	2.00E+00	8.36E+00	1.15E+01
Vanadium	5.71E-05	2.31E-01	9.17E-03	2.30E+00	2.54E+00	5.71E-05	2.31E-01	7.17E-03	2.11E+00	2.35E+00
Polygon E										
Arsenic	1.20E-04	1.02E+00	1.20E+00	1.20E+00	3.42E+00	1.10E-04	1.18E-01	1.39E-01	1.39E-01	3.96E-01
Cadmium	2.29E-06	2.87E-02	2.85E-01	1.90E+00	2.22E+00	5.44E-07	3.75E-03	3.73E-02	2.48E-01	2.89E-01
Chromium	1.92E-04	5.72E-01	2.22E-02	9.52E-01	1.55E+00	2.58E-05	1.42E-01	5.52E-03	2.36E-01	3.84E-01
Cobalt	1.30E-05	1.22E+00	2.71E-01	2.34E-01	1.72E+00	2.48E-06	1.50E-01	3.35E-02	2.89E-02	2.13E-01
Copper	1.43E-04	1.71E+01	6.46E+01	4.76E+01	1.29E+02	9.46E-05	1.84E+00	6.98E+00	5.14E+00	1.40E+01
Iron	2.54E-02	7.26E+02	1.72E+01	1.40E+02	8.84E+02	2.38E-03	1.54E+02	3.65E+00	2.98E+01	1.88E+02
Lead	2.24E-05	4.51E+00	6.62E+00	4.05E+00	1.52E+01	2.93E-06	5.23E-01	7.68E-01	4.71E-01	1.76E+00
Molybdenum	1.93E-04	3.24E-01	5.52E-01	1.66E+00	2.53E+00	1.69E-04	3.65E-02	6.23E-02	1.87E-01	2.86E-01
Nickel	1.00E-04	9.87E-01	2.20E+00	2.03E+00	5.22E+00	6.55E-05	1.63E-01	3.63E-01	3.35E-01	8.61E-01
Selenium	2.70E-05	4.68E-02	9.98E-02	2.19E+00	2.33E+00	2.01E-05	5.86E-03	1.25E-02	2.74E-01	2.92E-01
Sodium	5.66E+00	1.47E+01	8.35E+00	3.41E+02	3.69E+02	2.60E+00	2.88E+00	1.63E+00	6.67E+01	7.38E+01
Strontium	8.93E-02	5.78E+00	2.38E+01	1.64E+00	3.13E+01	3.14E-02	2.46E+00	1.01E+01	6.96E-01	1.33E+01
Tin	5.79E-05	8.26E-01	1.60E+00	7.44E-01	3.17E+00	4.53E-06	9.00E-02	1.75E-01	8.09E-02	3.46E-01
Zinc	1.86E-03	7.13E+01	4.39E+02	1.22E+03	1.74E+03	2.09E-04	7.74E+00	4.76E+01	1.33E+02	1.88E+02

Note

There is no surface water body in Polygon C, therefore the exposure through water intake is negligible.

Table D.16: Exposure Dose for Bank Swallow

Parameter	Bank Swallow							
	Maximum Dose				UCLM Dose			
	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Invertebrates (Caterpillar) mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Invertebrates (Caterpillar) mg/kg bw/day	Total Exposure mg/kg bw/day
Polygon AB								
Barium	1.48E-02	6.55E-01	2.59E+00	3.26E+00	1.37E-02	6.55E-01	2.04E+00	2.71E+00
Cadmium	1.97E-06	1.79E-03	3.70E-02	3.88E-02	1.68E-06	1.79E-03	3.70E-02	3.88E-02
Chromium	4.21E-04	1.40E-01	1.20E-01	2.60E-01	2.65E-04	1.40E-01	9.37E-02	2.34E-01
Copper	4.59E-04	1.06E-01	4.24E+00	4.34E+00	3.02E-04	1.06E-01	3.03E+00	3.14E+00
Manganese	1.83E-02	2.79E+00	2.81E+00	5.62E+00	1.26E-02	2.79E+00	2.81E+00	5.62E+00
Nickel	2.35E-04	8.18E-02	1.16E-01	1.98E-01	2.01E-04	8.18E-02	6.74E-02	1.49E-01
Strontium	1.34E-01	1.10E+00	1.36E+01	1.49E+01	1.29E-01	1.10E+00	7.93E+00	9.15E+00
Vanadium	6.75E-04	2.31E-01	3.70E-02	2.69E-01	5.68E-04	2.31E-01	3.70E-02	2.69E-01
Zinc	6.97E-04	3.97E-01	9.70E+00	1.01E+01	5.12E-04	3.97E-01	7.70E+00	8.10E+00
Polygon E								
Arsenic	2.24E-04	8.37E-01	3.68E+00	4.52E+00	2.05E-04	9.68E-02	4.26E-01	5.23E-01
Cadmium	4.27E-06	2.36E-02	5.83E+00	5.86E+00	1.02E-06	3.08E-03	7.62E-01	7.65E-01
Chromium	3.59E-04	4.71E-01	2.92E+00	3.39E+00	4.82E-05	1.17E-01	7.25E-01	8.42E-01
Cobalt	2.43E-05	1.00E+00	7.16E-01	1.72E+00	4.63E-06	1.24E-01	8.85E-02	2.12E-01
Copper	2.67E-04	1.40E+01	1.46E+02	1.60E+02	1.77E-04	1.52E+00	1.58E+01	1.73E+01
Iron	4.75E-02	5.97E+02	4.30E+02	1.03E+03	4.45E-03	1.27E+02	9.14E+01	2.18E+02
Lead	4.19E-05	3.71E+00	1.24E+01	1.61E+01	5.48E-06	4.31E-01	1.44E+00	1.87E+00
Molybdenum	3.60E-04	2.66E-01	5.08E+00	5.34E+00	3.16E-04	3.00E-02	5.73E-01	6.03E-01
Nickel	1.87E-04	8.12E-01	6.23E+00	7.04E+00	1.22E-04	1.34E-01	1.03E+00	1.16E+00
Selenium	5.04E-05	3.85E-02	6.71E+00	6.75E+00	3.75E-05	4.82E-03	8.39E-01	8.44E-01
Sodium	1.06E+01	1.21E+01	1.04E+03	1.07E+03	4.86E+00	2.37E+00	2.04E+02	2.12E+02
Strontium	1.67E-01	4.75E+00	5.02E+00	9.94E+00	5.86E-02	2.02E+00	2.13E+00	4.21E+00
Tin	1.08E-04	6.80E-01	2.28E+00	2.96E+00	8.46E-06	7.40E-02	2.48E-01	3.22E-01
Zinc	3.47E-03	5.87E+01	3.76E+03	3.81E+03	3.91E-04	6.37E+00	4.07E+02	4.14E+02

Table D.17: Exposure Dose for Song Sparrow

Parameter	Song Sparrow									
	Maximum Dose					UCLM Dose				
	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Fruit (Berries) mg/kg bw/day	Exposure via Invertebrates (Caterpillar) mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Fruit (Berries) mg/kg bw/day	Exposure via Invertebrates (Caterpillar) mg/kg bw/day	Total Exposure mg/kg bw/day
Polygon AB										
Barium	1.17E-02	9.32E-01	2.37E+01	5.87E-01	2.52E+01	1.08E-02	9.32E-01	1.52E+01	4.61E-01	1.66E+01
Cadmium	1.56E-06	2.55E-03	1.96E-02	8.38E-03	3.05E-02	1.33E-06	2.55E-03	1.02E-02	8.38E-03	2.12E-02
Chromium	3.33E-04	1.99E-01	3.89E-01	2.72E-02	6.16E-01	2.09E-04	1.99E-01	2.50E-01	2.12E-02	4.70E-01
Copper	3.63E-04	1.50E-01	2.75E+00	9.59E-01	3.86E+00	2.39E-04	1.50E-01	1.55E+00	6.86E-01	2.39E+00
Manganese	1.45E-02	3.97E+00	1.02E+01	6.37E-01	1.48E+01	1.00E-02	3.97E+00	6.09E+00	6.37E-01	1.07E+01
Nickel	1.86E-04	1.16E-01	3.80E-01	2.63E-02	5.23E-01	1.59E-04	1.16E-01	1.86E-01	1.53E-02	3.17E-01
Strontium	1.06E-01	1.56E+00	2.35E+01	3.08E+00	2.83E+01	1.02E-01	1.56E+00	1.95E+01	1.79E+00	2.29E+01
Vanadium	5.34E-04	3.29E-01	4.83E-01	8.38E-03	8.20E-01	4.49E-04	3.29E-01	2.16E-01	8.38E-03	5.53E-01
Zinc	5.52E-04	5.64E-01	1.97E+01	2.20E+00	2.24E+01	4.05E-04	5.64E-01	1.30E+01	1.74E+00	1.53E+01
Polygon C										
Strontium	NA	1.00E+00	7.86E+00	3.35E-01	9.20E+00	NA	1.00E+00	6.99E+00	3.35E-01	8.33E+00
Polygon D										
Barium	8.40E-03	9.58E-01	6.40E+00	2.51E-01	7.61E+00	8.40E-03	9.58E-01	4.33E+00	2.51E-01	5.55E+00
Cadmium	1.05E-06	2.45E-03	8.60E-03	8.38E-03	1.94E-02	1.05E-06	2.45E-03	5.05E-03	8.38E-03	1.59E-02
Copper	8.18E-05	1.35E-01	2.21E+00	6.50E-01	3.00E+00	8.18E-05	1.35E-01	1.71E+00	6.50E-01	2.50E+00
Strontium	4.75E-02	1.27E+00	1.25E+01	1.27E+00	1.51E+01	4.75E-02	1.27E+00	8.34E+00	1.27E+00	1.09E+01
Vanadium	8.44E-05	2.71E-01	3.82E-02	4.19E-03	3.13E-01	8.44E-05	2.71E-01	2.99E-02	4.19E-03	3.05E-01
Polygon E										
Arsenic	1.77E-04	1.19E+00	5.02E+00	8.34E-01	7.04E+00	1.62E-04	1.38E-01	5.80E-01	9.63E-02	8.14E-01
Cadmium	3.38E-06	3.36E-02	1.19E+00	1.32E+00	2.54E+00	8.04E-07	4.39E-03	1.55E-01	1.72E-01	3.32E-01
Chromium	2.84E-04	6.70E-01	9.25E-02	6.61E-01	1.42E+00	3.82E-05	1.66E-01	2.30E-02	1.64E-01	3.54E-01
Cobalt	1.92E-05	1.42E+00	1.13E+00	1.62E-01	2.71E+00	3.67E-06	1.76E-01	1.39E-01	2.00E-02	3.36E-01
Copper	2.11E-04	2.00E+01	2.69E+02	3.30E+01	3.22E+02	1.40E-04	2.16E+00	2.90E+01	3.57E+00	3.48E+01
Iron	3.75E-02	8.50E+02	7.16E+01	9.74E+01	1.02E+03	3.52E-03	1.81E+02	1.52E+01	2.07E+01	2.17E+02
Lead	3.31E-05	5.28E+00	2.75E+01	2.81E+00	3.56E+01	4.33E-06	6.13E-01	3.20E+00	3.27E-01	4.14E+00
Molybdenum	2.85E-04	3.79E-01	2.30E+00	1.15E+00	3.83E+00	2.50E-04	4.27E-02	2.59E-01	1.30E-01	4.32E-01
Nickel	1.48E-04	1.16E+00	9.15E+00	1.41E+00	1.17E+01	9.68E-05	1.91E-01	1.51E+00	2.33E-01	1.93E+00
Selenium	3.99E-05	5.48E-02	4.15E-01	1.52E+00	1.99E+00	2.96E-05	6.85E-03	5.19E-02	1.90E-01	2.49E-01
Sodium	8.35E+00	1.72E+01	3.48E+01	2.36E+02	2.97E+02	3.84E+00	3.37E+00	6.80E+00	4.63E+01	6.03E+01
Strontium	1.32E-01	6.76E+00	9.91E+01	1.14E+00	1.07E+02	4.64E-02	2.88E+00	4.21E+01	4.83E-01	4.55E+01
Tin	8.54E-05	9.67E-01	6.68E+00	5.16E-01	8.16E+00	6.70E-06	1.05E-01	7.27E-01	5.62E-02	8.89E-01
Zinc	2.74E-03	8.35E+01	1.83E+03	8.50E+02	2.76E+03	3.09E-04	9.06E+00	1.98E+02	9.22E+01	3.00E+02

Note

There is no surface water body in Polygon C, therefore the exposure through water intake is negligible.

Table D.18: Exposure Dose for Yellow Warbler

Parameter+A3:K39	Yellow Warbler									
	Maximum Dose					UCLM Dose				
	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Fruit (Berries) mg/kg bw/day	Exposure via Invertebrates (Caterpillar) mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Fruit (Berries) mg/kg bw/day	Exposure via Invertebrates (Caterpillar) mg/kg bw/day	Total Exposure mg/kg bw/day
Polygon AB										
Barium	1.50E-02	7.54E-01	1.40E+00	2.80E+00	4.97E+00	1.39E-02	7.54E-01	8.96E-01	2.20E+00	3.87E+00
Cadmium	2.00E-06	2.07E-03	1.16E-03	4.01E-02	4.33E-02	1.70E-06	2.07E-03	6.03E-04	4.01E-02	4.27E-02
Chromium	4.27E-04	1.61E-01	2.30E-02	1.30E-01	3.14E-01	2.68E-04	1.61E-01	1.48E-02	1.01E-01	2.77E-01
Copper	4.64E-04	1.22E-01	1.62E-01	4.58E+00	4.87E+00	3.06E-04	1.22E-01	9.17E-02	3.28E+00	3.49E+00
Manganese	1.85E-02	3.21E+00	5.99E-01	3.04E+00	6.87E+00	1.28E-02	3.21E+00	3.59E-01	3.04E+00	6.63E+00
Nickel	2.38E-04	9.43E-02	2.24E-02	1.26E-01	2.43E-01	2.03E-04	9.43E-02	1.09E-02	7.29E-02	1.78E-01
Strontium	1.35E-01	1.26E+00	1.39E+00	1.47E+01	1.75E+01	1.31E-01	1.26E+00	1.15E+00	8.57E+00	1.11E+01
Vanadium	6.83E-04	2.66E-01	2.85E-02	4.01E-02	3.35E-01	5.75E-04	2.66E-01	1.27E-02	4.01E-02	3.20E-01
Zinc	7.06E-04	4.57E-01	1.16E+00	1.05E+01	1.21E+01	5.18E-04	4.57E-01	7.67E-01	8.33E+00	9.56E+00
Polygon C										
Strontium	NA	8.12E-01	4.64E-01	1.60E+00	2.88E+00	NA	8.12E-01	4.13E-01	1.60E+00	2.83E+00
Polygon D										
Barium	1.07E-02	7.76E-01	3.77E-01	1.20E+00	2.37E+00	1.07E-02	7.76E-01	2.55E-01	1.20E+00	2.24E+00
Cadmium	1.35E-06	1.99E-03	5.07E-04	4.01E-02	4.25E-02	1.35E-06	1.99E-03	2.98E-04	4.01E-02	4.23E-02
Copper	1.05E-04	1.10E-01	1.30E-01	3.11E+00	3.35E+00	1.05E-04	1.10E-01	1.01E-01	3.11E+00	3.32E+00
Selenium	3.08E-05	2.13E-03	4.98E-04	4.73E-02	4.99E-02	3.08E-05	2.13E-03	4.45E-04	4.73E-02	4.99E-02
Strontium	6.08E-02	1.03E+00	7.39E-01	6.09E+00	7.92E+00	6.08E-02	1.03E+00	4.92E-01	6.09E+00	7.67E+00
Vanadium	1.08E-04	2.19E-01	2.25E-03	2.00E-02	2.41E-01	1.08E-04	2.19E-01	1.76E-03	2.00E-02	2.41E-01
Polygon E										
Arsenic	2.27E-04	9.65E-01	2.96E-01	3.98E+00	5.25E+00	2.08E-04	1.11E-01	3.42E-02	4.60E-01	6.06E-01
Cadmium	4.32E-06	2.72E-02	7.01E-02	6.31E+00	6.41E+00	1.03E-06	3.55E-03	9.15E-03	8.24E-01	8.37E-01
Chromium	3.63E-04	5.43E-01	5.46E-03	3.16E+00	3.71E+00	4.88E-05	1.35E-01	1.36E-03	7.84E-01	9.20E-01
Cobalt	2.46E-05	1.15E+00	6.65E-02	7.74E-01	1.99E+00	4.69E-06	1.43E-01	8.22E-03	9.57E-02	2.47E-01
Copper	2.70E-04	1.62E+01	1.59E+01	1.58E+02	1.90E+02	1.79E-04	1.75E+00	1.71E+00	1.70E+01	2.05E+01
Iron	4.81E-02	6.88E+02	4.22E+00	4.65E+02	1.16E+03	4.50E-03	1.46E+02	8.97E-01	9.89E+01	2.46E+02
Lead	4.24E-05	4.27E+00	1.63E+00	1.34E+01	1.93E+01	5.55E-06	4.96E-01	1.89E-01	1.56E+00	2.25E+00
Molybdenum	3.65E-04	3.07E-01	1.36E-01	5.49E+00	5.93E+00	3.20E-04	3.46E-02	1.53E-02	6.19E-01	6.70E-01
Nickel	1.90E-04	9.36E-01	5.40E-01	6.74E+00	8.21E+00	1.24E-04	1.54E-01	8.91E-02	1.11E+00	1.36E+00
Selenium	5.10E-05	4.44E-02	2.45E-02	7.26E+00	7.32E+00	3.79E-05	5.55E-03	3.06E-03	9.07E-01	9.16E-01
Sodium	1.07E+01	1.39E+01	2.05E+00	1.13E+03	1.16E+03	4.92E+00	2.73E+00	4.01E-01	2.21E+02	2.29E+02
Strontium	1.69E-01	5.48E+00	5.85E+00	5.42E+00	1.69E+01	5.94E-02	2.33E+00	2.49E+00	2.31E+00	7.18E+00
Tin	1.09E-04	7.83E-01	3.94E-01	2.47E+00	3.64E+00	8.57E-06	8.53E-02	4.29E-02	2.68E-01	3.97E-01
Zinc	3.51E-03	6.76E+01	1.08E+02	4.06E+03	4.24E+03	3.96E-04	7.33E+00	1.17E+01	4.41E+02	4.60E+02

Note

There is no surface water body in Polygon C, therefore the exposure through water intake is negligible.

Table D.19: Exposure Dose for Muskrat

Parameter	Common Muskrat							
	Maximum Dose				UCLM Dose			
	Exposure via Water mg/kg bw/day	Exposure via Sediment mg/kg bw/day	Exposure via Terrestrial Veg mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Sediment mg/kg bw/day	Exposure via Terrestrial Veg mg/kg bw/day	Total Exposure mg/kg bw/day
Polygon AB								
Barium	5.41E-03	3.92E-01	1.05E+00	1.44E+00	5.01E-03	3.87E-01	9.68E-01	1.36E+00
Cadmium	7.21E-07	3.95E-03	4.21E-02	4.60E-02	6.13E-07	3.11E-03	3.58E-02	3.89E-02
Chromium	1.54E-04	7.58E-02	4.73E-03	8.06E-02	9.67E-05	7.18E-02	2.97E-03	7.48E-02
Copper	1.68E-04	1.00E-01	1.54E+00	1.64E+00	1.10E-04	9.03E-02	1.02E+00	1.11E+00
Manganese	6.68E-03	1.33E+00	9.02E+01	9.15E+01	4.62E-03	1.33E+00	6.24E+01	6.38E+01
Nickel	8.58E-05	4.99E-02	1.37E-02	6.36E-02	7.34E-05	4.99E-02	1.17E-02	6.16E-02
Strontium	4.88E-02	1.09E+00	5.55E+01	5.66E+01	4.71E-02	1.09E+00	5.35E+01	5.47E+01
Vanadium	2.47E-04	1.47E-01	1.21E-01	2.68E-01	2.08E-04	1.36E-01	1.02E-01	2.38E-01
Zinc	2.55E-04	4.20E-01	1.10E+00	1.52E+00	1.87E-04	3.83E-01	8.04E-01	1.19E+00

Table D.20: Exposure Dose for Eastern Cottontail

Parameter	Eastern Cottontail							
	Maximum Dose				UCLM Dose			
	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Terrestrial Veg mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Terrestrial Veg mg/kg bw/day	Total Exposure mg/kg bw/day
Coot's Pond (Polygon AB)								
Barium	5.39E-03	4.35E-01	1.04E+01	1.09E+01	4.99E-03	4.35E-01	6.68E+00	7.12E+00
Cadmium	7.18E-07	1.19E-03	8.63E-03	9.82E-03	6.11E-07	1.19E-03	4.50E-03	5.69E-03
Chromium	1.53E-04	9.28E-02	1.71E-01	2.64E-01	9.63E-05	9.28E-02	1.10E-01	2.03E-01
Copper	1.67E-04	7.02E-02	1.21E+00	1.28E+00	1.10E-04	7.02E-02	6.84E-01	7.54E-01
Manganese	6.65E-03	1.85E+00	4.47E+00	6.33E+00	4.60E-03	1.85E+00	2.68E+00	4.53E+00
Nickel	8.54E-05	5.44E-02	1.67E-01	2.22E-01	7.31E-05	5.44E-02	8.16E-02	1.36E-01
Strontium	4.86E-02	7.28E-01	1.03E+01	1.11E+01	4.69E-02	7.28E-01	8.56E+00	9.33E+00
Vanadium	2.46E-04	1.53E-01	2.12E-01	3.66E-01	2.07E-04	1.53E-01	9.48E-02	2.49E-01
Zinc	2.54E-04	2.63E-01	8.66E+00	8.92E+00	1.86E-04	2.63E-01	5.72E+00	5.99E+00
Polygon C								
Strontium	NA	4.68E-01	3.46E+00	3.93E+00	NA	4.68E-01	3.08E+00	3.54E+00
Polygon D								
Barium	3.86E-03	4.47E-01	2.81E+00	3.27E+00	3.86E-03	4.47E-01	1.90E+00	2.36E+00
Cadmium	4.85E-07	1.15E-03	3.78E-03	4.93E-03	4.85E-07	1.15E-03	2.22E-03	3.37E-03
Copper	3.77E-05	6.31E-02	9.72E-01	1.04E+00	3.77E-05	6.31E-02	7.54E-01	8.17E-01
Strontium	2.18E-02	5.94E-01	5.51E+00	6.12E+00	2.18E-02	5.94E-01	3.67E+00	4.29E+00
Vanadium	3.88E-05	1.26E-01	1.68E-02	1.43E-01	3.88E-05	1.26E-01	1.31E-02	1.39E-01
Polygon E								
Arsenic	8.15E-05	5.56E-01	2.21E+00	2.76E+00	7.47E-05	6.43E-02	2.55E-01	3.19E-01
Cadmium	1.55E-06	1.57E-02	5.23E-01	5.38E-01	3.70E-07	2.05E-03	6.83E-02	7.03E-02
Chromium	1.31E-04	3.13E-01	4.07E-02	3.54E-01	1.76E-05	7.77E-02	1.01E-02	8.78E-02
Cobalt	8.83E-06	6.65E-01	4.96E-01	1.16E+00	1.69E-06	8.22E-02	6.13E-02	1.44E-01
Copper	9.70E-05	9.32E+00	1.18E+02	1.28E+02	6.43E-05	1.01E+00	1.28E+01	1.38E+01
Iron	1.73E-02	3.97E+02	3.15E+01	4.28E+02	1.62E-03	8.43E+01	6.69E+00	9.10E+01
Lead	1.52E-05	2.46E+00	1.21E+01	1.46E+01	1.99E-06	2.86E-01	1.41E+00	1.69E+00
Molybdenum	1.31E-04	1.77E-01	1.01E+00	1.19E+00	1.15E-04	2.00E-02	1.14E-01	1.34E-01
Nickel	6.82E-05	5.39E-01	4.02E+00	4.56E+00	4.45E-05	8.90E-02	6.64E-01	7.53E-01
Selenium	1.83E-05	2.56E-02	1.83E-01	2.08E-01	1.36E-05	3.20E-03	2.29E-02	2.61E-02
Sodium	3.84E+00	8.03E+00	1.53E+01	2.72E+01	1.77E+00	1.57E+00	2.99E+00	6.33E+00
Strontium	6.06E-02	3.16E+00	4.36E+01	4.68E+01	2.13E-02	1.34E+00	1.85E+01	1.99E+01
Tin	3.93E-05	4.52E-01	2.94E+00	3.39E+00	3.08E-06	4.92E-02	3.20E-01	3.69E-01
Zinc	1.26E-03	3.90E+01	8.04E+02	8.43E+02	1.42E-04	4.23E+00	8.72E+01	9.15E+01

Note

There is no surface water body in Polygon C, therefore the exposure through water intake is negligible.

Table D.21: Exposure Dose for Meadow Vole

Parameter	Meadow Vole							
	Maximum Dose				UCLM Dose			
	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Terrestrial Veg mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Terrestrial Veg mg/kg bw/day	Total Exposure mg/kg bw/day
Polygon AB								
Barium	7.70E-03	1.62E-01	1.02E+01	1.03E+01	7.13E-03	1.62E-01	6.51E+00	6.68E+00
Cadmium	1.03E-06	4.43E-04	8.41E-03	8.86E-03	8.74E-07	4.43E-04	4.38E-03	4.83E-03
Chromium	2.19E-04	3.45E-02	1.67E-01	2.02E-01	1.38E-04	3.45E-02	1.07E-01	1.42E-01
Copper	2.39E-04	2.61E-02	1.18E+00	1.20E+00	1.57E-04	2.61E-02	6.66E-01	6.93E-01
Manganese	9.51E-03	6.88E-01	4.35E+00	5.05E+00	6.59E-03	6.88E-01	2.61E+00	3.30E+00
Nickel	1.22E-04	2.02E-02	1.63E-01	1.83E-01	1.05E-04	2.02E-02	7.96E-02	9.99E-02
Strontium	6.96E-02	2.70E-01	1.01E+01	1.04E+01	6.72E-02	2.70E-01	8.34E+00	8.68E+00
Vanadium	3.51E-04	5.70E-02	2.07E-01	2.64E-01	2.96E-04	5.70E-02	9.25E-02	1.50E-01
Zinc	3.63E-04	9.78E-02	8.44E+00	8.54E+00	2.66E-04	9.78E-02	5.58E+00	5.68E+00
Polygon C								
Strontium	NA	1.74E-01	3.37E+00	3.55E+00	NA	1.74E-01	3.00E+00	3.17E+00
Polygon D								
Barium	5.53E-03	1.66E-01	2.74E+00	2.92E+00	5.53E-03	1.66E-01	1.86E+00	2.03E+00
Cadmium	6.94E-07	4.26E-04	3.69E-03	4.11E-03	6.94E-07	4.26E-04	2.17E-03	2.59E-03
Copper	5.39E-05	2.34E-02	9.48E-01	9.71E-01	5.39E-05	2.34E-02	7.35E-01	7.59E-01
Strontium	3.12E-02	2.21E-01	5.37E+00	5.62E+00	3.12E-02	2.21E-01	3.58E+00	3.83E+00
Vanadium	5.55E-05	4.69E-02	1.64E-02	6.33E-02	5.55E-05	4.69E-02	1.28E-02	5.98E-02
Polygon E								
Arsenic	1.17E-04	2.07E-01	2.15E+00	2.36E+00	1.07E-04	2.39E-02	2.49E-01	2.73E-01
Cadmium	2.22E-06	5.82E-03	5.10E-01	5.15E-01	5.29E-07	7.61E-04	6.65E-02	6.73E-02
Chromium	1.87E-04	1.16E-01	3.97E-02	1.56E-01	2.51E-05	2.89E-02	9.86E-03	3.87E-02
Cobalt	1.26E-05	2.47E-01	4.84E-01	7.30E-01	2.41E-06	3.05E-02	5.98E-02	9.03E-02
Copper	1.39E-04	3.46E+00	1.15E+02	1.19E+02	9.19E-05	3.74E-01	1.25E+01	1.28E+01
Iron	2.47E-02	1.47E+02	3.07E+01	1.78E+02	2.32E-03	3.13E+01	6.52E+00	3.78E+01
Lead	2.18E-05	9.15E-01	1.18E+01	1.27E+01	2.85E-06	1.06E-01	1.37E+00	1.48E+00
Molybdenum	1.87E-04	6.57E-02	9.85E-01	1.05E+00	1.64E-04	7.41E-03	1.11E-01	1.19E-01
Nickel	9.76E-05	2.00E-01	3.92E+00	4.12E+00	6.37E-05	3.31E-02	6.48E-01	6.81E-01
Selenium	2.62E-05	9.50E-03	1.78E-01	1.88E-01	1.95E-05	1.19E-03	2.23E-02	2.35E-02
Sodium	5.50E+00	2.98E+00	1.49E+01	2.34E+01	2.53E+00	5.83E-01	2.92E+00	6.03E+00
Strontium	8.68E-02	1.17E+00	4.25E+01	4.38E+01	3.05E-02	4.99E-01	1.81E+01	1.86E+01
Tin	5.62E-05	1.68E-01	2.87E+00	3.03E+00	4.41E-06	1.83E-02	3.12E-01	3.30E-01
Zinc	1.80E-03	1.45E+01	7.84E+02	7.98E+02	2.03E-04	1.57E+00	8.51E+01	8.66E+01

Note

There is no surface water body in Polygon C, therefore the exposure through water intake is negligible.

Table D.22: Exposure Dose for White-tailed Deer

Parameter	White-tailed Deer							
	Maximum Dose				UCLM Dose			
	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Terrestrial Veg mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Terrestrial Veg mg/kg bw/day	Total Exposure mg/kg bw/day
Polygon AB								
Barium	3.43E-03	6.19E-02	4.67E+00	4.74E+00	3.18E-03	6.19E-02	3.00E+00	3.06E+00
Cadmium	4.57E-07	1.70E-04	3.87E-03	4.04E-03	3.89E-07	1.70E-04	2.02E-03	2.19E-03
Chromium	9.77E-05	1.32E-02	7.68E-02	9.01E-02	6.13E-05	1.32E-02	4.94E-02	6.26E-02
Copper	1.06E-04	1.00E-02	5.42E-01	5.52E-01	7.01E-05	1.00E-02	3.07E-01	3.17E-01
Manganese	4.23E-03	2.64E-01	2.00E+00	2.27E+00	2.93E-03	2.64E-01	1.20E+00	1.47E+00
Nickel	5.44E-05	7.74E-03	7.50E-02	8.28E-02	4.66E-05	7.74E-03	3.66E-02	4.44E-02
Strontium	3.10E-02	1.04E-01	4.64E+00	4.77E+00	2.99E-02	1.04E-01	3.84E+00	3.97E+00
Vanadium	1.56E-04	2.18E-02	9.52E-02	1.17E-01	1.32E-04	2.18E-02	4.25E-02	6.45E-02
Zinc	1.62E-04	3.75E-02	3.88E+00	3.92E+00	1.19E-04	3.75E-02	2.57E+00	2.60E+00
Polygon C								
Strontium	NA	6.67E-02	1.55E+00	1.62E+00	NA	6.67E-02	1.38E+00	1.45E+00
Polygon D								
Barium	2.46E-03	6.37E-02	1.26E+00	1.33E+00	2.46E-03	6.37E-02	8.54E-01	9.20E-01
Cadmium	3.09E-07	1.63E-04	1.70E-03	1.86E-03	3.09E-07	1.63E-04	9.97E-04	1.16E-03
Copper	2.40E-05	8.99E-03	4.36E-01	4.45E-01	2.40E-05	8.99E-03	3.38E-01	3.47E-01
Strontium	1.39E-02	8.45E-02	2.47E+00	2.57E+00	1.39E-02	8.45E-02	1.65E+00	1.74E+00
Vanadium	2.47E-05	1.80E-02	7.53E-03	2.55E-02	2.47E-05	1.80E-02	5.89E-03	2.39E-02
Polygon E								
Arsenic	5.19E-05	7.92E-02	9.90E-01	1.07E+00	4.76E-05	9.15E-03	1.14E-01	1.24E-01
Cadmium	9.89E-07	2.23E-03	2.34E-01	2.37E-01	2.36E-07	2.92E-04	3.06E-02	3.09E-02
Chromium	8.32E-05	4.45E-02	1.83E-02	6.29E-02	1.12E-05	1.11E-02	4.53E-03	1.56E-02
Cobalt	5.63E-06	9.47E-02	2.22E-01	3.17E-01	1.07E-06	1.17E-02	2.75E-02	3.92E-02
Copper	6.18E-05	1.33E+00	5.31E+01	5.44E+01	4.09E-05	1.43E-01	5.73E+00	5.87E+00
Iron	1.10E-02	5.65E+01	1.41E+01	7.06E+01	1.03E-03	1.20E+01	3.00E+00	1.50E+01
Lead	9.71E-06	3.51E-01	5.43E+00	5.79E+00	1.27E-06	4.07E-02	6.31E-01	6.72E-01
Molybdenum	8.35E-05	2.52E-02	4.53E-01	4.79E-01	7.32E-05	2.84E-03	5.11E-02	5.41E-02
Nickel	4.35E-05	7.68E-02	1.80E+00	1.88E+00	2.84E-05	1.27E-02	2.98E-01	3.11E-01
Selenium	1.17E-05	3.64E-03	8.20E-02	8.56E-02	8.69E-06	4.55E-04	1.02E-02	1.07E-02
Sodium	2.45E+00	1.14E+00	6.86E+00	1.04E+01	1.13E+00	2.24E-01	1.34E+00	2.69E+00
Strontium	3.86E-02	4.49E-01	1.96E+01	2.00E+01	1.36E-02	1.91E-01	8.32E+00	8.52E+00
Tin	2.50E-05	6.43E-02	1.32E+00	1.38E+00	1.96E-06	7.00E-03	1.43E-01	1.50E-01
Zinc	8.04E-04	5.55E+00	3.61E+02	3.66E+02	9.06E-05	6.02E-01	3.91E+01	3.97E+01

Note

There is no surface water body in Polygon C, therefore the exposure through water intake is negligible.

Table D.23: Exposure Dose for Common Shrew

Parameter	Common Shrew							
	Maximum Dose				UCLM Dose			
	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Invertebrates (Caterpillar) mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Invertebrates (Caterpillar) mg/kg bw/day	Total Exposure mg/kg bw/day
Polygon AB								
Barium	9.48E-03	6.98E-01	6.91E+00	7.62E+00	8.77E-03	6.98E-01	5.43E+00	6.14E+00
Cadmium	1.26E-06	1.91E-03	9.87E-02	1.01E-01	1.07E-06	1.91E-03	9.87E-02	1.01E-01
Chromium	2.70E-04	1.49E-01	3.20E-01	4.69E-01	1.69E-04	1.49E-01	2.50E-01	3.99E-01
Copper	2.94E-04	1.13E-01	1.13E+01	1.14E+01	1.94E-04	1.13E-01	8.08E+00	8.19E+00
Manganese	1.17E-02	2.97E+00	7.50E+00	1.05E+01	8.10E-03	2.97E+00	7.50E+00	1.05E+01
Nickel	1.50E-04	8.73E-02	3.10E-01	3.97E-01	1.29E-04	8.73E-02	1.80E-01	2.67E-01
Strontium	8.55E-02	1.17E+00	3.63E+01	3.76E+01	8.26E-02	1.17E+00	2.11E+01	2.24E+01
Vanadium	4.32E-04	2.46E-01	9.87E-02	3.46E-01	3.64E-04	2.46E-01	9.87E-02	3.45E-01
Zinc	4.46E-04	4.23E-01	2.59E+01	2.63E+01	3.28E-04	4.23E-01	2.05E+01	2.10E+01
Polygon C								
Strontium	NA	7.52E-01	3.95E+00	4.70E+00	NA	7.52E-01	3.95E+00	4.70E+00
Polygon D								
Barium	6.80E-03	7.18E-01	2.96E+00	3.69E+00	6.80E-03	7.18E-01	2.96E+00	3.69E+00
Cadmium	8.54E-07	1.84E-03	9.87E-02	1.01E-01	8.54E-07	1.84E-03	9.87E-02	1.01E-01
Copper	6.62E-05	1.01E-01	7.66E+00	7.76E+00	6.62E-05	1.01E-01	7.66E+00	7.76E+00
Strontium	3.84E-02	9.53E-01	1.50E+01	1.60E+01	3.84E-02	9.53E-01	1.50E+01	1.60E+01
Vanadium	6.83E-05	2.03E-01	4.94E-02	2.52E-01	6.83E-05	2.03E-01	4.94E-02	2.52E-01
Polygon E								
Arsenic	1.43E-04	8.93E-01	9.82E+00	1.07E+01	1.31E-04	1.03E-01	1.14E+00	1.24E+00
Cadmium	2.73E-06	2.52E-02	1.55E+01	1.56E+01	6.50E-07	3.29E-03	2.03E+00	2.03E+00
Chromium	2.30E-04	5.02E-01	7.78E+00	8.29E+00	3.09E-05	1.25E-01	1.93E+00	2.06E+00
Cobalt	1.55E-05	1.07E+00	1.91E+00	2.98E+00	2.97E-06	1.32E-01	2.36E-01	3.68E-01
Copper	1.71E-04	1.50E+01	3.89E+02	4.04E+02	1.13E-04	1.62E+00	4.20E+01	4.36E+01
Iron	3.04E-02	6.37E+02	1.15E+03	1.78E+03	2.85E-03	1.35E+02	2.44E+02	3.79E+02
Lead	2.68E-05	3.95E+00	3.31E+01	3.71E+01	3.51E-06	4.59E-01	3.85E+00	4.31E+00
Molybdenum	2.30E-04	2.84E-01	1.35E+01	1.38E+01	2.02E-04	3.20E-02	1.53E+00	1.56E+00
Nickel	1.20E-04	8.66E-01	1.66E+01	1.75E+01	7.83E-05	1.43E-01	2.74E+00	2.88E+00
Selenium	3.23E-05	4.11E-02	1.79E+01	1.79E+01	2.40E-05	5.14E-03	2.24E+00	2.24E+00
Sodium	6.76E+00	1.29E+01	2.79E+03	2.81E+03	3.11E+00	2.52E+00	5.45E+02	5.51E+02
Strontium	1.07E-01	5.07E+00	1.34E+01	1.85E+01	3.75E-02	2.16E+00	5.69E+00	7.88E+00
Tin	6.91E-05	7.25E-01	6.08E+00	6.80E+00	5.42E-06	7.89E-02	6.62E-01	7.41E-01
Zinc	2.22E-03	6.26E+01	1.00E+04	1.01E+04	2.50E-04	6.79E+00	1.09E+03	1.09E+03

Note

There is no surface water body in Polygon C, therefore the exposure through water intake is negligible.

Table D.24: Exposure Dose for Raccoon

Parameter	Raccoon															
	Maximum Dose								Maximum Dose							
	Exposure via Water mg/kg bw/day	Exposure via Aquatic Invertebrates mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Terrestrial Veg mg/kg bw/day	Exposure via Fruit (Berries) mg/kg bw/day	Exposure via Invertebrates (Caterpillar) mg/kg bw/day	Exposure via Meadow Vole mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Aquatic Invertebrates mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Terrestrial Veg mg/kg bw/day	Exposure via Fruit (Berries) mg/kg bw/day	Exposure via Invertebrates (Caterpillar) mg/kg bw/day	Exposure via Meadow Vole mg/kg bw/day	Total Exposure mg/kg bw/day
Polygon AB																
Barium	4.58E-03	2.68E-01	4.93E-01	2.11E+00	6.32E-01	3.76E-01	2.02E-03	3.88E+00	4.24E-03	2.48E-01	4.93E-01	1.35E+00	4.05E-01	2.95E-01	1.31E-03	2.80E+00
Cadmium	6.10E-07	1.99E-05	1.35E-03	1.74E-03	5.23E-04	5.37E-03	7.18E-05	9.08E-03	5.19E-07	1.69E-05	1.35E-03	9.09E-04	2.73E-04	5.37E-03	3.91E-05	7.96E-03
Chromium	1.30E-04	1.65E-02	1.05E-01	3.46E-02	1.04E-02	1.74E-02	3.10E-03	1.87E-01	8.18E-05	1.04E-02	1.05E-01	2.23E-02	6.68E-03	1.36E-02	2.18E-03	1.60E-01
Copper	1.42E-04	1.94E-03	7.96E-02	2.44E-01	7.33E-02	6.14E-01	1.23E-02	1.03E+00	9.35E-05	1.28E-03	7.96E-02	1.38E-01	4.15E-02	4.39E-01	7.06E-03	7.07E-01
Manganese	5.65E-03	1.27E+00	2.10E+00	9.03E-01	2.71E-01	4.08E-01	4.23E-03	4.96E+00	3.91E-03	8.79E-01	2.10E+00	5.41E-01	1.62E-01	4.08E-01	2.77E-03	4.10E+00
Nickel	7.26E-05	2.36E-03	6.16E-02	3.38E-02	1.01E-02	1.69E-02	1.28E-03	1.26E-01	6.21E-05	2.02E-03	6.16E-02	1.65E-02	4.95E-03	9.77E-03	6.97E-04	9.56E-02
Strontium	4.13E-02	3.63E+00	8.25E-01	2.09E+00	6.27E-01	1.98E+00	1.88E-02	9.21E+00	3.99E-02	3.51E+00	8.25E-01	1.73E+00	5.19E-01	1.15E+00	1.56E-02	7.78E+00
Vanadium	2.09E-04	2.65E-02	1.74E-01	4.29E-02	1.29E-02	5.37E-03	5.17E-04	2.62E-01	1.76E-04	2.23E-02	1.74E-01	1.92E-02	5.75E-03	5.37E-03	2.92E-04	2.27E-01
Zinc	2.16E-04	1.26E-01	2.99E-01	1.75E+00	5.25E-01	1.41E+00	1.91E+00	6.02E+00	1.58E-04	9.27E-02	2.99E-01	1.16E+00	3.47E-01	1.12E+00	1.27E+00	4.28E+00
Polygon C																
Strontium	NA	NA	5.31E-01	7.31E-01	2.19E-01	2.81E-01	6.73E-03	1.77E+00	NA	NA	5.31E-01	6.51E-01	1.95E-01	2.81E-01	6.03E-03	1.66E+00
Polygon D																
Barium	3.28E-03	NA	5.07E-01	5.95E-01	1.79E-01	2.11E-01	5.95E-04	1.50E+00	3.28E-03	NA	5.07E-01	4.03E-01	1.21E-01	2.11E-01	4.14E-04	1.24E+00
Cadmium	4.12E-07	NA	1.30E-03	8.00E-04	2.40E-04	7.02E-03	3.49E-05	9.39E-03	4.12E-07	NA	1.30E-03	4.70E-04	1.41E-04	7.02E-03	2.20E-05	8.95E-03
Copper	3.20E-05	NA	7.16E-02	2.06E-01	6.17E-02	5.45E-01	1.04E-02	8.94E-01	3.20E-05	NA	7.16E-02	1.60E-01	4.79E-02	5.45E-01	8.09E-03	8.32E-01
Strontium	1.86E-02	NA	6.73E-01	1.16E+00	3.49E-01	1.07E+00	1.06E-02	3.28E+00	1.86E-02	NA	6.73E-01	7.76E-01	2.33E-01	1.07E+00	7.22E-03	2.77E+00
Vanadium	3.30E-05	NA	1.43E-01	3.55E-03	1.07E-03	3.51E-03	1.29E-04	1.51E-01	3.30E-05	NA	1.43E-01	2.78E-03	8.34E-04	3.51E-03	1.22E-04	1.50E-01
Polygon E																
Arsenic	6.93E-05	NA	6.30E-01	4.67E-01	1.40E-01	6.98E-01	6.89E-02	2.00E+00	6.34E-05	NA	7.28E-02	5.39E-02	1.62E-02	8.07E-02	7.96E-03	2.32E-01
Cadmium	1.32E-06	NA	1.78E-02	1.11E-01	3.32E-02	1.11E+00	4.37E-03	1.27E+00	3.14E-07	NA	2.32E-03	1.44E-02	4.33E-03	1.44E-01	5.70E-04	1.66E-01
Chromium	1.11E-04	NA	3.54E-01	8.61E-03	2.58E-03	5.53E-01	2.51E-03	9.22E-01	1.49E-05	NA	8.80E-02	2.14E-03	6.41E-04	1.37E-01	6.22E-04	2.29E-01
Cobalt	7.50E-06	NA	7.53E-01	1.05E-01	3.15E-02	1.36E-01	4.59E-04	1.03E+00	1.43E-06	NA	9.32E-02	1.30E-02	3.89E-03	1.68E-02	5.68E-05	1.27E-01
Copper	8.25E-05	NA	1.06E+01	2.50E+01	7.51E+00	2.77E+01	1.27E+00	7.21E+01	5.46E-05	NA	1.14E+00	2.70E+00	8.11E-01	2.99E+00	1.37E-01	7.78E+00
Iron	1.47E-02	NA	4.50E+02	6.66E+00	2.00E+00	8.15E+01	3.64E+00	5.44E+02	1.38E-03	NA	9.56E+01	1.42E+00	4.25E-01	1.73E+01	7.74E-01	1.15E+02
Lead	1.29E-05	NA	2.79E+00	2.56E+00	7.69E-01	2.36E+00	1.30E-02	8.49E+00	1.69E-06	NA	3.24E-01	2.98E-01	8.93E-02	2.74E-01	1.51E-03	9.86E-01
Molybdenum	1.11E-04	NA	2.00E-01	2.14E-01	6.41E-02	9.62E-01	1.54E-03	1.44E+00	9.77E-05	NA	2.26E-02	2.41E-02	7.23E-03	1.09E-01	1.73E-04	1.63E-01
Nickel	5.80E-05	NA	6.11E-01	8.51E-01	2.55E-01	1.18E+00	3.01E-02	2.93E+00	3.78E-05	NA	1.01E-01	1.40E-01	4.21E-02	1.95E-01	4.97E-03	4.83E-01
Selenium	1.56E-05	NA	2.90E-02	3.87E-02	1.16E-02	1.27E+00	2.74E-02	1.38E+00	1.16E-05	NA	3.63E-03	4.83E-03	1.45E-03	1.59E-01	3.43E-03	1.72E-01
Sodium	3.27E+00	NA	9.10E+00	3.23E+00	9.70E-01	1.98E+02	3.92E-01	2.15E+02	1.50E+00	NA	1.78E+00	6.33E-01	1.90E-01	3.87E+01	7.67E-02	4.29E+01
Strontium	5.15E-02	NA	3.58E+00	9.22E+00	2.77E+00	9.51E-01	8.30E-02	1.66E+01	1.81E-02	NA	1.52E+00	3.92E+00	1.18E+00	4.04E-01	3.53E-02	7.08E+00
Tin	3.34E-05	NA	5.12E-01	6.21E-01	1.86E-01	4.32E-01	4.88E-02	1.80E+00	2.62E-06	NA	5.57E-02	6.77E-02	2.03E-02	4.70E-02	5.31E-03	1.96E-01
Zinc	1.07E-03	NA	4.42E+01	1.70E+02	5.10E+01	7.12E+02	1.87E+02	1.16E+03	1.21E-04	NA	4.79E+00	1.85E+01	5.54E+00	7.72E+01	2.03E+01	1.26E+02

Note

There is no surface water body in Polygon C, therefore the exposure through water intake is negligible.

Other than Polygon AB, there is no Benthic Invertebrate in the Raccoon's diet. Therefore exposure through Aquatic Invertebrates does not apply in Polygons C, D, and E.

Table D.25: Exposure Dose for Red Fox

Parameter	Red Fox															
	Maximum Dose								UCLM Dose							
	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Terrestrial Veg mg/kg bw/day	Exposure via Meadow Vole mg/kg bw/day	Exposure via Eastern Cottontail mg/kg bw/day	Exposure via Bufflehead mg/kg bw/day	Exposure via Mallard mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Terrestrial Veg mg/kg bw/day	Exposure via Meadow Vole mg/kg bw/day	Exposure via Eastern Cottontail mg/kg bw/day	Exposure via Bufflehead mg/kg bw/day	Exposure via Mallard mg/kg bw/day	Total Exposure mg/kg bw/day
Coot's Pond (Polygon AB)																
Barium	4.72E-03	5.62E-02	4.33E-01	1.04E-03	4.00E-03	4.05E-04	3.77E-04	4.99E-01	4.37E-03	5.62E-02	2.78E-01	6.71E-04	2.62E-03	3.76E-04	3.53E-04	3.42E-01
Cadmium	6.29E-07	1.54E-04	3.59E-04	3.69E-05	1.50E-04	7.05E-05	1.70E-04	9.41E-04	5.35E-07	1.54E-04	1.87E-04	2.01E-05	8.69E-05	5.90E-05	1.42E-04	6.49E-04
Chromium	1.34E-04	1.20E-02	7.11E-03	1.59E-03	7.65E-03	1.28E-03	1.36E-03	3.11E-02	8.43E-05	1.20E-02	4.57E-03	1.12E-03	5.88E-03	8.58E-04	1.00E-03	2.55E-02
Copper	1.46E-04	9.08E-03	5.02E-02	6.31E-03	2.46E-02	4.21E-04	9.63E-04	9.17E-02	9.64E-05	9.08E-03	2.84E-02	3.63E-03	1.45E-02	2.94E-04	6.82E-04	5.67E-02
Manganese	5.82E-03	2.39E-01	1.86E-01	2.17E-03	9.98E-03	3.07E-04	4.49E-04	4.44E-01	4.03E-03	2.39E-01	1.11E-01	1.42E-03	7.16E-03	2.14E-04	3.16E-04	3.64E-01
Nickel	7.48E-05	7.02E-03	6.95E-03	6.58E-04	2.92E-03	9.36E-05	1.55E-04	1.79E-02	6.41E-05	7.02E-03	3.39E-03	3.58E-04	1.79E-03	8.54E-05	1.48E-04	1.29E-02
Strontium	4.26E-02	9.40E-02	4.30E-01	9.66E-03	3.79E-02	6.17E-03	6.21E-03	6.26E-01	4.11E-02	9.40E-02	3.56E-01	8.04E-03	3.18E-02	5.96E-03	6.00E-03	5.42E-01
Vanadium	2.15E-04	1.98E-02	8.82E-03	2.65E-04	1.35E-03	6.65E-05	7.65E-05	3.06E-02	1.81E-04	1.98E-02	3.94E-03	1.50E-04	9.15E-04	5.68E-05	6.67E-05	2.51E-02
Zinc	2.22E-04	3.40E-02	3.60E-01	9.81E-01	3.76E+00	5.18E-03	5.63E-03	5.15E+00	1.63E-04	3.40E-02	2.38E-01	6.52E-01	2.52E+00	3.89E-03	4.38E-03	3.45E+00
Polygon C																
Strontium	NA	6.05E-02	1.44E-01	5.29E-03	2.15E-02	NA	NA	2.31E-01	NA	6.05E-02	1.28E-01	4.74E-03	1.94E-02	NA	NA	2.13E-01
Polygon D																
Barium	3.38E-03	5.78E-02	1.17E-01	4.68E-04	1.92E-03	NA	NA	1.81E-01	3.38E-03	5.78E-02	7.91E-02	3.25E-04	1.39E-03	NA	NA	1.42E-01
Cadmium	4.25E-07	1.48E-04	1.57E-04	2.74E-05	1.20E-04	NA	NA	4.54E-04	4.25E-07	1.48E-04	9.24E-05	1.73E-05	8.23E-05	NA	NA	3.40E-04
Copper	3.30E-05	8.16E-03	4.04E-02	8.14E-03	3.18E-02	NA	NA	8.86E-02	3.30E-05	8.16E-03	3.13E-02	6.36E-03	2.51E-02	NA	NA	7.10E-02
Strontium	1.91E-02	7.68E-02	2.29E-01	8.35E-03	3.34E-02	NA	NA	3.67E-01	1.91E-02	7.68E-02	1.53E-01	5.67E-03	2.34E-02	NA	NA	2.77E-01
Vanadium	3.40E-05	1.63E-02	6.98E-04	1.02E-04	8.44E-04	NA	NA	1.80E-02	3.40E-05	1.63E-02	5.46E-04	9.60E-05	8.22E-04	NA	NA	1.78E-02
Polygon E																
Arsenic	7.14E-05	7.19E-02	9.17E-02	5.42E-02	2.33E-01	NA	NA	4.51E-01	6.54E-05	8.31E-03	1.06E-02	6.26E-03	2.69E-02	NA	NA	5.21E-02
Cadmium	1.36E-06	2.03E-03	2.17E-02	3.43E-03	1.32E-02	NA	NA	4.03E-02	3.24E-07	2.65E-04	2.84E-03	4.48E-04	1.72E-03	NA	NA	5.27E-03
Chromium	1.14E-04	4.04E-02	1.69E-03	1.97E-03	1.64E-02	NA	NA	6.06E-02	1.54E-05	1.00E-02	4.20E-04	4.89E-04	4.07E-03	NA	NA	1.50E-02
Cobalt	7.74E-06	8.59E-02	2.06E-02	3.61E-04	2.10E-03	NA	NA	1.09E-01	1.48E-06	1.06E-02	2.55E-03	4.46E-05	2.60E-04	NA	NA	1.35E-02
Copper	8.50E-05	1.21E+00	4.92E+00	9.97E-01	3.93E+00	NA	NA	1.10E+01	5.63E-05	1.30E-01	5.31E-01	1.08E-01	4.24E-01	NA	NA	1.19E+00
Iron	1.51E-02	5.13E+01	1.31E+00	2.86E+00	2.53E+01	NA	NA	8.07E+01	1.42E-03	1.09E+01	2.78E-01	6.08E-01	5.37E+00	NA	NA	1.72E+01
Lead	1.33E-05	3.18E-01	5.04E-01	1.02E-02	4.30E-02	NA	NA	8.75E-01	1.75E-06	3.70E-02	5.85E-02	1.19E-03	4.99E-03	NA	NA	1.02E-01
Molybdenum	1.15E-04	2.29E-02	4.20E-02	1.21E-03	5.00E-03	NA	NA	7.12E-02	1.01E-04	2.58E-03	4.74E-03	1.36E-04	5.64E-04	NA	NA	8.12E-03
Nickel	5.98E-05	6.97E-02	1.67E-01	2.37E-02	9.61E-02	NA	NA	3.57E-01	3.90E-05	1.15E-02	2.76E-02	3.91E-03	1.59E-02	NA	NA	5.89E-02
Selenium	1.61E-05	3.31E-03	7.59E-03	2.16E-02	8.78E-02	NA	NA	1.20E-01	1.19E-05	4.14E-04	9.49E-04	2.70E-03	1.10E-02	NA	NA	1.50E-02
Sodium	3.37E+00	1.04E+00	6.35E-01	3.08E-01	1.47E+00	NA	NA	6.82E+00	1.55E+00	2.03E-01	1.24E-01	6.03E-02	2.88E-01	NA	NA	2.23E+00
Strontium	5.31E-02	4.08E-01	1.81E+00	6.52E-02	2.56E-01	NA	NA	2.59E+00	1.87E-02	1.74E-01	7.70E-01	2.77E-02	1.09E-01	NA	NA	1.10E+00
Tin	3.44E-05	5.84E-02	1.22E-01	3.83E-02	1.57E-01	NA	NA	3.76E-01	2.70E-06	6.36E-03	1.33E-02	4.17E-03	1.71E-02	NA	NA	4.09E-02
Zinc	1.11E-03	5.04E+00	3.34E+01	1.47E+02	5.68E+02	NA	NA	7.53E+02	1.25E-04	5.47E-01	3.63E+00	1.59E+01	6.17E+01	NA	NA	8.18E+01

Note

There is no surface water body in Polygon C, therefore the exposure through water intake is negligible.

Other than Polygon AB, there is no Bufflehead and Mallard in the Red Fox's diet. Therefore corresponding exposure pathways do not apply in Polygons C, D, and E.

Table D.26: Exposure Dose for Short-tailed Weasel

Parameter	Short-tailed Weasel							
	Maximum Dose				UCLM Dose			
	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Meadow Vole mg/kg bw/day	Total Exposure mg/kg bw/day	Exposure via Water mg/kg bw/day	Exposure via Soil mg/kg bw/day	Exposure via Meadow Vole mg/kg bw/day	Total Exposure mg/kg bw/day
Polygon AB								
Barium	6.52E-03	4.85E-01	7.01E-03	4.98E-01	6.04E-03	4.85E-01	4.54E-03	4.95E-01
Cadmium	8.70E-07	1.33E-03	2.49E-04	1.58E-03	7.39E-07	1.33E-03	1.36E-04	1.47E-03
Chromium	1.86E-04	1.04E-01	1.08E-02	1.14E-01	1.17E-04	1.04E-01	7.57E-03	1.11E-01
Copper	2.02E-04	7.83E-02	4.27E-02	1.21E-01	1.33E-04	7.83E-02	2.45E-02	1.03E-01
Manganese	8.05E-03	2.07E+00	1.47E-02	2.09E+00	5.57E-03	2.07E+00	9.61E-03	2.08E+00
Nickel	1.03E-04	6.06E-02	4.45E-03	6.52E-02	8.85E-05	6.06E-02	2.42E-03	6.31E-02
Strontium	5.89E-02	8.11E-01	6.53E-02	9.35E-01	5.68E-02	8.11E-01	5.44E-02	9.22E-01
Vanadium	2.97E-04	1.71E-01	1.79E-03	1.73E-01	2.50E-04	1.71E-01	1.02E-03	1.72E-01
Zinc	3.07E-04	2.94E-01	6.63E+00	6.93E+00	2.25E-04	2.94E-01	4.41E+00	4.70E+00
Polygon C								
Strontium	NA	5.22E-01	2.24E-02	5.45E-01	NA	5.22E-01	2.00E-02	5.42E-01
Polygon D								
Barium	4.68E-03	4.99E-01	1.98E-03	5.06E-01	4.68E-03	4.99E-01	1.37E-03	5.05E-01
Cadmium	5.88E-07	1.28E-03	1.16E-04	1.39E-03	5.88E-07	1.28E-03	7.30E-05	1.35E-03
Copper	4.56E-05	7.04E-02	3.44E-02	1.05E-01	4.56E-05	7.04E-02	2.69E-02	9.73E-02
Strontium	2.64E-02	6.62E-01	3.53E-02	7.24E-01	2.64E-02	6.62E-01	2.40E-02	7.12E-01
Vanadium	4.70E-05	1.41E-01	4.30E-04	1.41E-01	4.70E-05	1.41E-01	4.06E-04	1.41E-01
Polygon E								
Arsenic	9.87E-05	6.20E-01	2.29E-01	8.49E-01	9.04E-05	7.17E-02	2.65E-02	9.82E-02
Cadmium	1.88E-06	1.75E-02	1.45E-02	3.20E-02	4.48E-07	2.28E-03	1.90E-03	4.18E-03
Chromium	1.58E-04	3.49E-01	8.32E-03	3.57E-01	2.13E-05	8.66E-02	2.07E-03	8.87E-02
Cobalt	1.07E-05	7.41E-01	1.52E-03	7.43E-01	2.04E-06	9.17E-02	1.89E-04	9.19E-02
Copper	1.18E-04	1.04E+01	4.21E+00	1.46E+01	7.78E-05	1.12E+00	4.55E-01	1.58E+00
Iron	2.09E-02	4.42E+02	1.21E+01	4.55E+02	1.96E-03	9.40E+01	2.57E+00	9.66E+01
Lead	1.84E-05	2.75E+00	4.33E-02	2.79E+00	2.41E-06	3.19E-01	5.02E-03	3.24E-01
Molybdenum	1.59E-04	1.97E-01	5.10E-03	2.02E-01	1.39E-04	2.23E-02	5.76E-04	2.30E-02
Nickel	8.26E-05	6.01E-01	1.00E-01	7.02E-01	5.39E-05	9.93E-02	1.65E-02	1.16E-01
Selenium	2.22E-05	2.85E-02	9.11E-02	1.20E-01	1.65E-05	3.57E-03	1.14E-02	1.50E-02
Sodium	4.65E+00	8.95E+00	1.30E+00	1.49E+01	2.14E+00	1.75E+00	2.55E-01	4.15E+00
Strontium	7.34E-02	3.52E+00	2.76E-01	3.87E+00	2.58E-02	1.50E+00	1.17E-01	1.64E+00
Tin	4.76E-05	5.04E-01	1.62E-01	6.66E-01	3.73E-06	5.48E-02	1.76E-02	7.25E-02
Zinc	1.53E-03	4.35E+01	6.20E+02	6.64E+02	1.72E-04	4.71E+00	6.73E+01	7.20E+01

Note

There is no surface water body in Polygon C, therefore the exposure through water intake is negligible.

Appendix E Sample Calculations

Table E.1: Sample Calculation for Oshawa Urban Resident (Toddler) Drinking Water Exposure and Risk to Lithium

		<u>Lithium</u>		
Environmental Media Concentration		Value	Unit	Source
Lake Water Concentration	A	1.02E-02	mg/L	Table 3.18
Dilution Factor (Outfall)	B	7	mg/L	Table 3.17
Dilution Factor (Oshawa WSP)	C	36	mg/L	Table 3.17
Estimated at Oshawa WSP (mg/L)	$D=A*B/C$	2.01E-03	mg/L	Calculation
Human Exposure Factors (Toddler)				
Drinking Water Intake	E	0.6	L/d	Table 3.12
Days per Week/7 (D2)	F	1	d/d	Table 3.12
Weeks per Year/52 (D3)	G	1	wk/wk	Table 3.12
Fraction of Water Obtained from WSP	H	0.834	unitless	Table 3.13
Body Weight	I	16.5	kg	Table 3.12
RAF_{GIT}	J	1	unitless	Table 3.12
TRV (Acceptable Daily Intake)	K	0.002	mg/kg d	Table 3.24
Human Dose and HQ				
Ingestion Dose	$L = (D*E*F*G*H*J)/I$	6.08E-05	mg/kg d	Calculation
HQ	$M = L/K$	3.04E-02	unitless	Calculation

Table E.2: Sample Calculation for Oshawa Urban Resident (Adult) Drinking Water Exposure and Risk to Hydrazine with Decay ($t_{1/2} = 1.3$ days)

Environmental Media Concentration		Hydrazine		
		Value	Unit	Source
Water Concentration	A	1.10E-04	mg/L	Table 3.18
Dilution Factor (Outfall)	B	7	unitless	Table 3.17
Dilution Factor (Oshawa WSP)	C	35.6	unitless	Table 3.17
Half-life hydrazine ($t_{1/2}$)	D	1.3	days	Section 3.2.6.1.2
Hydrazine Decay Constant (λ)	$E = \ln(2)/D$	0.53	unitless	Calculation
Distance to Oshawa WSP	F	7800	m	Table 3.17
Current Velocity to the West	G	0.085	m/s	Table 3.17
Travel Time	$H = F/G / (60\text{sec} * 60\text{min} * 24\text{hr})$	1.06	days	Calculation
Hydrazine Decayed Concentration $t_{1/2} = 1.3$ days	$I = A * \text{EXP}(-E * H)$	6.24E-05	mg/L	Calculation
Estimated at Oshawa WSP (mg/L)	$J = I * (B/C)$	1.23E-05	mg/L	Calculation
Human Exposure Factors (Adult)				
Drinking Water Intake	K	1.5	L/d	Table 3.12
Days per Week/7 (D2)	L	1	d/d	Table 3.12
Weeks per Year/52 (D3)	M	1	wk/wk	Table 3.12
Years Exposed (D4)	N	30	years	Table 3.12
Fraction of Water Obtained from WSP	O	0.834	unitless	Table 3.13
Body Weight	P	70.7	kg	Table 3.12
Life Expectancy	Q	70	years	Table 3.12
RAF_{GIT}	R	1	unitless	Table 3.12
TRV (Oral Slope Factor)	S	3	$(\text{mg/kg d})^{-1}$	Table 3.24
Human Dose and ILCR				
Ingestion Dose	$T = (J * K * L * M * N * O * R) / (P * Q)$	9.31E-08	mg/kg d	Calculation
ILCR	$U = S * T$	2.79E-07	unitless	Calculation

Table E.3: Sample Calculation for Sport Fisher Fish Consumption Exposure and Risk to Hydrazine

		Hydrazine		
Environmental Media Concentration		Value	Unit	Source
Lake Water Concentration	A	1.10E-04	mg/L	Table 3.18
Fish Concentration				
Bioaccumulation Factor (BAF)	B	3.16	L/kg fw	Section 3.2.6.1.3
Tissue Concentration	C=A*B	3.5E-04	mg/kg fw	Calculation
Human Exposure Factors (Adult)				
Fish Ingestion	D	0.111	kg/d	Table 3.12
Years Exposed (D4)	E	30	a	Table 3.12
D _{fish} (days in which consumption occurs)	F	365	d/a	Table 3.12
Fraction of Fish in Diet Obtained from Outfall	G	1	unitless	Table 3.13
Body Weight	H	70.7	kg	Table 3.12
Life Expectancy	I	70	years	Table 3.12
RAF _{GIT}	J	1	unitless	Table 3.12
TRV (Oral Slope Factor)	K	3	(mg/kg d) ⁻¹	Table 3.24
Human Dose and ILCR				
Ingestion Dose	$L = (C*D*F*G*J*E)/H*365*I$	2.34E-07	mg/kg d	Calculation
ILCR	$M = K*L$	7.02E-07	unitless	Calculation

Table E.4: Sample Calculation for Coot's Pond Benthic Invertebrate Dose Calculations for Cobalt-60

		Cobalt-60 (Radiological Dose)		
		Value	Unit	Source
Environmental Media Concentrations				
Coot's Pond Water Concentration	A	1.19E-01	Bq/L	Table 4.23
Coot's Pond Sediment Concentration (dry weight)	B	1.21E-01	Bq/kg	Table 4.23
Dry Weight Fraction of Sediment	C	2.00E-01	kg dw/ kg fw	Assumption
Coot's Pond Sediment Concentration fresh weight)	D = B * C	2.42E-02	Bq/kg fw	Calculated
Benthic Invertebrate Internal Dose (radiological)				
Bioaccumulation Factor - Benthic Invertebrate	E	1.10E+02	L/kg fw	Table 4.11
Modelled Benthic Invertebrate Tissue Concentration	F = A * E	1.31E+01	Bq/kg fw	Calculated
Dose Conversion Factor (Internal)	G	5.20E-05	(μGy/hr)/(Bq/kg fw)	Table 4.18
Internal Dose	H = F * G	6.81E-04	μGy/hr	Calculated
Internal Dose (converted units)	H' = H * 24 h/d / 1000 μGy/mGy	1.63E-05	mGy/d	Calculated
Benthic Invertebrate External Dose (radiological)				
Occupancy Factor, Water	I	0.00E+00	unitless	Table 4.10
Occupancy Factor, Water Surface	J	0.00E+00	unitless	Table 4.10
Occupancy Factor, Sediment	K	1.00E+00	unitless	Table 4.10
Occupancy Factor, Sediment Surface	L	0.00E+00	unitless	Table 4.10
Dose Conversion Factor (External)	M	1.40E-03	(μGy/hr)/(Bq/kg)	Table 4.18
Contribution of Water to External Dose	N = M * (I + 0.5*J + 0.5*L) * A	0.00E+00	μGy/hr	Calculated
Contribution of Sediment to External Dose	O = M * (K + 0.5*L) * D	3.39E-05	μGy/hr	Calculated
External Dose	P = N + O	3.39E-05	μGy/hr	Calculated
External Dose (converted units)	P' = P * 24 h/d / 1000 μGy/mGy	8.13E-07	mGy/d	Calculated
Benthic Invertebrate Total Dose (radiological)				
Total Dose	Q = H + P	7.15E-04	μGy/hr	Calculated
Total Dose (converted units)	Q' = H' + P'	1.71E-05	mGy/d	Calculated

Table E.5: Sample Calculation for Polygon AB Mallard Dose and Risk Calculations for Chromium (Maximum Concentration)

		Chromium (Toxic Dose)		
		Value	Unit	Source
Environmental Media Concentrations				
Coot's Pond Water Concentration	A	1.58E-03	mg/L	Table 4.23
Coot's Pond Sediment Concentration (dry weight)	B	3.07E+01	mg/kg dw	Table 4.23
Aquatic Plant Concentration				
Bioaccumulation Factor - Aquatic Plant	C	1.00E+01	L/kg fw	Table 4.12
Aquatic Plant Tissue Concentration	D = A * C	1.58E-02	mg/kg fw	Calculated
Benthic Invertebrate Concentration				
Bioaccumulation Factor - Benthic Invertebrate	E	3.90E+02	L/kg fw	Table 4.12
Benthic Invertebrate Tissue Concentration	F = A * E	6.16E-01	mg/kg fw	Calculated
Mallard Exposure Factors				
Intake Rate, Water	G	6.22E-02	L/d	Table 4.9
Intake Rate, Sediment	H	2.06E-03	kg dw/d	Table 4.9
Intake Rate, Aquatic Plant	I	6.25E-02	kg/d fw	Table 4.9
Intake Rate, Benthic Invertebrate	J	1.88E-01	kg/d fw	Table 4.9
Fraction of Time Spent on Site	K	5.00E-01	unitless	Section 4.2.4.1.2
Body Weight	L	1.08E+00	kg	Table 4.9
Mallard Exposure Dose (toxic)				
Exposure Dose, Water	M = A * G * K / L	4.54E-05	mg/kg d	Calculated
Exposure Dose, Sediment	N = B * H * K / L	2.93E-02	mg/kg d	Calculated
Exposure Dose, Aquatic Plant	O = D * I * K / L	4.56E-04	mg/kg d	Calculated
Exposure Dose, Aquatic Invertebrate	P = F * J * K / L	5.34E-02	mg/kg d	Calculated
Total Exposure Dose	Q = M + N + O + P	8.32E-02	mg/kg d	Calculated
Mallard HQ (toxic)				
Toxicity Reference Value - Birds	R	5.00E+00	mg/kg d	Table 4.43
Hazard Quotient	S = Q / R	1.66E-02	unitless	Calculation

Table E.6: Sample Calculation for Polygon AB Mallard Dose Calculations for Cobalt-60

		Cobalt-60 (Radiological Dose)		
		Value	Unit	Source
Environmental Media Concentrations				
Coot's Pond Water Concentration	A	1.19E-01	Bq/L	Table 4.23
Coot's Pond Sediment Concentration (dry weight)	B	1.21E-01	Bq/kg dw	Table 4.23
Sediment Dry Bulk Density	C	4.00E-01	kg dw/ L	CSA N288.1-14
Mixing Depth	D	5.00E-02	m	Assumption
Coot's Pond Sediment Surface Concentration (dry weight)	$E = B * C * D * 1000 \text{ L/m}^3$	2.42E+00	Bq dw/ m²	Calculated
Coot's Pond Aquatic Plant Concentration (fresh weight)	F	1.00E+00	Bq/kg fw	Table 4.23
Benthic Invertebrate Concentration				
Bioaccumulation Factor - Benthic Invertebrates	G	1.10E+02	L/kg fw	Table 4.11
Benthic Invertebrate Tissue Concentration	$H = A * G$	1.31E+01	Bq/kg fw	Calculated
Mallard Exposure Factors				
Intake Rate, Water	I	6.22E-02	L/d	Table 4.9
Intake Rate, Sediment	J	2.06E-03	kg dw/d	Table 4.9
Intake Rate, Aquatic Plant	K	6.25E-02	kg/d fw	Table 4.9
Intake Rate, Aquatic Invertebrate	L	1.88E-01	kg/d fw	Table 4.9
Fraction of Time Spent on Site	M	5.00E-01	unitless	Section 4.2.4.1.2
Mallard Internal Dose (radiological)				
Ingestion Transfer Factor - Mallard	N	1.54E+00	d/kg fw	Table 4.15
Mallard Tissue Concentration	$O = M*N*(A*I+B*J+F*K+H*L)$	1.95E+00	Bq/kg fw	Calculated
Dose Conversion Factor (Internal)	P	2.38E-04	(μGy/hr)/(Bq/kg fw)	Table 4.18
Internal Dose	$Q = O * P$	4.63E-04	μGy/hr	Calculated
Internal Dose (converted units)	$Q' = Q * 24 \text{ h/d} / 1000 \text{ μGy/mGy}$	1.11E-05	mGy/d	Calculated
Mallard External Dose (radiological)				
Occupancy Factor, Sediment - Mallard	R	0.00E+00	unitless	Table 4.10
Occupancy Factor, Sediment Surface - Mallard	S	5.00E-01	unitless	Table 4.10
Dose Conversion Factor (External, in soil)	T	0.00E+00	(μGy/hr)/(Bq/kg)	-
Dose Conversion Factor (External, on soil)	U	7.50E-06	(μGy/hr)/(Bq/m²)	Table 4.18
External Dose	$V = M * (T * R * E + U * S * E)$	4.54E-06	μGy/hr	Calculated
External Dose (converted units)	$V' = V * 24 \text{ h/d} / 1000 \text{ μGy/mGy}$	1.09E-07	mGy/d	Calculated
Mallard Total Dose (radiological)				
Total Dose	$X = V + Q$	4.67E-04	μGy/hr	Calculated
Total Dose (converted units)	$X' = V' + Q'$	1.12E-05	mGy/d	Calculated

Table E.7: Sample Calculation for Polygon AB White-tailed Deer Dose and Risk Calculations for Chromium (Maximum Concentration)

		Chromium (Toxic Dose)		
		Value	Unit	Source
Environmental Media Concentrations				
Coot's Pond Water Concentration	A	1.58E-03	mg/L	Table 4.23
Polygon AB Soil Concentration (dry weight)	B	2.22E+01	mg/kg dw	Table 4.23
Terrestrial Plant Concentration (dry weight)	C	5.16E-01	mg/kg fw	Table 4.23
Deer Exposure Factors				
Intake Rate, Water	G	6.80E+00	L/d	Table 4.9
Intake Rate, Soil	H	6.55E-02	kg dw/d	Table 4.9
Intake Rate, Terrestrial Plant	I	1.64E+01	kg fw/d	Table 4.9
Fraction of Time Spent on Site	K	1.00E+00	unitless	Section 4.2.4.1.2
Body Weight	L	1.10E+02	kg	Table 4.9
Deer Exposure Dose (toxic)				
Exposure Dose, Water	M = A * G * K / L	9.77E-05	mg/kg d	Calculated
Exposure Dose, Soil	N = B * H * K / L	1.32E-02	mg/kg d	Calculated
Exposure Dose, Terrestrial Plant	O = C * I * K / L	7.68E-02	mg/kg d	Calculated
Total Exposure Dose	Q = M + N + O + P	9.01E-02	mg/kg d	Calculated
Deer HQ (toxic)				
Toxicity Reference Value - Mammals	R	2.74E+03	mg/kg d	Table 4.42
Hazard Quotient	S = Q / R	3.29E-05	unitless	Calculation

Table E.8: Sample Calculation for Polygon AB White-tailed Deer Dose Calculations for Cobalt-60

		Cobalt-60 (Radiological Dose)		
		Value	Unit	Source
Environmental Media Concentrations				
Coot's Pond Water Concentration	A	1.19E-01	Bq/L	Table 4.23
AB Loam Concentration (dry weight)	B	0.00E+00	Bq/kg dw	Table 4.23
AB Terrestrial Vegetation/Grass (dry weight)	C	1.00E+00	Bq/kg fw	Table 4.23
Deer Exposure Factors				
Intake Rate, Water	D	6.80E+00	L/d	Table 4.8
Intake Rate, Soil	E	6.55E-02	kg dw/d	Table 4.8
Intake Rate, Grass (dry weight)	F	3.27E+00	kg dw/d	Table 4.8
Dry/Fresh Weight Ratio	G	2.00E-01	kg(dw)/kg(fw)	CSA N288.1-14
Fraction of Time Spent on Site	H	1.00E+00	unitless	Section 4.2.4.1.2
Deer Internal Dose (radiological)				
Transfer Factor Ingestion - Deer	I	1.54E-03	d/kg fw	Table 4.17
Deer Tissue Concentration	$J = H*(A*D+B*E+C*F/G)$	2.64E-02	Bq/kg fw	Calculated
Dose Conversion Factor (Internal)	K	8.33E-04	(μGy/hr)/(Bq/kg fw)	Table 4.18
Internal Dose	$L = J * K$	2.20E-05	μGy/hr	Calculated
Internal Dose (converted units)	$L' = L * 24 \text{ h/d} / 1000 \text{ μGy/mGy}$	5.27E-07	mGy/d	Calculated
Deer External Dose (radiological)				
Occupancy Factor, Soil - Deer	M	0.00E+00	unitless	Table 4.9
Occupancy Factor, Soil Surface - Deer	N	1.00E+00	unitless	Table 4.9
Dose Conversion Factor (External, in soil)	O	0.00E+00	(μGy/hr)/(Bq/kg)	-
Dose Conversion Factor (External, on soil)	P	4.04E-06	(μGy/hr)/(Bq/m²)	Table 4.18
External Dose	$Q = H * (B * M * O + B * N * P)$	0.00E+00	μGy/hr	Calculated
External Dose (converted units)	$Q' = V * 24 \text{ h/d} / 1000 \text{ μGy/mGy}$	0.00E+00	mGy/d	Calculated
Deer Total Dose (radiological)				
Total Dose	$R = L + Q$	2.20E-05	μGy/hr	Calculated
Total Dose (converted units)	$R' = L' + Q'$	5.27E-07	mGy/d	Calculated