ONTARIO POWER GENERATION

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Acknowledgement

Ontario Power Generation, Nuclear, would like to thank the residents of the local communities in the vicinity of Pickering Nuclear and Darlington Nuclear stations, and throughout the Province of Ontario who have voluntarily participated in our environmental monitoring programs. Their support in allowing OPG to have environmental monitoring stations on their properties and supplying samples of vegetables, fruits, honey, soil, animal feed, milk and water have helped ensure that the annual public dose estimates are realistic.

Revision Summary

Revision Number	Date	Comments
R000	2013-04-16	Initial issue.

Executive Summary

Ontario Power Generation (OPG) conducts Radiological Environmental Monitoring Programs (REMPs) in the vicinity of Darlington Nuclear (DN) and Pickering Nuclear (PN) stations to determine the radiological impact on the public resulting from the operation of these stations. This annual report is a requirement of the station operating licences. It contains the 2012 results of the monitoring programs, which include concentrations of radionuclides in the air, water, milk, soil, sediments, vegetation and fish samples taken in the vicinity of DN and PN, and the associated radiation dose assessments. Samples at provincial-background locations were also taken to determine background radiation levels in areas away from the influence of nuclear stations.

In 2012, OPG operated 10 nuclear reactors that produced 49.0 terawatt hours (TWh) of electricity. The production performance of DN and PN stations was 91.8% and 76.1% of their rated capacity, respectively. Station emissions remained at a very small fraction of their licensed Derived Release Limits.

A total of 1,994 laboratory analyses were performed on a variety of environmental media. The availabilities of samples analyzed for the dose calculation were above the minimum annual performance requirements. Several changes to the sampling program were implemented in 2012 for program optimization and as part of implementation of the Canadian Standards Association (CSA) N288.4-10 “Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills”. As part of the mitigation measures for the PN thermal impact to round whitefish reproduction, sampling of Lake Ontario whitefish was discontinued in 2012 [R-39] to reduce unnecessary mortality of this species. This course of action was accepted by the Canadian Nuclear Safety Commission (CNSC).

IMPACT 5.4.0 software, which is consistent with the method of dose calculation described in the CSA N288.1-08 standard [R-11], was used for the dose calculation.

The 2012 radiation dose assessments for DN and PN demonstrate that the critical group doses resulting from the operation of the OPG Nuclear Generating Stations continue to be a very small fraction of both the annual legal limit of 1,000 microsieverts (µSv) and the estimated annual average background radiation dose around DN and PN of 1,400 µSv [R-19, R-20]. The official public doses for the DN and PN sites are summarized in Table 1 below:

Table 1: OPG Public Dose Estimates – 2012

Facility	Critical Group (Receptor)	Effective Dose (*µ*Sv)	Percentage of Legal Limit (%)	Percentage of Background Radiation around DN and PN (%)
Darlington Nuclear	Dairy Farm (1-year old infant)	0.6	0.1	< 0.1
Pickering Nuclear	Urban Resident (Adult)	1.1	0.1	0.1

OPG is in the process of implementing Environmental Monitoring Programs (EMPs) in accordance with CSA N288.4-10. The EMP scope will encompass environmental monitoring of nuclear substances and hazardous substances to demonstrate protection of both the public and the environment. The present REMP scope is limited to environmental monitoring of nuclear substances to demonstrate protection of the public. This 2012 report will be the last REMP report. Going forward, an annual EMP report will be produced entitled “Results of Environmental Monitoring Programs”.

1.0 INTRODUCTION

Ontario Power Generation (OPG) owns and operates the Pickering Nuclear (PN) and Darlington Nuclear (DN) Generating Stations. To ensure nuclear activities at these stations are conducted in a manner that minimizes any adverse impact on the public and the natural environment, OPG has established an Environmental Management Program that is consistent with the Canadian Nuclear Safety Commission (CNSC) standard S-296. Additionally, this program is registered to the International Organization for Standardization (ISO) 14001 Environmental Management Systems standard.

As part of the implementation of this program, each station has a Radiological Environmental Monitoring Program (REMP), which monitors radiation in the environment surrounding the station to assess any radiological impact to the public. Samples are also collected from locations considered to be outside the influence of the PN and DN station operations to allow a baseline comparison with background values, and to allow determination of net values for dose calculations.

This annual REMP report is prepared and submitted to the CNSC in accordance with the operating licences issued to PN and DN. This report is also made available to the public.

The radiological emissions and environmental data collected for each site during the January 1st to December 31st 2012 period, their interpretations, and the estimates of radiation doses to the public resulting from the operation of PN and DN stations are provided in this report.

The radiological emissions and environmental data are summarized in Sections 3.3 and 5.0, respectively. The assessment of the doses to the public is provided in Section 7.0.

2.0 PROGRAM OBJECTIVES AND MODIFICATIONS IN 2012

2.1 REMP Objectives

The OPG REMPs are designed to satisfy the following primary objectives:

(a) To assess the radiological impact on human health and safety resulting from operation of OPG nuclear facilities.

(b) To demonstrate compliance with radiation dose limits through annual public dose estimations based on environmental data measured in the public domain.

(c) To demonstrate, independent of effluent monitoring, that nuclear site emissions of radioactive materials are properly controlled.

(d) To provide data for evaluation of assumptions and transport models used to calculate station Derived Release Limits (DRLs) and public doses.

(e) To provide data required to support operations or to plan for future stages of the facility lifecycle.

2.2 Program Modifications in 2012

For continual improvement of the REMPs and implementation of the Canadian Standards Association (CSA) N288.4-10, "Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills", a number of changes were made to the programs in the areas of sample types, sample locations, and sampling frequencies. These changes are discussed in detail in Section 4.0

3.0 OVERVIEW OF PICKERING AND DARLINGTON NUCLEAR STATIONS

3.1 Site Description

DN and PN Generating Stations have a combined generating capacity of about 6,600 megawatts (MW). A brief description of the two stations is as follows:

Darlington Nuclear

The DN Generating Station is an OPG CANDU (CANadian Deuterium Uranium) nuclear generating station. It is a four-unit station with a total output of 3,500 MW and is located on the shores of Lake Ontario in the Municipality of Clarington in Durham Region. It provides about 20% of Ontario's electricity needs, enough to serve a city of two million people.

DN also has the Tritium Removal Facility (TRF), where tritium is extracted from tritiated heavy water, and the Darlington Waste Management Facility for used fuel dry storage.

The immediate area around the Darlington station is mostly rural and farm lands with some industrial/commercial areas. The urban residential locations of Oshawa, Bowmanville and West/East Beach are more than 3 km from the site.

Based on the results of site-specific surveys, the residents around DN are grouped into nine categories which best represent their locations and/or lifestyle characteristics. The nine categories are: urban residents in Oshawa and in the community of Courtice, Bowmanville urban residents, West/East Beach urban residents, farmers, dairy farmers, rural residents, industrial/commercial workers, sport fishers, and campers.

Pickering Nuclear

The PN site is located on the shores of Lake Ontario, in the city of Pickering. The site contains the PN Generating Stations and the Pickering Waste Management Facility (PWMF), which consists of the Used Fuel Dry Storage Facility and the Re-Tube Components Storage Area.

PN has six operating CANDU reactors. This station has a total output of 3,100 MW, enough to serve a city of one and a half million people. PN Units 2 and 3 are in safe shutdown state.

Unlike DN, the area around PN is mainly urban residential and industrial/commercial. The closest farm lands are more than 6 km from the station.

Based on the results of site-specific surveys, the residents around PN are grouped into six categories: occupants of a correctional institute, urban residents, farmers, dairy farmers, industrial/commercial workers, and sport fishers.

3.2 Nuclear Generation Capacity

In 2012, OPG operated ten nuclear reactors that produced 49.0 terawatt hours (TWh) of electricity. This production is broken down as follows:

Darlington Nuclear: Net electrical output in 2012 was 28.3 TWh.

Pickering Nuclear: Net electrical output in 2012 was 20.7 TWh.

3.3 Radioactive Emissions Data

The radioactive emissions from DN and PN in 2012 remain at a very small fraction of the station DRLs. These licensing limits represent radionuclide release rates that correspond to an exposure at the legal public dose limit of 1,000 microsieverts per year (μSv/a) by the most affected critical group. See Section 4.1 for the description of a critical group.

Table 3-1 shows the 2012 total airborne and waterborne emissions for radionuclides measured at the DN and PN sites as the annual activity released and as a percentage of the respective DRLs.

Table 3-1: OPG Annual Nuclear Site Emissions – 2012

Site Emissions	DN		PN	
	Bq	% DRL	Bq	% DRL
AIR				
Tritium Oxide	1.3E+14	0.22	5.3E+14	0.97
Elemental Tritium (a)	2.6E+13	<0.01	NA	NA
Noble Gas (b)	1.9E+13	0.04	1.2E+14	0.43
I131	1.4E+08	<0.01	1.7E+07	<0.01
Particulate	3.4E+07	<0.01	8.1E+06	<0.01
C14	1.0E+12	0.29	1.8E+12	0.03
WATER				
Tritium Oxide	1.3E+14	<0.01	2.9E+14	0.06
Gross Beta/Gamma	3.0E+10	0.04	3.0E+10	0.64
C14	6.3E+08	<0.01	1.1E+10	0.02

NOTES: NA = Not Applicable, Bq = Bequerels

(a) Emissions from Darlington Tritium Removal Facility

(b) Units for noble gas emissions are γBq-MeV

3.3.1 Emissions Trends

The 10-year trends of tritium and C-14 emissions to air and tritium emissions to water from DN and PN are provided in Figures 3-1 to 3-7. Given that the reported noble gas stack emissions are at times below the instrument detection limits, the results of environmental noble gas monitors are used to trend the station noble gas emissions, as described in Section 5.1.2. Similarly, iodine and particulate in airborne emissions are typically low and are at times below instrument detection limits. Therefore, they are not trended. Carbon-14 (C-14) waterborne emissions are not trended because their contribution to the overall public dose is very small (<0.01%).

Elemental Tritium Airborne Emissions

DN – Figure 3-1

As indicated in Figure 3-1, the elemental tritium (HT) emissions at DN have remained at low levels. In 2012, the HT emissions at DN were 2.6 x 10^{13} becquerels (Bq). The elevated HT emissions in 2004 and 2005 had minimal impact on public dose and were the result of a rupture disk failure at the TRF, which has since been corrected.

PN

PN has no HT emissions as it does not have a TRF which is a producer of HT.

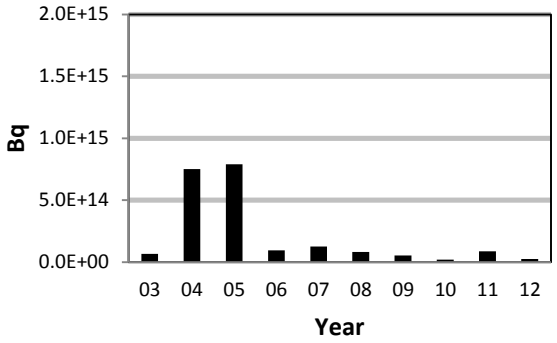

Figure 3-1: Darlington Nuclear Airborne Elemental Tritium Air Emissions

Tritium Oxide Airborne Emissions

DN – Figure 3-2

DN tritium oxide (HTO) airborne emissions have remained stable over the last five years. The 2012 HTO airborne emission was 1.3 x 10^{14} Bq.

PN – Figure 3-3

PN HTO airborne emissions trended downwards from 2008 to 2010 and have remained relatively stable since then as a result of improvements in leak management, reliability and operation of vapour recovery dryers, and reduction of HTO source terms. The increase observed in 2008 and 2009 was primarily due to dryer performance. Airborne HTO emissions in 2012 were 5.3 x 10^{14} Bq.

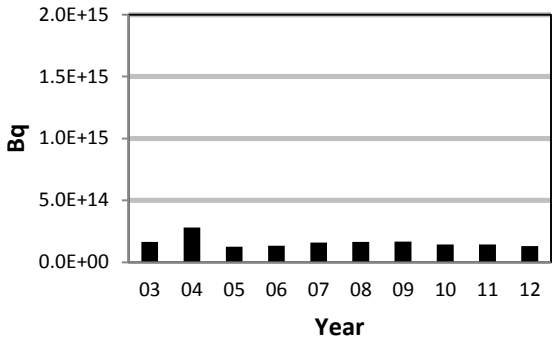

Figure 3-2: Darlington Nuclear Tritium Oxide Air Emissions

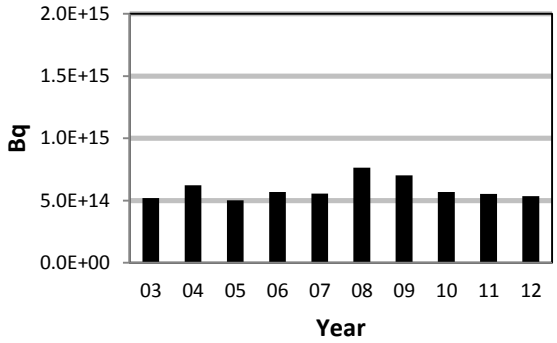

Figure 3-3: Pickering Nuclear Tritium Oxide Air Emissions

Carbon-14 Airborne Emissions

DN – Figure 3-4

DN C-14 airborne emissions have remained stable since 2004. The 2012 C-14 airborne emissions were 1.0 x 10^{12} Bq.

PN – Figure 3-5

PN C-14 airborne emissions have been trending down since 2007. The prior upward trend was due to a failed calandria tube at Unit 7, which leaked carbon dioxide (CO_2) from the annulus gas into the moderator system. The emission level returned to pre-2005 levels following the April 2008 replacement of the failed calandria tube. The 2012 C-14 airborne emissions were 1.8 x 10^{12} Bq.

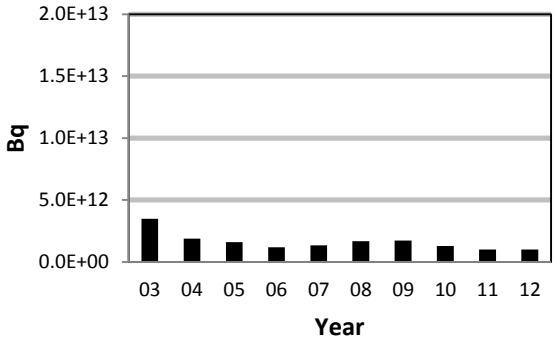

Figure 3-4: Darlington Nuclear C-14 Air Emissions

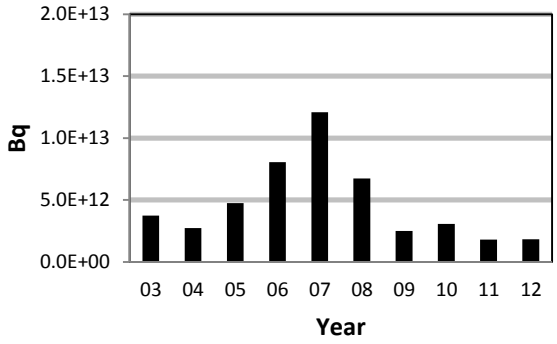

Figure 3-5: Pickering Nuclear C-14 Air Emissions

Tritium Oxide Waterborne Emissions

DN – Figure 3-6

DN HTO to water emissions trended down from 2008 to 2010 and have remained relatively stable since then. The upward trend from 2004 to 2008 was due to, a) apparent contamination from ambient air to the water samples in the auto-sampler,

which is not reflective of a true increase in emissions, and b) the drainage of the Emergency Coolant Injection (ECI) system and discharges of Vacuum Building Dousing Water in 2007 and 2008 to prepare for the 2009 Vacuum Building Outage (VBO). The 2012 DN tritium to water emission was 1.3 x 10^{14} Bq, which is similar to emissions observed over the last two years.

PN – Figure 3-7

The PN waterborne HTO emissions trended down from 2008 to 2010 and have remained relatively stable since then. The increases in 2008 and 2009 were due to a minor heavy water leak from a Unit 1 shutdown cooling heat exchanger and a small Unit 1 boiler tube leak, respectively. Repairs to the above mentioned leaks were completed during the 2010 VBO and HTO emissions have since decreased to the levels seen prior to 2008. The PN tritium to water emissions in 2012 were 2.9 x 10^{14} Bq.

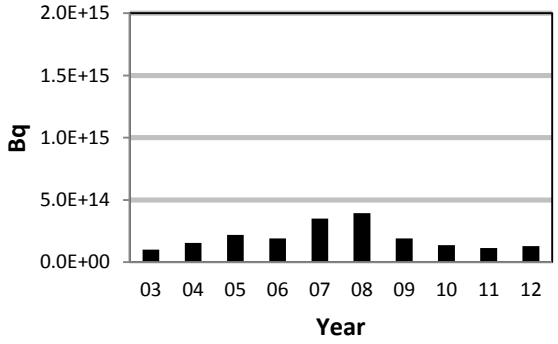

Figure 3-6: Darlington Nuclear Tritium Oxide Water Emissions

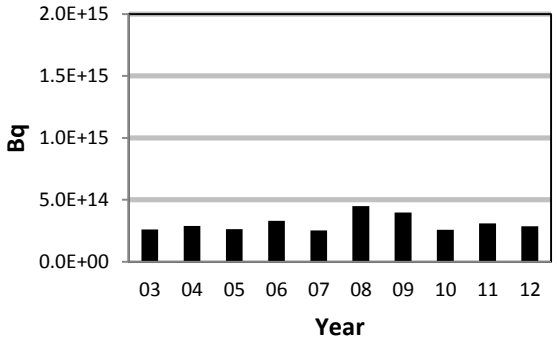

Figure 3-7: Pickering Nuclear Tritium Oxide Water Emissions

Gross Beta-Gamma Waterborne Emissions

DN

Gross beta-gamma waterborne emissions for DN were not trended because its emission levels and contribution to public dose were not significant over past years, and remain so.

PN – Figure 3-8

The 2012 PN gross beta-gamma emissions to water remain low and are consistent with performance observed prior to 2009. The increase in 2009 and 2010 was due to several samples that had anomalously high activity. OPG conducted an investigation on this matter, and a third-party review was performed. The review found no apparent cause of the high beta-gamma activities. Despite this, OPG has implemented several steps for prevention and contingency to ensure that samples and analyses are sufficiently robust and reliable. Examples include, a) obtaining daily samples to be analysed in the event of a high emission result from the routine weekly samples, and b) review of the air flow path to the analytical laboratory, as well as laboratory

contamination survey data, to ensure the integrity of samples. Since 2011, the emissions have returned to the pre-2009 levels, as shown in Figure 3-8.

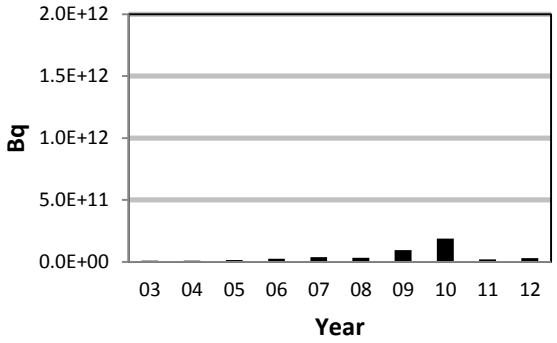

Figure 3-8: Pickering Nuclear Gross Beta-Gamma Water Emissions

3.4 OPG Nuclear Carbon-14 Inventory Data

The C-14 inventories within the PN and DN stations are included in this report to fulfill a regulatory commitment to the CNSC. The 2012 estimates of C-14 inventory within the PN and DN stations are 8.2 $x10^{14}$ Bq and 6.0 $x10^{14}$ Bq, respectively [R-2].

4.0 SAMPLING AND ANALYSIS PLAN

To ensure that the public dose estimation is as realistic as possible, various exposure pathways, such as food ingestion, inhalation, and water ingestion (as shown in Figure 4-1, Model of Exposure Pathways from Station Emissions) were evaluated and assessed in the design of the OPG REMPs.

The significant human exposure pathways and radionuclides for the most affected receptors are routinely monitored so that the best estimate of site public dose can be performed. To achieve this, a site-specific survey is conducted in the areas within approximately a 10 km radius from DN and PN sites. Data from the site-specific surveys are used to establish the lifestyle characteristics (e.g., drinking water sources, consumption of local products, etc.) of the population around the sites and to identify the various potential critical groups for each site as defined in Section 4.1. Also, a site-specific pathway analysis is performed to identify the important radionuclides and human exposure pathways. The results of these two studies, along with the REMP governing documents and individual site programs, form a basis for establishing the annual sampling plan for the site REMPs.

Every five years, the site-specific survey and pathway analysis are reviewed and the sampling plans are updated based on the results. The most recent site-specific survey reviews were conducted during the summer of 2012. However, since the annual sampling plan for 2012 was established seven months prior to the start of the 2012 site specific survey reviews, it was based on the results of the previous site specific survey reviews.

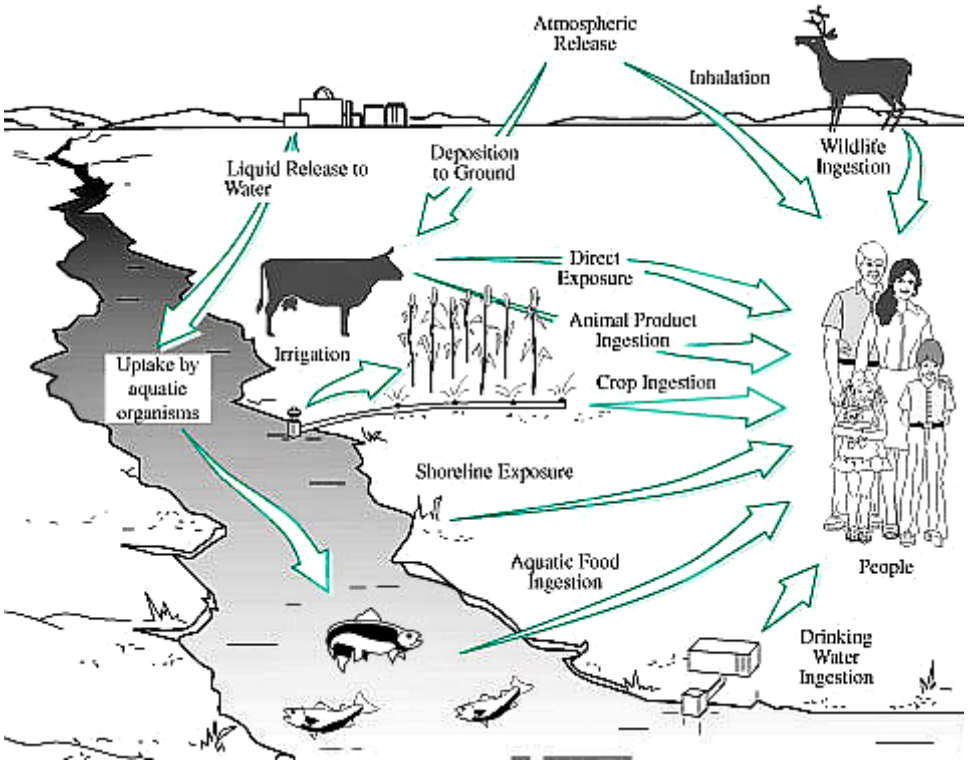

Figure 4-1: Model of Exposure Pathways from Station Emissions

Source: Based on United States Department of Energy/Hanford Site

4.1 Critical Groups and Representative Person

Members of the public living near the nuclear generating stations are represented using the “Critical Group” concept. Doses received by individual members of the public, as a result of station operations, vary depending on factors such as proximity to the station, diet, behavioural habits, age, and variations in environment. Individuals who form a homogeneous group with respect to these exposure factors can be grouped together into “potential critical groups”. An individual with the average characteristics of the group is known as the “Representative Person” as described in CSA N288.1-08 [R-11].

The site-specific surveys identified six potential critical groups at the PN site and nine potential critical groups at the DN site. The critical group, and corresponding Representative Person, who receives the highest annual dose may vary slightly from year to year; therefore doses are calculated for all potential critical groups. The highest estimated potential critical group dose for each site establishes the official public dose for that site.

4.2 REMP Sampling Plan

The REMP sampling plan outlines the radionuclides monitored, the locations, sample types and frequency of collection. Table 4-1 summarizes some of this information.

Samples are collected at station boundary locations as well as at critical group locations. Boundary locations are generally located close to the station perimeter. In Appendix D tables, the following represent boundary locations: D1, D2, D3, D4, D5, D6, P2, P3, P4, P6, P7, P8, P9, P10, and P11. Critical group sample locations are at the location of critical group members. For sample types that are not available at critical group locations, radionuclide concentrations at the critical group are estimated from concentrations measured at the boundary locations using ratios of modeled atmospheric dispersion factors.

The required sample media and locations are reviewed every five years after the site-specific survey reviews are conducted. In the most recent program reviews [R-27] [R-28], the existing REMP sampling programs were found to fulfill the sampling requirements for dose assessment purposes.

Starting in Q3 2012, some of the historically performed analyses, which are not used for the annual public dose calculation, and are not necessary components of the REMPs, were discontinued. Refer to the footnotes of Table 4-1. Past analytical data for these samples will be maintained in OPG's REMP database and referred to as required for trending purposes.

4.2.1 Radionuclides Monitored

Radionuclides that are emitted from PN and DN station operations are monitored in the REMPs and are listed below. The specific sample analyses used in the public dose calculation are indicated in Table 4-1.

C-14 – is produced from the operation of nuclear stations. It is also a naturally occurring radionuclide and a by-product of past nuclear weapons testing with average background concentrations between 220 becquerels per kilogram carbon (Bq/kg-C) to 250 Bq/kg-C. C-14 values detected above background are included in the dose calculation.

HTO – is a tritiated water molecule. T is used to represent a tritium atom. HTO is a normal station emission of CANDU plants. Concentrations measured in plants and animals refer to the HTO concentration in the free water portion of the sample.

HT – is a tritiated hydrogen gas molecule. HT is present in the atmosphere as a result of the emissions from the TRF at DN. Pickering does not have HT emissions. HT concentration in air is modeled from emissions and not monitored in the environment. However, some HT is converted to HTO in the environment, and this HTO is monitored.

Organically Bound Tritium (OBT) – is tritium that is bound to the organic molecules in organisms and is not readily exchanged with other hydrogen atoms. OBT is incorporated during the formation of plant and animal products where HTO is present. OBT is monitored by OPG but sample results are not used in dose calculations, as a standard method for the measurement of OBT in environmental samples is still in the process of being established. OBT concentrations are currently modeled from HTO concentrations measured in sample media at each critical group location and in fish. OPG dose calculations incorporate dose from OBT via intake of terrestrial plants and animal products, and from fish.

Noble Gases – Radioactive noble gases released from the DN and PN plants are mostly Argon-41 (Ar-41), Xenon-133 (Xe-133) and Xenon-135 (Xe-135). The environmental detectors that measure noble gas doses may also detect Iridium-192 (Ir-192) skyshine from industrial radiography carried out in the stations. They also detect the external gamma dose from Iodine-131 (I-131) in air.

Iodine-131 – The dose from radioiodine emissions is calculated from I-131 emissions, with the assumption that I-131 emissions are accompanied by an equilibrium mixture of other short lived iodine fission products (i.e., I-132, I-133, I-134 and I-135) or mixed fission products [I(mfp)]. I-131 is monitored in milk, but is not normally detected; therefore concentrations modeled from emissions are used for dose calculations.

Particulates and gross beta-gamma – Atmospheric particulate emissions are represented by Cobalt-60 (Co-60) and liquid effluent beta-gamma emissions are represented by Cesium-137 (Cs-137) as this provides the most conservative assignment of dose. Cs-137 is also present in the environment as a result of historic weapons testing. Co-60 and Cesium-134 (Cs-134) are representative of station emissions and are analyzed together with Cs-137, which helps distinguish between the Cs-137 resulting from station operations and that from weapons testing.

Table 4-1: Environmental Samples Used for the Darlington and Pickering REMPs

Environmental Medium of Interest	Monitored For	Sampling Frequency	Analyses Frequency
SAMPLES USED FOR PUBLIC DOSE CALCULATIONS			
Atmospheric Sampling			
Air	HTO (active monitor)	Continuously	Monthly
Air	C-14 (passive monitor)	Continuously	Quarterly
Air	Noble gases (Ar-41, Xe-133, Xe-135), Ir-192[(a)]	Continuously	Reported monthly
Terrestrial Sampling			
Fruits, Vegetables, Animal Feed	HTO and C-14	Annual (harvest)	Annual
Milk	HTO and C-14	Weekly[(b)]	Monthly composite
Aquatic Sampling			
Municipal Drinking Water[(c)]	HTO	2-3 times/day	Weekly composite
Well Water	HTO	Monthly	Monthly
Lake Water	HTO	Monthly	Monthly
Fish	HTO, C-14, Cs-137, Cs-134, Co-60	Annual	Annual
Beach Sand	Cs-137, Cs-134, Co-60	Annual	Annual
SAMPLES FOR OTHER REMP OBJECTIVES			
Air	Gamma (Thermoluminescent dosimeter)[(d)]	Continuously	Quarterly
Air	I-131 gamma dose	Continuously	Reported Monthly
Precipitation	HTO[(d)]	Monthly	Monthly
Dry/Wet Fallout	Gross beta[(d)]	Monthly	Monthly
Fruits, Vegetables, Animal Feed	OBT	Annual (harvest)	Annual
Garden and Inland Soils	Cs-137, Cs-134, Co-60	Annual (harvest)	Annual
Milk	I-131[(d)]	Weekly	Weekly composite of locations
Milk	OBT	Weekly[(b)]	Monthly
Municipal Drinking Water[(c)]	Gross beta	2-3 times/day	Monthly composite
Well Water, Lake Water	Gross beta	Monthly	Quarterly composite
Fish	OBT	Bi-annual (June and November)	Annual
Sediment	C-14, Cs-137, Cs-134, Co-60	Every five years	Every five years
Lake water	Potassium	Every three years	Every three years
Honey	HTO, C-14, Cs-137, Cs-134, Co-60	Annual	Annual

(a) Air kerma is measured and converted to external air immersion dose.
(b) Sampling frequency reduced to monthly starting in Q3 2012
(c) Sampling frequency is quarterly for provincial-background locations.
(d) Discontinued starting in Q3 2012

4.2.2 Atmospheric Sampling

Samples of air, precipitation, and fallout are collected to monitor the environment around the DN and PN sites. Background samples are also collected to provide a comparison benchmark and to allow determination of net values for dose calculations. The radionuclide analyses performed and the sample collection frequency are detailed in Table 4-1 and discussed below.

The results of atmospheric sampling are summarized in Section 5.1 and detailed data is given in Appendix D, Environmental Monitoring Data, Tables D1 to D5.

4.2.2.1 Air

Tritium Oxide

The active sampler collects water vapour by passing air continuously at a steady rate through two molecular sieve canisters in series. The active samplers are located at six site boundary REMP monitoring locations around DN and nine around PN, as identified in Figures C1 and C2 in Appendix C. These samples are collected and analyzed monthly.

The background concentration of HTO in air is measured at the Nanticoke location which is considered to be far from the influence of OPG nuclear stations.

Carbon-14

C-14 in air is sampled using passive sampling technology. The passive C-14 sampler works by absorption of CO_2 in air into soda lime pellets exposed for a period of an annual quarter. Samples are analyzed after each quarter.

C-14 in air concentrations have historically been measured at ten critical group locations around DN and three site boundary locations. In 2012, the C-14 monitor used to represent DN's Farm critical group, F1, was removed from the field at the participant's request. A replacement C-14 monitor was installed at nearby boundary location D5 to represent the Farm critical group. Therefore, for 2012, C-14 in air concentrations were measured at nine critical group locations around Darlington and four site boundary locations. For Pickering, eight critical group locations are monitored for C-14, three of which are also site boundary locations. Since C-14 in air is not a significant dose pathway via inhalation, only the high wind frequency sectors were chosen as site boundary monitoring locations for PN and DN.

Background concentrations of C-14 in air were measured at six locations considered to be far from the influence of OPG nuclear stations.

Noble Gas Detectors

External gamma radiation doses from noble gases, Ir-192, and I-131 are measured using sodium iodide (NaI) spectrometers set up around the DN and PN sites. There are a total of seven detectors around the DN site and nine detectors around the PN site. These detectors continuously monitor doses and an annual total is used in the dose calculation, with the exception of dose from I-131, which is modeled from emissions as per Section 4.2.1. Natural background dose has been subtracted from noble gas detector results.

Thermoluminescent Dosimeters

Thermoluminescent Dosimeters (TLDs) measure total gamma dose from background, as well as any gamma emitting radionuclides in the air or radiography skyshine.

Six REMP TLDs are located around the DN site boundary and four TLDs are located at critical group locations. PN has a total of nine REMP TLDs around the site boundary and one TLD at a nearby critical group location. REMP TLDs are collected and analyzed every quarter.

REMP TLDs were discontinued in the third quarter of 2012, as external gamma doses are determined from the noble gas detector results. The 2012 TLD analytical results reported for PN and DN in Table D-4 are based on data from the first two quarters of the year extrapolated over the full year.

4.2.2.2 Precipitation and Wet/Dry Fallout

Precipitation and wet/dry fallout samples are collected monthly and analyzed for HTO and gross beta activity. Precipitation and wet/dry fallout data are not used in the calculation of public dose. They are used to assess impacts of HTO in biota and in groundwater. Sufficient years of data have been collected to satisfy the above purpose, and as such, sampling of precipitation and wet/dry fallout was discontinued in Q3 of 2012.

Five locations around DN (location F1 removed at request of participant) and six locations around PN were measured in Q1 and Q2 of 2012 and the corresponding results are reported in Table D-5.

Precipitation and wet/dry fallout samples are not obtained from background locations.

4.2.3 Terrestrial Sampling

Terrestrial biota receives exposure from both airborne and waterborne emissions, as indicated in Figure 4-1. Cow's milk, for example, is affected by the air, plants, and various water sources that the cow consumes. It is therefore important to consider the combined effect of all these pathways when assessing the station impact on terrestrial samples.

Samples of soil, fruits, vegetables, animal feed, milk and honey are collected to monitor the environment around the DN and PN sites. Background samples are also collected to provide a comparison benchmark and to allow determination of net values for dose calculations. The radionuclides monitored and the sample collection frequency are summarized in Table 4-1 and discussed below.

The results of terrestrial sampling are summarized in Section 5.2 and detailed data are given in Appendix D, Tables D6 to D9.

4.2.3.1 Garden and Inland Soils

As part of the operation of OPG nuclear stations, very small amounts of Cs-134, Cs-137, and Co-60 are released to the environment. These radionuclides can deposit on surrounding soil from the atmosphere and through irrigation. Soil samples around DN, PN, and background locations are collected and analyzed for gamma emitters to determine if OPG operations are having an effect on the surrounding soils, particularly if there is any accumulation over time. Soil data are not used in the calculation of public dose but the long-term trend assists in understanding and verifying transfer model calculations.

Three samples of garden soils and one open field (undisturbed soil) sample were obtained at local farms and residences close to the DN site. Another open field sample that was previously collected from location F1 was removed from the program at the request of the participant.

One garden soil and one open field sample were obtained from location P11 located NW of the PN site.

Replicate soil samples were collected from two background locations (Cobourg and Lakefield).

4.2.3.2 Fruits, Vegetables, Animal Feed, and Honey

Samples of fruits, vegetables and animal feed representative of the growing season were taken from the vicinity of the DN and PN sites. Analyses were carried out for C-14 and HTO.

Sample locations from which fruit, vegetable and animal feed samples were taken at background locations and the areas surrounding DN and PN, are shown in Appendix C, Maps of Environmental Monitoring and Critical Group Locations, Figures C1 to C3. Where multiple sample types were available (e.g., carrot and corn at a given location) the samples were combined into composites for analysis.

A total of 26 fruit and vegetable samples were obtained from various critical group locations around DN along with five animal feed samples. The population around PN is much more urban and, as a result, fewer residents in the surrounding areas grow their own fruits and vegetables. A total of 20 samples were collected from critical group locations around PN including one locally grown animal feed sample. Vegetables were sampled from five background locations.

Honey samples from commercial apiaries in the DN and PN area were obtained and analyzed for HTO, C-14, and gamma emitters. Honey sample results are used to assess the air dispersion model. Dose from honey is modeled from air emissions. Analytical data from 2003 to 2012 shows that C-14 and gamma emitters in honey have been historically consistent. HTO in honey follows similar trends to those observed for boundary HTO in air and HTO in vegetation.

In 2012, honey from PN location R154 was not available. However, results of HTO in air and vegetation at locations within the same wind sector as R154, and closer to PN, remained low and within the normal range. It is therefore expected that HTO in honey at R154 remained within its normal range of 40 Bq/L to 70 Bq/L.

As sufficient historical data on honey produced in the areas surrounding DN and PN has been collected to verify the air dispersion model, the honey sampling program was discontinued at the beginning of 2013.

4.2.3.3 Milk

Milk sampling is used to estimate the portion of dose received from milk ingestion for the Dairy Farm critical group. Milk consumed by other members of the public comes from a commercial dairy whose product consists of a composite from many dairy farms across Ontario. Values in this report are only applicable to residents of the surrounding dairy farms consuming raw milk and are not representative of milk that is sold at a grocery store.

Milk samples are collected on a weekly basis from dairy farms around DN and PN. For each of the site programs (DN and PN), a portion of the weekly samples from all dairy farms is combined to form a weekly composite sample and analyzed for I-131 to minimize losses by decay. At the end of the month, a portion of the weekly samples from each farm is combined to form a monthly composite for each farm and analyzed for HTO and C-14. Milk samples are collected from the five dairy farms around DN and two dairy farms around PN. Quarterly milk samples are collected from two dairy farms in background locations.

For the past ten years, I-131 in milk has not been detected and concentrations have been modelled from emissions for the public dose calculations. As such, weekly milk samples are no longer required. In Q3 2012, the frequency of milk sampling was changed from weekly to monthly for PN and DN dairy farm locations. Additionally, since concentrations of HTO and C-14 in milk samples from DN locations DF7 and DF9 have historically been lower than the other three dairy farm locations, milk sampling at DF7 and DF9 was discontinued in Q3 2012.

4.2.4 Aquatic Sampling

Samples of drinking water sources (municipal and well water), lake water, lake sediment, beach sand and fish are collected to monitor the aquatic environment around the DN and PN sites. Background samples are also collected to provide a comparison benchmark and to allow determination of net values for dose calculations. The radionuclides monitored and the sample collection frequency are detailed in Table 4-1 and discussed below.

The results of aquatic sampling are summarized in Section 5.3 and detailed data is given in Appendix D, Tables D10 to D13.

4.2.4.1 Lake Water and Water Supply Plants

Samples of drinking water are taken during each 8-12 hour shift at water supply plants (WSPs) that supply water to Durham Region and the City of Toronto. Weekly composites of these samples are analyzed for HTO, and monthly composites are analyzed for gross beta activity.

The locations of the WSPs sampled relative to the nearest nuclear station discharge are indicated in Table 4-2.

Table 4-2: Water Supply Plants Monitored and Distance from Stations

	Distance from Site
DN AREA WSPs	
Bowmanville WSP	7 km ENE of DN
Newcastle WSP	13 km E of DN
Oshawa WSP	8 km W of DN
PN AREA WSPs	
R.C. Harris WSP	22 km WSW of PN
Horgan WSP	11 km SW of PN
Ajax WSP	7 km ENE of PN
Whitby WSP	12 km ENE of PN

Lake water samples (non-drinking water) from three beach area locations around PN and three beach area locations around DN are collected and analyzed monthly for HTO and quarterly for gross beta activity.

Background grab samples are taken quarterly from drinking water supplies throughout the province and analyzed for HTO and gross beta activity.

4.2.4.2 Well Water

Monthly well water samples are collected from 14 wells around the DN area (six farms/dairy farms and eight residential locations). Note that sampling at DN location F1 was discontinued at the request of the participant.

Monthly well water samples are collected from five wells around the PN area.

Samples are analyzed monthly for HTO at PN and DN locations and quarterly for gross beta activity at DN locations. Gross beta activity in well water is not monitored at PN locations as the wells selected for PN gross beta analysis are no longer in use and were removed from the REMP in 2011.

Historical data indicates that gross beta in well water results are normally below OPG's internal screening level of 1 Bq/L. Any exceedances of the internal screening level were due to the presence of naturally occurring K-40. As such, gross beta in well water will not be monitored as part of the EMP starting in 2013.

4.2.4.3 Fish

At the DN site, fish sampling takes place over the cooling water discharge diffuser. At the PN site, the sampling location is in the PN outfall. Background samples were previously taken from the New York side of Lake Ontario. However, due to an unreliable fish supply, the background location was changed in 2011 to the Bay of Quinte area of Lake Ontario, which is a sufficient distance away from the influence of the stations.

- Target fish species to be collected at DN, PN, and at background locations is White Sucker, with Brown Bullhead as the backup species. Whitefish is no longer a target species for REMP. To mitigate the PN thermal impact to round whitefish reproduction, sampling of Lake Ontario whitefish was discontinued in 2012 [R-39] to reduce unnecessary mortality of this species.

- Eight replicate fish samples are collected and analyzed at each location.

- Four replicate samples of pan fish (i.e., crappie, sunfish, etc.) are obtained from McLaughlin Bay in Darlington Provincial Park, as campers are known to fish in this area.

- HTO, C-14, Co-60, Cs-134, Cs-137, and Potassium-40 (K-40) measurements are performed on each fish sample.

4.2.4.4 Sediment

Sediment is sampled every five years. The last sampling took place in 2009. Therefore, no sampling of sediment was conducted in 2012.

4.2.4.5 Beach Sand/Silt Samples

Sand/silt from beaches around DN and PN sites is collected annually as it represents a potential pathway for external dose. Gamma spectrometry is performed on these samples.

Beach sand samples were collected at Cobourg to determine the Cs-137 concentration in Lake Ontario background sand due to atmospheric weapons test fallout. Wave action continuously moves the beach sand around disturbing the original deposition patterns of cesium and, as a result, it is not possible to determine evidence of accumulation unless the concentrations of Cs-137 are significantly higher than background.

5.0 RESULTS OF ENVIRONMENTAL MONITORING DATA

This section contains the results of the environmental monitoring programs for the DN and PN sites, and those of the provincial-background locations. All sampling locations are shown in Appendix C, Figures C1 to C3.

Radionuclide concentrations in the environment are low and at times below levels which can be detected by routine analytical techniques. In these situations the analytical result is reported as being below the detection limit (Ld) or critical level (Lc).

Lc: The critical level is the level (relative to background) below which a quantity cannot reliably be measured. More specifically, the critical level is the largest value of the quantity for which the probability of a wrong conclusion that a quantity is present exceeds a specified probability [R-15]. The REMP uses a probability of 5%.

Ld: The detection limit is the level (relative to background) above which a quantity can confidently be measured. More specifically, the detection limit is the smallest value of the quantity for which the probability of a wrong conclusion that the quantity is not present does not exceed a specified probability [R-15]. The REMP uses a probability of 5%.

When reporting the analytical data in Appendix D tables, the following protocols were used:

- If the measured value is lower than the Ld of the analytical method but higher than the Lc, the measured value is reported and is in bold type.
- If the measured value is less than the Lc, then "< Lc" is reported (for Appendix D Table D3, it is reported as Lc in italics).
- When averages or other calculations are performed, they are calculated using the measured values even if they are below the Lc.
- Gamma spectrometer results are reported as "< Ld" when their measured values are below the Ld.

5.1 Atmospheric Sampling

5.1.1 Air

Tritium Oxide

The 2012 annual average results of airborne HTO measured by molecular sieve monitors at the DN, PN, and background sites are summarized in Appendix D, Table D1.

The annual average HTO in air measured at the background location was consistently below the active sampler detection limit of 0.2 Bq/m^3.

The boundary average values provide a valid year-to-year comparison of the HTO in air concentration around the sites. The levels of HTO observed in the environment depend on station emissions, wind direction, wind speed, ambient humidity, and seasonal variations. As such, fluctuations from year to year are expected even if station HTO emissions remain constant.

The annual boundary average of HTO in air has decreased since 2010 due to the replacement of passive samplers with active tritium in air samplers. The passive samplers were discontinued following two years of field testing which demonstrated that the tritium results from the passive samplers were inaccurate and overestimated [R-5] [R-30]. The reduction is more apparent at PN than at DN given that PN has higher measurements of airborne tritium.

DN – Figure 5-1

The 2012 HTO in air annual average concentrations measured at boundary locations ranged from 0.2 to 0.6 Bq/m^3. The average boundary concentration of 0.4 Bq/m^3 is consistent with those observed in the environment over the last two years as illustrated in Figure 5-1, and is also consistent with the emissions trend.

PN – Figure 5-2

The 2012 HTO in air annual average concentrations measured at boundary locations ranged from 0.9 to 10.4 Bq/m^3. The average boundary concentration of 4.1 Bq/m^3 is consistent with those observed in the environment over the last two years as illustrated in Figure 5-2, and is also consistent with the emissions trend. The decrease observed in 2010 is due to the discontinuation of the passive samplers, as described above.

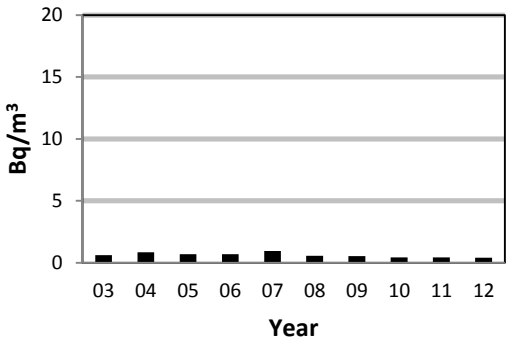

Figure 5-1: Darlington Nuclear Boundary Average HTO in Air

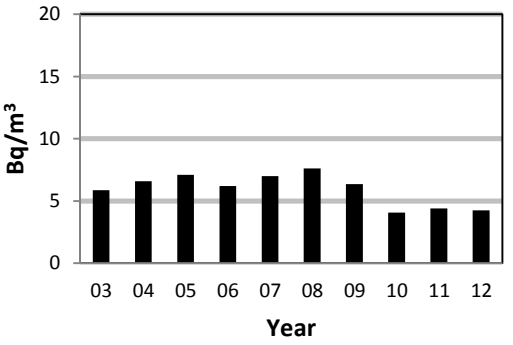

Figure 5-2: Pickering Nuclear Boundary Average HTO in Air

Carbon-14

The 2012 annual averages of airborne C-14 measured at the DN, PN and background sampling locations are summarized in Appendix D, Table D2.

C-14 is naturally occurring in the environment but is also a by-product of past nuclear weapons testing from the early 1960's. C-14 background concentrations around the world are currently decreasing as weapons test C-14 is removed naturally from the environment over time. Pre-atmospheric weapons test levels were measured at 226 Bq/kg-C [R-8]. The annual average C-14 in air concentration observed at background locations in 2012 was 243 Bq/kg-C.

DN – Figure 5-3

The annual average C-14 in air concentrations measured at all DN sampling locations ranged from 228 to 270 Bq/kg-C. The 2012 C-14 in air average concentration measured at the three select high wind frequency boundary locations around DN, plus the new boundary location C-14 monitor at D5 (used to represent the Farm critical group), was 245 Bq/kg-C. The long-term trend of C-14 in air, as illustrated in Figure 5-3, shows that the 2012 average is consistent with levels observed over the last five years.

PN – Figure 5-4

The annual average C-14 in air concentrations measured at all PN sampling locations ranged from 232 to 454 Bq/kg-C. The 2012 C-14 in air average concentration measured at the three select high wind frequency boundary locations around PN was 407 Bq/kg-C. The long-term trend of C-14 in air, as illustrated in Figure 5-4, shows that the average C-14 concentration in air remains similar to the previous three years and reflects the station C-14 airborne emissions trends over the last ten years as discussed in Section 3.3.1.

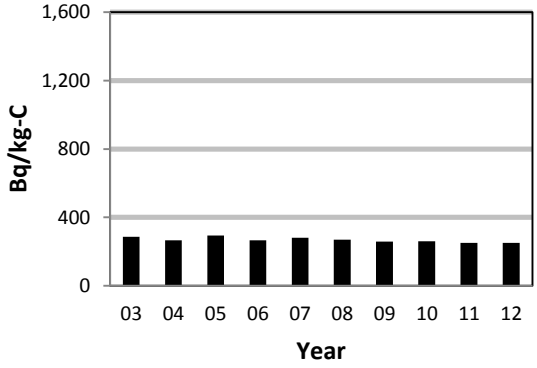

Figure 5-3: Darlington Nuclear Boundary Average C-14 in Air

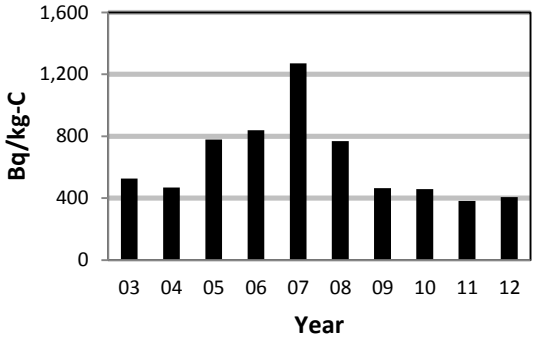

Figure 5-4: Pickering Nuclear Boundary Average C-14 in Air

5.1.2 External Gamma

Noble Gas Detectors

The annual boundary average noble gas dose rate is estimated from the monthly data from each detector. Results obtained in 2012 from the noble gas detectors are summarized in Appendix D, Table D3 and discussed below.

DN

Due to a different station design, DN does not experience the same level of emissions of noble gases as PN. The DN boundary average dose rates for Ar-41, Xe-133, Xe-135, Ir-192 and I-131 were all below the detection limits for the past five years. Thus, no trend graph is presented for DN.

PN – Figure 5-5

Ar-41 is the predominant radionuclide measured in noble gas around PN followed by Xe-135 and Xe-133. The PN boundary average Ar-41 dose in air was 1.5 microgray (µGy)/yr in 2012.

Ar-41 emissions and measurements in the environment are largely related to the number of operating days of PN Units 1 and 4. Figure 5-5 illustrates the trend of the boundary average Ar-41 dose rate for PN. The increasing trend of Ar-41 emissions starting in 2003 is the result of Unit 4 returning to service, and an additional contribution from Unit 1 returning to service in November 2005. The boundary average dose rate for Ar-41 decreased in 2011 as result of repairs completed to reduce air ingress via Unit 4 calandria vault dryers. The increase in dose rate from 2011 to 2012 is attributed to a higher number of operating days of Units 1 and 4 in 2012.

Xe-133 and Xe-135 were also measured above the detection limit at PN. Measured boundary average values in 2012 were 0.03 µGy/yr for Xe-133 and 0.05 µGy/yr for Xe-135, which are consistent with those observed in previous years.

Doses from Ir-192 and I-131 were below the detection limits.

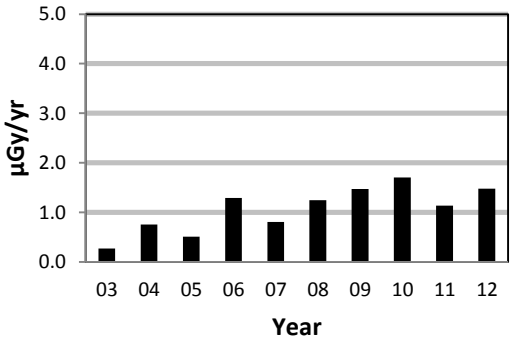

Figure 5-5: Pickering Nuclear Boundary Average Ar-41 Dose Rate in Air

Thermoluminescent Dosimeters

The 2012 annual average results from the TLDs at PN, DN and background sampling locations are summarized in Appendix D, Table D4. Figures 5-6 and 5-7 illustrate the trends in external gamma dose rates observed at DN and PN boundary locations over the last 10 years. As mentioned in Section 4.2.2.1, REMP TLD sampling at PN and DN was discontinued in Q3 of 2012.

The 2012 boundary average external dose rates in air for the DN and PN sites, based on extrapolation of results from the first two quarters of the year, are similar in value to the dose rates established over the last 10 years. A small step change was observed in 2007 resulting from the replacement of the Panasonic TLD reader with the Harshaw TLD system. The difference was attributed to the difference in energy response between the two systems [R-3].

The 2012 background external total gamma dose rate in air averaged 506 µGy/yr from nine locations.

DN – Figure 5-6

The boundary average external total gamma dose rate in air for 2012, extrapolated over the full year using data from the first two quarters, was approximately 514 µGy/yr. This dose rate falls within the variability of natural background gamma. The graph below depicts the projected average external gamma dose rate for 2012 based on data from the first two quarters.

PN – Figure 5-7

The boundary average external total gamma dose rate in air for 2012, extrapolated over the full year using data from the first two quarters, was approximately 462 µGy/yr. This dose rate falls within the variability of natural background gamma. The graph below depicts the projected average external gamma dose rate for 2012 based on data from the first two quarters.

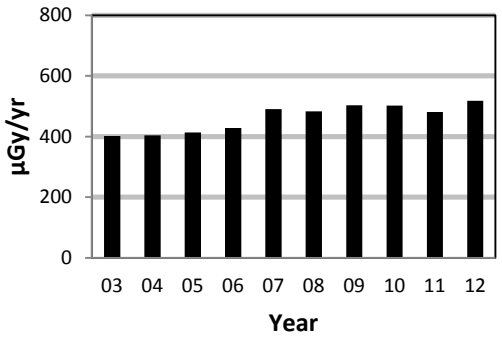

Figure 5-6: Darlington Nuclear Boundary Average TLD Gamma Dose Rate

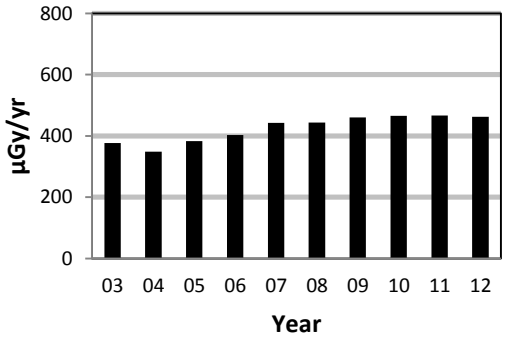

Figure 5-7: Pickering Nuclear Boundary Average TLD Gamma Dose Rate

5.1.3 Precipitation and Dry/Wet Fallout

Tritium Oxide

The 2012 annual average precipitation and wet/dry fallout sample results from DN and PN sampling locations are presented in Appendix D, Table D5, and annual trend plots of HTO in precipitation are shown in Figures 5-8 and 5-9.

As explained in section 4.2.2.2, monitoring of HTO in precipitation at PN and DN was discontinued in Q3 2012.

DN – Figure 5-8

The DN boundary average tritium in precipitation concentration reflects the DN airborne tritium emissions trend which has been stable over the last five years. The 2012 boundary average based on Q1 and Q2 data was 21 Bq/L.

PN – Figure 5-9

The 2012 boundary average based on Q1 and Q2 data was 274 Bq/L which is within the range of data observed over the last five years and follows the HTO airborne emissions trend (refer to Figure 3-3).

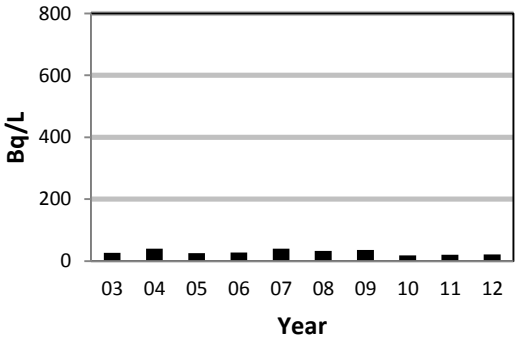

Figure 5-8: Darlington Nuclear Boundary Average HTO in Precipitation

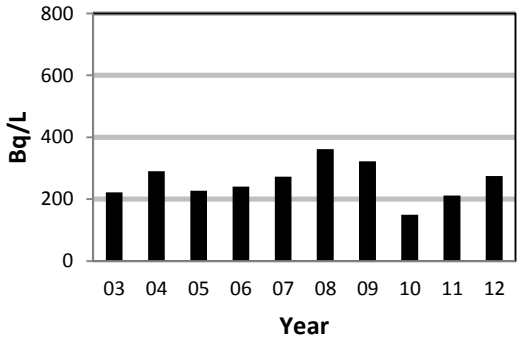

Figure 5-9: Pickering Nuclear Boundary Average HTO in Precipitation

Gross Beta

Measurements of gross beta activity in wet/dry fallout are reported in units of Bq/(m^2·month). These measurements represent the total fallout as a result of deposition of airborne radionuclides both as dry deposition and wet deposition (via precipitation). Gross beta in fallout in Canada normally averages from 5 Bq/(m^2·month) to 40 Bq/(m^2·month) on an annual basis due to radioactive fallout from natural sources (Berylium-7 [Be-7], K-40, Uranium (U) and Thorium (Th) series radionuclides in dust from surface soil and other natural sources) and atmospheric nuclear weapons testing [R-4]. The 2012 average measurements of 15.3 Bq/(m^2·month) and 18.7 Bq/(m^2·month) for the DN and PN sites, respectively, were within this range.

Monitoring of gross beta in precipitation at PN and DN was discontinued in Q3 2012 as stated in section 4.2.2.2.

5.2 Terrestrial Sampling

5.2.1 Garden and Inland Soils

The results for garden and inland soils are provided in Appendix D, Table D6.

Gamma Spectrometry

Background values of Cs-137 are present in the soil as a result of historic weapons testing fallout. Co-60 and Cs-134, if detected, would be a result of emissions from DN or PN.

Cs-137 concentrations in background soil samples analyzed in 2012 ranged from <0.2 Bq/kilogram (kg) to 5.9 Bq/kg. All measured Cs-137 concentrations around the

sites are within the range of values seen at the background locations over the last 10 years (from 0.4 to 12.5 Bq/kg). At the DN locations, Cs-137 concentrations in soil ranged from 2.4 to 4.5 Bq/kg, and at PN locations the Cs-137 concentration in soil was 3.1 Bq/kg in the PN garden soil sample and 5.1 Bq/kg in the open area sample. There is no indication of a buildup of activity in soil. Neither Cs-134 nor Co-60 were detected in any PN or DN soil samples in 2012. It is therefore concluded that the Cs-137 measured in these soil samples is from historic weapons testing fallout and not from OPG operations.

5.2.2 Vegetation

The results for vegetation are provided in Appendix D, Table D7.

Tritium Oxide

The average HTO concentration measured in the vegetables at five provincial-background locations was 1.7 Bq/L for 2012.

HTO concentrations in vegetation around the nuclear sites tend to vary from year to year due to prevailing winds, HTO emissions, humidity, etc. Furthermore, the number of samples and their locations have changed over the years. These variations should be noted when comparing long-term trends of HTO in vegetation surrounding the DN and PN sites as shown in Figures 5-10 and 5-11.

DN – Figure 5-10

Local fruit and vegetables collected around the DN site had HTO concentrations above the background average. The 2012 average concentration of HTO in vegetation was 12.8 Bq/L which is in line with the values observed over the last two years.

PN – Figure 5-11

Local fruit and vegetables collected around the PN site had HTO concentrations above the background average. The 2012 average concentration of HTO in vegetation was 49.5 Bq/L which is in line with the values observed over the last two years and consistent with the station emissions trend.

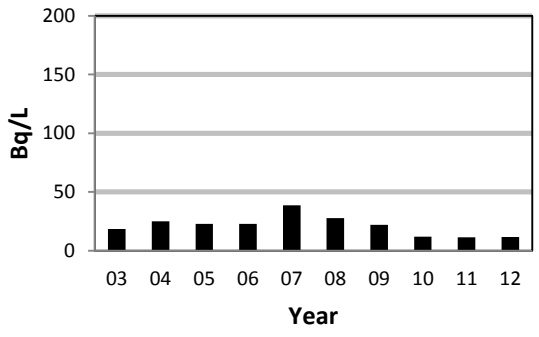

Figure 5-10: Darlington Nuclear HTO in Vegetation

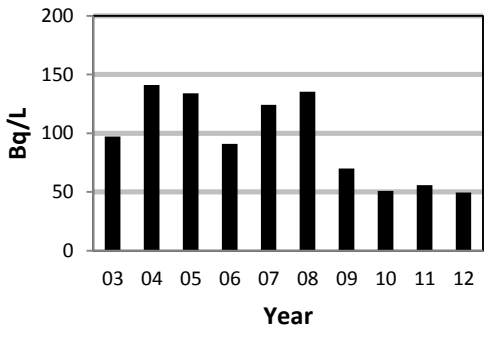

Figure 5-11: Pickering Nuclear HTO in Vegetation

Carbon-14

In 2012, the annual average C-14 in background vegetation was 245 Bq/kg-C.

DN – Figure 5-12

The 2012 average concentration of C-14 in DN vegetation was 238 Bq/kg-C. Figure 5-12 indicates that over the long term, C-14 levels in vegetation around DN are stable and near background levels.

PN – Figure 5-13

For PN, the average C-14 concentration in vegetation for 2012 was 283 Bq/kg-C. Figure 5-13 illustrates the trend of C-14 concentration in vegetation around PN, which roughly follows the trend observed in station C-14 airborne emissions discussed in Section 3.3.

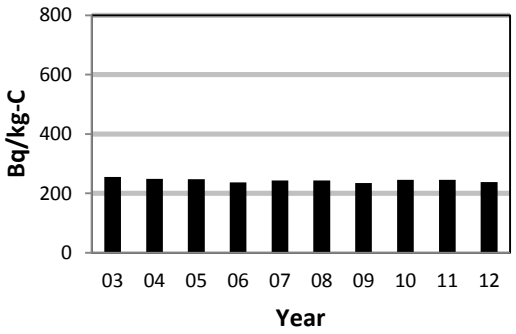

Figure 5-12: Darlington Nuclear C-14 in Vegetation

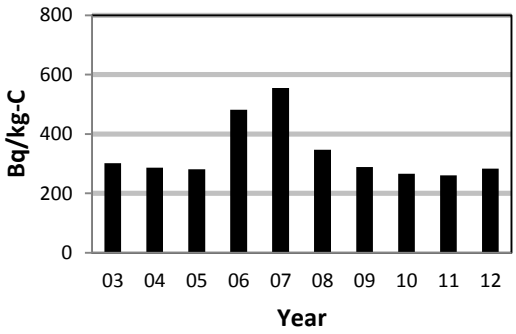

Figure 5-13: Pickering Nuclear C-14 in Vegetation

5.2.3 Milk and Animal Feed

Annual average values of HTO and C-14 in milk and animal feed are provided in Appendix D, Table D9 and D7, respectively.

The annual average HTO and C-14 in milk measurements around the nuclear sites vary from year to year due to changes in prevailing winds, emissions, humidity, cow's diet, and water sources. Furthermore, the number and location of dairy farms sampled at both PN and DN have changed over the years, which should be noted when reviewing long-term trends.

Tritium Oxide

The background average HTO in milk concentration was below the Lc of 2.3 Bq/L, based on sampling at two farms outside the influence of the stations.

As expected, both the DN and PN values of HTO in milk were above the background average concentration.

DN – Figure 5-14

At the DN site, the average level of HTO in milk was 4.6 Bq/L in 2012 based on five dairy farms located within 15 km of the site. This result is slightly above the Ld. The trend of HTO in milk shown in Figure 5-14 indicates that the 2012 value is in the lower range of values observed in the past five years.

PN – Figure 5-15

At the PN site, the average concentration of HTO in milk was 14.9 Bq/L in 2012 based on two dairy farms located within 12 km of the site. PN HTO in milk has trended down since 2004 as illustrated in Figure 5-15.

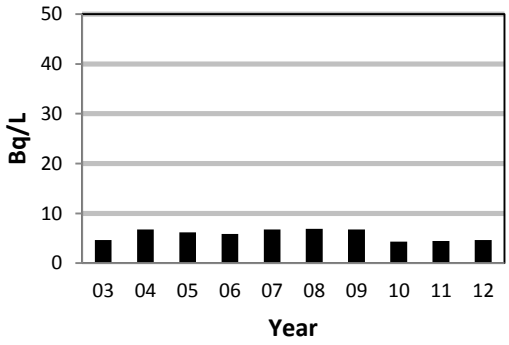

Figure 5-14: Darlington Nuclear HTO in Milk

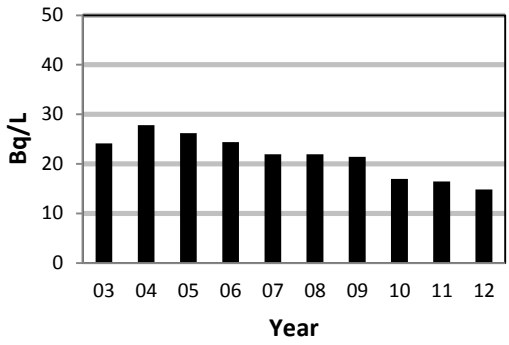

Figure 5-15: Pickering Nuclear HTO in Milk

Carbon-14

The background average C-14 in milk sampled from two farms on a quarterly basis was 250 Bq/kg-C. The 2012 C-14 levels in milk measured at the dairy farms around DN and PN were close to the background level.

The C-14 level in animal feed consumed by the cows is the main contributing factor to the C-14 levels in milk. The animal feed contains C-14 from the previous year when it was grown, therefore emissions from the previous year would affect the C-14 values measured in milk in the current year.

DN – Figure 5-16

The 2012 average concentration of C-14 in milk at surrounding DN locations was 259 Bq/kg-C. Figure 5-16 indicates that C-14 levels in milk around DN are stable and near background levels.

The average C-14 concentration in animal feed was 242 Bq/kg-C over five samples at DN (Table D7), which is within the range of values seen over the last five years.

PN – Figure 5-17

For PN, the average C-14 concentration in milk for 2012 was 259 Bq/kg-C. Figure 5-17 illustrates the trend of C-14 concentration in milk around PN. The concentration of C-14 in milk remains consistent with previous years and near background levels.

The C-14 concentration in animal feed was 236 Bq/kg-C from a single sample at PN (Table D7), which is in the lower range of values seen over the last five years.

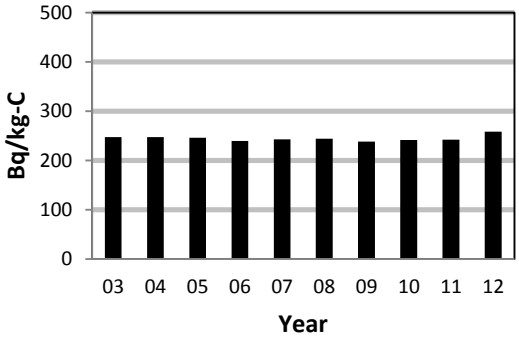

Figure 5-16: Darlington Nuclear C-14 in Milk

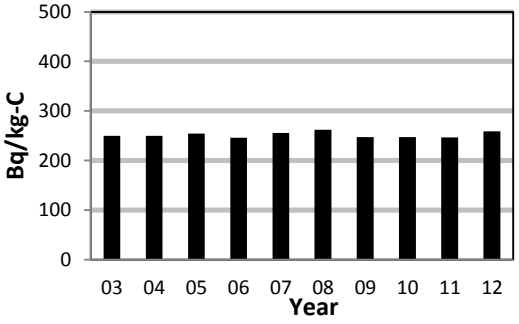

Figure 5-17: Pickering Nuclear C-14 in Milk

Iodine-131

In 2012, I-131 was not detected in any milk samples. The Ld for I-131 averaged approximately 0.1 Bq/L for all samples. This is consistent with previous years. Analysis of I-131 in milk at PN and DN was discontinued in Q3 of 2012 as indicated in Section 4.2.3.3.

5.3 Aquatic Sampling

5.3.1 Lake Water and Water Supply Plants

The results of water sampled from lake water and water supply plants are provided in Appendix D, Table D10.

The impact of HTO emissions from OPG stations on the nearby WSPs varies depending upon distance from the station, lake current direction, location and depth of the WSP intake pipe and general dispersion conditions. Annual average HTO levels at all WSPs were well below the Ontario Drinking Water Quality Standard of 7,000 Bq/L [R-29]. They were also below 100 Bq/L. OPG has voluntarily committed to maintaining the annual average HTO levels at all nearby WSPs below 100 Bq/L.

Tritium Oxide

HTO in Lake Ontario, along with all the Great Lakes, originates from several sources: natural cosmogenic tritium, residual tritium fallout from atmospheric weapons testing, current emissions from nuclear plants, and residual HTO from past emissions of nuclear plants. The total background concentration of tritium in Lake Ontario was

measured at four locations farther than 40 km from either PN or DN (Brockville, Burlington, Cobourg, and Kingston). The average annual concentration measured was 3.4 Bq/L, which includes residual HTO from previous years of emissions.

For the purpose of calculating public dose resulting from OPG operations, the sum of contributions from current emissions and residual HTO from past emissions was used. The background HTO value, subtracted from HTO measurements, included only natural cosmogenic tritium and residual weapons fallout tritium. This produces a conservative estimate of dose from tritium in lake water. This Lake Ontario background component for 2012 was conservatively estimated to be 1.6 Bq/L, using the Great Lakes Time-Concentration Tritium Model [R-6].

The monthly average HTO concentrations for 2012 at the Darlington and Pickering area WSPs are shown in Figures 5-18 and 5-19.

The trend plots of all the WSPs annual average concentrations of tritium in drinking water are shown in Figures 5-20 through 5-26. In the past five years, the annual average tritium concentrations at all WSPs have remained less than 10 Bq/L.

DN – Figure 5-18

For WSPs located in the DN area, the pattern observed for the 2012 monthly average HTO in water concentrations is similar to that of previous years. Annual average HTO concentrations measured at the Bowmanville, Newcastle, and Oshawa WSPs ranged from 4.5 to 6.2 Bq/L (refer to Figures 5-20, 5-21, and 5-23 respectively). HTO concentrations at these WSPs are consistent with results from previous years.

PN – Figure 5-19

For WSPs located in the PN area, the pattern observed for the 2012 monthly average HTO in water concentrations is similar to that of previous years. Annual average HTO concentrations measured at the Ajax, Horgan, Harris, and Whitby WSPs ranged from 4.4 to 5.0 Bq/L (Refer to Figures 5-22, 5-24, 5-25, and 5-26 respectively). HTO concentrations at these WSPs are consistent with results from previous years.

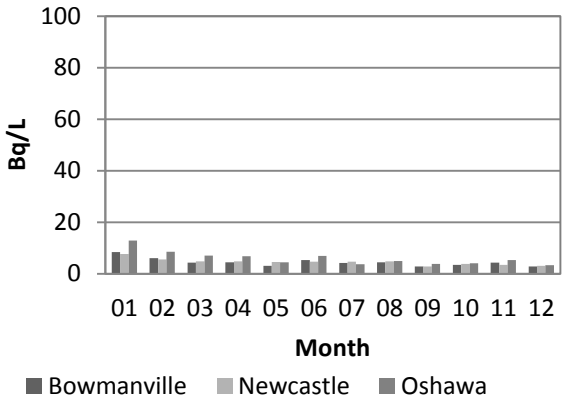

Figure 5-18: Darlington Nuclear WSPs 2012 Monthly HTO in Water Concentrations

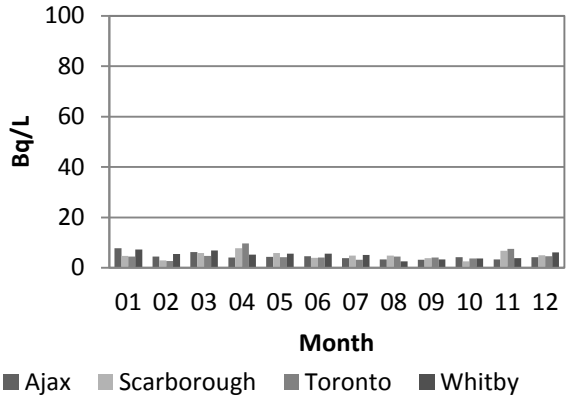

Figure 5-19: Pickering Nuclear WSPs 2012 Monthly HTO in Water Concentrations

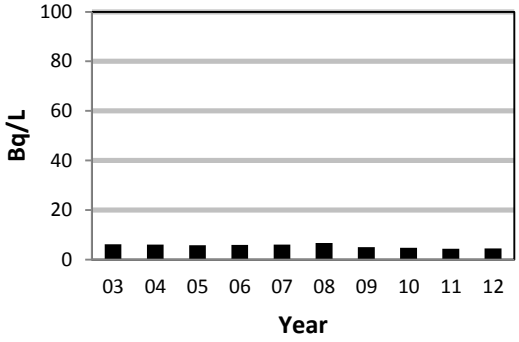

Figure 5-20: Bowmanville WSP – HTO in Water

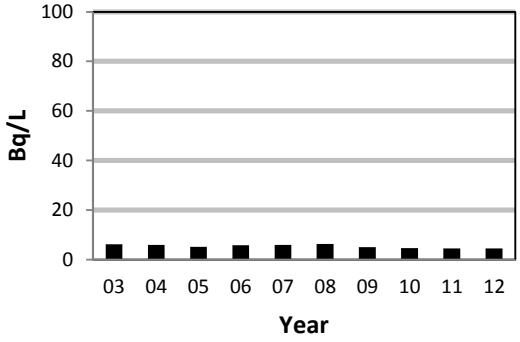

Figure 5-21: Newcastle WSP – HTO in Water

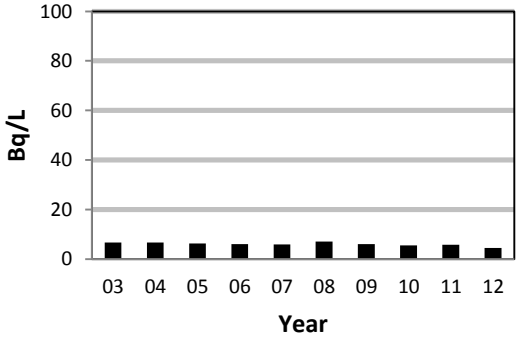

Figure 5-22: Ajax WSP – HTO in Water

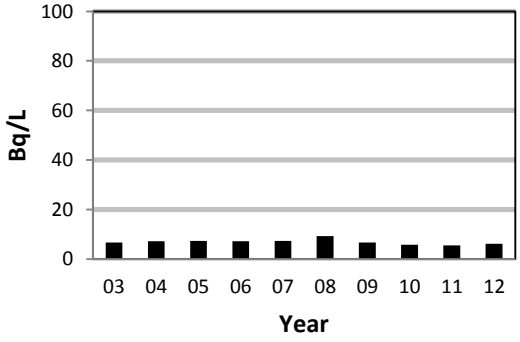

Figure 5-23: Oshawa WSP – HTO in Water

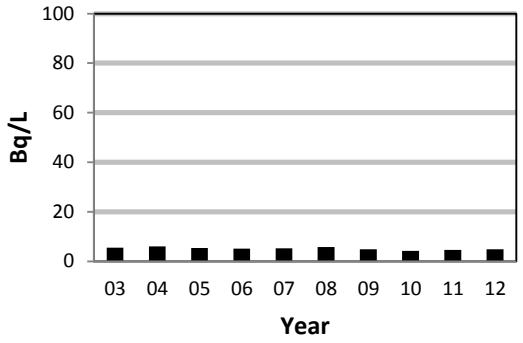

Figure 5-24: Scarborough Horgan WSP – HTO in Water

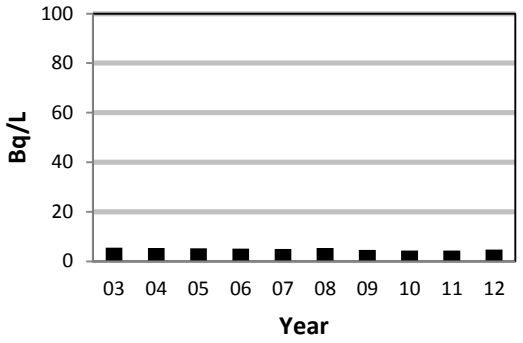

Figure 5-25: Toronto Harris WSP – HTO in Water

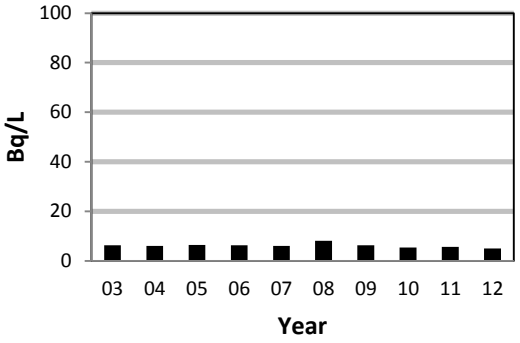

Figure 5-26: Whitby WSP – HTO in Water

Gross Beta

Annual average gross beta activity levels in samples from DN and PN area WSPs were 0.10 Bq/L and 0.11 Bq/L, respectively. These results are consistent with the average gross beta activity levels measured at the four provincial-background Lake Ontario locations of 0.11 Bq/L, and are well below the gross beta activity screening level of 1 Bq/L, which is both an internal OPG level and a level recommended by Health Canada [R-37].

5.3.2 Well Water

Monthly well water samples are collected from farms and residents near the DN and PN sites and results are in Appendix D, Table D10.

Tritium Oxide

HTO concentrations in well water depend on the depth of the well and thus the amount of time it takes for precipitation to reach the aquifer from where the well draws its water. Radioactive decay of the tritium during its transit time to the aquifer determines the residual activity level in the well water. Deeper wells tend to have lower HTO concentrations. Well water HTO concentrations reflect the level of past atmospheric HTO releases because of the time it takes for precipitation to reach the well.

DN

The maximum annual average HTO concentration observed in well water samples collected from the DN area was 25.3 Bq/L, which is consistent with the values seen over the last five years.

PN

The maximum annual average HTO concentration observed in well water samples collected from the PN area was 14.9 Bq/L, which is significantly lower than the maximum values seen in previous years. This is a result of the removal of R11 wells, as this location is no longer a residential property and the wells are no longer in use. These wells formerly had the highest HTO concentrations.

Gross Beta

DN

Samples from one residential well around DN had gross beta activity higher than OPG's internal screening level of 1 Bq/L. The annual average of gross beta activities measured at this location was 4.6 Bq/L. Analysis done to identify the specific radionuclide(s) responsible for the higher activity confirmed that the gross beta activity at this location was due to naturally occurring K-40. Annual average gross beta activity from all other well water samples was between 0.04 and 0.8 Bq/L. These results are similar to those over the last five years.

PN

There were no results for gross beta activity in well water at PN as indicated in Section 4.2.4.2.

5.3.3 Fish

The results for fish are provided in Appendix D, Table D11.

Tritium Oxide

The HTO levels in fish change quickly in response to changes in water HTO levels from station waterborne emissions. Thus, HTO concentrations measured in fish tissue reflect the HTO concentration in the water in the few hours before they were sampled. Long-term graphs of fish HTO levels for PN and DN are provided in Figures 5-27 and 5-28.

In 2012, the HTO in Lake Ontario background fish samples averaged 4.8 Bq/L.

DN – Figure 5-27

The HTO levels in the DN outfall fish samples averaged 5.5 Bq/L. This value is consistent with the levels observed over the last five years.

PN – Figure 5-28

The HTO concentration in the PN outfall fish samples averaged 9.8 Bq/L. This value is consistent with the levels observed over the last five years.

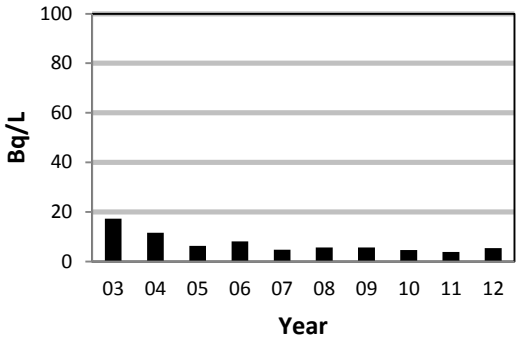

Figure 5-27: Darlington Nuclear HTO in Fish

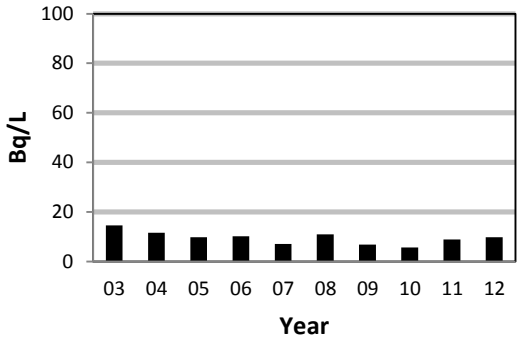

Figure 5-28: Pickering Nuclear HTO in Fish

Carbon-14

The average C-14 level in fish measured at a background Lake Ontario location was 246 Bq/kg-C in 2012.

The concentrations of C-14 in fish at both DN and PN for the past five years are consistent and comparable to background levels, as shown in Figures 5-29 and 5-30.

DN – Figure 5-29

The 2012 annual average C-14 level in DN fish was 260 Bq/kg-C.

PN – Figure 5-30

The 2012 annual average C-14 level in PN fish was 265 Bq/kg-C.

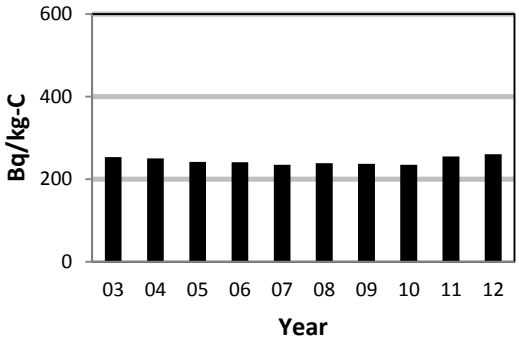

Figure 5-29: Darlington Nuclear C-14 in Fish

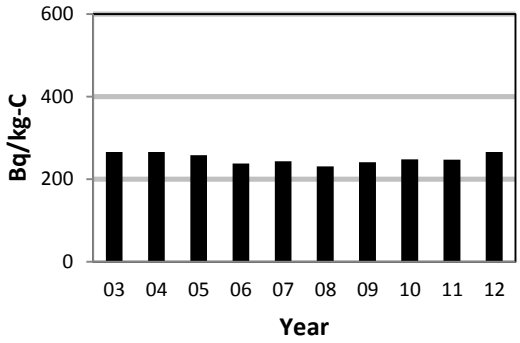

Figure 5-30: Pickering Nuclear C-14 in Fish

Gamma Spectrometry

The majority of the gamma activity in fish is naturally occurring K-40. A small amount of Cs-137 is usually present which is primarily due to nuclear weapons testing and not reactor operation given that Cs-134 and Co-60, which are indicative of reactor operation, were not detected.

The average Cs-137 value for background Lake Ontario fish was 0.4 Bq/kg.

Figures 5-31 and 5-32 illustrate that the Cs-137 levels in fish around DN and PN in the past five years are stable.

DN – Figure 5-31

The average Cs-137 value for DN fish was 0.2 Bq/kg, which is slightly below background. Cs-134 and Co-60, which are indicative of reactor operation, were not detected in any fish samples at DN site in 2012.

PN – Figure 5-32

The average Cs-137 value for PN fish was 0.2 Bq/kg, which is slightly below background. Cs-134 and Co-60, which are indicative of reactor operation, were not detected in any fish samples at PN site in 2012.

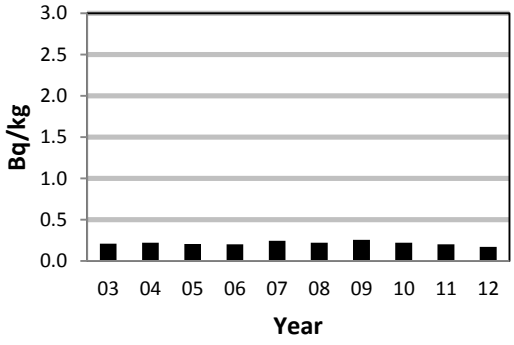

Figure 5-31: Darlington Nuclear Cs-137 in Fish

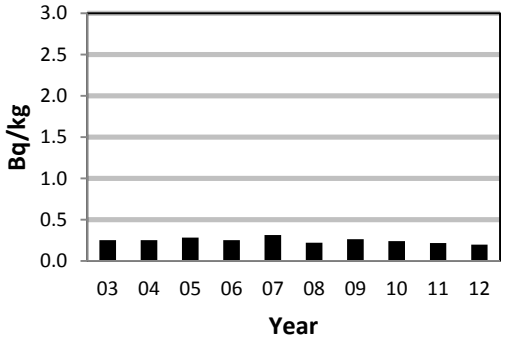

Figure 5-32: Pickering Nuclear Cs-137 in Fish

5.3.4 Sediment

As indicated in Section 4.2.4.4, sediment was not sampled in 2012. The 2009 results for sediment sampling are provided in Appendix D, Table D12. See the 2009 Results of Radiological Environmental Monitoring Programs report [R-36] for discussion on the results.

5.3.5 Beach Sand/Silt Samples

The results for beach sand/silt are provided in Appendix D, Table D13.

Gamma Spectrometry

Background Cs-137 concentrations in beach sand samples measured at Cobourg averaged 0.5 Bq/kg. These values are consistent with values observed over the past five years.

DN

The Cs-137 concentrations measured in DN beach sand samples ranged from below detection limit to 0.3 Bq/kg. Similar to previous years, there was no Co-60 or Cs-134 detected in the samples. The average limit of detection for C-137, Co-60, and Cs-134 gamma emitters in beach sand was 0.1 Bq/kg.

PN

The Cs-137 concentrations measured at PN area beaches ranged from 0.4 Bq/kg to 0.7 Bq/kg. Similar to previous years, there was no Co-60 or Cs-134 detected in the samples. The average limit of detection for C-137, Co-60, and Cs-134 gamma emitters in beach sand was 0.1 Bq/kg.

Wave action continuously moves the beach sand around, disturbing the original deposition patterns. This range of Cs-137 values is close to the background values measured and, without the presence of other radionuclides such as Co-60 or Cs-134 that are more closely related to reactor operation, the Cs-137 measured along the shoreline cannot be confirmed to be the result of OPG operations.

5.4 Sewage Sampling

The results for PN sewage samples are provided in Appendix D, Table D14.

5.4.1 PN Sewage Effluent- HTO and C-14

The 2012 average HTO concentration in sewage was 4,935 Bq/L. HTO in sewage has been trending upwards. This may be attributed to discharge of a heating steam condensate line from the administration building to a sewage sump since 2008. The line was re-routed to an appropriate location in March 2013.

The measured HTO concentration has a very small dose implication (0.01 µSv) to the WPCP workers, which is 0.001% of the DRL. C-14 was not detected in any of the quarterly composite samples.

5.5 Special Studies and Other Studies

5.5.1 Special Studies: Impact of Radioactivity in PN Sewage

Special Studies are conducted to investigate specific REMP issues or findings. Special Studies exclude development work such as improvement of measurement techniques or instruments. The assessment of potential impact of radioactivity in PN Sewage to

the Duffin Creek Water Pollution Control Plant (WPCP) worker is the only special study currently being conducted.

The WPCP is located about 2 km east of the PN site and receives sewage streams from the PN site and from other sources including hospitals and laboratories. PN sewage is not a radioactive effluent stream from the station. However, small amounts of incidental radioactivity from showers, toilets and janitorial sinks may enter the sewage stream.

At the request of Durham Region, OPG conducted a pathway analysis of potential radionuclides released from the site, to demonstrate that handling of PN sewage does not pose a risk to WPCP workers. A characterization study performed in 1996 showed elevated levels of I-131 in incinerator ash. Other radionuclides used in medical treatments were also detected, but I-131 was the only radionuclide common to PN operations. In 2001, a sampling program for radioactivity in Duffin Creek WPCP ash was initiated to confirm that radioactivity levels from PN sewage are low and not concentrated in the incinerator ash.

The study consists of weekly sampling of PN sewage and monthly sampling of the WPCP ash. PN sewage samples are analyzed for gamma emitters. Monthly ash samples are analyzed by high resolution gamma spectrometry. The results for PN sewage and WPCP incinerator ash are provided in Appendix D, Table D14.

5.5.1.1 WPCP Incinerator Ash

The concentrations of I-131 in ash were above the detection level with an annual average of 6.0 Bq/L. However, I-131 was not detected in any of the PN sewage samples. These results strongly suggest that PN operations are not a major contributor to the I-131 detected in the WPCP ash samples. The ash sample gamma scans also identified other radionuclides of medical or industrial origin, but these are not quantified in this report.

5.5.2 Other Studies

Concentrations of potassium in lake water around PN, DN, and Cobourg are monitored to support validation of the CSA N288.1-08 [R-11] default cesium bioaccumulation factor (Cs BAF) for fish of 3,500, which is used for the calculation of station DRLs. This study is conducted every three years [R-36]. The next potassium in lake water measurements will take place in 2013.

6.0 ATMOSPHERIC MODELLING

6.1 Integrated Model for Probabilistic Assessment of Contaminant Transport (IMPACT)

The IMPACT version 5.4.0 program was used to calculate doses to the critical groups using 2012 environmental monitoring data. Where measured environmental data is not available, IMPACT calculates the doses from emissions. IMPACT 5.4.0 is consistent with the method of dose calculation described in the CSA N288.1-08 standard [R-11].

6.2 Calculated Atmospheric Dispersion Factors

Atmospheric dispersion factors (Ka) provide a measure of the dilution of station radiological stack emissions to the atmosphere. Ka values are used to estimate radionuclide concentrations in air at the boundary monitor locations when local measured values are not available. Details of how and when the Ka values are used are provided in Appendix F, Dose Calculation Procedure and Concentrations.

Factors influencing atmospheric dispersion at a specific location include wind speed and direction, as well as the level of turbulence in the atmosphere.

Ka values are calculated from the measured HTO in air concentrations and station HTO emissions using the relationship:

$Ka = C/Q\ (s/m^3)$

Where C is the annual average HTO in air concentration (Bq/m^3) above background measured outside the station boundary, and Q is the average annual HTO release rate (Bq/s) measured by stack monitors at the point of release. The release rate is determined by dividing the station total annual emission of HTO as given in Table 3-1 by 3.16×10^7 seconds per year.

For the purpose of maintaining a consistent historical comparison, Ka values have been calculated using HTO in air concentrations from the active samplers at the boundary locations. These values are listed in Tables 6-1 and 6-2 for DN and PN, respectively. Figures 6-1 and 6-2 graphically show how these measured Ka values have varied historically at the DN and PN sites.

The boundary average Ka values at both DN and PN show a decrease since 2007. A decrease in Ka values means there is more dilution of emissions released to air. The Ka values obtained from the boundary HTO in air measurements represent a valid year-over-year comparison of air dispersion around DN and PN since the locations are always the same.

Ka values for each indicator site are calculated for the dose calculations based on the measured concentration of HTO in air at each boundary monitor location.

Table 6-1: Darlington Nuclear Annual Boundary Dispersion Factors – 2012

INDICATOR SITES	Measured Average Airborne Tritium Concentration (Bq/m^3)	Measured Ka (s/m^3)
D1 – Southeast Fence	0.6	1.4E-07
D2 – East Fence	0.5	1.2E-07
D3 – Maple Grove	0.3	7.5E-08
D4 – Park Road	0.3	6.1E-08
D5 – Knight Road	0.2	5.4E-08
D6 – Provincial Park	0.2	4.5E-08
Average		**8.3E-08**

NOTE: The measured annual HTO to air emission is used together with the measured levels of HTO in the environment to calculate Ka.

Table 6-2: Pickering Nuclear Annual Boundary Dispersion Factors – 2012

INDICATOR SITES	Measured Average Airborne Tritium Concentration (Bq/m^3)	Measured Ka (s/m^3)
P2 – Montgomery Park Rd.	10.3	6.1E-07
P3 – Sandy Beach Rd.	3.0	1.7E-07
P4 – Liverpool Rd.	1.0	5.9E-08
P6 – East Boundary	4.3	2.5E-07
P7 – Central Maintenance – West	5.1	3.0E-07
P8 – Frenchman's Bay	1.1	6.2E-08
P9 – Petticoat Creek	0.8	5.0E-08
P10 – Central Maintenance –East	8.6	5.1E-07
P11 – Alex Robertson Park	2.3	1.4E-07
Average		**2.4E-07**

NOTE: The measured annual HTO to air emission is used together with the measured levels of HTO in the environment to calculate Ka.

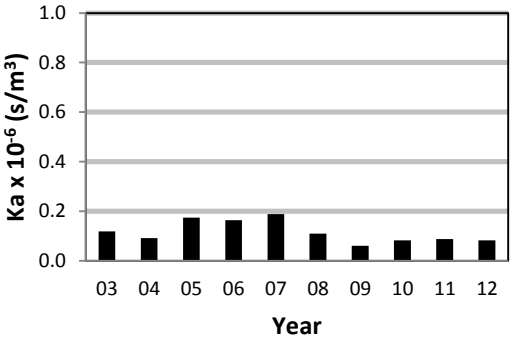

Figure 6-1: Darlington Nuclear Calculated Boundary Average Ka Values

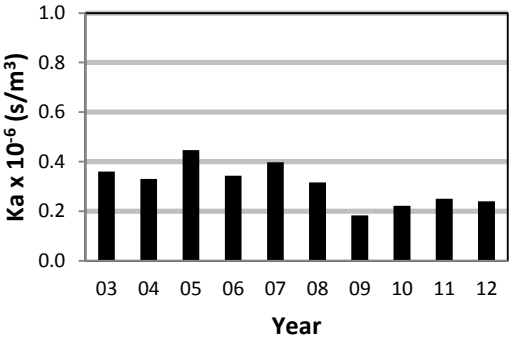

Figure 6-2: Pickering Nuclear Calculated Boundary Average Ka Values

6.3 Meteorological Data

Wind speed, direction and frequency are measured continuously at meteorological towers at each nuclear site. The average annual wind frequencies at a 10 m height in 2012 for the DN and PN sites are presented in Table 6-3 for 16 wind sectors.

The meteorological data are used in the IMPACT program to model radionuclide concentrations at the critical group locations where measured data is not available (such as pathways for I(mfp), Co-60, Cs-137+ and HT). In 2012, the wind sectors from which the wind predominantly blew towards the land were the SW for DN and the SSW for PN. Table 6-3 indicates the wind frequencies blowing from each direction.

Table 6-3: Darlington and Pickering Nuclear – 2012 Annual Average Wind Frequency by Direction (at 10 m height)

Direction Wind Blowing From	Darlington Nuclear Wind Frequency (%)	Pickering Nuclear Wind Frequency (%)
N	7.10	9.32
NNE	4.74	6.11
NE	3.18	2.55
ENE	4.98	3.80
E	7.96	6.23
ESE	4.90	5.61
SE	2.97	3.32
SSE	2.54	1.98
S	2.69	3.54
SSW	5.93	**10.22**
SW	**9.09**	8.37
WSW	6.22	5.80
W	8.07	6.44
WNW	7.98	8.42
NW	11.98	9.25
NNW	9.66	9.06
Total	100.00	100.00

Note: Shaded fields indicate landward wind sectors.

7.0 ASSESSMENT OF DOSES TO THE PUBLIC

This section contains an assessment of doses to the public resulting from the operation of OPG's Nuclear Generating Stations. These doses are based, as much as possible, on environmental concentrations of radionuclides measured at the potential critical group locations and surrounding environment. For the radionuclides and pathways where environmental measurements were not available, dose was modeled from emissions.

In this report, dose to members of the public is calculated only for members of potential critical groups that reside in the vicinity of DN and PN. The calculation follows the method described in OPG's Methodology for Data Analysis and Public Dose Determination for the Radiological Environmental Monitoring Program [R-9]. Assumptions, modeling parameters, and mean intake rates were used in accordance with CSA N288.1-08 [R-11]. Annual average meteorological data was used along with local intake fractions and representative locations for critical groups identified in the latest site-specific survey reviews [R-1] [R-13], incorporating any recent changes. Details on how the data were used are provided in Appendix F.

7.1 Critical Group Dose

The calculation of public dose in this report is intended to be realistic, using the potential critical group lifestyles and attributes collected in the DN and PN site-specific surveys [R-1] [R-10] [R-12] [R-13].

In public dose assessments, “critical groups” are used to estimate the mean realistic impacts of emissions on the most affected individuals. An individual with the average characteristics of the group is known as the “Representative Person” as described in CSA N-288.1-08 [R-11]. A single critical group with the highest total dose estimate is identified for each nuclear site; DN and PN. Since it is not apparent beforehand which group this may be, a number of potential critical groups are identified and dose estimates are calculated for each one. Doses are calculated for three age classes within each potential critical group; adult, child, and infant.

For groups that occupy a relatively small geographic location, radionuclide measurements taken at that location were used in the potential critical group calculations. For groups such as the Farm, Dairy Farm or Urban Resident that are spread over much wider geographic areas, the maximum measured value of each sample type from all group members was used in order to keep the calculated doses conservative.

A small fraction of the adult residents living near PN or DN also work within 5 km of the stations, thereby receiving a different dose while at work and at home. Similarly, a small fraction of the Industrial/Commercial critical group workers live near PN or DN station and continue to receive a dose while at home. As a result, the dose estimates for these critical groups have been adjusted to account for this portion of the population.

7.1.1 Age Classes

In accordance with CSA N-288.1-08 [R-11], three age classes are used for estimating annual dose to the representative person. The three age classes are 0-5 years (infant), 6-15 years (child), and 16-70 years (adult). The dose estimates to these three age groups are sufficient to characterize doses to the public. For practical implementation in dose calculations, the dose coefficients and characteristics for a one-year old infant, a 10-year old child, and an adult are used to represent the three age classes [R-7].

7.1.2 Darlington Nuclear Potential Critical Groups

The nine potential critical groups at DN for which doses are calculated in this report are shown in Figure C1, Appendix C and are described in Appendix E, Potential Critical Group Descriptions. The critical groups and their representative locations are primarily based on the DN site-specific survey review [R-1] conducted in 2006 and modified, if required, when significant changes are identified prior to the next site-specific survey review.

7.1.3 Pickering Nuclear Potential Critical Groups

The six potential critical groups at PN for which doses are calculated in this report are shown in Figure C2, Appendix C and are described in Appendix E. The potential critical groups and their representative locations are primarily based on the site-specific survey review conducted in 2005 [R-13] and modified, if required, when significant changes are identified prior to the next site-specific review cycle.

7.2 Exposure Pathways

The dose calculations include all pathways of radionuclide uptake or external exposure by humans, as illustrated previously in Section 4.0, Figure 4-1. The dose contribution from each pathway was estimated with IMPACT 5.4.0 either using direct measurements in the environment or by modeling from emissions.

7.3 Critical Group Dose Calculations

Although doses are calculated for several potential critical groups, only the group and age class with the highest dose is reported as the official site public dose in the given year. The following sections provide the basis for the dose calculation, results, and interpretation of the official public dose for DN and PN. Details on the calculations, how the radionuclide concentrations are determined, background subtractions, and whether data is measured or modeled are provided in Appendix F. Tables of doses calculated for all the potential critical groups are provided in Appendix G, Tables of Public Doses by Radionuclide, Pathway and Age Group for Darlington Nuclear and Pickering Nuclear Critical Groups.

7.3.1 Basis of Dose Calculation

- For each potential critical group, the highest annual average concentration of each medium sampled from that group was used for the dose calculation with the background subtracted.

- OBT doses from terrestrial animals and plants were modeled from measured HTO concentrations in terrestrial media.

- Doses from HTO and noble gases in air were estimated based on measurements at the fence line boundary and applying a calculated air dispersion ratio for the critical group location.

- Doses from the remaining radionuclide pathways for I(mfp), Co-60, Cs-137+ and HT, were modeled from emissions applying the Ka dispersion factor as well as the calculated air dispersion ratio for the critical group location (see Section F.2.1)

7.3.2 Darlington Nuclear Public Dose

For 2012, the limiting critical group at DN was the Dairy Farm 1-year old infant, with a dose of 0.6 µSv/a, as indicated in Table 7-1.

The Dairy Farm critical group represents dairy farms located within approximately 10 km of the DN site. The closest dairy farm is in the North wind sector about 3 km from the site. 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 local sources. Members also consume some locally caught fish and are externally exposed to beach sand at local beaches.

7.3.2.1 Dose Calculation Results

The results of the 2012 DN public dose calculation are presented in Table 7-1.

Table 7-1: 2012 Darlington Nuclear Critical Group Doses

Potential Critical Group	Dose per Age Class (microsieverts)		
	Adult	Child (10-year old)	Infant (One-year old)
Campers	0.1	0.1	0.1
Dairy Farm Residents	0.5	0.4	**0.6**
Farm Residents	0.3	0.3	0.2
Sport Fishers	0.0	0.0	0.0
Bowmanville Residents	0.1	0.1	0.1
Oshawa Residents	0.1	0.1	0.0
Rural Residents	0.3	0.2	0.1
West/East Beach Residents	0.1	0.1	0.1
Industrial/Commercial Workers	0.1		

Table 7-2 illustrates the dose contribution from each radionuclide for the Dairy Farm 1-year old infant and percent contribution to the total dose. C-14 and HTO contribute more than 90% of the total dose.

Table 7-2: 2012 Darlington Nuclear Public Dose

Radionuclide	Dose (µSv/a)	% Dose Contribution
C-14	5.23E-01	81%
Co-60	1.33E-03	0%
Cs-137+	0.00E+00	0%
HT	2.26E-07	0%
HTO	8.52E-02	13%
Noble Gases	1.17E-02	2%
OBT	1.13E-02	2%
I (mfp)	1.43E-02	2%
Total	6.47E-01	100%

"+" indicates that contributions from progeny are included.

This distribution of dose by radionuclides reflects the characteristics of the Dairy Farm group. C-14 dose is mostly from ingestion of terrestrial plants and animal products. The Dairy Farm one-year old infant consumes animal products that are almost entirely from local sources, including milk from local cows, as well as a portion of its fruits and vegetables. Dose from HTO is attributed to air inhalation and ingestion of local terrestrial plants and animal products.

The public dose trend for DN is presented in Figure 7-1.

The DN dose remains essentially unchanged over the last five years and is below 1% of the legal limit.

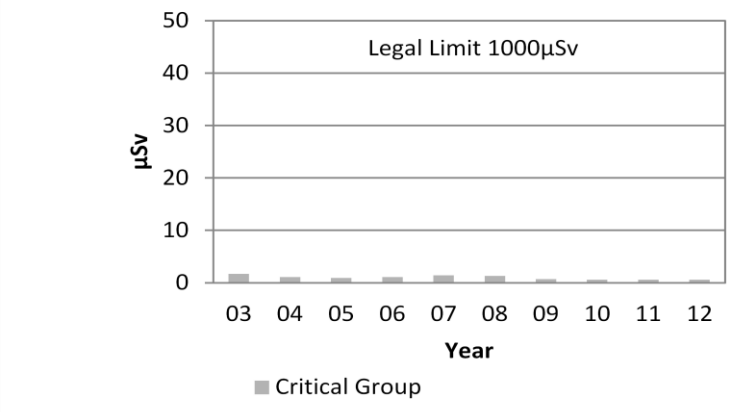

Figure 7-1: Darlington Nuclear Public Dose Trend

7.3.2.2 Discussion of Results

The 2012 DN site public dose of 0.6 µSv, as represented by the Dairy Farm infant, is about 0.1% of the 1000 µSv/a legal limit for a member of the public. The DN dose for 2012 is the same as the site public dose of 0.6 µSv for the Farm adult reported in 2011.

The DN dose for 2012 is less than 0.1% of the total public background dose. The estimated average background public dose around DN from naturally occurring and anthropogenic (man-made) radiation is about 1,400 µSv/a (excluding medical doses, refer to Section 7.4). Figure 7-2 is a graphical representation of critical group dose compared to background radiation around DN. As an additional source of comparison, Table 7-5 provides examples of typical doses from exposure to natural and anthropogenic sources.

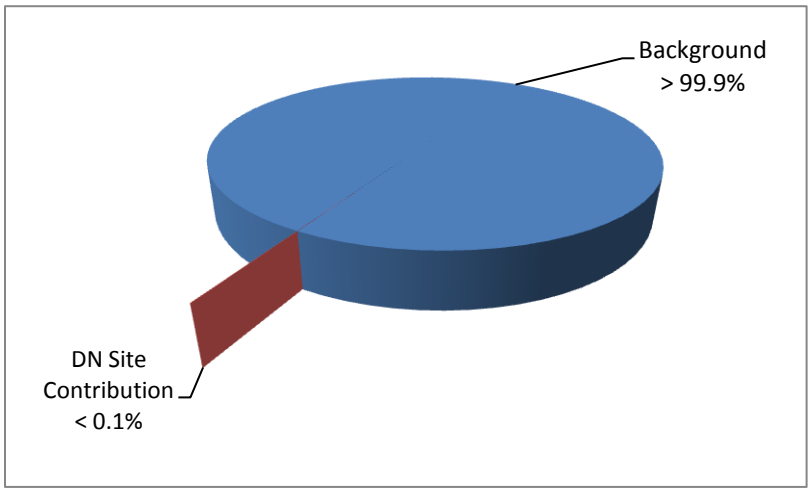

Figure 7-2: Comparison of Darlington Nuclear Public Dose to Background Dose

7.3.3 Pickering Nuclear Public Dose

For 2012, the limiting critical group at PN was the Urban Resident adult, with a dose of 1.1 µSv/a, as indicated in Table 7-3.

The Urban Resident critical group consists of Pickering and Ajax residents in the areas surrounding the PN site. Members of this group drink mostly water from Ajax WSP and also consume a diet comprised in part of locally grown produce and some locally caught fish. Members of this group are also externally exposed to beach sand at local beaches.

A fraction of adult residents within the Urban Resident critical group also work within 5 km of PN station and receive some dose from the station while at work. The average dose for the Urban Resident Adult has been adjusted to account for these residents.

7.3.3.1 Dose Calculation Results

The results of the 2012 PN public dose calculation are presented in Table 7-3.

Table 7-3: 2012 Pickering Nuclear Critical Group Doses

Potential Critical Group	Dose per Age Class (microsieverts)		
	Adult	Child (10-year old)	Infant (One-year old)
Farm Residents	0.3	0.3	0.2
Dairy Farm Residents	0.3	0.2	0.2
Sport Fishers	0.2	0.2	0.2
Urban Residents	1.1	1.0	1.0
C2 Correctional Institution	0.7	0.8	
Industrial Workers	0.8		

Table 7-4 illustrates the dose from each radionuclide and percent contribution to the total dose. HTO and noble gases contribute more than 90% of the total dose.

Table 7-4: 2012 Pickering Nuclear Public Dose

Radionuclide	Dose (µSv/a)	% Dose Contribution
C-14	2.75E-02	3%
Co-60	1.90E-03	0%
Cs-137+	3.00E-02	3%
HTO	4.88E-01	45%
Noble Gases	5.29E-01	49%
OBT	3.02E-03	0%
I (mfp)	3.84E-05	0%
Total	1.08E+00	100%

"+" indicates that contributions from progeny are included.

This distribution of dose by radionuclides reflects the characteristics of the Urban Resident group since their exposure is mainly from inhalation of HTO and external exposure to noble gases.

The public dose trend for PN is presented in Figure 7-3. The PN dose remains below 1% of the legal limit.

The reduction in dose from 2005 to 2006 is due to the closure of the correctional institution (C1) and the expropriation of the Squires Beach community for the expansion of the municipal WPCP. These two former potential critical groups were located close to the station and often had the highest doses around the PN site.

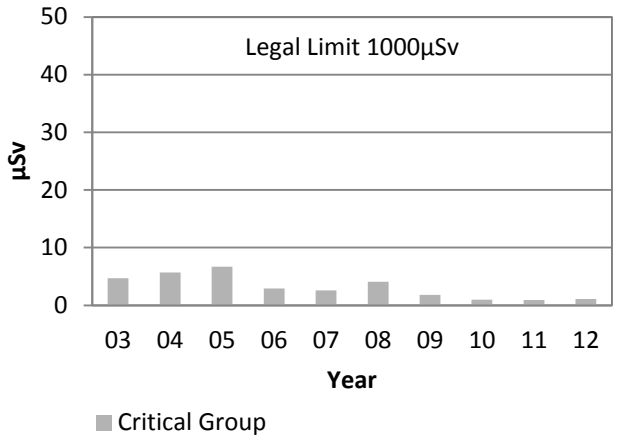

Figure 7-3: Pickering Nuclear Public Dose Trend

7.3.3.2 Discussion of Results

The 2012 PN site public dose of 1.1 µSv, as represented by the Urban Resident adult , is 0.1% of the 1000 µSv/a legal limit for a member of the public. The PN dose for 2012 is about the same as the site public dose of 0.9 µSv for the Urban Resident adult and child reported in 2011.

This small difference is attributed to higher noble gas concentrations measured at boundary locations in 2012, as compared with 2011, due to a higher number of operating days of Units 1 and 4 in 2012.

The PN dose for 2012 was equivalent to about 0.1% of the total public background dose. The estimated background dose around PN is 1,400 µSv/a from naturally occurring and anthropogenic (man-made) radiation (excluding medical doses, refer to Section 7.4). Figure 7-4 is a graphical representation of critical group dose compared to background radiation around PN.

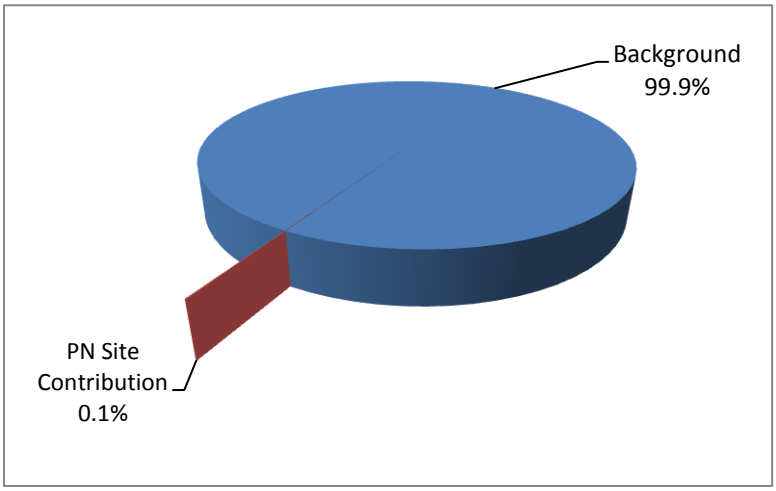

Figure 7-4: Comparison of Pickering Nuclear Public Dose to Background Dose

7.4 Natural and Anthropogenic Data

Table 7-5 provides some typical doses received by members of the public from exposure to natural and anthropogenic sources.

Table 7-5: Typical Doses from Exposure to Natural and Anthropogenic Sources

Source of Exposure	Effective Dose (µSv)
Annual External Exposure during Precipitation Events (Gamma Radiation from Naturally Occurring Radon Gas Decay Products) [R-33]	4
Chest X-Ray (single film) [R-34]	10
Airplane Travel (two hour flight) [R-35]	12

Information on Canadian public doses from naturally occurring sources was updated in 2002, including new data from ground gamma surveys in four major Canadian cities [R-19] [R-20]. Results are summarized in Table 7-6, where it can be seen that most of the variation is due to the inhalation dose from Radon-222 (Rn-222).

Table 7-6: Naturally Occurring Annual Public Effective Doses

Radiation Source	Worldwide Average (µSv)	Canada (µSv)	Toronto (µSv)	Montreal (µSv)	Winnipeg (µSv)	Pickering Nuclear Site (µSv)	Darlington Nuclear Site (µSv)
Cosmic	380	318	313	313	315	313	313
Internal	306	306	306	306	306	306	306
Inhalation[(a)]	1,256	926	757	667	3,225	565	565
External	480	219	178	278	176	154	154
Total[(b)]	**2,400**	**1,800**	**1,600**	**1,600**	**4,000**	**1,300**	**1,300**

(a) Mostly from Rn-222.
(b) Total doses have been rounded to two significant figures to reflect the inherent uncertainty. Some components are based on direct measurements and others are estimated from related measurements.

In addition to naturally occurring radiation, the public also receives about 70 µSv/a effective dose from anthropogenic sources such as nuclear weapon test fallout, and exposures from technological processes and consumer products and services, excluding medical sources. Thus, the total background dose around PN and DN from naturally occurring and anthropogenic sources is 1,400 µSv/a. The average Canadian dose from medical sources averages 1,100 µSv/a per person. The legal limit of 1,000 µSv per year from licensed industrial practices is over and above the dose the public already receives from the natural environment and from medical procedures. [R-21]

8.0 QUALITY ASSURANCE PROGRAM

The Quality Assurance (QA) program for the REMP encompasses all activities in field sample collection, laboratory analysis, laboratory quality control, and external laboratory comparison. The objectives are to ensure that REMP samples are representative and their analytical results are accurate such that best estimates of

radiation doses to the public resulting from the operations of OPG Nuclear Generating Stations are provided. This section provides an overview of quality assurance activities that are critical to ensuring the quality of the REMP data.

8.1 Laboratory Quality Assurance and Quality Control

The OPG Health Physics Laboratory (HPL) is accredited for radioanalysis of drinking water and soil by the Canadian Association for Laboratory Accreditation (CALA). The accreditation is based on demonstrated compliance with ISO 17025, General Requirements for the Competence of Testing and Calibration Laboratories. HPL is also licensed for radioanalysis of drinking water by the Province of Ontario's Ministry of Environment. HPL performs laboratory activities in accordance with the OPG Dosimetry and Radiological Environmental Quality Assurance Program [R-22].

8.1.1 Laboratory Quality Control

Quality control (QC) samples are used to estimate the precision and accuracy of analytical results and to examine any sources of error introduced by laboratory practices which require corrective actions. Two types of QC samples are used to accompany the analyses of the environmental samples collected for the REMP:

(a) Process control samples are 'dead water' (radiation-free water/blank) samples that go through the same handling process as the real samples.

(b) QC standards are samples with predetermined values (usually traceable standards) to be included for final analysis. The analysis of the environmental sample is considered valid when the results of the accompanying QC samples are within $\pm$ 10-20% of the known/expected values, depending on the analysis type.

For 2012, the results for the QC samples were all within the required range. These results provide added confidence in terms of the quality of data for the program and the consistency of laboratory measurements.

8.1.2 Laboratory Performance Testing

The main purpose of the laboratory performance testing programs is to provide assurance to OPG Nuclear and the CNSC of the laboratory's analytical proficiency (i.e., the accuracy of the measurements). The testing programs provide a quality check to laboratory operations including equipment calibration, analytical procedures, data review and internal QC. These testing programs are a crucial part of the laboratory QA program to demonstrate that the laboratory is performing within the acceptable limits as measured against external unbiased standards.

OPG Nuclear participated in two independent laboratory performance testing programs in 2012 [R-23]. The suppliers of the test samples and irradiations were:

(a) Eckert and Ziegler Analytics Inc.; and
(b) National Research Council of Canada (NRCC).

These programs involved the measurement of tritium in water, gross beta in water, gamma in water/drinking water, and gamma emitters in milk and soil, and environmental gamma measurements using TLDs.

(a) Eckert and Ziegler Analytics Inc.

QA test samples are supplied on a quarterly basis by Eckert and Ziegler Analytics Inc. Results of analyses are reported back to Eckert and Ziegler Analytics who then provide performance reports for each of the analytical types. The performance test limits are as follows:

$$-25\% \leq \text{Relative Difference} \leq +50\%$$

$$\text{Relative Precision} \leq 40\%$$

These test limits are adapted from the *in vitro* accuracy specifications of the CNSC's Regulatory Standard S-106 Revision 1, Technical and Quality Assurance Requirements for Dosimetry Services.

All QA performance test results in 2012 met the specified limits. The maximum and minimum Relative Difference and Relative Precision are summarized for each sample type and presented in Table 8-1.

Table 8-1: Summary of Analytics Performance Test Results – 2012

Sample Types	Relative Difference (%)		Relative Precision (%)	
	High	Low	High	Low
Tritium in Water	0	-4	3	2
Gross Beta in Water	+8	-4	10	7
Gamma in Milk	+12	-12	13	1
Gamma in Water	+14	-10	33	2
Gamma in Soil	+13	-9	6	1

(b) NRCC Environmental Gamma QA Program

The laboratory QA test program for environmental gamma measurements consists of sending 16 Harshaw TLDs on a quarterly basis to the NRCC where they are irradiated to two different levels of exposure.

The Mean Relative Bias is required to be less than ± 30%. The coefficient of variation of the responses is required to be less than 0.35. In addition, the sum of the mean relative bias (as a fraction) and the coefficient of variation is required to be less than 0.50. [R-23]

All testing met performance requirements.

8.2 Audits and Self-Assessments

In 2012, Environment Programs Department (EPD) performed two self assessments on different elements of the REMPs. A CNSC compliance inspection (Type II) was conducted from October 15th to 19th 2012 on the PN REMP. A similar CNSC Type II compliance verification inspection was conducted for the DN REMP from March 8th to 9th of 2011.

A summary of the audits and assessments are provided in the following sections.

8.2.1 Audits

The CNSC performed a Type II compliance inspection on the PN REMP in 2012. The objective of the inspection was to verify compliance with regulatory requirements for assessment and monitoring activities that support environmental protection. The scope of the inspection included radiological environmental monitoring equipment maintenance and calibration, sampling procedures, data processing and record management. CNSC staff concluded that assessment and monitoring activities governed by the REMP at Pickering Nuclear are in compliance with regulatory requirements for environmental protection. Minor non-compliances with OPG documentation were identified, none of which represent a significant or immediate risk to the environment. Action tracking was used to monitor the resolution of the minor non-compliances identified [R-40].

A similar inspection on the DN REMP was conducted from March 8th to 9th in 2011. It was concluded that the DN REMP is in compliance with all requirements, with only one area for improvement identified associated with document revision and control [R-41].

8.2.2 Self Assessments

(a) Analytical Data Reporting QA/QC

Self assessment NO12-000610 was carried out by the EPD to assess procedural compliance and suitability of QA/QC approval processes in place at HPL for generation of the REMP monthly, quarterly, and annual analytical reports. The self assessment found these approval processes to be thorough and effectively executed. Minor improvements pertaining to sample commentary were recommended.

(b) REMP Station Maintenance Process

Self assessment NO12-000624 was carried out by the EPD to review the current REMP station maintenance process, evaluate its success, and identify areas of improvement. The need for a Service Level Agreement between EPD and OPG maintenance staff was identified, and is in the process of being implemented.

8.3 Third-Party Verification

An independent third-party verification of the annual dose calculations and this report was carried out by Enviro Health Physics Incorporated. Verification was done on the methodology used, assumptions made, input parameter values and data used. This involved checking the dose calculations, IMPACT scenarios, and performing independent replicate IMPACT model runs and hand calculations to validate the results obtained by OPG. Any necessary changes identified by the third-party verification have been addressed and incorporated in this report.

9.0 PROGRAM PERFORMANCE

9.1 Sample Unavailability

A total of 1,994 laboratory analyses were performed for the 2012 REMPs. The analyses covered HTO, gross beta, C-14, I-131, TLD gamma, OBT, and gamma scan. The DN site accounted for 43% of these sample analyses, while the PN and provincial-background programs accounted for 40% and 17% respectively. More samples were analyzed for DN than PN because samples are required to represent a greater number of potential critical groups at DN. Of the total analyses performed, 1,034 analyses were used in the dose calculation. Table 9-1 shows the sample types, number of locations, and number of samples used for the dose calculation. It should be noted that Table 9-1 only lists the sample analyses used for dose assessment and does not include all REMP samples.

The unavailability indicator tracks the performance of sample collection and analysis for the REMP. The field sampling portion of the REMP is designed to collect representative field samples from selected pathways near each nuclear site and from background locations, in order to meet the program objectives as defined in Section 2.0. The sample analyses unavailability percentage is determined by dividing the number of missed or invalid sample analyses by the number of planned sample analyses for each REMP site.

An important objective of the REMP is to estimate the doses to the public based on environmental data measured in the public domain. In accordance with the REMP governing document [R-31], the requirement to meet unavailability limits is specific to the analysis of samples used in the dose calculation. These limits are applied to the PN, DN and provincial-background REMPs separately.

The unavailability limits for samples used in the dose calculation are provided in Table 9-1 and range from 10 to 25%. The unavailability limits were derived based on the relative contributions to total dose, therefore higher dose contributors have a lower unavailability limit. The overall unavailability for PN, DN and provincial-background REMPs were 0%, 3% and 0%, respectively. For 2012, all unavailability limits were met for individual analyses used in dose calculations.

Table 9-1: Unavailability of REMP Sample Data Used for Dose Calculation Purposes

Sample Types	Collection Frequency	Pickering Nuclear				Darlington Nuclear				Provincial Controls				Unavailability Limit
		Locations	Planned Analyses	Actual Analyses	Unavailability	Locations	Planned Analyses	Actual Analyses	Unavailability	Locations	Planned Analyses	Actual Analyses	Unavailability	
Tritium														
Tritium in Air (Molecular Sieve)	Monthly/Quarterly	7	84	82	2%	6	72	70	3%	1	12	12	0%	10%
Water Supply Plants	Weekly Composite	1	48	48	0%	2	93	93	0%					15%
Residential Wells	Monthly	5	60	60	0%	14	166	164	1%					15%
Milk	Monthly Composite - Q1 and Q2	2	12	12	0%	5	30	30	0%					25%
Milk	Monthly Composite - Q3 and Q4	2	12	12	0%	3	18	18	0%					25%
Milk	Quarterly									2	8	8	0%	25%
Lake Water	Monthly [a]	2	16	16	0%	3	24	24	0%					25%
Fruits	Annual	8	8	8	0%	18	18	15	17%					20%
Vegetables	Annual	11	11	11	0%	14	14	13	7%	5	5	5	0%	20%
Animal Silage Feed	Annual	1	1	1	0%	5	5	5	0%					25%
Fish	Annual	1	8	8	0%	2	12	12	0%					25%
Carbon-14														
Carbon-14 in Air	Quarterly	8	32	32	0%	13	52	49	6%	6	24	24	0%	25%
Milk	Monthly Composite - Q1 and Q2	2	12	12	0%	5	30	30	0%					10%
Milk	Monthly Composite - Q3 and Q4	2	12	12	0%	3	18	18	0%					10%
Milk	Quarterly									2	8	8	0%	10%
Fruits	Annual	8	8	8	0%	18	18	15	17%					20%
Vegetables	Annual	11	11	11	0%	14	14	13	7%	5	5	5	0%	20%
Animal Silage Feed	Annual	1	1	1	0%	5	5	5	0%					25%
Fish	Annual	1	8	8	0%	2	12	12	0%	1	8	8	0%	25%
Noble Gases														
External Gamma (Noble Gas Monitors) [b]	Continuous	4	NA	NA	3%	5	NA	NA	2%					25%
Gamma														
Fish	Annual	1	8	8	0%	2	12	12	0%	1	8	8	0%	25%
Beach Sand	Annual	3	3	3	0%	2	3	3	0%	1	2	2	0%	25%
Overall dose sample Unavailability [c]			355	353	**0%**		616	601	**3%**		80	80	**0%**	

Notes: NA = Not Applicable.

(a) For safety considerations, samples are not required during the winter months (Dec. - Mar.).

(b) Noble gas detector unavailability is based on an average of actual run time of all monitors for PN and DN.

(c) Unavailability defined as an average of the percent unavailability of all sample types

10.0 SUMMARY

10.1 Overall Program Performance

The results of OPG's 2012 REMPs are summarized as follows:

- Overall, the REMPs met their objectives in collecting radiological environmental data for the PN and DN site public dose estimations, for supporting the DRL model and assumptions, and for confirming station emission control.
- Several changes to the sampling program were implemented in 2012 for program optimization and implementation of CSA N288.4.
- There were no significant deficiencies in sample collection and sample analyses this year. 1,994 environmental data analyses were completed for samples collected around DN and PN sites and at various Ontario background locations. The performance of sample analyses used in the dose calculations was excellent. The overall unavailabilities were 0%, 3%, and 0% for the PN, DN, and provincial-background REMPs, respectively.
- An inspection and two self assessments were completed this year for the REMPs. No significant findings were identified. Minor improvements were recommended for documentation and REMP station maintenance procedures.

10.2 Darlington

10.2.1 Summary of Sampling Results

- HTO, C-14, and HT emissions to air and HTO emissions to water remained at very small fractions of their respective DRLs in 2012. Boundary noble gas detector dose rates remained below detection limits.
- Annual average tritium concentrations in drinking water from the nearby water supply plants were below 10 Bq/L. The maximum average HTO activity in well water was below 26 Bq/L. Gross beta-gamma activity in well water remained similar to previous years.
- Soil samples had Cs-137 at levels within the range of historic background over the last 10 years and had no detectable Co-60 or Cs-134. There is no indication of buildup of activity in soil.
- Concentrations of HTO and C-14 in air and fish, Cs-137 in fish, and C-14 in vegetation and milk were in line with results seen over the last five years. HTO measured in milk and vegetation was in the lower range of results seen in the last five years.

10.2.2 Summary of Site Public Dose

The 2012 public dose for the DN site was 0.6 µSv and was represented by the 1-year old infant of the Dairy Farm critical group. The site public dose has not changed significantly over the last five years.

10.3 Pickering

10.3.1 Summary of Sampling Results

- HTO emissions to air and water, C-14 emissions to air, and gross beta-gamma emissions to water remained at a very small fraction of their respective DRLs in 2012.
- The average dose measured by environmental noble gas monitors at the boundary locations increased in 2012 as compared to 2011, due to a higher number of operating days of Units 1 and 4 in 2012.
- Annual average tritium concentrations in drinking water from the nearby water supply plants were below 10 Bq/L. The maximum average HTO activity in well water was below 15 Bq/L.
- Soil samples had Cs-137 at levels within the range of historic background over the last 10 years and had no detectable Co-60 or Cs-134. There was no indication of a buildup of activity in soil.
- Concentrations of HTO and C-14 in fish, Cs-137 in fish, and C-14 in milk were in line with results seen over the last five years. HTO levels in milk were lower than results seen in the last five years. HTO and C-14 levels in air and HTO and C-14 measured in vegetation were similar to 2011.

10.3.2 Summary of Site Public Dose

The 2012 public dose for the PN site was 1.1 µSv and was represented by the adult of the Urban Resident group. This dose remains consistently low as compared with the previous two years.

11.0 OUTLOOK FOR 2013

11.1 Implementation of CSA N288.4-10

The CSA standard N288.4-10, “Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills”, was issued in 2010 to supersede the 1990 version of the standard. The 1990 version addressed the protection of humans from nuclear substances. The current version, N288.4-10, expands the scope to include the protection of both humans and the environment from nuclear substances, hazardous substances and physical stressors. This expanded program is called the Environmental Monitoring Program (EMP).

Detailed designs of the DN and PN EMPs to comply with CSA N288.4-10 were developed in 2011. The new EMPs consist of a routine monitoring program and one-time supplementary studies. The new designs are being implemented. The first annual EMP report will be published in 2014, and will provide the results of the 2013 EMP.

11.2 Discontinuation of Annual REMP Report

With the implementation of the EMPs, this 2012 report is the last annual REMP report that will be issued. Going forward, an annual EMP report entitled “Results of Environmental Monitoring Programs” will be produced.

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Appendix A: Radiological Units and Conversions

Absorbed Dose

1 gray (Gy)	=	1 joule/kg
1 gray (Gy)	=	100 rad
1 milligray (mGy)	=	100 millirad (mrad)

Effective Dose

1 sievert (Sv)	=	100 rem
1 millisievert (mSv)	=	100 millirem (mrem)
1 microsievert (µSv)	=	0.1 millirem (mrem)

Quantity of Radionuclide

1 becquerel (Bq)	=	1 disintegration per second
1 curie (Ci)	=	3.7×10^{10} Bq
1 mCi/(km^2·month)	=	37 Bq/(m^2·month)

Appendix B: Glossary of Acronyms and Symbols

Radionuclides and Units of Measure

Ar-41	Argon-41
Be-7	Beryllium-7
C-14	Carbon-14
CO_2	Carbon Dioxide
Co-60	Cobalt-60
Cs-134	Cesium-134
Cs-137	Cesium-137
Cs-137+	Cesium-137 including progeny
H-3	Tritium (Hydrogen-3)
HT	Elemental Tritium
HTO	Tritium Oxide
I(mfp)	Mixed Fission Products Radioiodines
I-131	Iodine-131
Ir-192	Iridium-192
K-40	Potassium-40
Rn-222	Radon-222
Th	Thorium
U	Uranium
Xe-133	Xenon-133
Xe-135	Xenon-135
µGy	microgray
µSv	microsievert
Bq	becquerel
Bq/kg-C	becquerels per kilogram carbon
Ci	Curie
Gy	Gray
kg	kilogram
L	Litre
mGy	milligray
mSv	millisievert
Sv	Sievert

Acronyms and Abbreviations

BAF	Bioaccumulation Factor
CALA	Canadian Association for Laboratory Accreditation
CANDU	Canada Deuterium Uranium
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group
CSA	Canadian Standards Association
DN	Darlington Nuclear
DRL	Derived Release Limit
dw	Dry weight
E	East wind sector
ECI	Emergency Coolant Injection

EMP	Environmental Monitoring Program
ENE	East North East wind sector
EPD	Environment Programs Department
ESE	East South East wind sector
HPL	OPG Health Physics Laboratory
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IMPACT	Integrated Model for Probabilistic Assessment of Contaminant Transport
ISO	International Organization for Standardization
Ka	Atmospheric Dispersion Factor (s/m^3)
Lc	Critical Level
Ld	Limit of Detection
MW	Megawatts
N	North wind sector
NaI	Sodium Iodide
NE	North East wind sector
NNE	North North East wind sector
NNW	North North West wind sector
NRCC	National Research Council of Canada
NW	North West wind sector
OBT	Organically Bound Tritium
OPG	Ontario Power Generation
PN	Pickering Nuclear
PN1-4	Reactors 1 through 4 at the Pickering Nuclear Site
PN5-8	Reactors 5 through 8 at the Pickering Nuclear Site
PWMF	Pickering Waste Management Facility
QA	Quality Assurance
QC	Quality Control
REMP	Radiological Environmental Monitoring Program
S	South wind sector
SE	South East wind sector
SSE	South South East wind sector
SSW	South South West wind sector
SW	South West wind sector
TFWT	Tissue Free Water Tritium
TLD	Thermoluminescent Dosimeter
TRF	Tritium Removal Facility
TWh	Terawatt Hour
VBO	Vacuum Building Outage
W	West wind sector
w.e.	Water Equivalent
WNW	West North West wind sector
WPCP	Water Pollution Control Plant
WSP	Water Supply Plant
WSW	West South West wind sector
WWMF	Western Waste Management Facility

Appendix C: Maps of Environmental Monitoring and Critical Group Locations

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Figure C1 Darlington Nuclear Site Critical Groups and Environmental Monitoring Locations

0 1 2 3 4 km

LEGEND Data as of February, 2013

- MILK
- FRUIT / VEGETABLES
- WELL WATER
- LAKE WATER
- WATER SUPPLY PLANT
- HONEY
- PRECIPITATION
- PASSIVE C-14 (AIR)
- ACTIVE TRITIUM (AIR) / DRY-WET FALLOUT / TLD / NOBLE GAS / PRECIPITATION
- BEACH SAND / SOIL
- LAKE SEDIMENT
- ANIMAL FEED
- FISH NETTING LOCATIONS
- HOSPITAL
- TRANSMISSION LINES
- RAILROAD LINES
- Urban area
- Large industrial/ commercial buildings
- Potential Critical Group

NOTE: 1) Noble Gas monitors at Air Monitoring Stations 1, 2, 3, 4, 5, 6, 8
2) TLD's at locations R275 and DF5.
3) Precipitation/Fallout sampling included at Air Monitoring Stations 1, 3, and 4.
4) Sediment sampling performed every five years.

DF12 (15 km NW of DN site)

10.0 km

5.0 km

5.0 km

NNW N NW NNE WNW NE W ENE WSW SW SSW SSE SE ESE E

OSHAWA/COURTICE RESIDENT

RURAL RESIDENT

CAMPER

INDUSTRIAL/ COMMERCIAL

NON-DAIRY FARM

DAIRY FARM

FISHER

BOWMANVILLE RESIDENT

WEST/EAST BEACH RESIDENT

Oshawa WSP

Bowmanville WSP

Newcastle WSP (13 km ENE of DN site)

DF9 (13 km ENE of DN site)

DN

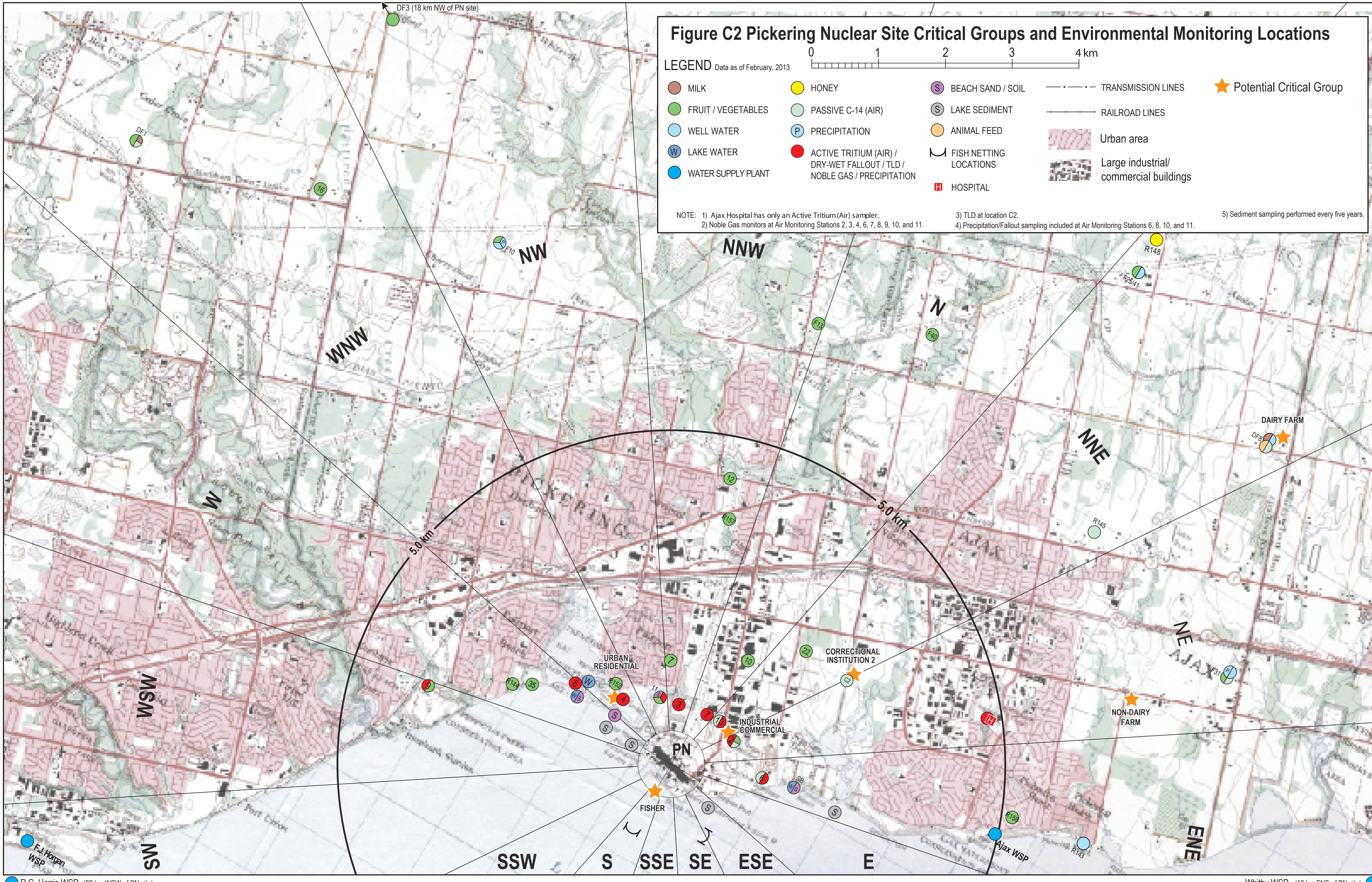
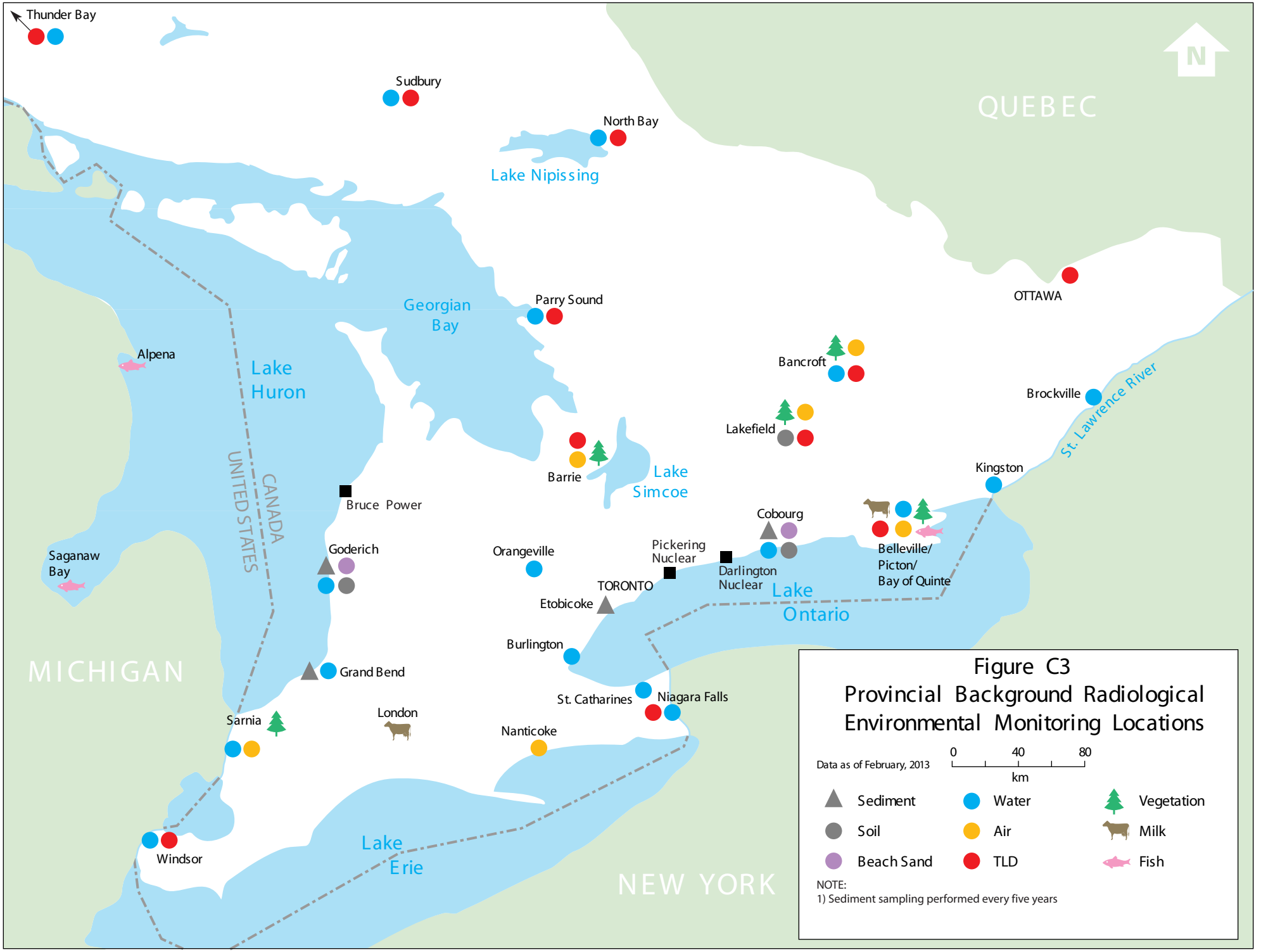


Figure C2 Pickering Nuclear Site Critical Groups and Environmental Monitoring Locations
LEGEND Data as of February, 2013
0 1 2 3 4 km
MILK
FRUIT / VEGETABLES
WELL WATER
LAKE WATER
WATER SUPPLY PLANT
HONEY
PASSIVE C-14 (AIR)
PRECIPITATION
ACTIVE TRITIUM (AIR) / DRY-WET FALLOUT / TLD / NOBLE GAS / PRECIPITATION
BEACH SAND / SOIL
LAKE SEDIMENT
ANIMAL FEED
FISH NETTING LOCATIONS
HOSPITAL
TRANSMISSION LINES
RAILROAD LINES
Urban area
Large industrial/ commercial buildings
Potential Critical Group
NOTE: 1) Ajax Hospital has only an Active Tritium (Air) sampler.
2) Noble Gas monitors at Air Monitoring Stations 2, 3, 4, 6, 7, 8, 9, 10, and 11.
3) TLD at location C2.
4) Precipitation/Fallout sampling included at Air Monitoring Stations 6, 8, 10, and 11.
5) Sediment sampling performed every five years.
DF3 (18 km NW of PN site)
DF1
16
NW
NNW
WNW
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
F10
R148
F25/41
F13
F40
DAIRY FARM
DF8
12
R157
R145
5.0 km
PICKERING
AJAX
URBAN RESIDENTIAL
CORRECTIONAL INSTITUTION 2
INDUSTRIAL COMMERCIAL
NON-DAIRY FARM
FISHER
PN
22
10
7
R144
35
R152
C2
F31
R158
R143
Ajax WSP
F.J. Horgan WSP
R.C. Harris WSP (22 km WSW of PN site)
Whitby WSP (12 km ENE of PN site)


Thunder Bay
Sudbury
North Bay
Lake Nipissing
QUEBEC
N
OTTAWA
Georgian Bay
Parry Sound
Alpena
Lake Huron
Bancroft
Brockville
St. Lawrence River
Lakefield
Barrie
Lake Simcoe
Kingston
CANADA
UNITED STATES
Bruce Power
Cobourg
Saganaw Bay
Goderich
Orangeville
Pickering Nuclear
Belleville/ Picton/ Bay of Quinte
Darlington Nuclear
TORONTO
Etobicoke
Lake Ontario
Burlington
MICHIGAN
Grand Bend
St. Catharines
Niagara Falls
Sarnia
London
Nanticoke
Windsor
Lake Erie
NEW YORK
Figure C3
Provincial Background Radiological Environmental Monitoring Locations
Data as of February, 2013
0
40
80
km
Sediment
Water
Vegetation
Soil
Air
Milk
Beach Sand
TLD
Fish
NOTE:
1) Sediment sampling performed every five years

Appendix D: Environmental Monitoring Data

Table D1: Tritium-in-Air Concentrations – 2012

DN REMP Locations		PN REMP Locations		Background Locations	
Location	Molecular Sieve Tritium-in-Air (Bq/m^3)[(a)]	Location	Molecular Sieve Tritium-in-Air (Bq/m^3)[(a)]	Location	Molecular Sieve Tritium-in-Air (Bq/m^3)[(a)]
D1	0.6	P10	8.6	Nanticoke	<0.1
D2	0.6	P11	2.4		
D3	0.4	Ajax Hospital	0.7		
D4	0.3	P2	10.4		
D5	0.3	P3	3.0		
D6	0.2	P4	1.1		
D8	0.2	P6	4.3		
		P7	5.1		
		P8	1.1		
		P9	0.9		
Boundary Location Average[(b)]	0.4	Boundary Location Average[(b)]	4.1	Average	<0.1

NOTES:
Bolded values are greater than Lc but less than Ld. "<"indicates less than Lc.

(a) Molecular Sieve Tritium Ld = 0.2 Bq/m^3 and Lc = 0.1 Bq/m^3

(b) DN Boundary Locations: D1, D2, D3, D4, D5, D6. PN Boundary Locations: P2, P3, P4, P6, P7, P8, P9, P10, P11.

Table D2: Carbon-14 in Air Concentrations – 2012

DN REMP Locations		PN REMP Locations		Background Locations	
Location	Passive Sampler C-14 in Air (Bq/kg-C)[(a)]	Location	Passive Sampler C-14 in Air (Bq/kg-C)[(a)]	Location	Passive Sampler C-14 in Air (Bq/kg-C)[(a)]
D1	254	C2	296	Bancroft	251
D2	255	DF1	232	Barrie	243
D6	244	DF8	236	Belleville	256
DF12	236	F31	249	Lakefield	238
DF5	238	P10	454	Lambton	224
DF7	270	P2	444	Picton	245
DF8	237	P6	324		
DF9	236	R145	237		
D5	228				
R2	232				
R27	261				
R275	252				
R329	256				
Boundary Location Average[(b)]	245	Boundary Location Average[(b)]	407	Average	243

NOTES:

(a) Bq/kg-C (Bq per kg of carbon). Ld for C-14 = 40 Bq/kg-C.

(b) DN Boundary Locations: D1, D2, D5, D6. PN Boundary Locations: P2,P6, P10.

Table D3: Noble Gas, Skyshine and I-131 Dose in Air – 2012

Boundary Locations	Total Measured Air Kerma Rates (µGy/yr)				
	Ar-41	I-131[(a)]	Ir-192	Xe-133	Xe-135
DN REMP					
D1	**0.035**	*0.018*	**0.027**	**0.003**	**0.008**
D2	**0.038**	*0.024*	**0.030**	**0.004**	**0.009**
D3	**0.038**	**0.020**	**0.032**	**0.005**	**0.011**
D4	**0.036**	**0.018**	**0.030**	**0.004**	**0.009**
D5	**0.035**	**0.018**	**0.032**	**0.004**	**0.009**
D6	**0.039**	**0.015**	**0.029**	**0.004**	**0.009**
D8	**0.037**	**0.014**	**0.028**	**0.004**	**0.009**
Average[(b)]	**0.037**	**0.016**	**0.030**	**0.004**	**0.009**
PN REMP					
P10	3.130	**0.012**	**0.024**	0.063	0.051
P11	1.077	**0.021**	**0.036**	0.013	0.025
P2	2.441	**0.020**	**0.031**	0.050	0.127
P3	1.435	**0.019**	**0.030**	0.029	0.031
P4	0.816	*0.023*	**0.030**	*0.007*	0.022
P6	1.402	**0.021**	**0.033**	0.026	0.077
P7	2.032	**0.018**	**0.028**	0.028	0.050
P8	0.666	**0.016**	**0.029**	0.010	0.019
P9	0.302	**0.015**	**0.029**	*0.006*	**0.009**
Average[(b)]	1.478	**0.018**	**0.030**	0.026	0.045

Notes:
Italicized values are greater than Lc but less than Ld. Bolded font indicates that the result is less than Lc, and Lc is reported here.

(a) In this context, dose means the air immersion effective dose from gamma radiation.

(b) Annual averages are calculated from monthly measurements and compared with the average Lc or Ld to determine how they will be reported.

Table D4: TLD External Gamma Measurements – 2012

DN REMP Locations		PN REMP Locations		Background Locations	
Location	Annual Dose in Air (µGy/yr)[c]	Location	Annual Dose in Air (µGy/yr)[c]	Location	Annual Dose in Air (µGy/yr)
D1	500	C2	566	Bancroft	571
D2	532	P10	400	Barrie	527
D3	544	P11	510	Belleville	582
D4	474	P2	462	Lakefield	561
D5	496	P3	454	Niagara Falls	397
D6	542	P4	466	North Bay	542
D8	510	P6	558	Ottawa	450
DF5	544	P7	416	Parry Sound	480
R275	564	P8	426	Sudbury	571
		P9	470	Thunder Bay	523
				Windsor	442
Boundary Location Average[a]	515	Boundary Location Average[a]	462	Average[b]	506

NOTES:

(a) DN Boundary Locations: D1, D2, D3, D4, D5, D6. PN Boundary Locations: P2, P3, P4, P6, P7, P8, P9, P10, P11.

(b) Bancroft and Thunder Bay are excluded from the average due to historically higher than normal levels of natural radioactivity that are inappropriate to be used in comparison with nuclear facility results [R-24].

(c) PN and DN data is projected for the year based on Q1 and Q2 data. TLDs discontinued starting in Q3.

Table D5: Tritium in Precipitation and Gross Beta in Wet/Dry Fallout – 2012

DN REMP Locations			PN REMP Locations		
Location	Average Tritium Concentration in Precipitation (Bq/L)[(a)(d)]	Average Gross Beta Deposition Rate (Bq/(m^{2}month))[(b)(d)]	Location	Average Tritium Concentration in Precipitation (Bq/L)[(a)(d)]	Average Gross Beta Deposition Rate (Bq/(m^{2}month))[(b)(d)]
D1	28	14.7	P10	435	14.3
D3	20	15.5	P11	249	14.2
D4	16	15.9	P6	189	16.0
DF12	9	NR	P8	224	30.1
DF8	6	NR	F10	21	NR
			F31	18	NR
Boundary Location Average[(c)]	21	15.3	Boundary Location Average[(c)]	274	18.7

NOTES: NR = Not Required by Program

Bolded values are greater than Lc but less than Ld. "<"indicates less than Lc.

(a) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L.

(b) Ld for gross beta = 0.03 Bq/L and Lc = 0.02 Bq/L.

(c) DN Boundary Locations: D1, D3, D4. PN Boundary Locations: P6, P8, P10, P11.

(d) Averages based on Q1 and Q2 data only. Precipitation and wet/dry fallout sampling discontinued as of Q3.

Table D6: Inland Soils and Garden Soils – 2012

Location	Sample Type	Gamma Analysis (Bq/kg dw)[a]					
		Co-60 Result	Cs-134 Result	Cs-137 Result	Cs-137 Uncertainty (±2σ)	K-40 Result	K-40 Uncertainty (±2σ)
DN REMP							
F16	Soil - Undisturbed	< 0.2	< 0.3	2.4	0.2	615.0	8.6
F16	Soil - Irrigated	< 0.2	< 0.3	4.5	0.2	621.3	7.2
R2	Soil - Irrigated	< 0.2	< 0.3	4.3	0.2	803.4	7.5
R316	Soil - Irrigated	< 0.2	< 0.3	3.3	0.2	738.9	7.5
PN REMP							
P11	Soil - Undisturbed	< 0.2	< 0.3	5.1	0.2	688.5	7.0
P11	Soil - Irrigated	< 0.2	< 0.3	3.1	0.2	542.7	7.4
Background Locations							
Cobourg (A)	Soil - Undisturbed	< 0.2	< 0.3	3.3	0.2	620.2	8.0
Cobourg (B)	Soil - Undisturbed	< 0.2	< 0.2	3.5	0.2	638.7	7.1
Goderich (A)	Soil - Undisturbed	< 0.2	< 0.2	< 0.2	NA	302.5	5.8
Goderich (B)	Soil - Undisturbed	< 0.1	< 0.1	0.5	0.1	327.3	4.5
Lakefield (A)	Soil - Undisturbed	< 0.1	< 0.2	5.9	0.3	749.0	7.5
Lakefield (B)	Soil - Undisturbed	< 0.1	< 0.4	5.9	0.3	706.2	9.5

NOTES:

a) For gamma analysis, "<" indicates less than Ld.

Table D7: Terrestrial Biota – 2012

DN REMP Locations				
Location	HTO (Bq/L)[a]		C-14 (Bq/kg-C)[a]	
	Result	Uncertainty (±2σ)	Result	Uncertainty (±2σ)
Fruit[b]				
DF7	4.9	2.3	253	20
DF9	7.9	2.4	243	20
F18	6.9	2.4	254	21
F26	8.5	2.5	242	20
R122	8.7	2.5	251	21
R19	14.3	2.7	249	21
R2	22.8	3.1	234	20
R228	16.6	2.9	268	21
R24	10.3	2.6	244	21
R27	20.2	3.0	255	22
R275	17.9	2.9	246	20
R335	22.6	3.1	265	21
R35	9.0	2.5	241	21
R39	13.5	2.7	243	20
R63	10.1	2.5	251	20
Vegetables[b]				
DF2	6.5	2.3	202	20
F13	6.5	2.3	219	21
F16	11.0	2.5	227	21
F25	10.0	2.5	223	20
R19	10.4	2.5	233	20
R2	15.8	2.8	243	20
R228	13.3	2.7	214	20
R275	24.9	3.2	215	20
R335	18.7	2.9	231	21
R356	8.1	2.4	215	19
R358	13.1	2.7	219	20
Average[c]	12.8	2.6	238	20
Animal Feed				
DF12	10.3	2.5	245	21
DF5	19.6	2.8	238	20
DF7	25.5	3.0	278	23
DF8	12.3	2.6	240	21
DF9	**3.1**	2.2	208	20

PN REMP Locations						
Location	HTO (Bq/L)[a]		C-14 (Bq/kg-C)[a]		OBT (Bq/L (w.e.))	
	Result	Uncertainty (±2σ)	Result	Uncertainty (±2σ)	Result	Uncertainty (±2σ)
Fruit[b]						
F10	18.1	3.2	261	20	41	3
F31	25.0	3.5	278	22	NR	NR
LOC10	104.0	6.0	375	24	NR	NR
LOC12	42.4	4.2	280	22	NR	NR
LOC22	73.1	5.1	330	23	68	3
LOC35	89.8	5.6	303	22	NR	NR
LOC7	83.7	5.4	331	23	NR	NR
R152	60.6	4.8	284	21	NR	NR
Vegetables[b]						
DF1	8.4	2.5	238	20	NR	NR
DF3	6.5	2.4	249	20	NR	NR
F13	10.4	2.6	254	20	NR	NR
F40	16.1	2.9	271	22	NR	NR
F41	11.2	2.7	236	20	21	3
LOC16	7.2	2.5	228	20	15	2
P11	204.8	7.6	413	24	NR	NR
P9	77.9	5.0	286	22	NR	NR
R144	59.1	4.4	265	21	NR	NR
R157	20.1	3.1	277	21	NR	NR
R158	22.5	3.2	218	18	NR	NR
Average[c]	49.5	4.0	283	21	36	3
Animal Feed						
DF8	24.5	3.0	236	21	NR	NR

Background Locations						
Location	HTO (Bq/L)[a]		C-14 (Bq/kg-C)[a]		OBT (Bq/L (w.e.))	
	Result	Uncertainty (±2σ)	Result	Uncertainty (±2σ)	Result	Uncertainty (±2σ)
Vegetables[b]						
Bancroft	**0.6**	2.1	232	21	6	2
Barrie	**1.9**	2.2	248	21	7	2
Lakefield	**2.6**	2.2	253	22	12	2
Picton	**1.6**	2.2	249	21	7	2
Sarnia	**1.7**	2.2	243	21	8	2
Average	**1.7**	2.2	245	21	8	2

NOTES:

NR = Not Required by Program. Bolded values are greater than Lc but less than Ld. "<"indicates less than Lc.

(a) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L. Ld for C-14 = 40 Bq/kg-C.

(b) Composite vegetables are from the following categories: Above ground (e.g., cucumber, zucchini, tomato, beans and peppers); Below ground (e.g., onion, potato, beet and carrot);Leafy (e.g., chard, cabbage, parsley, sorrel, rhubarb and beet leaves). Two of the three types (i.e., above ground, below ground or leafy) are required to form a valid composite. Typical fruits collected are apples, pears, berries, chestnuts and grapes.

(c) Annual averages for vegetation include fruits and vegetables.

Table D8: Terrestrial Biota (Honey) – 2012

Location	HTO (Bq/L)[(b)]		C-14 (Bq/kg-C)[(b)]		Gamma Analysis (wet weight) (Bq/kg)[(a)]				
	Result	Uncertainty (±2σ)	Result	Uncertainty (±2σ)	Co-60 Result	Cs-134 Result	Cs-137 Result	K-40 Result	K-40 Uncertainty (±2σ)
DN REMP									
F27	15.9	2.7	246	21	<0.1	<0.1	<0.1	44.2	1.8
R32	44.2	3.6	250	20	<0.1	<0.1	<0.1	18.3	1.5
R326	16.9	2.7	273	22	<0.1	<0.1	<0.1	29.8	2.3
PN REMP									
R148	26.4	3.1	280	22	<0.1	<0.1	<0.1	30.4	1.7

NOTES:
NR = Not Required by Program
(a) For gamma analysis, "<" indicates less than Ld.
(b) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L. Ld for C-14 = 40 Bq/kg-C. Bolded values are greater than Lc but less than Ld. "<"indicates less than Lc.

Table D9: Annual Average Concentrations in Milk – 2012

Location	HTO (Bq/L)[a][b]	C-14 (Bq/kg-C)[a][b]	I-131 (Bq/L)[c]	OBT (Bq/L w.e.)
	Result	Result	Result	Result
DN REMP				
DF12	7.1	248		
DF5	**4.0**	257		
DF7	**3.1**	264		NR
DF8	4.7	256		
DF9	**4.2**	269		
Average	4.6	259	<0.1	NR
PN REMP				
DF1	14.1	257		NR
DF8	15.7	260		18
Average	14.9	259	<0.1	18
Background Locations				
Belleville	<2.3	258	<0.1	NR
London	<2.3	243	<0.2	
Average[d]	<2.3	250	<0.2	NR

NOTES:
NR = Not Required by Program

(a) Weekly samples are used to form monthly composite samples at each farm for HTO and C-14 analysis.
(b) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L. Ld for C-14 = 40 Bq/kg-C. Bolded values are greater than Lc but less than Ld. "<"indicates less than Lc.
(c) For I-131, "<" indicates less than Ld. Weekly samples from all farms are combined to form a weekly composite for I-131 analysis. The annual average I-131 concentration is presented in the table.The background average tritium concentration is calculated from the actual measurements and then compared to the Lc and Ld.

Table D10: Drinking Water and Lake Water – 2012

DN REMP Locations			PN REMP Locations			Background Locations		
Location	Annual Average Gross Beta Activity Concentration (Bq/L)[b]	Annual Average Tritium Concentration (Bq/L)[a]	Location	Annual Average Gross Beta Activity Concentration (Bq/L)[b]	Annual Average Tritium Concentration (Bq/L)[a]	Location	Annual Average Gross Beta Activity Concentration (Bq/L)[b]	Annual Average Tritium Concentration (Bq/L)[a]
WSP			**WSP**			Bancroft	0.06	<2.3
Bowmanville WSP	0.11	**4.5**	Ajax WSP	0.11	4.4	Belleville	0.05	**3.3**
Newcastle WSP	0.10	4.6	F. J. Horgan WSP	0.11	4.9	Cobourg	0.11	**4.0**
Oshawa WSP	0.10	6.2	R.C. Harris WSP	0.11	4.8	Brockville WSP	0.10	**2.8**
			Whitby WSP	0.12	5.0	Burlington WSP	0.11	**3.9**
Well Water			**Well Water**			Goderich WSP	0.07	**3.7**
DF12	0.36	5.8	DF8	NR	13.3	Kingston WSP	0.10	**3.0**
DF5	0.08	<2.3	F10	NR	8.4	London WSP	0.07	**3.7**
DF7	0.22	<2.3	F25	NR	<2.3	Niagara Falls WSP	0.10	**2.7**
DF8	0.17	**3.1**	F31	NR	14.4	North Bay	0.04	<2.3
DF9	0.06	<2.3	R143	NR	14.9	Orangeville	0.07	<2.3
F15	0.04	<2.3				Parry Sound	0.04	**2.7**
R2	4.58	25.3				Sarnia	0.06	**3.5**
R279	0.07	<2.3				St. Catherines	0.08	**2.3**
R29	0.12	<2.3				Sudbury	0.04	<2.3
R294	0.10	12.4				Thunder Bay	0.04	<2.3
R316	0.06	10.5				Windsor	0.10	**3.8**
R320	0.05	9.4						
R329	0.82	9.3						
R47	0.08	9.2						
Lake Water[c]			**Lake Water[c]**					
Darlington Provincial Park	0.12	8.6	Beach Point Promenade	NR	18.8			
McLaughlin Bay	0.19	18.0	Frenchman's Bay	NR	23.4			
West/East Beach	0.12	5.3	Squires Beach	NR	17.8			

NOTES:
NR = Not Required by Program
Bolded values are greater than Lc but less than Ld. "<"indicates less than Lc.

(a) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L.
(b) Ld for gross beta = 0.03 Bq/L and Lc = 0.02 Bq/L.
(c) Samples are not required during the winter months.

Table D11: Lake Fish – 2012

DN REMP													
Location	HTO (Bq/L)[a]		C-14 (Bq/kg-C)[a]		Gamma Analysis (wet weight) (Bq/kg)[b]						OBT Composites (Bq/L [water equivalent (w.e.)])	
	Result	Uncertainty (±2σ)	Result	Uncertainty (±2σ)	Co-60 Result	Cs-134 Result	Cs-137 Result	Cs-137 Uncertainty (±2σ)	K-40 Result	K-40 Uncertainty (±2σ)	Result	Uncertainty (±2σ)
DN Diffuser (White Sucker) - A	8.4	2.9	264	21	< 0.1	< 0.1	0.2	0.1	133.6	3.8		
- B	7.4	2.9	249	20	< 0.1	< 0.1	< 0.1	NA	133.8	3.4		
- C	5.5	2.8	244	20	< 0.1	< 0.1	0.2	0.1	126.8	2.9		
- D	4.6	2.7	245	21	< 0.1	< 0.1	< 0.1	NA	125.3	3.3	12	2
- E	**4.2**	2.7	274	21	< 0.1	< 0.1	0.1	0.1	126.2	2.9		
- F	**4.1**	2.7	275	21	< 0.1	< 0.1	0.1	0.1	125.1	2.9		
- G	**3.4**	2.7	265	21	< 0.1	< 0.1	< 0.1	NA	124.2	2.9		
- H	6.0	2.8	265	21	< 0.1	< 0.1	0.2	0.1	116.7	3.6		
Average	5.5	2.8	260	21	<0.1	<0.1	0.2	0.1	126.4	3.2	12	2
McLaughlin Bay - A	15.5	3.1	222	20	< 0.1	< 0.1	< 0.1	NA	102.5	2.9		
- B	15.5	3.1	244	21	< 0.1	< 0.1	< 0.1	NA	95.6	2.4	35	3
- C	17.6	3.2	210	20	< 0.1	< 0.1	< 0.1	NA	99.6	3.3		
- D	18.3	3.2	235	21	< 0.1	< 0.1	< 0.1	NA	107.8	2.7		

NOTES:

(a) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L. Ld for C-14 = 40 Bq/kg-C. Bolded values are greater than Lc but less than Ld. "<"indicates less than Lc.

(b) For gamma analysis, "<" indicates less than Ld.

Table D11: Lake Fish – 2012 (Continued)

PN REMP												
Location	HTO (Bq/L)[a]		C-14 (Bq/kg-C)[a]		Gamma Analysis (wet weight) (Bq/kg)[b]						OBT Composites (Bq/L [water equivalent (w.e.)])	
	Result	Uncertainty (±2σ)	Result	Uncertainty (±2σ)	Co-60 Result	Cs-134 Result	Cs-137 Result	Cs-137 Uncertainty (±2σ)	K-40 Result	K-40 Uncertainty (±2σ)	Result	Uncertainty (±2σ)
Pickering 5-8 Outfall (White Sucker) - A	9.9	3.0	270	21	<0.1	<0.1	0.2	0.1	143.4	3.1	15	2
- B	9.1	3.0	255	21	<0.1	<0.1	0.2	0.1	128.6	3.0		
- C	8.8	2.9	269	21	<0.1	<0.1	0.2	0.1	117.4	3.5		
- D	14.4	3.2	270	21	<0.1	<0.1	0.2	0.1	131.1	3.3		
- E	9.2	3.0	259	21	<0.1	<0.1	0.2	0.1	120.4	3.6		
- F	8.8	2.9	270	21	<0.1	<0.1	0.3	0.1	131.5	3.0		
- G	10.4	3.0	264	21	<0.1	<0.1	0.2	0.1	122.4	2.7		
- H	7.9	2.9	267	21	<0.1	<0.1	0.2	0.1	133.3	2.9		
Average	9.8	3.0	265	21	<0.1	<0.1	0.2	0.1	128.5	3.1	15.0	2.4

NOTES:
(a) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L. Ld for C-14 = 40 Bq/kg-C. Bolded values are greater than Lc but less than Ld. "<"indicates less than Lc.
(b) For gamma analysis, "<" indicates less than Ld.

Table D11: Lake Fish – 2012 (Continued)

Background Locations												
Location	HTO (Bq/L)[a]		C-14 (Bq/kg-C)[a]		Gamma Analysis (wet weight) (Bq/kg)[b]						OBT Composites (Bq/L [water equivalent (w.e.)])	
	Result	Uncertainty (±2σ)	Result	Uncertainty (±2σ)	Co-60 Result	Cs-134 Result	Cs-137 Result	Cs-137 Uncertainty (±2σ)	K-40 Result	K-40 Uncertainty (±2σ)	Result	Uncertainty (±2σ)
Lake Ontario (US) Far Field (White Sucker) -A	4.7	2.2	242	21	< 0.1	< 0.1	0.4	0.1	116.8	3.5	9	2
- B	5.1	2.2	226	19	< 0.1	< 0.1	0.2	0.1	123.1	3.2		
- C	6.9	2.3	249	21	< 0.1	< 0.1	0.4	0.1	132.1	2.9		
- D	**3.4**	2.1	248	21	< 0.1	< 0.1	0.6	0.1	123.4	2.9		
- E	**4.3**	2.1	254	21	< 0.1	< 0.1	0.5	0.1	115.9	3.1		
- F	5.8	2.2	253	21	< 0.1	< 0.1	0.5	0.1	122.7	2.8		
- G	5.3	2.2	249	21	< 0.1	< 0.1	0.5	0.1	126.7	3.0		
- H	2.9	2.1	244	21	< 0.1	< 0.1	0.3	0.1	111.2	3.4		
Average	**4.8**	2.2	246	21	<0.1	<0.1	0.4	0.1	121.5	3.1	8.6	2.2

NOTES:
(a) Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L. Ld for C-14 = 40 Bq/kg-C. Bolded values are greater than Lc but less than Ld. "<"indicates less than Lc.
(b) For gamma analysis, "<" indicates less than Ld.

Table D12: Lake Sediment

Location	C-14 Composites (Bq/kg-C)[b]		Gamma Analysis (Bq/kg dw)[a]					
	Result	Uncertainty (±2σ)	Co-60 Result	Cs-134 Result	Cs-137 Result	Cs-137 Uncertainty (±2σ)	K-40 Result	K-40 Uncertainty (±2σ)
DN REMP								
Darlington Provincial Park - A	134	27	< 0.1	< 0.1	0.5	0.1	343.5	4.3
- B			< 0.2	< 0.2	0.5	0.1	319.5	5.7
- C			< 0.1	< 0.1	0.4	0.1	351.5	5
- D			< 0.2	< 0.2	0.5	0.1	354.2	5.1
DN Diffuser - A	193[c]	27	< 0.2	< 0.1	0.8	0.1	392	6.3
- B			< 0.1	< 0.1	0.5	0.1	363.8	5.1
- C			< 0.2	< 0.1	1.3	0.1	472.9	5.6
- D			< 0.2	< 0.2	0.8	0.2	408.6	6.4
Port Darlington - A	153	28	< 0.2	< 0.1	0.3	0.1	376.5	5.5
- B			< 0.2	< 0.2	0.3	0.1	406.1	6.6
- C			< 0.2	< 0.2	0.3	0.1	399.3	6.6
- D			< 0.1	< 0.1	0.3	0.1	408.3	5.6
PN REMP								
Duffin's Creek - A	104	26	< 0.2	< 0.2	0.3	0.2	382	6.3
- B			< 0.2	< 0.1	< 0.2		401.6	5.6
- C			< 0.1	< 0.2	0.3	0.1	372.6	6.1
- D			< 0.2	< 0.1	0.3	0.1	385.4	5.3
Liverpool Road Beach - A	195	28	< 0.1	< 0.1	1.6	0.2	409.7	5.5
- B			< 0.2	< 0.2	1.8	0.2	411.1	6.5
- C			< 0.2	< 0.2	1.6	0.2	401	6.5
- D			< 0.2	< 0.2	1.6	0.2	421.4	5.6
Pickering 1-4 Outfall - A	281[d]	31	< 0.1	< 0.1	1.4	0.1	396.7	4.8
- B			< 0.1	< 0.1	1.7	0.1	406.9	5.6
- C			< 0.2	< 0.2	1.3	0.2	340.1	5.9
- D			< 0.1	< 0.1	1.4	0.1	383.2	4.7
Pickering 5-8 Outfall - A	204[e]	30	< 0.1	< 0.2	1.8	0.1	410.5	4.7
- B			< 0.1	< 0.1	1.3	0.1	377.4	5.3
- C			< 0.1	< 0.1	1.5	0.1	414	4.9
- D			< 0.2	< 0.1	1.3	0.2	367.8	6.1
Background Locations								
Cobourg - A	190[f]	27	< 0.1	< 0.1	0.9	0.1	503.4	5.7
- B			< 0.2	< 0.1	0.7	0.1	468.5	6.1
- C			< 0.2	< 0.2	1	0.2	464.6	7.5
- D			< 0.2	< 0.2	1	0.1	473	6.4
Marie Curtis Park - A	NR	NR	< 0.2	< 0.1	0.7	0.1	574	6.1
- B			< 0.2	< 0.2	0.5	0.1	504.3	7.4
- C			< 0.1	< 0.2	0.6	0.1	528.9	6.7
- D			< 0.1	< 0.2	0.4	0.1	485.3	5.3

NOTES:
Starting in 2009, the frequency of lake sediment sampling for REMP has been reduced to once every five years. The data presented here is from 2009.

(a) For gamma analysis, "<" indicates less than Ld.
(b) Ld for C-14 = 40 Bq/kg-C.
(c) The total organic carbon content of the DN Diffuser composite sediment samples was 5,100 ppm.
(d) The total organic carbon content of the PN "A" discharge sediment samples was 1,100 ppm.
(e) The total organic carbon content of the PN "B" discharge composite sediment samples was 1,000 ppm.
(f) The total organic carbon content of the Cobourg composite sediment samples was 7,200 ppm.

Table D13: Beach Sand – 2012

Location	Gamma Analysis (Bq/kg dw)[a]					
	Co-60 Result	Cs-134 Result	Cs-137 Result	Cs-137 Uncertainty (±2σ)	K-40 Result	K-40 Uncertainty (±2σ)
DN REMP						
Darlington Provincial Park[b]	< 0.1	< 0.2	< 0.2	NA	429.4	6.6
Darlington Provincial Park[b]	< 0.2	< 0.2	< 0.1	NA	371.9	4.6
West/East Beach	< 0.1	< 0.1	0.3	0.1	403.8	4.8
PN REMP						
Beach Point Promenade	< 0.1	< 0.1	0.7	0.1	393.6	4.7
Liverpool Road Beach	< 0.1	< 0.1	0.4	0.1	280.4	3.9
Squire Beach	< 0.1	< 0.2	0.5	0.1	409.7	4.7
Background Locations						
Cobourg [A]	< 0.2	< 0.3	0.5	0.2	334.6	6.0
Cobourg [B]	< 0.1	< 0.1	0.5	0.1	356.5	4.5

NOTES:
(a) For gamma analysis, "<" indicates less than Ld.
(b) Darlington Provincial Park samples are for 2nd and 3rd quarters, respectively.

Table D14: Pickering Nuclear Sewage Effluent Results – 2012

Location		HTO (Bq/L)[a]		C-14 (Bq/L)[a]		Gamma Analysis (wet weight) (Bq/kg)[b]				
		Result	Uncertainty (±2σ)	Result	Uncertainty (±2σ)	Co-60 Result	Cs-134 Result	Cs-137 Result	I-131 Result	K-40 Result
PN Sewage Effluent	Quarter 1[c]	3,788	30	<2.3	1.0					
	Quarter 2[c]	6,652	42	<2.3	1.2					
	Quarter 3[c]	4,667	37	<2.3	1.0					
	Quarter 4[c]	4,632	35	<2.3	1.1					
	Annual Average	4,935	36	<2.3	1.1	**0.1**	**0.2**	0.4	**0.4**	7.5
Duffin Creek Water Pollution Control Plant Ash[d]	Annual Average	NR				**0.3**	**0.6**	0.6	6.0	228.0

NOTES:
NR = Not Required by Program

(a) Ld for C-14 is 4.5 Bq/L and Lc is 2.3 Bq/L. Ld for tritium = 4.5 Bq/L and Lc = 2.3 Bq/L. Bolded values are greater than Lc but less than Ld. "<"indicates less than Lc.
(b) Annual average of PN Site Sewage Effluent weekly sample results. The sewage stream is treated at the Duffin Creek WPCP. For gamma analysis, bolded font indicates less than Ld.
(c) Quarterly composite samples are prepared from weekly samples.
(d) The ash samples contain elevated concentrations of natural background and medical source radionuclides. The low Cs-137 levels detected are believed to be from atmospheric testing of nuclear weapons from the 1960's.

Appendix E: Potential Critical Group Descriptions

E.1.0 DARLINGTON NUCLEAR POTENTIAL CRITICAL GROUPS

Nine potential critical groups are identified for Darlington Nuclear and are shown in Figure C1 (see Appendix C, Maps of Environmental Monitoring and Critical Group Locations). All of the potential critical groups, with exception of the Industrial/Commercial critical group, consume some locally caught fish near the DN diffuser or in McLaughlin Bay. All critical groups with the exception of the Fisher and Industrial/Commercial critical groups are assumed to be exposed to local beach sand (Darlington Provincial Park). The one-year old infant is assumed to drink cow's milk and water (not infant formula). For all potential critical groups except the dairy farm infant, who drinks fresh local cow's milk, the assumption is made that the milk is a composite from dairy farms all over Ontario which are not affected by station operations.

Based on the site-specific survey review [R-1], a small fraction of residents from the Oshawa/Courtice, Bowmanville, West/East Beach, and Rural Resident potential critical groups work within 5 km of DN. In addition, a small fraction of Industrial/Commercial workers reside close to DN. Therefore, the average Adult doses for these groups have been adjusted to account for the exposure this portion of population receives while at work and at home.

The DN potential critical groups are described as follows:

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(e) 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.

(f) The **Rural Residents** potential critical group consists 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.

(g) The **Industrial/Commercial** potential critical group consists of adult workers whose work location is close to the nuclear site. The closest location for this group is the St. Mary's 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.

(h) The **Sport 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.

(i) 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.

E.2.0 PICKERING NUCLEAR POTENTIAL CRITICAL GROUPS

Six potential critical groups are identified for Pickering Nuclear and are shown in Figure C2 (see Appendix C). The one-year old infant is assumed to drink cow's milk and water (not infant formula). For all potential critical groups except the dairy farm infant, who drinks fresh local cow's milk, the assumption is made that the milk is a composite from dairy farms all over Ontario which are not affected by station operations.

Based on the site-specific survey [R-13], a small fraction of Industrial/Commercial workers reside close to PN. Similarly, a fraction of residents from the Urban Resident potential critical group work within 5 km of PN. Therefore, the average Adult doses for these groups have been adjusted to account for the exposure this portion of population receives while at work and at home.

The PN potential critical groups are described as follows.

(a) The **C2** potential critical group consists of inhabitants at a correctional institute, located approximately 3 km NNE of the PN Site. The C2 group obtains drinking water from the Ajax WSP and does not consume locally produced fruits or vegetables. The C2 resident is conservatively assumed to be at this location 100 percent of the time over at least one year.

(b) The **Industrial/Commercial** potential critical group consists of adult workers whose work location is close to the nuclear site. Members of this group are typically at this location about 23% of the time. They consume water from the Ajax WSP. The closest location for this group is about 1 km NNE of the site.

(c) The **Urban Residents** potential critical group consists of Pickering and Ajax area residents which surround the PN Site (e.g., Fairport, Fairport Beach, Rosebank, Liverpool, Pickering Village, etc.). The members of this group mostly consume water from the Ajax WSP and also consume a diet composed in part of locally grown produce and some locally caught fish. Members of this potential critical group are also externally exposed to beach sand at local beaches (Beachpoint Promenade, Liverpool Rd. Beach or Squires Beach).

(d) The **Farm** potential critical group consists of residents of agricultural farms (but not dairy farms) within a 10 km radius of the PN Site. Members of this group obtain most of their water supply from wells but also a portion from the Ajax WSP. Members of this potential critical group consume locally grown produce and animal products, as well as locally caught fish. They are also externally exposed to beach sand at local beaches (Beachpoint Promenade, Liverpool Rd. Beach or Squires Beach).

(e) The **Dairy Farm** potential critical group consists of residents of dairy farms within a 20 km radius of the PN Site. This group obtains most of their water supply from local wells. They also consume locally grown fruit and vegetables and locally produced animal products, including fresh cow's milk. Members of this potential

critical group are also externally exposed to beach sand at local beaches (Beachpoint Promenade, Liverpool Rd. Beach or Squires Beach).

(f) The **Sport Fisher** potential critical group is comprised of non-commercial individuals fishing near the PN site outfalls, 0.5 km S of the PN site. Members of this group were conservatively assumed to obtain their entire amount of fish for consumption from the vicinity of the PN site and spend 1% of their time at the outfall location where atmospheric exposure occurs.

Appendix F: Dose Calculation Procedure and Concentrations

F.1.0 CRITICAL GROUP DOSE CALCULATION PROCEDURE

The dose calculations were performed according to N-INS-03481.21-10000, Methodology for Data Analysis and Public Dose Determination for the Radiological Environmental Monitoring Program [R-9]. Deviations from this methodology are listed below. However, the methodology used is consistent with CSA N288.1-08 [R-11] and software used for dose calculation, IMPACT 5.4.0, is also compliant with CSA N288.1-08.

- An update to N288.1-08 was issued in 2011. Only one change in this update affects the dose calculation and it is related to the parameters used for beef cows consuming dry feed. Given that use of the existing parameters produces a conservative dose estimate, this change has not yet been applied and will be incorporated for future dose assessments.

- OBT doses from terrestrial animals and terrestrial plants were modeled using HTO concentrations measured in terrestrial samples at the critical groups. OBT doses from fish were modeled from HTO concentrations in fish.

- HTO and C-14 concentrations in terrestrial animal products other than milk are modeled from measured concentrations of HTO and C-14 in animal feed, forage, air and water. The concentrations are used to calculate the dose from ingestion of animal products. The dose resulting from I(mfp) and particulate is modeled from emissions and empirical Ka values and the ratio of modeled Ka values for the boundary monitor location and the critical group location.

- Location specific measures of each radionuclide were used in the potential critical group calculations where the group occupied a relatively small geographic location. Some groups such as the Farm, Dairy Farm or Urban Resident are spread over much wider geographic areas, and for these the maximum value of all measurements for members of the group was used in order to keep the calculated doses conservative.

- Only dairy farm residents ingest local cow's milk.

- People are generally assumed to be at the critical group location 100% of the time, with the exception of the Industrial/Commercial workers and the Fisher groups. Details are provided in Appendix E. Based on the site specific surveys, a small fraction of residential critical group members at both PN and DN work within 5 km of the station. In addition, a small fraction of Industrial/Commercial workers reside close to the station at both PN and DN. Therefore, the average Adult doses for these groups have been adjusted at both PN and DN to account for the exposure this portion of the population receives while at work and at home.

- No local grain products are consumed by humans.

- The Fisher critical group is located offshore and it is impractical to measure radionuclide concentrations in the air at that location. Therefore, air concentrations are modeled from emissions for this critical group location, while fish concentrations are measured.

F.2.0 CRITICAL GROUP RADIONUCLIDE CONCENTRATIONS AND BACKGROUND SUBTRACTIONS

The following section details how the radionuclide concentrations are determined, whether they are measured or modeled, and any calculations made to obtain results.

A summary on the radionuclides and pathways measured and modeled in the critical group dose calculation is presented in Table F1. DRL Guidance document [R-14] provides a description of each pathway.

Table F1: Radionuclide and Pathway Data Used in the Critical Group Dose Calculation

Pathway	Radionuclide	Modeled[a]	Measured
Air Inhalation	HTO	✓(Fisher)	✓
	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(mfp)	✓	
	Cs-137+, Co-60	✓	
Sand External Exposure	C-14	✓	
	I(mfp)	✓	
	Cs-137+		✓
Water External Exposure (Lakes, WSPs, Wells)	HTO	✓(wells)	✓
	C-14	✓	
	I(mfp)	✓	
	Cs-137+	✓	
Terrestrial Animals Ingestion	HTO	✓	✓(milk)
	C-14	✓	✓(milk)
	I(mfp)	✓	
	Cs-137+, Co-60	✓	
	OBT	✓[d]	
Terrestrial Plants Ingestion	HTO		✓
	C-14		✓
	I(mfp)	✓	
	Cs-137+, Co-60	✓	
	OBT	✓[d]	
Aquatic Animals Ingestion	HTO		✓
	C-14		✓
	I(mfp)	✓	
	Cs-137+		✓
	OBT	✓[d]	
Sand and Soil Incidental Ingestion	HTO	✓	
	C-14	✓	
	I(mfp)	✓	
	Cs-137+, Co-60	✓	✓(sand)
Water Ingestion (WSPs, Wells)	HTO		✓
	C-14	✓	
	I(mfp)	✓	
	Cs-137+	✓	

"+" indicates that contributions from progeny are included.

(a) Modeling is based on emissions or from local air measurements where they are available.
(b) Concentrations are modeled from emissions and adjusted using empirical Ka determined for each critical group location.
(c) Doses are measured directly at the site boundary and adjusted to critical group locations using the ratio of modeled air dispersion factors for the boundary monitor and critical group.
(d) OBT dose is modeled from HTO concentration in terrestrial plants, terrestrial animals, or fish respectively.

F.2.1 Tritium

For the purpose of estimating the critical group dose, the concentrations used in the corresponding pathways were determined as follows:

Air – Tritium-in-air is measured at boundary locations with measured background tritium-in-air subtracted, and these values are used to estimate concentrations at each critical group location using the ratio of modeled atmospheric dispersion factors for the boundary monitor location and the critical group location (except for the Fisher critical group where it is modeled from emissions).

Concentrations of radionuclides in air that are not monitored at boundary sites or critical groups are obtained for the critical group location as follows:

The concentrations at the boundary monitor sites are estimated using their emissions data and empirical Ka values obtained from HTO emissions and HTO boundary monitor measurements. The concentrations at critical group locations are modeled from the empirically estimated boundary location concentration by using the ratio of modeled air dispersion factors for the boundary monitor location and the critical group location.

- **Water** – Drinking water is sampled and measured at the local WSPs and also at wells where local residents obtain their water. For the WSPs, the annual average concentration is used with background tritium concentration subtracted. The background tritium concentration is calculated for natural and weapons fallout contributions using the Great Lakes Time-Concentration Tritium Model [R-6]. For wells, the maximum annual average concentration found at each critical group is used and background is assumed to be zero. Tritium concentration in wells used for purposes other than drinking water is modeled. Lake water HTO concentrations are measured monthly and used to calculate the dose from water immersion. Background HTO concentrations from the Great Lakes Time-Concentration Tritium model [R-6], are subtracted.

- **Milk** – Milk from local dairy farms is sampled on a weekly basis and a monthly composite is analyzed. The highest annual average of all the dairy farms is used for the dose calculation, with background tritium in milk concentration subtracted. Only dairy farm residents drink local milk since it is illegal to sell unprocessed milk.

- **Fruits and Vegetables** – Fruit and vegetable tritium concentrations are measured at each critical group location and the background tritium concentration is subtracted. The maximum concentration measured from all samples measured for each critical group is used in the dose calculation.

- **Animal Feed** – The animal feed (e.g. hay, corn) is collected from farms and dairy farms and is usually harvested from the previous year. In Pickering, one animal feed sample is obtained from a Dairy Farm around the site. Since the Farms and the Dairy Farms are located at a fair distance away from the nuclear station (>8 km) it is assumed that there is not a large difference in radionuclide concentrations in animal feed obtained at these locations. Therefore, an animal feed sample taken

at one location is applied to both the Farm and Dairy Farm critical groups. Background values are subtracted. At Darlington, animal feed samples are obtained from Dairy Farms. The maximum value is used for the Dairy Farm critical group. However, this value cannot be used for the Farm critical group because it is located much closer to DN, therefore radionuclide concentrations in animal feed for the DN Farm is modeled from concentrations in air.

- **Forage** – Forage includes plants consumed by animals during pasture or in the wild. Where possible, measured HTO and C-14 in vegetable concentrations were used to represent forage in the dose model. For critical groups with forage as a dose pathway but for which vegetable samples are not collected (i.e. DN Camper), forage is modeled from radionuclide concentrations in air.

- **Fish** – The radionuclide concentrations used for locally caught fish are the maximum measured values in the fish samples, minus the background tritium in water concentration, as calculated using the Great Lakes Time-Concentration Tritium Model [R-6].

F.2.2 Carbon-14

For the purpose of estimating the critical group dose, the concentrations used in the corresponding pathways were determined as follows:

(a) **Air** – C-14 via air inhalation is not a significant contributor to public dose and, therefore, is only monitored at select high frequency wind sector locations. Where C-14 in air measurements are available, the concentration of C-14 in air is based on the annual average of measurements for each critical group location. If more than one sample location is used to represent one critical group, then the maximum of the annual averages is taken. Where C-14 in air measurements are not available (PN Urban Residents, DN Oshawa Residents and DN Bowmanville Residents), C-14 in air is modeled from emissions and adjusted using the empirical Ka as described in Section 6.2. For all measurements, the average background C-14 concentration in air is subtracted.

(b) **Water** – Concentrations of C-14 in well water are modeled from measured local air concentrations at each critical group location, and concentrations in the WSPs and lake water are modeled from site waterborne emissions.

(c) **Terrestrial media** – The concentrations of C-14 in terrestrial media (plants, milk, hay) are based on the maximum of the measurements for each sample type for each critical group, minus the average C-14 concentration measured in background vegetables.

(d) **Fish** – For fish, the maximum C-14 concentration of all samples per site is used, minus the average concentration of C-14 in Lake Ontario fish measured in background locations.

F.2.3 Noble Gases and Skyshine

The noble gas detectors measure the air kerma rate, which is converted to effective dose using appropriate age-specific conversion factors (effective dose/air kerma rate) [R-16] and standard occupancy and shielding factors for air immersion dose as described in CSA N288.1-08 [R-11].

Noble gas dose is measured directly in most landward wind sectors around the DN site and PN site boundaries, and adjusted to the critical group location using calculated air dispersion ratios.

The air kerma rate from the PWMF at the PN site was measured in September 2000 over water on Lake Ontario [R-17]. The results showed a rapid drop in the measured air kerma rate with distance, such that it is below the detection limit (0.13 nGy/h) at a distance of 500 m from these storage areas. At 1 km distance, the air kerma rate is estimated to be negligible assuming an inverse square relation with distance as well as a further reduction of a factor of 1,000 due to scattering in air (effective half distance of 56 m for skyshine radiation at 300 keV [R-18]). The skyshine dose from this source is, therefore, not significant for critical groups outside the 1 km boundary, which are all the critical groups except the Fisher which is assumed to be located 500 m south of PN in Lake Ontario. Skyshine doses from the PWMF and PN station are estimated and included in the total noble gas dose for all critical groups.

Similarly, skyshine doses at DN are estimated and included in the critical group noble gas doses. Skyshine doses are found to be negligible for all critical groups.

F.2.4 Radioiodines

Radioiodine emissions are assumed to have an equilibrium mixture of radioiodines based on I(mfp). This is to account for short-lived radioiodines which may be emitted along with I-131. Emissions for each short-lived radioiodine are incorporated into the dose model based on its equilibrium ratio to the measured I-131 emission. Doses are modeled for the individual radioiodines and summed for the total I(mfp) dose. Due to the very short half-lives of some of these radioiodines, this calculation may overestimate the doses.

Radioiodines are an airborne emission, therefore radioiodine concentrations at critical group locations are obtained as described in Section F.2.1. Where no empirical Ka values are available, air concentrations are directly modeled from emissions.

F.2.5 Particulates and Gross-Beta Gamma

Both airborne particulates and waterborne gross-beta emissions represent a mixture of beta and gamma emitting radionuclides. In order to obtain conservative doses for these mixtures, they are represented by the most limiting radionuclides typically found in the mixtures. According to the latest REMP reviews [R-27][R-28], the most limiting radionuclide for atmospheric particulate emissions is Co-60 and for liquid effluent beta-gamma emissions it is Cs-137. There was no analysis for alpha radioactivity because alpha radionuclide emissions from the stations are extremely low [R-25].

For airborne particulates, concentrations in air are modeled using emissions, the empirical Ka at each critical group location and modeled atmospheric dispersion factors, as described in Section F.2.1, and concentrations in terrestrial media are subsequently modeled from the airborne concentrations. These concentrations are used to calculate doses to critical group individuals.

For waterborne gross-beta gamma, critical group doses are directly modeled from emissions in aquatic media where no local measurements are available. The only pathways used for dose calculation in which gross beta-gamma activity is measured in environmental samples are fish and beach sand. Background values of activity in Lake Ontario fish and beach sand are subtracted from these measurements.

F.2.6 Elemental Tritium

For HT, the inhalation pathway is the only direct pathway to humans resulting in dose. Concentrations in air are modeled using emissions, the empirical Ka at each critical group location and modeled atmospheric dispersion factors, as described in Section F.2.1. HT converts into HTO through interaction with microbes in the soil. The resultant HTO is routinely measured in air and local biota around nuclear sites.

Appendix G: Tables of Public Doses by Radionuclide, Pathway and Age Group for Darlington Nuclear and Pickering Nuclear Critical Groups

Table G1: Darlington Nuclear – Farm Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	1.87E-04	2.15E-07	2.90E-06	3.66E-11	0.00E+00	0.00E+00	5.27E-11	3.37E-12	0.00E+00	5.02E-04	7.20E-03	4.99E-02	5.78E-02
	Co-60	uSv/a	7.60E-06	2.88E-07	1.65E-07	2.24E-08	7.36E-09	7.63E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.56E-05	3.34E-06	7.73E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	3.23E-05	4.73E-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	3.71E-05
	HT	uSv/a	1.16E-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	1.16E-06
	HTO	uSv/a	8.80E-02	0.00E+00	7.47E-02	2.18E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.45E-05	2.02E-02	1.51E-02	2.00E-01
	NobleGases	uSv/a	0.00E+00	4.70E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.70E-02
	OBT	uSv/a	0.00E+00	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	3.00E-03	1.05E-02	1.35E-02
	I (mfp)	uSv/a	9.46E-05	7.88E-06	7.81E-07	4.10E-09	4.87E-10	2.15E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.44E-03	9.71E-04	3.54E-03
	Total	uSv/a	8.83E-02	4.70E-02	7.47E-02	2.18E-03	7.85E-09	7.65E-03	5.27E-11	3.37E-12	0.00E+00	5.37E-04	3.29E-02	7.64E-02	3.30E-01
Child-10y	C-14	uSv/a	2.67E-04	2.15E-07	2.06E-06	3.66E-11	0.00E+00	0.00E+00	2.91E-10	3.37E-12	0.00E+00	2.97E-04	5.41E-03	3.14E-02	3.74E-02
	Co-60	uSv/a	1.08E-05	2.88E-07	2.75E-07	2.24E-08	9.53E-08	7.63E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.39E-04	6.19E-06	7.79E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	1.28E-05	4.73E-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	1.75E-05
	HT	uSv/a	1.38E-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	1.38E-06
	HTO	uSv/a	1.05E-01	0.00E+00	4.80E-02	1.81E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.31E-05	1.35E-02	8.36E-03	1.76E-01
	NobleGases	uSv/a	0.00E+00	4.70E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.70E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.17E-06	2.29E-03	6.23E-03	8.52E-03
	I (mfp)	uSv/a	2.14E-04	7.88E-06	9.49E-07	4.10E-09	4.60E-09	2.15E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-03	1.61E-03	4.73E-03
	Total	uSv/a	1.05E-01	4.70E-02	4.80E-02	1.82E-03	9.99E-08	7.65E-03	2.91E-10	3.37E-12	0.00E+00	3.16E-04	2.43E-02	4.76E-02	2.82E-01
Infant_1y	C-14	uSv/a	1.82E-04	2.15E-07	0.00E+00	1.31E-11	0.00E+00	0.00E+00	5.82E-10	3.37E-12	0.00E+00	1.75E-04	7.55E-03	2.73E-02	3.52E-02
	Co-60	uSv/a	7.95E-06	3.75E-07	0.00E+00	2.91E-08	2.34E-07	9.92E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-04	9.80E-06	1.01E-02
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HT	uSv/a	9.45E-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	0.00E+00	0.00E+00	9.45E-07
	HTO	uSv/a	7.17E-02	0.00E+00	0.00E+00	6.01E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.19E-06	1.36E-02	7.37E-03	9.33E-02
	NobleGases	uSv/a	0.00E+00	5.77E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.77E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.75E-06	2.10E-03	5.07E-03	7.17E-03
	I (mfp)	uSv/a	2.51E-04	1.02E-05	0.00E+00	5.33E-09	1.61E-08	2.79E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.99E-03	4.56E-03	8.85E-03
	Total	uSv/a	7.22E-02	5.77E-02	0.00E+00	6.01E-04	2.50E-07	9.95E-03	5.82E-10	3.37E-12	0.00E+00	1.87E-04	2.74E-02	4.43E-02	2.12E-01

Table G2: Darlington Nuclear – Dairy Farm Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	3.82E-04	4.40E-07	8.83E-06	6.96E-11	0.00E+00	0.00E+00	5.27E-11	3.37E-12	0.00E+00	9.98E-05	2.79E-03	3.15E-01	3.18E-01
	Co-60	uSv/a	1.82E-06	6.90E-08	0.00E+00	0.00E+00	9.24E-10	9.58E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.19E-05	4.59E-06	9.96E-04
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	4.73E-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	4.73E-06
	HT	uSv/a	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	0.00E+00	0.00E+00	0.00E+00	2.78E-07
	HTO	uSv/a	2.11E-02	0.00E+00	5.93E-02	1.75E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.88E-06	9.01E-03	2.10E-02	1.12E-01
	NobleGases	uSv/a	0.00E+00	9.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.51E-03
	OBT	uSv/a	0.00E+00	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-06	1.37E-03	5.34E-03	6.70E-03
	I (mfp)	uSv/a	2.27E-05	1.81E-06	0.00E+00	0.00E+00	1.14E-10	5.03E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.54E-04	1.60E-03	2.58E-03
	Total	uSv/a	2.15E-02	9.51E-03	5.93E-02	1.75E-03	1.04E-09	9.63E-04	5.27E-11	3.37E-12	0.00E+00	1.07E-04	1.42E-02	3.43E-01	4.50E-01
Child-10y	C-14	uSv/a	5.45E-04	4.40E-07	6.26E-06	6.96E-11	0.00E+00	0.00E+00	2.91E-10	3.37E-12	0.00E+00	5.90E-05	2.10E-03	3.04E-01	3.07E-01
	Co-60	uSv/a	2.60E-06	6.90E-08	0.00E+00	0.00E+00	1.20E-08	9.58E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.16E-05	1.41E-05	1.03E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	4.73E-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	4.73E-06
	HT	uSv/a	3.30E-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	0.00E+00	0.00E+00	3.30E-07
	HTO	uSv/a	2.51E-02	0.00E+00	3.81E-02	1.46E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-06	6.04E-03	2.62E-02	9.69E-02
	NobleGases	uSv/a	0.00E+00	9.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.51E-03
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.23E-06	1.04E-03	5.40E-03	6.44E-03
	I (mfp)	uSv/a	5.15E-05	1.81E-06	0.00E+00	0.00E+00	1.07E-09	5.03E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-03	3.72E-03	4.91E-03
	Total	uSv/a	2.57E-02	9.51E-03	3.81E-02	1.46E-03	1.30E-08	9.63E-04	2.91E-10	3.37E-12	0.00E+00	6.28E-05	1.04E-02	3.39E-01	4.25E-01
Infant_1y	C-14	uSv/a	3.72E-04	4.40E-07	0.00E+00	2.65E-11	0.00E+00	0.00E+00	5.82E-10	3.37E-12	0.00E+00	3.47E-05	2.93E-03	5.19E-01	5.23E-01
	Co-60	uSv/a	1.90E-06	8.98E-08	0.00E+00	0.00E+00	2.94E-08	1.25E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.01E-05	3.50E-05	1.33E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HT	uSv/a	2.26E-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	0.00E+00	0.00E+00	2.26E-07
	HTO	uSv/a	1.72E-02	0.00E+00	0.00E+00	3.25E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.63E-06	5.83E-03	6.19E-02	8.52E-02
	NobleGases	uSv/a	0.00E+00	1.17E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.46E-07	9.25E-04	1.04E-02	1.13E-02
	I (mfp)	uSv/a	6.02E-05	2.36E-06	0.00E+00	0.00E+00	3.76E-09	6.54E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-03	1.27E-02	1.43E-02
	Total	uSv/a	1.76E-02	1.17E-02	0.00E+00	3.25E-04	3.31E-08	1.25E-03	5.82E-10	3.37E-12	0.00E+00	3.71E-05	1.13E-02	6.04E-01	6.47E-01

Table G3: Darlington Nuclear – Bowmanville Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	9.31E-05	1.07E-07	5.16E-07	1.24E-11	1.60E-13	2.99E-12	5.14E-11	3.29E-12	0.00E+00	5.76E-05	3.41E-03	4.25E-03	7.81E-03
	Co-60	uSv/a	2.66E-06	1.01E-07	0.00E+00	0.00E+00	1.43E-09	1.48E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.57E-05	3.36E-07	1.51E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	5.52E-04	1.14E-05	6.58E-08	4.30E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.23E-05	0.00E+00	4.88E-03
	HT	uSv/a	4.06E-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	0.00E+00	0.00E+00	4.06E-07
	HTO	uSv/a	3.09E-02	0.00E+00	2.33E-02	1.52E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.81E-06	7.88E-03	2.05E-03	6.56E-02
	NobleGases	uSv/a	0.00E+00	2.44E-02	0.00E+00	0.00E+00	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-02
	OBT	uSv/a	0.00E+00	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-06	1.16E-03	1.33E-03	2.49E-03
	I (mfp)	uSv/a	3.32E-05	2.74E-06	0.00E+00	0.00E+00	1.67E-10	7.39E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.45E-04	7.95E-05	8.68E-04
	Total	uSv/a	3.10E-02	2.44E-02	2.39E-02	1.53E-03	6.74E-08	5.79E-03	5.14E-11	3.29E-12	0.00E+00	6.17E-05	1.32E-02	7.71E-03	1.08E-01
Child-10y	C-14	uSv/a	1.30E-04	1.05E-07	3.64E-07	1.27E-11	9.07E-13	3.06E-12	2.91E-10	3.37E-12	0.00E+00	3.49E-05	2.62E-03	2.74E-03	5.53E-03
	Co-60	uSv/a	3.65E-06	9.69E-08	0.00E+00	0.00E+00	1.69E-08	1.35E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.27E-05	6.12E-07	1.40E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	2.17E-04	1.17E-05	2.08E-07	4.41E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.13E-06	0.00E+00	4.65E-03
	HT	uSv/a	4.64E-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	0.00E+00	0.00E+00	4.64E-07
	HTO	uSv/a	3.52E-02	0.00E+00	1.49E-02	1.30E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-06	5.43E-03	1.14E-03	5.80E-02
	NobleGases	uSv/a	0.00E+00	2.40E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.27E-07	9.02E-04	7.98E-04	1.70E-03
	I (mfp)	uSv/a	7.23E-05	2.63E-06	0.00E+00	0.00E+00	1.51E-09	7.08E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.01E-04	1.41E-04	1.12E-03
	Total	uSv/a	3.54E-02	2.40E-02	1.51E-02	1.31E-03	2.26E-07	5.77E-03	2.91E-10	3.37E-12	0.00E+00	3.72E-05	9.89E-03	4.82E-03	9.63E-02
Infant_1y	C-14	uSv/a	8.86E-05	1.05E-07	0.00E+00	1.96E-12	1.81E-12	3.06E-12	5.82E-10	3.37E-12	0.00E+00	2.06E-05	3.67E-03	2.64E-03	6.42E-03
	Co-60	uSv/a	2.67E-06	1.26E-07	0.00E+00	0.00E+00	4.14E-08	1.76E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.23E-05	7.67E-07	1.80E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	2.35E-06	2.49E-07	5.75E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-06	0.00E+00	5.76E-03
	HT	uSv/a	3.18E-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	0.00E+00	0.00E+00	3.18E-07
	HTO	uSv/a	2.41E-02	0.00E+00	0.00E+00	1.62E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.65E-07	5.62E-03	1.10E-03	3.10E-02
	NobleGases	uSv/a	0.00E+00	2.94E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.94E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.42E-07	8.52E-04	7.48E-04	1.60E-03
	I (mfp)	uSv/a	8.46E-05	3.42E-06	0.00E+00	0.00E+00	5.28E-09	9.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-03	2.86E-04	1.65E-03
	Total	uSv/a	2.43E-02	2.94E-02	0.00E+00	1.64E-04	2.96E-07	7.52E-03	5.82E-10	3.37E-12	0.00E+00	2.20E-05	1.15E-02	4.77E-03	7.77E-02

Table G4: Darlington Nuclear – Industrial/Commercial Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	6.41E-05	7.37E-08	2.84E-07	3.33E-12	4.30E-14	8.02E-13	1.38E-11	8.83E-13	0.00E+00	1.55E-05	9.15E-04	1.14E-03	2.14E-03
	Co-60	uSv/a	2.24E-06	8.48E-08	0.00E+00	0.00E+00	1.77E-09	1.83E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.90E-06	9.02E-08	1.84E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	3.04E-04	3.06E-06	1.77E-08	1.16E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.30E-06	0.00E+00	1.47E-03
	HT	uSv/a	3.41E-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	0.00E+00	0.00E+00	3.41E-07
	HTO	uSv/a	2.59E-02	0.00E+00	1.29E-02	4.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.56E-07	2.12E-03	5.51E-04	4.18E-02
	NobleGases	uSv/a	0.00E+00	1.60E-02	0.00E+00	0.00E+00	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-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.25E-07	3.10E-04	3.58E-04	6.69E-04
	I (mfp)	uSv/a	2.79E-05	2.30E-06	0.00E+00	0.00E+00	1.42E-10	6.28E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-04	2.14E-05	2.58E-04
	Total	uSv/a	2.60E-02	1.60E-02	1.32E-02	4.11E-04	1.96E-08	2.99E-03	1.38E-11	8.83E-13	0.00E+00	1.66E-05	3.55E-03	2.07E-03	6.42E-02

Table G5: Darlington Nuclear – West/East Beach Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	1.30E-04	1.50E-07	1.62E-06	2.60E-11	4.48E-14	8.36E-13	5.20E-11	3.32E-12	0.00E+00	1.13E-03	3.18E-03	3.05E-04	4.75E-03
	Co-60	uSv/a	3.77E-06	1.43E-07	6.34E-08	6.37E-09	1.46E-09	1.52E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.64E-05	1.86E-07	1.55E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	1.08E-04	4.95E-06	1.84E-08	1.20E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-06	2.39E-07	1.32E-03
	HT	uSv/a	5.76E-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	0.00E+00	0.00E+00	5.76E-07
	HTO	uSv/a	4.37E-02	0.00E+00	6.44E-02	1.71E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.52E-05	7.71E-03	2.34E-04	1.18E-01
	NobleGases	uSv/a	0.00E+00	8.93E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.93E-03
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.37E-05	1.13E-03	1.46E-04	1.30E-03
	I (mfp)	uSv/a	4.70E-05	3.57E-06	7.50E-07	2.92E-09	2.34E-10	1.03E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.61E-04	3.25E-05	8.55E-04
	Total	uSv/a	4.39E-02	8.93E-03	6.45E-02	1.72E-03	2.01E-08	2.73E-03	5.20E-11	3.32E-12	0.00E+00	1.21E-03	1.28E-02	7.18E-04	1.36E-01
Child-10y	C-14	uSv/a	1.85E-04	1.49E-07	1.16E-06	2.64E-11	2.51E-13	8.48E-13	2.91E-10	3.37E-12	0.00E+00	6.77E-04	2.42E-03	2.61E-04	3.55E-03
	Co-60	uSv/a	5.32E-06	1.41E-07	1.07E-07	6.46E-09	1.81E-08	1.45E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.35E-05	2.91E-07	1.50E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	3.94E-05	5.02E-06	5.75E-08	1.22E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.41E-07	7.35E-08	1.27E-03
	HT	uSv/a	6.77E-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	0.00E+00	0.00E+00	6.77E-07
	HTO	uSv/a	5.14E-02	0.00E+00	4.17E-02	1.45E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-05	5.23E-03	1.31E-04	9.99E-02
	NobleGases	uSv/a	0.00E+00	8.47E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.47E-03
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.41E-05	8.64E-04	8.66E-05	9.64E-04
	I (mfp)	uSv/a	1.05E-04	3.52E-06	9.24E-07	2.96E-09	2.18E-09	1.02E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.09E-04	5.59E-05	1.09E-03
	Total	uSv/a	5.17E-02	8.47E-03	4.17E-02	1.45E-03	7.78E-08	2.68E-03	2.91E-10	3.37E-12	0.00E+00	7.21E-04	9.46E-03	5.35E-04	1.17E-01
Infant_1y	C-14	uSv/a	1.26E-04	1.49E-07	0.00E+00	8.19E-12	5.02E-13	8.48E-13	5.82E-10	3.37E-12	0.00E+00	3.99E-04	3.38E-03	3.16E-04	4.22E-03
	Co-60	uSv/a	3.90E-06	1.84E-07	0.00E+00	8.40E-09	4.44E-08	1.88E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.31E-05	3.45E-07	1.93E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	3.78E-07	6.90E-08	1.59E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.23E-07	3.70E-08	1.59E-03
	HT	uSv/a	4.64E-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	0.00E+00	0.00E+00	4.64E-07
	HTO	uSv/a	3.52E-02	0.00E+00	0.00E+00	3.67E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.87E-05	5.45E-03	1.42E-04	4.12E-02
	NobleGases	uSv/a	0.00E+00	1.04E-02	0.00E+00	0.00E+00	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-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.57E-06	8.23E-04	9.16E-05	9.23E-04
	I (mfp)	uSv/a	1.23E-04	4.57E-06	0.00E+00	3.85E-09	7.64E-09	1.32E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.28E-03	9.76E-05	1.52E-03
	Total	uSv/a	3.55E-02	1.04E-02	0.00E+00	3.67E-04	1.21E-07	3.49E-03	5.82E-10	3.37E-12	0.00E+00	4.26E-04	1.10E-02	6.47E-04	6.18E-02

Table G6: Darlington Nuclear – Rural Resident Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	2.57E-04	2.96E-07	2.75E-06	4.52E-11	1.55E-14	2.90E-13	5.18E-11	3.31E-12	0.00E+00	3.37E-04	3.81E-03	4.38E-03	8.79E-03
	Co-60	uSv/a	5.71E-06	2.16E-07	1.48E-07	1.13E-08	5.14E-09	5.33E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.93E-05	1.05E-06	5.37E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	1.21E-04	4.91E-06	6.38E-09	4.17E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.72E-06	1.91E-07	5.47E-04
	HT	uSv/a	8.71E-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	0.00E+00	0.00E+00	8.71E-07
	HTO	uSv/a	6.61E-02	0.00E+00	1.08E-01	1.76E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.64E-05	1.09E-02	2.31E-03	1.89E-01
	NobleGases	uSv/a	0.00E+00	4.60E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.60E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.06E-06	1.64E-03	1.48E-03	3.13E-03
	I (mfp)	uSv/a	7.17E-05	6.33E-06	7.51E-07	2.28E-09	3.65E-10	1.65E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.50E-04	1.46E-04	1.09E-03
	Total	uSv/a	6.65E-02	4.61E-02	1.08E-01	1.77E-03	1.19E-08	5.76E-03	5.18E-11	3.31E-12	0.00E+00	3.60E-04	1.72E-02	8.32E-03	2.54E-01
Child-10y	C-14	uSv/a	3.69E-04	2.98E-07	1.98E-06	4.61E-11	8.73E-14	2.95E-13	2.91E-10	3.37E-12	0.00E+00	2.03E-04	2.91E-03	2.91E-03	6.39E-03
	Co-60	uSv/a	8.12E-06	2.16E-07	2.51E-07	1.15E-08	6.63E-08	5.31E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.84E-05	1.86E-06	5.37E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	4.37E-05	5.01E-06	2.00E-08	4.25E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.54E-06	6.99E-08	4.75E-04
	HT	uSv/a	1.03E-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	0.00E+00	0.00E+00	1.03E-06
	HTO	uSv/a	7.83E-02	0.00E+00	7.04E-02	1.50E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.97E-06	7.45E-03	1.24E-03	1.59E-01
	NobleGases	uSv/a	0.00E+00	4.61E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.61E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.22E-06	1.28E-03	8.57E-04	2.14E-03
	I (mfp)	uSv/a	1.62E-04	6.32E-06	9.29E-07	2.32E-09	3.43E-09	1.64E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E-03	2.69E-04	1.48E-03
	Total	uSv/a	7.89E-02	4.61E-02	7.04E-02	1.50E-03	8.97E-08	5.75E-03	2.91E-10	3.37E-12	0.00E+00	2.16E-04	1.27E-02	5.28E-03	2.21E-01
Infant_1y	C-14	uSv/a	2.52E-04	2.98E-07	0.00E+00	1.56E-11	1.75E-13	2.95E-13	5.82E-10	3.37E-12	0.00E+00	1.19E-04	4.08E-03	4.32E-03	8.78E-03
	Co-60	uSv/a	5.95E-06	2.80E-07	0.00E+00	1.50E-08	1.63E-07	6.90E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.71E-05	2.97E-06	6.96E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	3.60E-07	2.40E-08	5.54E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.06E-07	4.18E-08	5.55E-04
	HT	uSv/a	7.07E-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	0.00E+00	0.00E+00	7.07E-07
	HTO	uSv/a	5.37E-02	0.00E+00	0.00E+00	3.86E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.60E-06	7.30E-03	1.65E-03	6.30E-02
	NobleGases	uSv/a	0.00E+00	5.66E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.66E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.56E-06	1.15E-03	1.09E-03	2.24E-03
	I (mfp)	uSv/a	1.89E-04	8.22E-06	0.00E+00	3.02E-09	1.20E-08	2.13E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.42E-03	8.89E-04	2.53E-03
	Total	uSv/a	5.41E-02	5.66E-02	0.00E+00	3.86E-04	1.99E-07	7.48E-03	5.82E-10	3.37E-12	0.00E+00	1.28E-04	1.40E-02	7.95E-03	1.41E-01

Table G7: Darlington Nuclear – Provincial Park Camper Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	1.15E-05	1.32E-08	3.02E-07	8.64E-12	0.00E+00	0.00E+00	5.27E-11	3.37E-12	0.00E+00	2.42E-03	1.43E-03	2.74E-03	6.61E-03
	Co-60	uSv/a	2.58E-06	9.77E-08	0.00E+00	0.00E+00	2.37E-09	2.45E-03	0.00E+00	0.00E+00	0.00E+00	4.64E-07	1.75E-05	5.42E-07	2.47E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	3.23E-04	7.95E-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	3.31E-04
	HT	uSv/a	3.93E-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	0.00E+00	0.00E+00	3.93E-07
	HTO	uSv/a	2.98E-02	0.00E+00	2.35E-02	1.44E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.07E-04	4.09E-03	1.14E-03	6.04E-02
	NobleGases	uSv/a	0.00E+00	3.48E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.48E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.75E-04	6.10E-04	7.30E-04	1.51E-03
	I (mfp)	uSv/a	3.23E-05	2.78E-06	0.00E+00	0.00E+00	1.65E-10	7.41E-06	0.00E+00	0.00E+00	0.00E+00	4.61E-07	4.98E-04	8.34E-05	6.24E-04
	Total	uSv/a	2.99E-02	3.48E-02	2.38E-02	1.45E-03	2.53E-09	2.46E-03	5.27E-11	3.37E-12	0.00E+00	3.01E-03	6.65E-03	4.69E-03	1.07E-01
Child-10y	C-14	uSv/a	1.64E-05	1.32E-08	2.14E-07	8.64E-12	0.00E+00	0.00E+00	2.91E-10	3.37E-12	0.00E+00	1.43E-03	1.07E-03	1.79E-03	4.31E-03
	Co-60	uSv/a	3.68E-06	9.77E-08	0.00E+00	0.00E+00	3.06E-08	2.45E-03	0.00E+00	0.00E+00	0.00E+00	6.42E-07	2.82E-05	9.20E-07	2.49E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	1.28E-04	7.95E-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	1.36E-04
	HT	uSv/a	4.67E-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	0.00E+00	0.00E+00	4.67E-07
	HTO	uSv/a	3.55E-02	0.00E+00	1.51E-02	1.20E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.18E-04	2.74E-03	5.96E-04	5.53E-02
	NobleGases	uSv/a	0.00E+00	3.48E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.48E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.03E-04	4.63E-04	4.10E-04	9.76E-04
	I (mfp)	uSv/a	7.32E-05	2.78E-06	0.00E+00	0.00E+00	1.55E-09	7.41E-06	0.00E+00	0.00E+00	0.00E+00	4.66E-07	5.85E-04	1.54E-04	8.23E-04
	Total	uSv/a	3.56E-02	3.48E-02	1.52E-02	1.21E-03	3.22E-08	2.46E-03	2.91E-10	3.37E-12	0.00E+00	1.75E-03	4.89E-03	2.95E-03	9.88E-02
Infant_1y	C-14	uSv/a	1.12E-05	1.32E-08	0.00E+00	9.07E-13	0.00E+00	0.00E+00	5.82E-10	3.37E-12	0.00E+00	8.43E-04	1.51E-03	2.18E-03	4.54E-03
	Co-60	uSv/a	2.69E-06	1.27E-07	0.00E+00	0.00E+00	7.52E-08	3.19E-03	0.00E+00	0.00E+00	0.00E+00	4.64E-07	2.75E-05	1.10E-06	3.22E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	1.09E-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	1.09E-06
	HT	uSv/a	3.20E-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	0.00E+00	0.00E+00	3.20E-07
	HTO	uSv/a	2.43E-02	0.00E+00	0.00E+00	1.29E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E-04	2.74E-03	7.48E-04	2.81E-02
	NobleGases	uSv/a	0.00E+00	4.27E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.27E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.23E-05	4.26E-04	5.01E-04	9.89E-04
	I (mfp)	uSv/a	8.56E-05	3.61E-06	0.00E+00	0.00E+00	5.44E-09	9.63E-06	0.00E+00	0.00E+00	0.00E+00	4.81E-07	8.12E-04	3.52E-04	1.26E-03
	Total	uSv/a	2.44E-02	4.27E-02	0.00E+00	1.30E-04	8.06E-08	3.20E-03	5.82E-10	3.37E-12	0.00E+00	1.04E-03	5.51E-03	3.78E-03	8.08E-02

Table G8: Darlington Nuclear – Oshawa Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	3.70E-05	4.25E-08	5.05E-07	1.20E-11	1.51E-13	2.81E-12	5.23E-11	3.34E-12	0.00E+00	1.09E-03	1.43E-03	1.54E-04	2.72E-03
	Co-60	uSv/a	1.06E-06	4.01E-08	0.00E+00	0.00E+00	1.00E-09	1.04E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-05	4.94E-09	1.05E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	5.41E-04	1.11E-05	6.19E-08	4.05E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.75E-06	0.00E+00	4.61E-03
	HT	uSv/a	1.61E-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	0.00E+00	0.00E+00	1.61E-07
	HTO	uSv/a	1.22E-02	0.00E+00	3.91E-02	1.87E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.33E-05	3.61E-03	7.54E-05	5.69E-02
	NobleGases	uSv/a	0.00E+00	6.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.53E-03
	OBT	uSv/a	0.00E+00	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	5.31E-04	4.99E-05	6.04E-04
	I (mfp)	uSv/a	1.30E-05	9.20E-07	0.00E+00	0.00E+00	6.75E-11	2.92E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E-04	1.74E-07	3.62E-04
	Total	uSv/a	1.23E-02	6.54E-03	3.96E-02	1.88E-03	6.30E-08	5.09E-03	5.23E-11	3.34E-12	0.00E+00	1.17E-03	5.94E-03	2.79E-04	7.28E-02
Child-10y	C-14	uSv/a	5.09E-05	4.10E-08	3.57E-07	1.21E-11	8.39E-13	2.83E-12	2.91E-10	3.37E-12	0.00E+00	6.50E-04	1.09E-03	8.86E-05	1.88E-03
	Co-60	uSv/a	1.43E-06	3.81E-08	0.00E+00	0.00E+00	1.23E-08	9.87E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.98E-05	6.69E-09	1.01E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	2.13E-04	1.12E-05	1.92E-07	4.08E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.60E-06	0.00E+00	4.31E-03
	HT	uSv/a	1.82E-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	0.00E+00	0.00E+00	1.82E-07
	HTO	uSv/a	1.38E-02	0.00E+00	2.52E-02	1.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-05	2.44E-03	3.94E-05	4.31E-02
	NobleGases	uSv/a	0.00E+00	6.20E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.20E-03
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-05	4.08E-04	2.86E-05	4.50E-04
	I (mfp)	uSv/a	2.81E-05	8.63E-07	0.00E+00	0.00E+00	6.05E-10	2.77E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.10E-04	1.72E-07	4.42E-04
	Total	uSv/a	1.39E-02	6.20E-03	2.54E-02	1.58E-03	2.05E-07	5.07E-03	2.91E-10	3.37E-12	0.00E+00	6.93E-04	4.37E-03	1.57E-04	5.74E-02
Infant_1y	C-14	uSv/a	3.48E-05	4.10E-08	0.00E+00	1.81E-12	1.68E-12	2.83E-12	5.82E-10	3.37E-12	0.00E+00	3.83E-04	1.51E-03	1.13E-04	2.04E-03
	Co-60	uSv/a	1.05E-06	4.95E-08	0.00E+00	0.00E+00	3.03E-08	1.28E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.96E-05	1.05E-08	1.30E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	2.17E-06	2.31E-07	5.32E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.74E-06	0.00E+00	5.32E-03
	HT	uSv/a	1.25E-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	0.00E+00	0.00E+00	1.25E-07
	HTO	uSv/a	9.47E-03	0.00E+00	0.00E+00	2.58E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-05	2.51E-03	5.34E-05	1.23E-02
	NobleGases	uSv/a	0.00E+00	7.62E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.62E-03
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.23E-06	3.82E-04	3.77E-05	4.28E-04
	I (mfp)	uSv/a	3.29E-05	1.12E-06	0.00E+00	0.00E+00	2.12E-09	3.59E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.78E-04	3.85E-07	6.17E-04
	Total	uSv/a	9.54E-03	7.62E-03	0.00E+00	2.60E-04	2.63E-07	6.61E-03	5.82E-10	3.37E-12	0.00E+00	4.09E-04	5.00E-03	2.05E-04	2.96E-02

Table G9: Darlington Nuclear – Fisher Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	9.58E-05	1.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.69E-03	0.00E+00	0.00E+00	9.79E-03
	Co-60	uSv/a	2.69E-06	1.02E-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	0.00E+00	2.80E-06
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HT	uSv/a	4.11E-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	0.00E+00	0.00E+00	4.11E-07
	HTO	uSv/a	3.15E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.73E-04	0.00E+00	0.00E+00	3.20E-02
	NobleGases	uSv/a	0.00E+00	2.05E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.05E-03
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.03E-04	0.00E+00	0.00E+00	2.03E-04
	I (mfp)	uSv/a	3.35E-05	2.20E-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	3.56E-05
	Total	uSv/a	3.17E-02	2.05E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-02	0.00E+00	0.00E+00	4.41E-02
Child-10y	C-14	uSv/a	1.37E-04	1.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.73E-03	0.00E+00	0.00E+00	5.86E-03
	Co-60	uSv/a	3.84E-06	1.02E-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	0.00E+00	3.95E-06
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HT	uSv/a	4.89E-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	0.00E+00	0.00E+00	4.89E-07
	HTO	uSv/a	3.75E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.53E-04	0.00E+00	0.00E+00	3.77E-02
	NobleGases	uSv/a	0.00E+00	2.05E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.05E-03
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-04	0.00E+00	0.00E+00	1.19E-04
	I (mfp)	uSv/a	7.59E-05	2.20E-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	7.81E-05
	Total	uSv/a	3.77E-02	2.05E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.10E-03	0.00E+00	0.00E+00	4.59E-02
Infant_1y	C-14	uSv/a	9.33E-05	1.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.37E-03	0.00E+00	0.00E+00	3.47E-03
	Co-60	uSv/a	2.82E-06	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	0.00E+00	2.95E-06
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HT	uSv/a	3.35E-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	0.00E+00	0.00E+00	3.35E-07
	HTO	uSv/a	2.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.58E-04	0.00E+00	0.00E+00	2.59E-02
	NobleGases	uSv/a	0.00E+00	2.51E-03	0.00E+00	0.00E+00	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-03
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.24E-05	0.00E+00	0.00E+00	7.24E-05
	I (mfp)	uSv/a	8.88E-05	2.85E-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	9.16E-05
	Total	uSv/a	2.59E-02	2.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.60E-03	0.00E+00	0.00E+00	3.20E-02

Table G10: Pickering Nuclear – Farm Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	8.58E-05	9.86E-08	1.43E-05	2.02E-09	1.63E-12	3.04E-11	2.01E-08	1.29E-09	0.00E+00	3.73E-04	5.65E-02	2.64E-02	8.34E-02
	Co-60	uSv/a	3.64E-07	1.38E-08	3.25E-09	3.90E-10	1.67E-10	1.73E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-06	1.09E-07	1.75E-04
	Cs-137+	uSv/a	0.00E+00	0.00E+00	7.97E-04	1.03E-04	3.73E-08	2.44E-03	1.17E-06	5.93E-04	0.00E+00	0.00E+00	7.43E-05	1.12E-05	4.02E-03
	HTO	uSv/a	7.21E-02	0.00E+00	7.99E-02	1.49E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-05	2.10E-02	3.37E-03	1.78E-01
	NobleGases	uSv/a	0.00E+00	7.16E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.16E-02
	OBT	uSv/a	0.00E+00	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-05	3.12E-03	2.12E-03	5.26E-03
	I (mfp)	uSv/a	2.40E-06	1.67E-07	1.68E-08	7.70E-11	1.21E-11	5.22E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.03E-05	1.38E-05	5.73E-05
	Total	uSv/a	7.22E-02	7.16E-02	8.07E-02	1.59E-03	3.75E-08	2.61E-03	1.19E-06	5.93E-04	0.00E+00	4.33E-04	8.07E-02	3.19E-02	3.42E-01
Child-10y	C-14	uSv/a	1.22E-04	9.86E-08	1.02E-05	2.02E-09	8.99E-12	3.04E-11	1.11E-07	1.29E-09	0.00E+00	2.21E-04	4.18E-02	1.69E-02	5.90E-02
	Co-60	uSv/a	5.19E-07	1.38E-08	5.40E-09	3.90E-10	2.15E-09	1.73E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.07E-06	1.82E-07	1.76E-04
	Cs-137+	uSv/a	0.00E+00	0.00E+00	3.15E-04	1.03E-04	1.15E-07	2.44E-03	3.60E-06	5.93E-04	0.00E+00	0.00E+00	3.02E-05	3.79E-06	3.49E-03
	HTO	uSv/a	8.58E-02	0.00E+00	5.14E-02	1.24E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.23E-05	1.41E-02	1.86E-03	1.54E-01
	NobleGases	uSv/a	0.00E+00	7.16E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.16E-02
	OBT	uSv/a	0.00E+00	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	2.38E-03	1.26E-03	3.65E-03
	I (mfp)	uSv/a	5.44E-06	1.67E-07	2.05E-08	7.70E-11	1.14E-10	5.22E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.75E-05	2.14E-05	7.51E-05
	Total	uSv/a	8.59E-02	7.16E-02	5.17E-02	1.34E-03	1.17E-07	2.61E-03	3.71E-06	5.93E-04	0.00E+00	2.53E-04	5.83E-02	2.00E-02	2.92E-01
Infant_1y	C-14	uSv/a	8.35E-05	9.86E-08	0.00E+00	4.49E-11	1.80E-11	3.04E-11	2.22E-07	1.29E-09	0.00E+00	1.30E-04	3.84E-02	1.29E-02	5.15E-02
	Co-60	uSv/a	3.80E-07	1.79E-08	0.00E+00	5.07E-10	5.29E-09	2.24E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.96E-06	1.86E-07	2.28E-04
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	2.68E-06	1.38E-07	3.18E-03	4.32E-06	7.70E-04	0.00E+00	0.00E+00	1.64E-05	1.76E-06	3.97E-03
	HTO	uSv/a	5.88E-02	0.00E+00	0.00E+00	3.42E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.39E-05	1.41E-02	1.74E-03	7.50E-02
	NobleGases	uSv/a	0.00E+00	8.73E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.73E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.36E-06	2.19E-03	1.15E-03	3.35E-03
	I (mfp)	uSv/a	6.36E-06	2.16E-07	0.00E+00	1.00E-10	3.99E-10	6.79E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.55E-05	3.53E-05	1.08E-04
	Total	uSv/a	5.89E-02	8.73E-02	0.00E+00	3.45E-04	1.43E-07	3.40E-03	4.54E-06	7.70E-04	0.00E+00	1.50E-04	5.48E-02	1.58E-02	2.21E-01

Table G11: Pickering Nuclear – Dairy Farm Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	0.00E+00	0.00E+00	1.66E-06	1.96E-09	0.00E+00	0.00E+00	2.01E-08	1.29E-09	0.00E+00	0.00E+00	6.85E-03	2.40E-02	3.08E-02
	Co-60	uSv/a	2.88E-07	1.09E-08	0.00E+00	1.03E-10	1.58E-10	1.63E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.62E-06	3.43E-07	1.66E-04
	Cs-137+	uSv/a	0.00E+00	0.00E+00	9.91E-05	1.01E-04	0.00E+00	0.00E+00	1.17E-06	5.93E-04	0.00E+00	0.00E+00	0.00E+00	4.66E-07	7.94E-04
	HTO	uSv/a	5.84E-02	0.00E+00	8.89E-02	1.37E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.19E-03	1.74E-02	1.73E-01
	NobleGases	uSv/a	0.00E+00	4.58E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.58E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-03	5.47E-03	6.64E-03
	I (mfp)	uSv/a	1.85E-06	9.55E-08	0.00E+00	1.66E-11	9.42E-12	4.04E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.18E-05	4.37E-05	7.79E-05
	Total	uSv/a	5.84E-02	4.58E-02	8.90E-02	1.47E-03	1.67E-10	1.64E-04	1.19E-06	5.93E-04	0.00E+00	0.00E+00	1.53E-02	4.69E-02	2.58E-01
Child-10y	C-14	uSv/a	0.00E+00	0.00E+00	1.18E-06	1.96E-09	0.00E+00	0.00E+00	1.11E-07	1.29E-09	0.00E+00	0.00E+00	5.03E-03	3.15E-02	3.66E-02
	Co-60	uSv/a	4.11E-07	1.09E-08	0.00E+00	1.03E-10	2.04E-09	1.63E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-06	8.51E-07	1.67E-04
	Cs-137+	uSv/a	0.00E+00	0.00E+00	3.92E-05	1.01E-04	0.00E+00	0.00E+00	3.60E-06	5.93E-04	0.00E+00	0.00E+00	0.00E+00	1.38E-07	7.36E-04
	HTO	uSv/a	6.94E-02	0.00E+00	5.71E-02	1.14E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.79E-03	1.98E-02	1.52E-01
	NobleGases	uSv/a	0.00E+00	4.58E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.58E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.98E-04	4.80E-03	5.70E-03
	I (mfp)	uSv/a	4.22E-06	9.55E-08	0.00E+00	1.66E-11	8.90E-11	4.04E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.74E-05	8.77E-05	1.30E-04
	Total	uSv/a	6.94E-02	4.58E-02	5.72E-02	1.24E-03	2.13E-09	1.64E-04	3.71E-06	5.93E-04	0.00E+00	0.00E+00	1.08E-02	5.63E-02	2.41E-01
Infant_1y	C-14	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E-07	1.29E-09	0.00E+00	0.00E+00	3.80E-03	6.80E-02	7.18E-02
	Co-60	uSv/a	3.02E-07	1.42E-08	0.00E+00	1.34E-10	5.01E-09	2.12E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-06	1.95E-06	2.17E-04
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.32E-06	7.70E-04	0.00E+00	0.00E+00	0.00E+00	1.24E-07	7.75E-04
	HTO	uSv/a	4.76E-02	0.00E+00	0.00E+00	2.41E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.83E-03	4.47E-02	9.64E-02
	NobleGases	uSv/a	0.00E+00	5.58E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.58E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.91E-04	8.12E-03	8.82E-03
	I (mfp)	uSv/a	4.94E-06	1.24E-07	0.00E+00	2.16E-11	3.12E-10	5.25E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.99E-05	3.08E-04	3.63E-04
	Total	uSv/a	4.76E-02	5.58E-02	0.00E+00	2.41E-04	5.32E-09	2.13E-04	4.54E-06	7.70E-04	0.00E+00	0.00E+00	8.37E-03	1.21E-01	2.34E-01

Table G12: Pickering Nuclear – Industrial/Commercial Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	7.27E-04	8.36E-07	1.95E-05	1.70E-10	1.10E-12	2.06E-11	1.24E-09	7.93E-11	0.00E+00	3.42E-07	1.71E-03	3.24E-07	2.46E-03
	Co-60	uSv/a	2.25E-06	8.53E-08	2.23E-296	7.81E-12	1.17E-10	1.22E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.03E-08	5.37E-12	1.24E-04
	Cs-137+	uSv/a	0.00E+00	0.00E+00	1.16E-03	8.72E-06	2.53E-08	1.65E-03	7.21E-08	3.65E-05	0.00E+00	0.00E+00	3.79E-06	8.60E-11	2.86E-03
	HTO	uSv/a	4.47E-01	0.00E+00	8.33E-03	9.16E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.81E-08	1.21E-03	1.29E-07	4.56E-01
	NobleGases	uSv/a	0.00E+00	3.68E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.68E-01
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.64E-08	1.93E-04	7.62E-08	1.93E-04
	I (mfp)	uSv/a	1.49E-05	1.08E-06	0.00E+00	7.62E-13	4.11E-12	1.82E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-06	1.94E-09	1.74E-05
	Total	uSv/a	4.48E-01	3.68E-01	9.51E-03	1.00E-04	2.54E-08	1.77E-03	7.33E-08	3.65E-05	0.00E+00	3.96E-07	3.12E-03	5.31E-07	8.30E-01

Table G13: Pickering Nuclear – Correctional Institute (C2) Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	7.58E-04	8.72E-07	6.92E-05	2.08E-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	8.28E-04
	Co-60	uSv/a	1.99E-06	7.54E-08	0.00E+00	0.00E+00	1.05E-09	1.09E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	4.13E-03	1.07E-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	4.14E-03
	HTO	uSv/a	4.03E-01	0.00E+00	2.94E-02	1.85E-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	4.32E-01
	NobleGases	uSv/a	0.00E+00	2.85E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.85E-01
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	I (mfp)	uSv/a	1.30E-05	8.73E-07	0.00E+00	0.00E+00	6.51E-11	2.91E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E-05
	Total	uSv/a	4.04E-01	2.85E-01	3.36E-02	1.96E-04	1.11E-09	1.09E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.23E-01
Child-10y	C-14	uSv/a	1.08E-03	8.72E-07	4.91E-05	2.08E-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	1.13E-03
	Co-60	uSv/a	2.84E-06	7.54E-08	0.00E+00	0.00E+00	1.36E-08	1.09E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	1.63E-03	1.07E-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	1.64E-03
	HTO	uSv/a	4.79E-01	0.00E+00	1.89E-02	1.54E-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	4.98E-01
	NobleGases	uSv/a	0.00E+00	2.85E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.85E-01
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	I (mfp)	uSv/a	2.96E-05	8.73E-07	0.00E+00	0.00E+00	6.15E-10	2.91E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.34E-05
	Total	uSv/a	4.80E-01	2.85E-01	2.06E-02	1.65E-04	1.42E-08	1.09E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.87E-01

Table G14: Pickering Nuclear – Fisher Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	1.71E-04	1.97E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.93E-03	0.00E+00	0.00E+00	8.10E-03
	Co-60	uSv/a	6.32E-07	2.40E-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	0.00E+00	6.56E-07
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HTO	uSv/a	1.26E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.83E-04	0.00E+00	0.00E+00	1.26E-01
	NobleGases	uSv/a	0.00E+00	7.22E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.22E-02
	OBT	uSv/a	0.00E+00	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-04	0.00E+00	0.00E+00	3.79E-04
	I (mfp)	uSv/a	4.17E-06	2.72E-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	0.00E+00	4.45E-06
	Total	uSv/a	1.26E-01	7.22E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.19E-03	0.00E+00	0.00E+00	2.07E-01
Child-10y	C-14	uSv/a	2.44E-04	1.97E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.68E-03	0.00E+00	0.00E+00	4.93E-03
	Co-60	uSv/a	9.02E-07	2.40E-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	0.00E+00	9.26E-07
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HTO	uSv/a	1.49E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.73E-04	0.00E+00	0.00E+00	1.50E-01
	NobleGases	uSv/a	0.00E+00	7.22E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.22E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E-04	0.00E+00	0.00E+00	2.22E-04
	I (mfp)	uSv/a	9.47E-06	2.72E-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	0.00E+00	9.75E-06
	Total	uSv/a	1.50E-01	7.22E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.38E-03	0.00E+00	0.00E+00	2.27E-01
Infant_1y	C-14	uSv/a	1.67E-04	1.97E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E-03	0.00E+00	0.00E+00	2.92E-03
	Co-60	uSv/a	6.61E-07	3.12E-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	0.00E+00	6.92E-07
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	HTO	uSv/a	1.02E-01	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-04	0.00E+00	0.00E+00	1.03E-01
	NobleGases	uSv/a	0.00E+00	8.86E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.86E-02
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-04	0.00E+00	0.00E+00	1.35E-04
	I (mfp)	uSv/a	1.11E-05	3.53E-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	0.00E+00	1.14E-05
	Total	uSv/a	1.03E-01	8.86E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.19E-03	0.00E+00	0.00E+00	1.94E-01

Table G15: Pickering Nuclear – Urban Resident Critical Group Doses – 2012

HumanType	Radionuclide	Unit	Air (inhalation)	Air (external)	Water (ingestion)	Water (external)	Soil (ingestion)	Soil (external)	Sediment (ingestion)	Sediment (external)	Aquatic plants	Aquatic animals	Terrestrial plants	Terrestrial animals	Total
Adult	C-14	uSv/a	6.21E-04	7.14E-07	5.80E-05	2.66E-09	1.73E-11	3.22E-10	1.94E-08	1.24E-09	0.00E+00	5.35E-06	2.68E-02	5.07E-06	2.75E-02
	Co-60	uSv/a	2.23E-06	8.44E-08	3.49E-295	1.22E-10	1.83E-09	1.90E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.26E-06	8.40E-11	1.90E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	3.45E-03	1.36E-04	3.95E-07	2.58E-02	1.13E-06	5.71E-04	0.00E+00	0.00E+00	5.92E-05	1.34E-09	3.00E-02
	HTO	uSv/a	4.42E-01	0.00E+00	2.57E-02	1.43E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.95E-07	1.89E-02	2.01E-06	4.88E-01
	NobleGases	uSv/a	0.00E+00	5.29E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.29E-01
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.56E-07	3.02E-03	1.19E-06	3.02E-03
	I (mfp)	uSv/a	1.48E-05	1.17E-06	0.00E+00	1.19E-11	6.42E-11	2.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.96E-05	3.03E-08	3.84E-05
	Total	uSv/a	4.43E-01	5.29E-01	2.92E-02	1.57E-03	3.97E-07	2.77E-02	1.15E-06	5.71E-04	0.00E+00	6.20E-06	4.87E-02	8.31E-06	1.08E+00
Child-10y	C-14	uSv/a	7.56E-04	6.09E-07	4.08E-05	2.76E-09	9.89E-11	3.34E-10	1.11E-07	1.29E-09	0.00E+00	3.28E-06	2.04E-02	6.62E-06	2.13E-02
	Co-60	uSv/a	2.79E-06	7.42E-08	6.04E-295	1.27E-10	2.46E-08	1.97E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.11E-06	2.54E-10	1.98E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	1.36E-03	1.42E-04	1.26E-06	2.68E-02	3.60E-06	5.93E-04	0.00E+00	0.00E+00	2.48E-05	5.19E-10	2.89E-02
	HTO	uSv/a	4.62E-01	0.00E+00	1.64E-02	1.24E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.31E-07	1.31E-02	1.39E-06	4.93E-01
	NobleGases	uSv/a	0.00E+00	4.93E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.93E-01
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.56E-07	2.40E-03	8.25E-07	2.40E-03
	I (mfp)	uSv/a	2.95E-05	1.05E-06	0.00E+00	1.24E-11	6.30E-10	2.95E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E-05	6.76E-08	5.74E-05
	Total	uSv/a	4.63E-01	4.93E-01	1.78E-02	1.38E-03	1.29E-06	2.88E-02	3.71E-06	5.93E-04	0.00E+00	3.77E-06	3.60E-02	8.91E-06	1.04E+00
Infant_1y	C-14	uSv/a	5.16E-04	6.09E-07	0.00E+00	2.05E-10	1.98E-10	3.34E-10	2.22E-07	1.29E-09	0.00E+00	1.93E-06	1.65E-02	1.41E-05	1.71E-02
	Co-60	uSv/a	2.05E-06	9.65E-08	0.00E+00	1.65E-10	6.05E-08	2.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E-06	6.58E-10	2.57E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	1.36E-05	1.52E-06	3.49E-02	4.32E-06	7.70E-04	0.00E+00	0.00E+00	1.22E-05	3.68E-10	3.57E-02
	HTO	uSv/a	3.17E-01	0.00E+00	0.00E+00	2.36E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-07	1.09E-02	2.02E-06	3.28E-01
	NobleGases	uSv/a	0.00E+00	6.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.00E-01
	OBT	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.46E-08	1.90E-03	1.02E-06	1.90E-03
	I (mfp)	uSv/a	3.44E-05	1.36E-06	0.00E+00	1.61E-11	2.21E-09	3.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.24E-05	2.51E-07	7.23E-05
	Total	uSv/a	3.17E-01	6.00E-01	0.00E+00	2.50E-04	1.58E-06	3.75E-02	4.54E-06	7.70E-04	0.00E+00	2.23E-06	2.94E-02	1.74E-05	9.86E-01

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