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2010 Results of Radiological Environmental Monitoring Programs

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Prepared by:
C. Cheng — Date: Apr. 12, 2011
Assistant Scientist/Technical Officer
Environment Programs Department
Ontario Power Generation

Verified by:
I. Benovich
Principal
Enviro Health Physics Consulting Inc.

Reviewed by:
T. Le — Date: Apr 12, 2011
Section Manager
Environment Programs Department
Ontario Power Generation

Reviewed by:
R. McCalla — Date: Apr 12, 2011
Manager
Environment Programs Department
Ontario Power Generation

Approved by:
L. Swami — Date: April 12, 2011
Vice President
Nuclear Regulatory Programs
Ontario Power Generation

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Ontario Power Generation, Nuclear, would like to thank the residents of the local communities in the vicinity of Pickering and Darlington 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, silage, milk and water have helped ensure that the estimations for the annual public dose estimates are realistic.

Revision Summary

Revision Number	Date	Comments
R000	2011-04-15	Initial issue. This document contains 68 physical pages.

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 licenses. It contains the 2010 results of the above 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 locations were also taken to determine background radiation levels in areas away from the influence of nuclear stations.

A total of 2,354 laboratory analyses were performed on a variety of environmental media in 2010. With the exception of Lake Ontario far field fish samples, the availabilities of samples analyzed for the dose calculation were above the minimum annual performance requirements.

Several notable changes were made to the REMPs in 2010. As recommended by various studies on the inconsistent performance of the passive tritium-in-air samplers, all passive tritium-in-air samplers were discontinued in January 2010. At DN, lake water sampling at St. Mary's Cement plant has been replaced with lake water and beach sand sampling at West/East beach to better represent the dose to members of the public using the beach area.

IMPACT 5.4.0 software, which represents the method of dose calculation described in the CSA N288.1-08 standard [R-14], was used for the dose calculation.

The 2010 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 well below 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. The official public doses for the DN and PN sites are summarized in Table 1 and described as follows:

- At the DN site, the highest dose calculated for the nine potential critical groups was 0.6 µSv (0.1% of the regulatory limit) for a one-year old infant of the Dairy Farm critical group. This dose is similar to the 2009 dose of 0.7 µSv, reported for the same critical group.

- At the PN site, the highest dose calculated for the six potential critical groups was 1.0 µSv (0.1% of the regulatory limit) for an adult from the Urban Resident critical group. This dose is less than the 2009 dose of 1.8 µSv reported for the Industrial/Commercial adult and is primarily attributed to a reduction in tritium oxide (HTO) emissions to air, discontinuation of passive tritium-in-air samplers, which historically had higher results than the active samplers, and lower dose from noble gas as the result of a correction made to the building shielding factor to align with CSA N288.1-08.

Table 1: OPG Public Dose Estimates – 2010

Facility	Critical Group (Receptor)	Effective Dose (μSv)	Percentage of Legal Limit (%)	Percentage of Background Radiation around DN and PN (%)
Darlington Nuclear	Dairy Farm (1 yr. old infant)	0.6	0.1	< 0.1
Pickering Nuclear	Urban Resident (Adult)	1.0	0.1	0.1

Looking ahead, the following activities will take place in 2011 for the REMPs:

- Development of the implementation plan to comply with the new CSA N288.4-10 standard, Environmental Monitoring at Class I Nuclear Facilities and Uranium Mines and Mills, will be developed.

- Replacement of existing aging active tritium-in-air samplers with the new active tritium-in-air sampler model.

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. 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.

This annual REMP report is prepared and submitted to the Canadian Nuclear Safety Commission (CNSC) in accordance with the operating licenses issued to PN and DN. This report is also made available to the public.

This report provides the radiological emissions and environmental data collected for the period from January 1st to December 31st, 2010 for each site, their interpretations, and the estimates of radiation doses to the public resulting from the operation of PN and DN stations. The REMP results for OPG's Western Waste Management Facility (WWMF) are reported by Bruce Power in their annual summary REMP report.

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

2.0 REMP OBJECTIVES

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

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

(b) To estimate annual doses to the public based on environmental data measured in the public domain.

(c) To provide data for evaluation of assumptions and transport models used to calculate station derived release limits and public doses.

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 these two stations is as follows:

Darlington Nuclear

The DN Generating Station is OPG's newest CANDU (CANadian Deuterium Uranium) nuclear generating station. It is a four-unit station with a total output of 3,500 MW and is located 70 km east of Toronto 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, about 30 km east of Toronto in the city of Pickering. The site contains the Pickering A (PN-A) and Pickering B (PN-B) Nuclear Generating Stations, and the Pickering Waste Management Facility (PWMF) which consists of the Used Fuel Dry Storage and the Re-Tube Components Storage Area.



PN-A has two operating CANDU reactors and PN-B has four operating CANDU reactors. Together these stations have a total output of 3,100 MW, enough to serve a city of one and a half million people. PN-A 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: inhabitants of a correctional institute, urban residents, farmers, dairy farmers, industrial/commercial workers and sport fishers.

3.2 2010 Nuclear Generation Capacity

In 2010, OPG operated ten nuclear reactors that produced 45.6 terawatt hours (TWh) of electricity. This production is broken down as follows:

Darlington Nuclear DN's net electrical output in 2010 was 26.5 TWh.

Pickering Nuclear PN-A's net electrical output in 2010 was 5.5 TWh.

PN-B's net electrical output in 2010 was 13.6 TWh.

3.3 2010 Radioactive Emissions Data

The radioactive emissions from DN and PN in 2010 remain well below the station Derived Release Limits (DRLs). These limits represent radionuclide release rates that correspond to an exposure at the legal public dose limit of 1000 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 2010 total airborne and waterborne emissions for radionuclides measured at the DN and PN sites as both the annual activity released and as a percentage of the respective DRLs.

Table 3-1: OPG Annual Nuclear Site Emissions – 2010

Site Emissions	DN		PN	
	Bq	% DRL	Bq	% DRL
AIR				
Tritium Oxide	1.4E+14	0.30	5.7E+14	1.0
Elemental Tritium [(a)]	2.1E+13	<0.01	NA	NA
Noble Gas [(b)]	1.9E+13	0.05	2.3E+14	0.80
^{131}I	1.3E+08	<0.01	2.7E+07	<0.01
Particulate	7.4E+07	<0.01	5.5E+07	<0.01
^{14}C	1.3E+12	0.07	3.1E+12	0.05
WATER				
Tritium Oxide	1.4E+14	<0.01	2.6E+14	0.05
Gross Beta/Gamma	2.8E+10	0.04	1.9E+11	4.0
^{14}C	4.8E+08	<0.01	3.6E+09	<0.01

NOTES: NA = Not Applicable, Bq = becquerels

(a) Emissions from Darlington Tritium Removal Facility (TRF)

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

3.3.1 Emissions Trends

Iodine and particulate in airborne emissions, and carbon-14 (C-14) waterborne emissions remain very low and have minimal contribution to public dose, therefore they are not trended. The long-term tritium and carbon-14 (C-14) emissions to air and tritium emissions to water from DN and PN are provided in Figures 3-1 to 3-7. Since the reported noble gas stack emissions are at times below the instrument detection limits, the results of environmental noble gas monitors are used to track the station noble gas emissions, as described in Section 5.1.2.

The station emissions continue to be significantly below the station DRLs (as indicated in Table 3-1) and the resulting public dose remains a small fraction of the regulatory limit as shown in Section 7.0.

Elemental Tritium Airborne Emissions

DN – Figure 3-1

As indicated in Figure 3-1, since 2006 the elemental tritium (HT) emissions at DN have returned to the low levels seen prior to 2004. In 2010, the HT emissions at DN reduced to 2.1×10^{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 and a human error event at the TRF, which have since been addressed.

PN

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

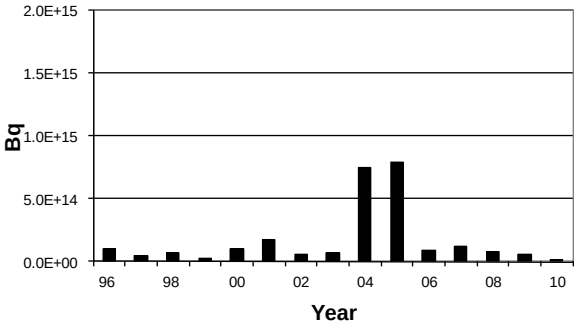


Figure 3-1: Darlington Nuclear Airborne Elemental Tritium Air Emissions

Tritium Oxide Airborne Emissions

DN – Figure 3-2

DN HTO airborne emissions have remained stable over the last five years. The 2010 HTO airborne emission was 1.4 x 10^{14} Bq.

PN – Figure 3-3

PN HTO airborne emissions decreased in 2010, and were at about the average level seen prior to 2008. Airborne HTO emissions in 2010 were 5.7 x 10^{14} Bq. The decrease was attributed to a reduction of PN-A HTO emissions and to the shutdown of all reactors for the 2010 Vacuum Building Outage (VBO). Work is continuing in efforts to further reduce HTO emissions for both PN-A and PN-B by improving leak management, improving reliability and operation of vapour recovery dryers, and reducing HTO source terms.

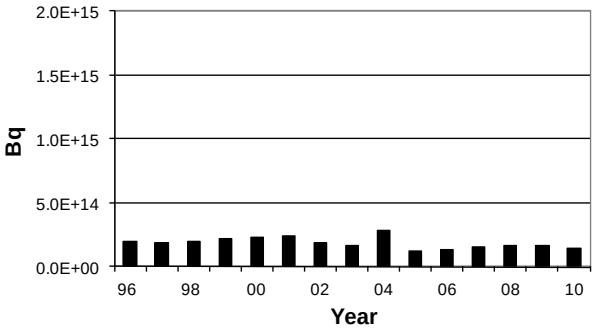


Figure 3-2: Darlington Nuclear Tritium Oxide Air Emissions

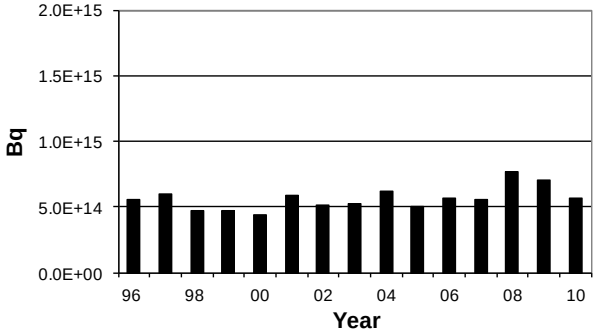


Figure 3-3: Pickering Nuclear Tritium Oxide Air Emissions

Carbon-14 Airborne Emissions

DN – Figure 3-4

DN C-14 airborne emissions have remained stable since 2004. The 2010 C-14 airborne emissions were 1.3 x 10^{12} Bq.

PN – Figure 3-5

PN C-14 airborne emissions trended upward from 2004 to 2007 due to a failed calandria tube that leaked carbon dioxide (CO_2) from the annulus gas into the Unit 7 moderator system. Moderator purification was increased in response to the leak to minimize airborne C-14 emissions. The emission level dropped significantly following the April 2008 replacement of the failed calandria tube and has since returned to pre-2005 levels. The 2010 C-14 airborne emissions were 3.1 x 10^{12} Bq.

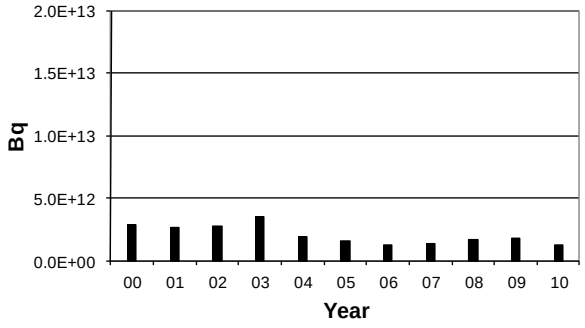


Figure 3-4: Darlington Nuclear C-14 Air Emissions

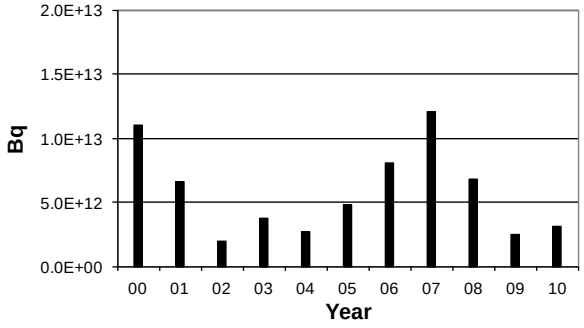


Figure 3-5: Pickering Nuclear C-14 Air Emissions

Tritium Oxide Waterborne Emissions

DN – Figure 3-6

The reported DN HTO to water emissions have trended slightly upward since 2004 due to contamination of the autosampler, which is not reflective of a true increase in emissions. The increase in emissions observed in 2007 and 2008, which were still <0.01% of the DRL, was the result of the drainage of the Emergency Coolant Injection (ECI) system and discharges of Vacuum Building Dousing Water in preparation for the 2009 VBO. The 2010 DN tritium to water emission was 1.4 x 10^{14} Bq, which is reflective of the level prior to the VBO activities.

PN – Figure 3-7

The PN waterborne HTO emissions were slightly elevated in 2008 and 2009, but in 2010 they have returned to the level observed prior to 2008. The increase in 2008 was due to a minor heavy water leak from a Unit 1 shutdown cooling heat exchanger. The leak was subsequently contained and the water sent to the upgraders for recovery. The elevated level in 2009 was due to a small Unit 1 boiler tube leak. Repairs to both

the shutdown cooling heat exchanger and boiler tube leaks were completed during the 2010 VBO and HTO emissions have since decreased. The PN tritium to water emissions in 2010 were 2.6 x 10^{14} Bq.

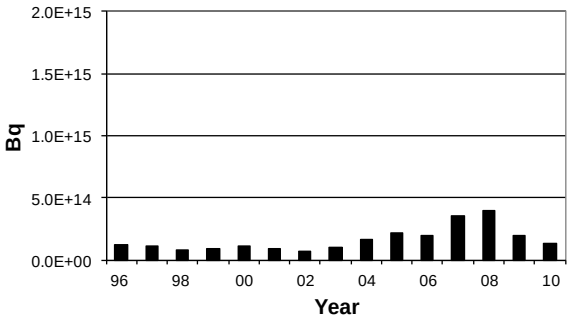


Figure 3-6: Darlington Nuclear Tritium Oxide Water Emissions

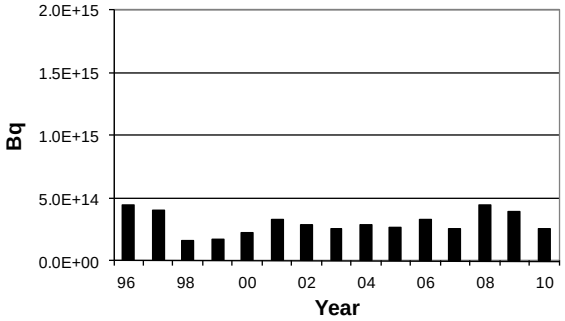


Figure 3-7: Pickering Nuclear Tritium Oxide Water Emissions

Gross Beta-Gamma Waterborne Emissions

In previous years, gross beta-gamma waterborne emissions were not graphed because its contribution to public dose was minimal. This is still true for DN, however PN has experienced an increase in emissions during the last few years as shown on Figure 3-8.

PN – Figure 3-8

In the last two years, PN has seen an increase in gross beta-gamma emissions to water. The increase is due to short duration spikes which are believed to be discharges of active particulates that may be the result of material held onto piping that was released during station system perturbations. PN gross beta-gamma emissions to water were elevated in 2010 due to two isolated spikes in the weekly station effluent samples, one occurring at PN-A and one at PN-B. Plans are currently underway for a third-party review of the station in-house investigations and to provide direction on the next steps needed to address this issue. Dose from these emissions contributed to less than 0.2 μSv of the estimated public dose.

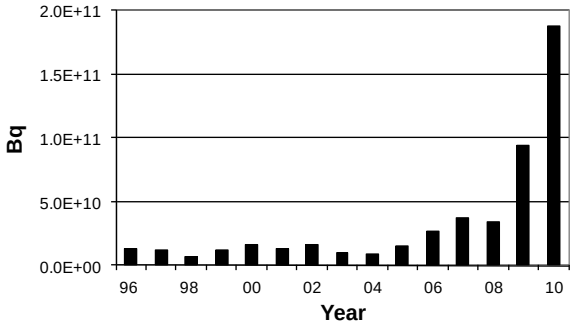


Figure 3-8: Pickering Nuclear Gross Beta-Gamma Water Emissions

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 2010 estimates of C-14 inventory within the PN and DN stations are 7.9 $x10^{14}$ Bq and 6.9 $x10^{14}$ Bq, respectively [R-2].

4.0 2010 SAMPLING AND ANALYSIS PLAN

To ensure the local members of the public living and working around a nuclear power station are properly protected from any station radionuclide emissions, 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 do 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 these results. However, the next site-specific survey reviews will be in 2012, to align with the 5 year frequency of the release of Census of Canada data so that the most up-to-date census information will be used.

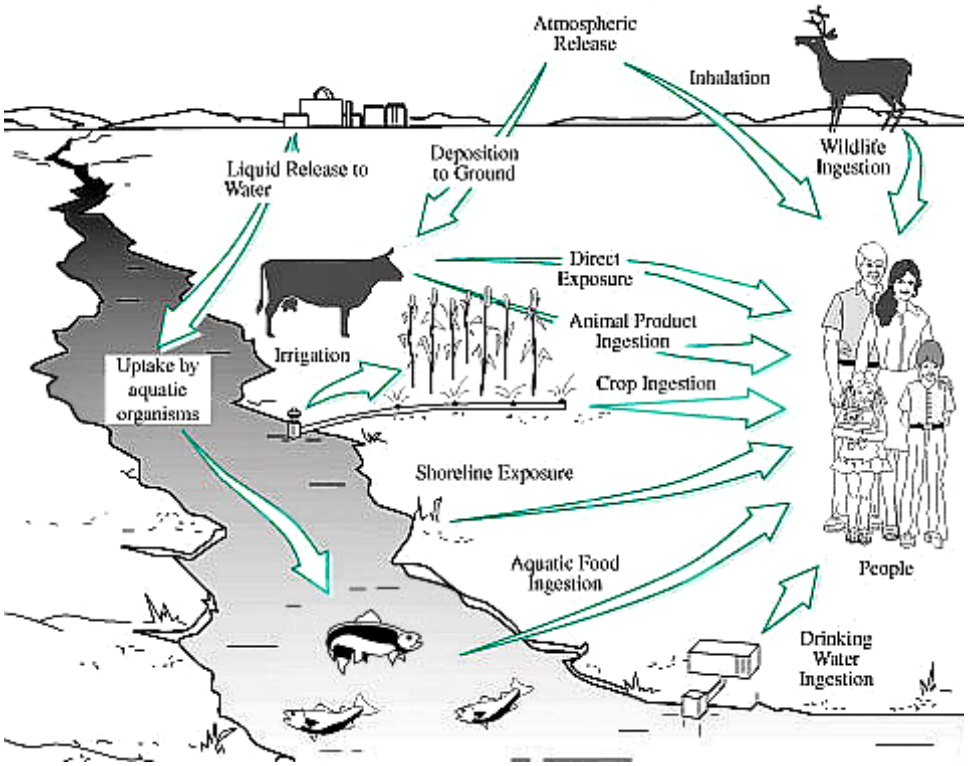


Figure 4-1: Model of Exposure Pathways from Station Emissions
Source: Based on United States Department of Energy/Hanford Site

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-14].

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, that receives the highest annual dose may vary 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 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 surveys have been conducted. In the most recent reviews [R-37] [R-38], the existing REMP sampling programs were found to fulfill the sampling requirements for dose assessment purposes.

4.2.1 Radionuclides Monitored

Radionuclides that are emitted from PN and DN station operations are monitored in the REMP 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 240 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 an H-3 atom. HTO is a normal station emission of CANDU plants. Concentration 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 still needs to be established. OBT concentrations are currently modeled from HTO concentrations measured in sample media at each critical group location and in and fish.

OPG public 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 I-131 in air.

Iodine-131 (I-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. Cobalt-60 (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	Radionuclides Monitored	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) and Ir-192, I-131*	Continuously	Reported monthly
Terrestrial Sampling			
Fruits, Vegetables, Silage	HTO and C-14	Annual (harvest)	Annual
Milk	HTO and C-14	Weekly	Monthly composite
Aquatic Sampling			
Municipal Drinking Water	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	Bi-annual (June and November)	Annual
Beach Sand	Cs-137, Cs-134, Co-60	Annual	Annual
SAMPLES FOR OTHER REMP OBJECTIVES			
Air	Noble Gases (Thermoluminescent dosimeters)	Continuously	Quarterly
Precipitation	HTO	Monthly	Monthly
Dry/Wet Fallout	Gross beta	Monthly	Monthly
Fruits, Vegetables, Silage	OBT	Annual (harvest)	Annual
Garden and Inland Soils	Cs-137, Cs-134, Co-60	Annual (harvest)	Annual
Milk	I-131	Weekly	Weekly composite of locations
Milk	OBT	Weekly	Monthly
Municipal Drinking Water	Gross beta	2-3 times/day	Monthly composite
Well 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

*air kerma is measured and converted to external air immersion dose

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.

Noble gas dose rate monitors are set up around the sites and thermoluminescent dosimeters (TLDs) are located around the sites and at background locations to continuously monitor external gamma dose.

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

HTO in air around PN and DN was previously sampled continuously by two technologies; the molecular sieve (active) sampler and the passive sampler. In 2010, the passive sampler was discontinued due to its inconsistent performance and incapability of providing accurate measurements, as demonstrated in an assessment conducted on the variability and accuracy of the active and passive tritium-in-air samplers. The assessment was based on the results of a 2006 CANDU Owners Group (COG) study [R-6] and the results of a seven month OPG field test in 2009 using the passive sampler recommended by COG [R-41]. This assessment also concluded that active samplers provide accurate measurements of HTO in air and are the preferred HTO in air sampling method [R-41].

As the existing active samplers are aging and spare parts for key components are no longer available, by the end of 2011, existing active samplers will be replaced with new active samplers recommended by COG.

The active sampler collects water vapour by passing air continuously at a steady rate through two molecular sieve canisters. 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. The active sampler at Lambton was discontinued in 2010 since multiple background locations are only needed when a potential for effects has been identified in several areas with different environmental conditions. Since OPG historic data of tritium-in-air concentrations at both background locations showed no significant differences, only the background location at Nanticoke is retained.

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 were measured at 10 critical group locations around DN and three site boundary locations, and at eight critical group locations around PN, three of which are also site boundary locations. Since C-14 in air is not a significant dose pathway via inhalation, it is not necessary to measure C-14 in air at all boundary locations. 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 boundary and nine detectors around the PN site boundary. 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

TLDs measure total gamma dose from background, as well as any gamma emitting radionuclides in the air or radiography skyshine. Any normal station contribution is too small to be distinguished from the high and variable contribution from natural background because TLDs do not distinguish between different contributing radionuclides. However, a significant station emission would be captured by the TLD at levels where the noble gas detectors may become saturated.

A total of six TLDs are placed around the DN site boundary and four TLDs are located at critical group locations. PN has a total of nine TLDs around the site boundary and one TLD at a nearby critical group location.

Background measurements are taken at 11 locations around Ontario.

All TLDs around DN, PN and at background locations are collected and analyzed every quarter.

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 data are not used in the calculation of public dose but the long-term data assists in understanding other indicators such as HTO in biota and HTO which will eventually reach the shallow drinking water well aquifers.

Based on an assessment in 2009, the 2010 sample locations were reduced from 20 to six locations around DN and from 14 to six locations around PN, which provide representative overviews of each area. Precipitation and wet/dry fallout samples are not obtained from background locations.

4.2.3 Terrestrial Sampling

Terrestrial biota receive 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, honey and milk 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 D10 to D12.

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 establish 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 two open field (undisturbed soil) samples are obtained at local farms and residences close to the DN site.

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

Replicate soil samples are collected from three background locations (Cobourg, Goderich, and Lakefield).

4.2.3.2 Fruits, Vegetables, Silage and Honey

Samples of fruits, vegetables and silage representative of the 2010 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 silage samples were taken, in 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 number of commercial apiaries are located in the DN and PN area from which honey samples were obtained and analyzed for HTO, C-14, and gamma emitters. Honey data were compiled from 2003 to 2010, which showed that C-14 and gamma results have been historically consistent, and HTO results correspond roughly to the trends seen in boundary HTO in air and HTO in vegetation. Since historical data have been consistent and honey samples are not used in the dose calculation (dose from honey

is modeled from air emissions), the reduction of sample collection frequency from annually to once every five years will be assessed in 2011.

A total of 31 fruit and vegetable samples were obtained from various critical group locations around DN along with five silage 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 19 samples were collected from critical group locations around PN including one locally grown silage sample. Vegetables were sampled from five background locations.

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 weekly 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. 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. Quarterly samples from background locations are collected and analyzed for HTO, C-14 and I-131.

Milk samples are collected from five dairy farms around DN, two dairy farms around PN and two dairy farms in background locations.

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.

In 2010, lake water sampling at St. Mary's Cement plant was discontinued and replaced with lake water and beach sand sampling at a publicly accessible location along West/East beach. The reason for this change was that West/East beach is a more representative sample location for water immersion and external exposure dose for members of the public using the beach area for recreational swimming.

The results of aquatic sampling are summarized in Section 5.3 and detailed data is given in Appendix D, Tables D6 to D9.

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 15 wells around the DN area (seven farms/dairy farms and eight residential locations).

Monthly well water samples were collected from seven wells around the PN area, but this was reduced in 2010 to five wells as fewer residents obtain their water from wells.

Samples are analyzed monthly for HTO and quarterly for gross beta activity.

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-B outfall. Background locations on the New York side of Lake Ontario were chosen to be a sufficient distance away from the influence of the stations.

- Target fish species to be collected at each site and at background locations are Lake Whitefish and White Sucker, with Round Whitefish and Brown Bullhead as their respective backup species.

- Eight replicate fish samples for two different species 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.

In 2010, problems were experienced in acquiring a sufficient number of replicate fish samples from the Lake Ontario background location. Alternative actions to address this issue are being assessed for the 2011 sampling season.

4.2.4.4 Sediment

Lake bottom sediment can be an indicator of potential radionuclide build-up in the environment. Four replicate samples of sediment are obtained from each of three locations around the DN site, four locations around the PN site and two Lake Ontario background locations near Cobourg and Etobicoke.

Samples are collected and analyzed annually for Cs-134 and Co-60, which are solely reactor produced, and for Cs-137 and C-14 which are a product of reactor operations and nuclear weapon tests.

Since sediment samples are not utilized in the dose calculation and historical data has shown no indication of accumulation, starting in 2010, the frequency of sample collection has been reduced to once every five years.

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 provincial 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 establish accumulation unless the concentrations of Cs-137 are significantly higher than background.

4.2.5 Sewage Sampling

The Duffin Creek Water Pollution Control Plant (WPCP) is located about 2 km east of the PN site. The WPCP treats sewage effluent streams from the PN site and from York-Durham Regions, and a portion of the resulting sludge is incinerated. Sewage sludge from the DN site sewage treatment plant may also be shipped to the Duffin Creek WPCP for treatment and disposal. This sludge is sampled and analyzed at DN before shipment to check for radioactivity. It is important to note that there is radioactivity in the sewage streams from sources other than PN and DN, primarily from the use of radionuclides in medical diagnosis and treatment.

4.2.5.1 WPCP Incinerator Ash

WPCP incinerator ash is collected as it is the form of sewage that has the highest concentration of gamma emitting radionuclides and has the potential to cause the highest dose to WPCP workers. Monthly samples of ash are analyzed by high resolution gamma spectrometry.

4.2.5.2 PN Sewage Effluent

PN sewage effluent contains only a very small amount of incidental radioactivity from showers, toilets, janitorial sinks, etc. Since WPCP ash contains radionuclides from other sources such as medical treatment, PN sewage effluent is analyzed to determine the radioactivity of sewage leaving the property boundary that will end up at the WPCP. Weekly samples of PN sewage are analyzed for gamma emitters and quarterly composite samples, made up from the weekly samples, are analyzed for HTO and C-14.

5.0 2010 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 measurand cannot reliably be measured. More specifically, the critical level is the largest value of the measurand for which the probability of a wrong conclusion that a measurand is present exceeds a specified probability [R-24]. The REMP uses a probability of 5%.

Ld: The detection limit is the level (relative to background) above which a measurand can confidently be measured. More specifically, the detection limit is the smallest value of the measurand for which the probability of a wrong

conclusion that the measurand is not present does not exceed a specified probability [R-24]. The REMP uses a probability of 5%.

When reporting the environmental measurement values in the tables in Appendix D, the following protocols were used:

- If the sample analysis is lower than the Ld of the analytical method but higher than the Lc, the actual measurement is reported and is in bold type.
- If the measurement is less than the Lc, then "< Lc" is reported.
- When measurement averages or other calculations are performed, they are calculated using actual results obtained even if they are below the Lc.
- Gamma spectrometer results are reported as "< Ld" when their actual values are below the Ld.

5.1 Atmospheric Sampling

5.1.1 Air

Tritium Oxide

The 2010 annual average results of airborne HTO measured by molecular sieve monitors at the DN, PN, and background sites are summarized in Appendix D, Table D3.

The annual average HTO in air measured at the background locations 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 since the measurements are consistently taken at the same locations. Apart from the station emissions, which are the main contributor to HTO concentrations in air, the levels of HTO observed in the environment are also affected by the 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.

In the past, due to their inconsistent performance, the passive tritium-in-air samplers often gave higher results than the active samplers. To remain conservative, for locations where both technologies were present, the higher result was used for the dose estimates. Since the passive samplers were discontinued for 2010, a reduction was seen in the tritium-in-air values used for dose calculations. The impact is more apparent at PN than at DN since PN has higher measurements of airborne tritium.

DN – Figure 5-1

The 2010 HTO in air annual average concentrations measured at boundary locations ranged from 0.2 to 0.8 Bq/m^3. The average boundary concentration of 0.4 Bq/m^3 is consistent with those observed in the environment over the last five years which fluctuated between 0.5 and 1.0 Bq/m^3, as illustrated in Figure 5-1.

PN – Figure 5-2

The 2010 HTO in air annual average concentrations measured at boundary locations ranged from 1.3 to 11.1 Bq/m^3. The average boundary concentration of 4.1 Bq/m^3 is lower than those observed in the environment over the last five years which fluctuated between 6.2 and 7.7 Bq/m^3, as illustrated in Figure 5-2. This is a reflection of the lower station HTO emissions to air as described in Section 3.3.

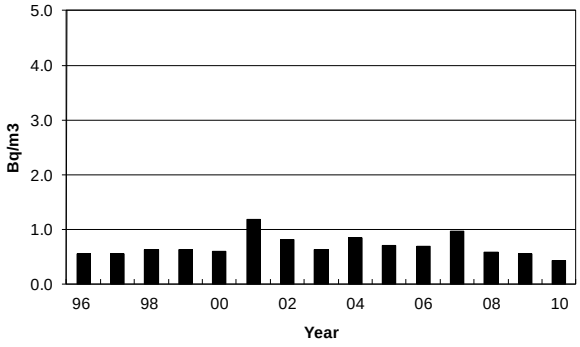


Figure 5-1: Darlington Nuclear Boundary Average HTO in Air

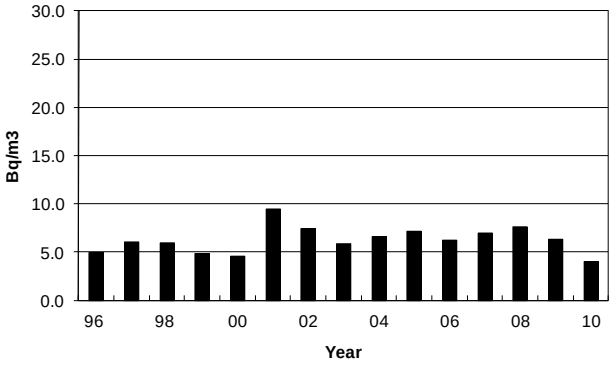


Figure 5-2: Pickering Nuclear Boundary Average HTO in Air

Carbon-14

The 2010 annual averages of airborne C-14 measured at the DN, PN and background sampling locations are summarized in Appendix D, Table D4.

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 weapon test C-14 is being removed naturally from the environment. Pre-atmospheric weapons test levels were measured at 226 Bq/kg-C [R-11]. The annual average C-14 in air concentration observed at background locations was 242 Bq/kg-C in 2010.

DN – Figure 5-3

The annual average C-14 in air concentrations measured at the DN sampling locations ranged from 232 to 271 Bq/kg-C. The 2010 C-14 in air average concentration measured at select high wind frequency boundary locations around DN was 261 Bq/kg-C. The values observed in the environment in previous years are illustrated in

Figure 5-3, which shows that the 2010 average is consistent with levels observed at the same locations over the last five years.

PN – Figure 5-4

The annual average C-14 in air concentrations measured at the PN sampling locations ranged from 242 to 492 Bq/kg-C. The 2010 C-14 in air average concentration measured at select high wind frequency boundary locations around PN was 458 Bq/kg-C. The values observed in the environment in previous years are illustrated in Figure 5-4. In 2010, the average C-14 concentration in air at the same locations remain similar to 2009 and reflects the station C-14 airborne emissions trends discussed in Section 3.3.

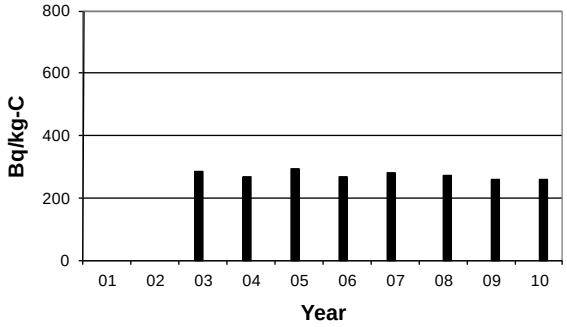


Figure 5-3: Darlington Nuclear Boundary Average C-14 in Air

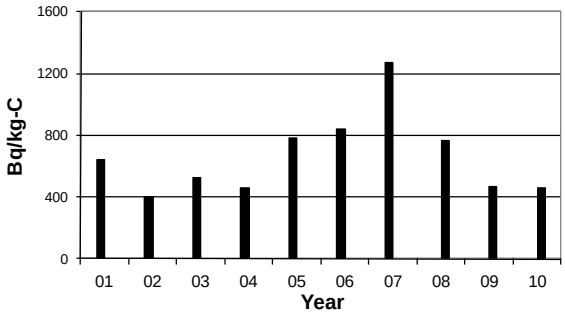


Figure 5-4: Pickering Nuclear Boundary Average C-14 in Air

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 2010 from the noble gas detectors are summarized in Appendix D, Table D2 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.

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 1.7 microgray (µGy)/yr in 2010.

Ar-41 emissions and measurements in the environment are largely related to the number of operating days of PN Units 1 and 4. 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. In 2010, overall electricity power production remained similar to 2009, with a decrease from PN Unit 1 and increase from Unit 4. However, Units 4 and 5 experienced some elevated noble gas emissions during periods when the wind was blowing towards the nearest noble gas detectors, which resulted in a small increase in Ar-41 boundary average dose rates. Figure 5-5 illustrates the trend of the boundary average Ar-41 dose rate for PN.

Xe-133 and Xe-135 were also measured above the detection limit at PN. Measured boundary average values in 2010 were 0.03 µGy/yr for Xe-133 and 0.05 µGy/yr for Xe-135. These values are consistent with air doses observed in previous years from Xe-133 and Xe-135.

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

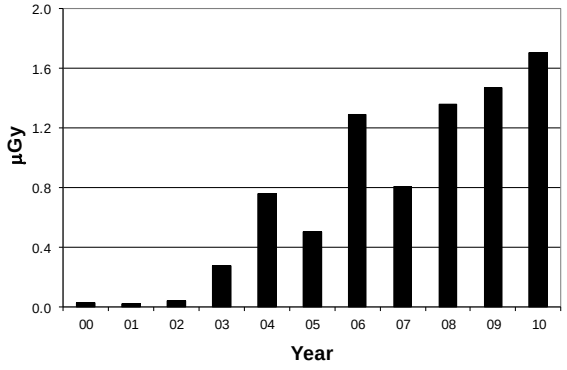


Figure 5-5: Pickering Nuclear Boundary Average Ar-41 Dose Rate in Air

Thermoluminescent Dosimeters

The 2010 annual average results from the TLDs at PN, DN and background sampling locations are summarized in Appendix D, Table D1. Figures 5-6 and 5-7 illustrate the trends in external gamma dose rates observed at DN and PN boundary locations over the last 15 years. TLD measurements are largely comprised of the natural background gamma dose while the noble gas detector results have the background dose subtracted (see Section 4.2.2.1 for more detail).

The 2010 boundary average external dose rates in air for the DN and PN sites remained consistent with the values established over the last 15 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 2010 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 2010 was 507 µGy/yr. This dose rate is representative of background contributions.

PN – Figure 5-7

The boundary average external total gamma dose rate in air for 2010 was 469 µGy/yr. This dose rate falls within the variability of natural background gamma.

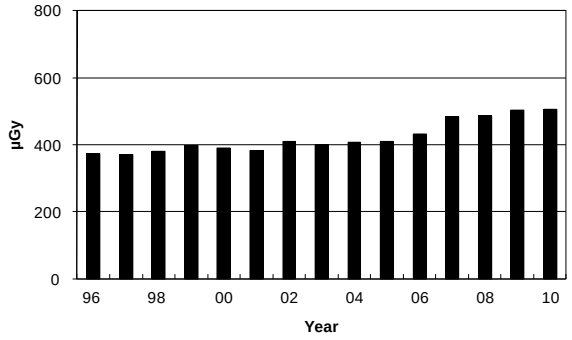


Figure 5-6: Darlington Nuclear Boundary Average TLD Gamma Dose Rate

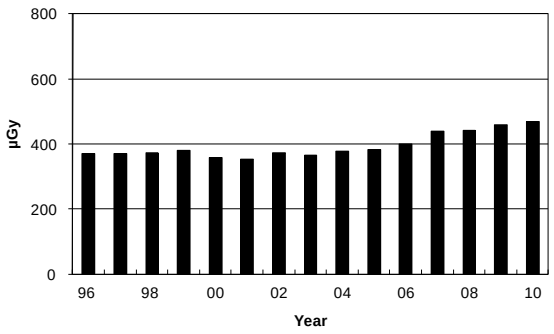


Figure 5-7: Pickering Nuclear Boundary Average TLD Gamma Dose Rate

5.1.3 Precipitation and Dry/Wet Fallout

Tritium Oxide

The 2010 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.

HTO in precipitation values closely follow airborne HTO emissions trends.

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 past few years, but decreased slightly in 2010. The boundary average value decreased from 36 Bq/L in 2009 to 18 Bq/L in 2010.

PN – Figure 5-9

The decrease in PN tritium-in-air emissions in 2010 over 2009 is reflected in the decreased level for PN boundary average HTO in precipitation of 149 Bq/L, down from 322 Bq/L in 2009.

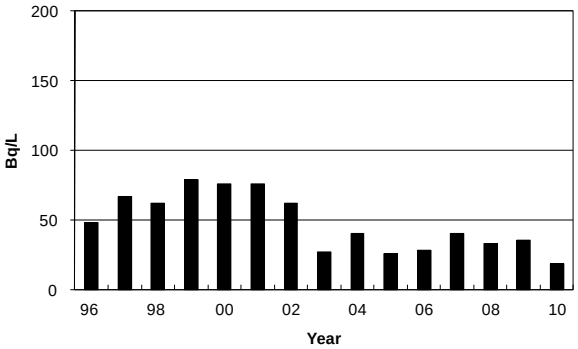


Figure 5-8: Darlington Nuclear Boundary Average HTO in Precipitation

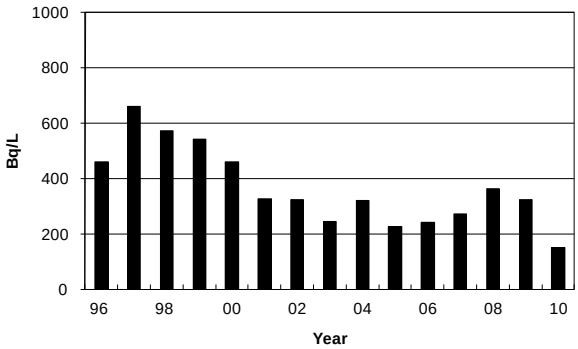


Figure 5-9: Pickering Nuclear Boundary Average HTO in Precipitation

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 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-5]. The 2010 averages of 15.3 Bq/(m^2·month) and 15.8 Bq/(m^2·month) for the DN and PN sites respectively were within this range.

5.2 Terrestrial Sampling

5.2.1 Garden and Inland Soils

The results for garden and inland soils are provided in Appendix D, Table D11.

Gamma Spectrometry

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

Background soil samples analyzed in 2010 ranged in Cs-137 concentration from 2.4 Bq/kilogram (kg) to 5.8 Bq/kg. All the values 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). Neither Cs-134 nor Co-60 were detected in any PN or DN soil samples in 2010. It is therefore concluded that the Cs-137 measured in these soil samples is from historic weapons testing fallout and not from OPG operations.

DN

At the DN locations, Cs-137 in soil concentrations ranged from 2.8 to 8.7 Bq/kg. The non-irrigated soil at location F16, which in 2009 had a higher value than the historical

range of background values, now falls within the historical range. Therefore, there is no indication of accumulation at F16. Cs-134 and Co-60 were not detected in any of the samples.

PN

At PN locations the Cs-137 in soil concentration was measured as 3.0 Bq/kg in the PN garden soil sample and 5.0 Bq/kg in the open area sample. Again, Cs-134 and Co-60 were not detected in any of the samples.

5.2.2 Vegetation

The results for vegetation are provided in Appendix D, Table D10.

Tritium Oxide

The average HTO concentration measured in the vegetables in provincial background locations was 4.2 Bq/L for 2010. This average is based on 5 locations considered to be outside the area impacted by station operations.

HTO concentrations in vegetation around the nuclear sites tend to be variable from year to year as the values reflect the conditions (i.e., prevailing winds, HTO emissions, humidity etc.) a few hours prior to the time of sampling. Furthermore, the number of samples and their locations has changed throughout the years. These limitations 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 2010 average concentration of HTO in vegetation was 12.3 Bq/L which is below the values observed in the last five years. This may be attributed to lower HTO and HT airborne emissions.

PN – Figure 5-11

Local fruit and vegetables collected around the PN site had HTO concentrations above the background average. The 2010 average concentration of HTO in vegetation was 50.8 Bq/L which is well below the values observed in 2006 to 2008, and similar to 2009. This may be attributed to a downward trend in HTO emissions to air from 2008 to 2010 and excluding an on-site vegetable sample location from the off-site average starting in 2009 since it is not representative of produce consumed by the public.

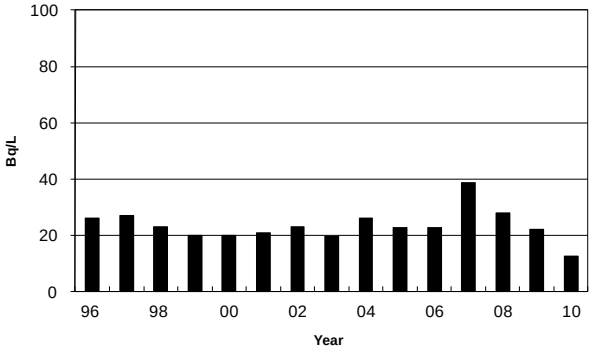


Figure 5-10: Darlington Nuclear HTO in Vegetation

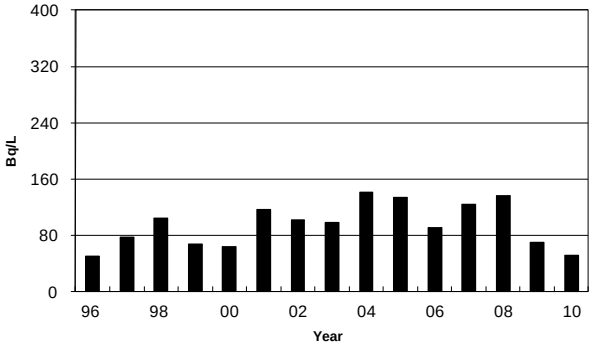


Figure 5-11: Pickering Nuclear HTO in Vegetation

Carbon-14

Background C-14 measurements have been trending downwards with time and are now similar to the conditions prior to weapons testing [R-36]. In 2010, the annual average C-14 in background vegetation was measured at 230 Bq/kg-C. This value was used as the background C-14 value for terrestrial vegetation.

DN – Figure 5-12

The 2010 average concentration of C-14 in DN vegetation was 246 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 2010 was 298 Bq/kg-C. Figure 5-13 illustrates the trend of C-14 concentration in vegetation around PN. The increase in 2006 and 2007, and the drop observed from 2008 onwards emulate the trend observed in station C-14 airborne emissions discussed in Section 3.3.

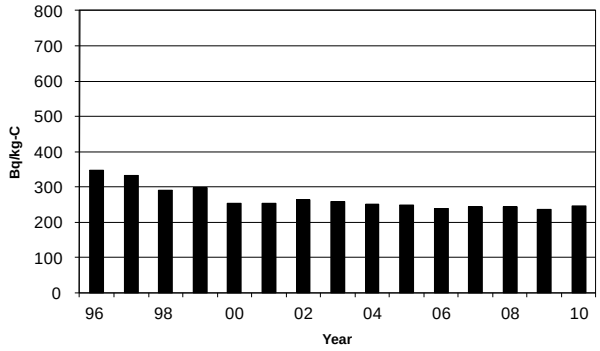


Figure 5-12: Darlington Nuclear C-14 in Vegetation

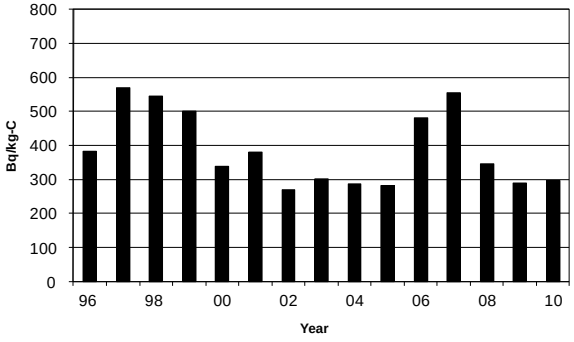


Figure 5-13: Pickering Nuclear C-14 in Vegetation

5.2.3 Milk and Silage

Annual average values of HTO and C-14 in milk and silage are provided in Appendix D, Table D12 and D10, 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.

Due to the large distance between the dairy farms and the DN and PN sites, and the many pathways which affect the concentration in milk as shown in Figure 4-1, it is expected that the trend of HTO in milk will follow the trend of airborne HTO emissions only in a general way. As expected, both the DN and PN values of HTO in milk were greater than the background average concentration.

DN – Figure 5-14

At the DN site, the average level of HTO in milk was slightly below the Ld at 4.3 Bq/L in 2010 from five dairy farms located within 15 km of the site. The trend of HTO in milk shown in Figure 5-14 indicates that the 2010 value is lower than values observed in the past five years.

PN – Figure 5-15

At the PN site, the average concentration of HTO in milk was 17 Bq/L in 2010 based on two dairy farms located within 12 km of the site. The PN trend for HTO in milk shows a decline since 2004 as illustrated in Figure 5-15.

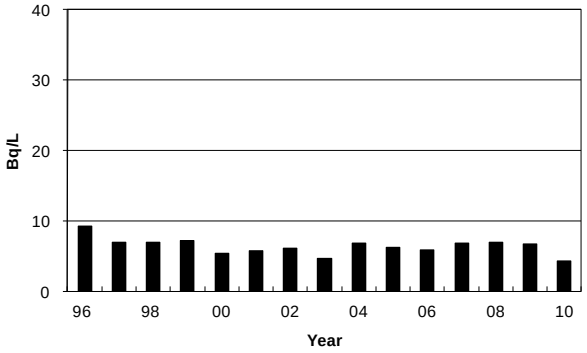


Figure 5-14: Darlington Nuclear HTO in Milk

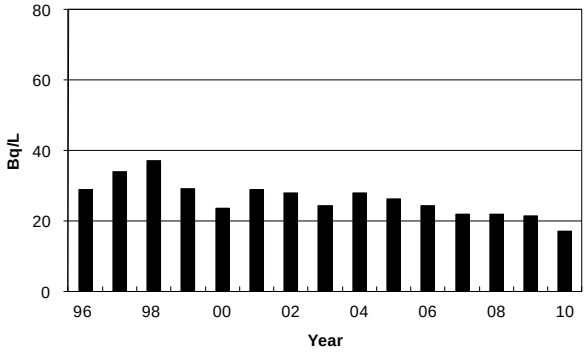


Figure 5-15: Pickering Nuclear HTO in Milk

Carbon-14

The background average C-14 in milk sampled from two farms on a quarterly basis was 228 Bq/kg-C. The 2010 C-14 levels in milk measured at the dairy farms around DN and PN are not significantly above background.

Since the cow's diet is the main contributing factor to the C-14 levels in milk, the C-14 levels in silage consumed by the cows serve as a verification of the concentrations found in milk. The silage contains C-14 from the previous year when it was grown, therefore emissions from the previous year could have an effect on the C-14 values measured in milk in the current year.

DN – Figure 5-16

The 2010 average concentration of C-14 in milk at surrounding DN locations was 242 Bq/kg-C. Figure 5-16 indicates that over the long term, C-14 levels in milk around DN are fairly stable and near background levels.

The average C-14 concentration in silage was 231 Bq/kg-C over five samples at DN (Table D10), 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 2010 was 247 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 silage was 232 Bq/kg-C from a single sample at PN (Table D10), which is within the range of values seen over the last five years.

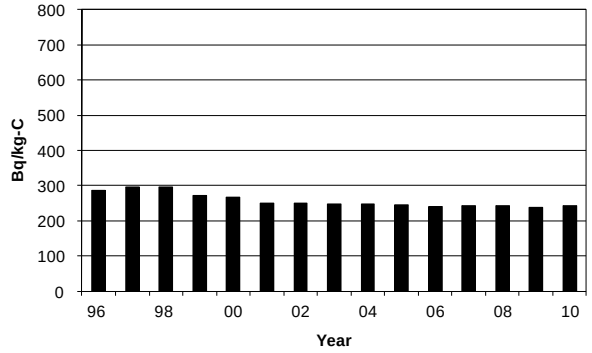


Figure 5-16: Darlington Nuclear C-14 in Milk

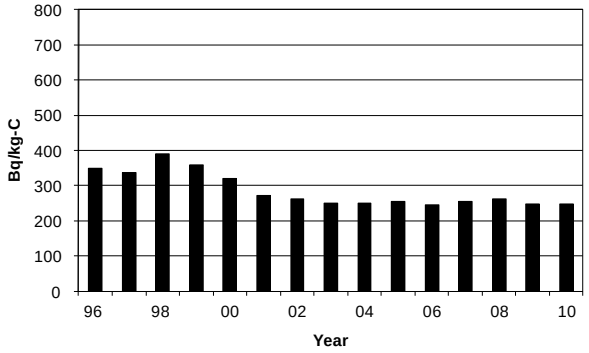


Figure 5-17: Pickering Nuclear C-14 in Milk

Iodine-131

In 2010, I-131 was not detected in any milk samples. The Ld for I-131 averaged approximately 0.1 Bq/L for all samples.

5.3 Aquatic Sampling

5.3.1 Lake Water and Water Supply Plants

The results for lake water and water supply plants are provided in Appendix D, Table D6.

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 7,000 Bq/L, which is the Ontario Drinking Water Quality Standard [R-39] for HTO. OPG also met its voluntary commitment to maintain annual average HTO levels at all 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. For the purpose of calculating public dose resulting from OPG operations, the sum of 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. The Lake Ontario background for 2010 was conservatively estimated to be 1.6 Bq/L, using the Great Lakes Time-Concentration Tritium Model [R-7].

The 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 3.2 Bq/L, which includes residual HTO from previous years of emissions. This supports OPG's practice of using

the tritium value generated by the Great Lakes Time-Concentration Tritium model of 1.6 Bq/L as it is a conservative background subtract.

The monthly average HTO concentrations for 2010 at the Darlington and Pickering area WSPs are given 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 annual average HTO concentrations at the Newcastle, Bowmanville and Oshawa WSPs ranged from 4.6 to 5.8 Bq/L in 2010. HTO concentrations at these WSPs are consistent with results from previous years.

PN – Figure 5-19

The WSPs located in the PN area, Ajax, Whitby, Harris and Horgan, had annual average HTO concentrations between 4.2 and 5.5 Bq/L in 2010. HTO concentrations at these WSPs are consistent with results from previous years.

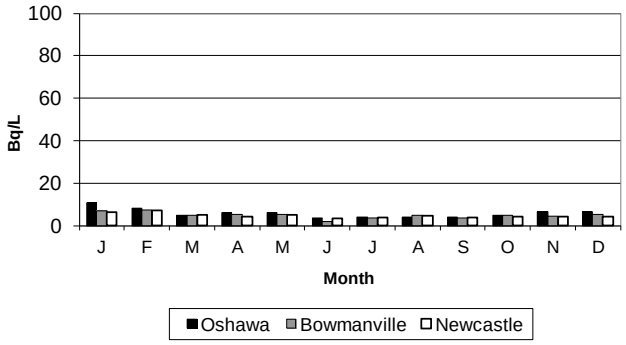


Figure 5-18: Darlington Nuclear WSPs HTO in Water Concentrations – 2010

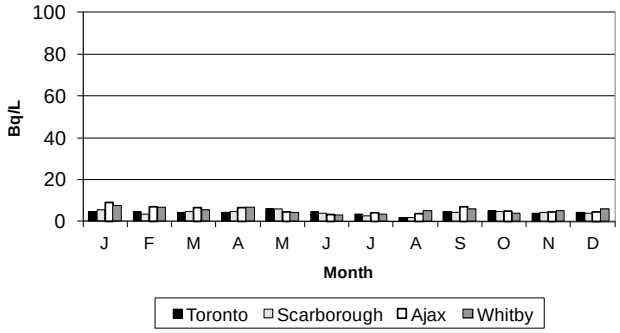


Figure 5-19: Pickering Nuclear WSPs HTO in Water Concentrations – 2010

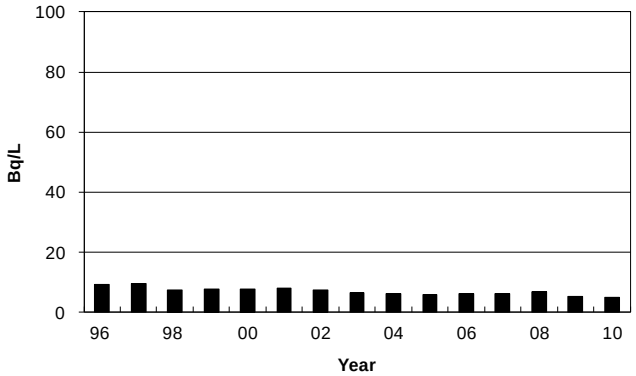


Figure 5-20: Bowmanville WSP – HTO in Water

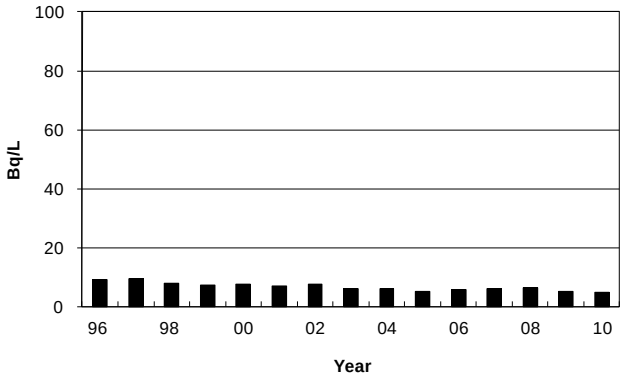


Figure 5-21: Newcastle WSP – HTO in Water

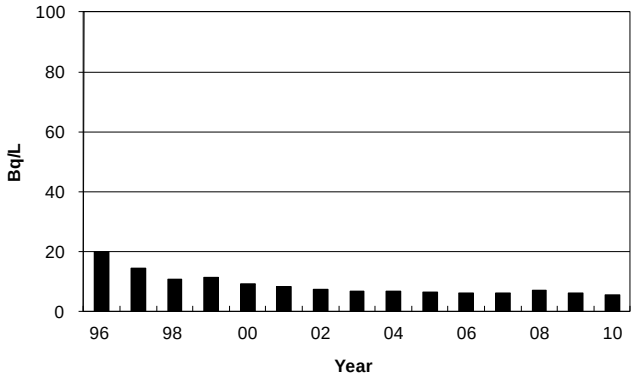


Figure 5-22: Ajax WSP – HTO in Water

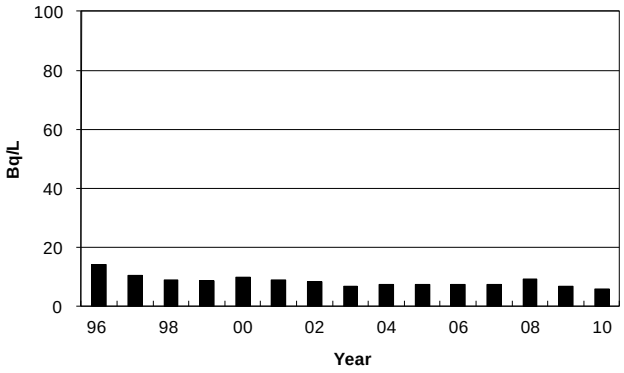


Figure 5-23: Oshawa WSP – HTO in Water

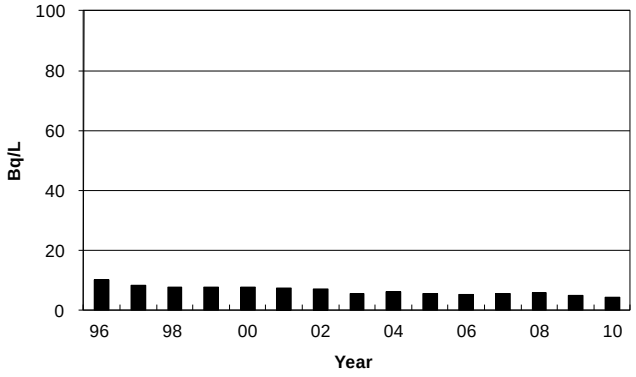


Figure 5-24: Scarborough Horgan WSP – HTO in Water

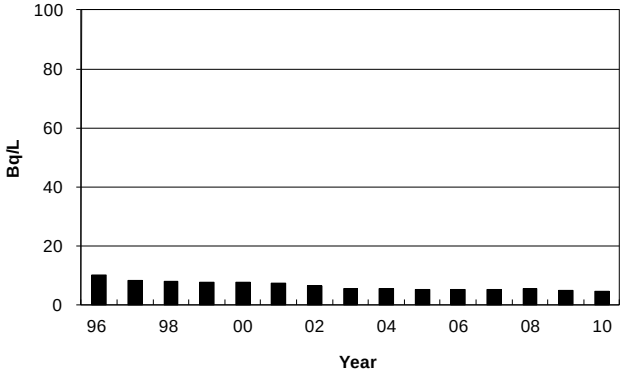


Figure 5-25: Toronto Harris WSP – HTO in Water

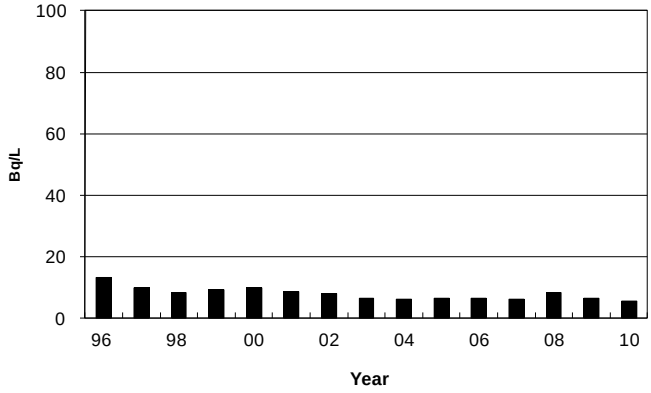


Figure 5-26: Whitby WSP – HTO in Water

Gross Beta

Annual average gross beta activity levels in samples from DN and PN area WSPs were both 0.11 Bq/L. These results are consistent with the average of the four provincial background Lake Ontario measurements of 0.10 Bq/L.

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 Table D6.

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 concentrations are also related to 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 22.5 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 81.5 Bq/L, which is consistent with the values seen over the last five years.

Gross Beta

DN

In samples from two residential wells around DN, gross beta activity was found to be higher than OPG's internal screening level of 1 Bq/L. The annual average gross beta activities at these two locations were measured as 1.3 and 2.7 Bq/L. Subsequent gamma analysis confirmed that the gross beta activity at these locations were due to naturally occurring K-40. Annual average gross beta activity from all other well water samples was below 0.4 Bq/L. These results are similar to those over the last five years.

PN

Similar to the last five years, annual average gross beta activity in PN well water samples was below 0.2 Bq/L.

5.3.3 Fish

The results for fish are provided in Appendix D, Table D9.

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 2010, the HTO in Lake Ontario background fish samples averaged 2.8 Bq/L.

DN – Figure 5-27

The HTO levels in the DN outfall fish samples averaged 4.7 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 5.6 Bq/L. This value is consistent with the levels observed over the last five years.

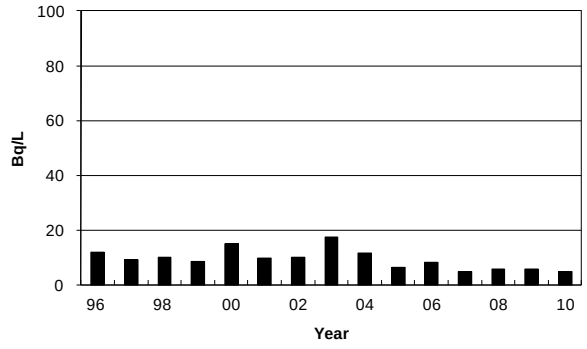


Figure 5-27: Darlington Nuclear HTO in Fish

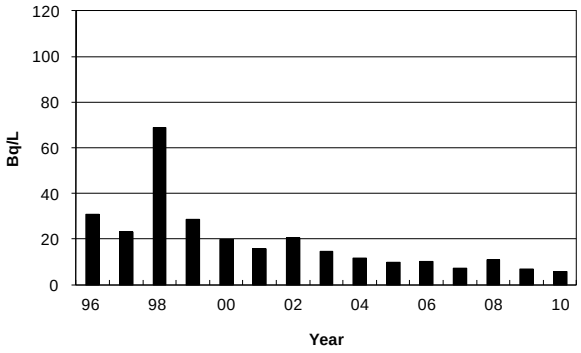


Figure 5-28: Pickering Nuclear HTO in Fish

Carbon-14

The average C-14 level in fish measured at a background Lake Ontario location was 219 Bq/kg-C in 2010.

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 2010 annual average C-14 level in DN fish was 234 Bq/kg-C.

PN – Figure 5-30

The 2010 annual average C-14 level in PN fish was 248 Bq/kg-C.

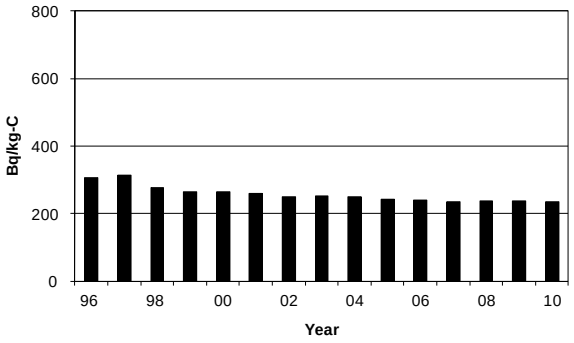


Figure 5-29: Darlington Nuclear C-14 in Fish

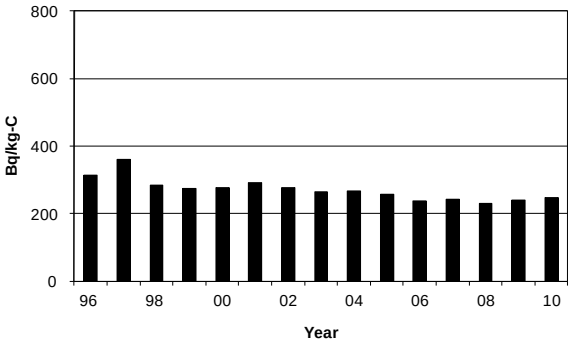


Figure 5-30: Pickering Nuclear C-14 in Fish

Gamma Spectrometry

The major portion of the gamma activity in fish is naturally occurring K-40. A small amount of Cs-137 is usually present due to nuclear weapons testing and, to a lesser extent, from reactor operation.

The average Cs-137 value for background Lake Ontario fish was 0.2 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, the same as background. Cs-134 and Co-60, which are indicative of reactor operation, were not detected in any fish samples at DN site in 2010.

PN – Figure 5-32

The average Cs-137 values for PN fish was 0.2 Bq/kg, the same as background. Cs-134 and Co-60, which are indicative of reactor operation, were not detected in any fish samples at PN site in 2010.

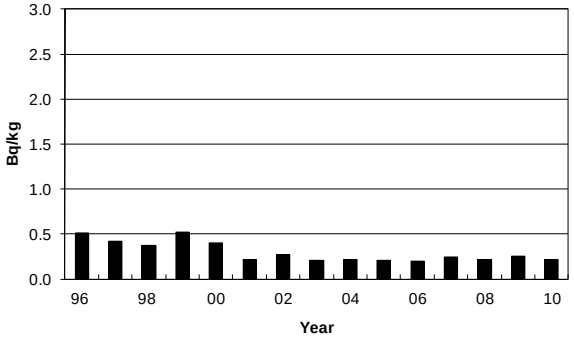


Figure 5-31: Darlington Nuclear Cs-137 in Fish

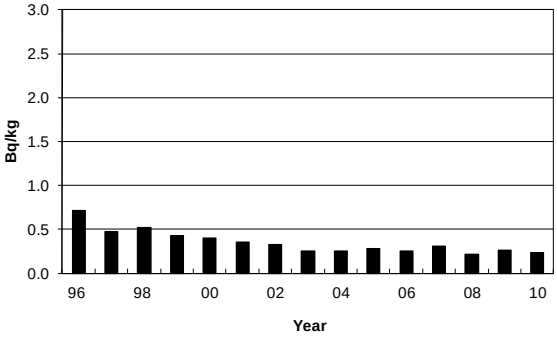


Figure 5-32: Pickering Nuclear Cs-137 in Fish

5.3.4 Sediment

As per Section 4.2.4.4, the frequency of lake sediment sampling has been reduced to once every five years. Therefore, the results shown below are 2009 data.

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

Gamma Spectrometry

A major portion of the activity in sediment in the vicinity of the stations comes from naturally occurring radionuclides, such as K-40.

Background sediment samples collected at two background locations in Lake Ontario had Cs-137 concentrations ranging from 0.4 to 1.0 Bq/kg.

DN

Sediment samples collected around DN had an average Cs-137 concentration of 0.5 Bq/kg, which is within the range of background values. Cs-134 and Co-60 were not detected in any of the sediment samples at the DN site in 2009.

PN

Sediment samples collected around PN had an average Cs-137 concentration of 1.2 Bq/kg. The Cs-137 concentration in PN surrounding sediments is slightly above the background values but is consistent with the values observed over the last five years, which ranged from 0.2 Bq/kg to 1.8 Bq/kg, which does not indicate accumulation.

Cs-134 and Co-60 were not detected in any of the sediment samples at PN site.

Carbon-14

The average concentrations of C-14 in sediments measured at PN, DN and background locations were below the terrestrial vegetation C-14 background level of 230 Bq/kg-C (see Section 5.2.2). This indicates the presence of low activity inorganic carbon, from lake bottom geologic material diluting the samples. The Lake Ontario background measurement of C-14 in sediments at Cobourg was 190 Bq/kg-C in 2009. Given the low C-14 measurements at PN and DN, it is not possible to observe accumulation from reactor operations.

DN

Measurements of C-14 in lake bottom sediments averaged 160 Bq/kg-C around DN.

PN

Measurements of C-14 in lake bottom sediments averaged 196 Bq/kg-C around PN.

5.3.5 Beach Sand/Silt Samples

The results for beach sand/silt are provided in Appendix D, Table D8.

Gamma Spectrometry

Background Cs-137 concentrations in beach sand samples measured at Cobourg averaged 0.3 Bq/kg. These values are consistent with values observed over the past five years.

DN

The Cs-137 concentrations measured DN beaches ranged from <0.1 Bq/kg to 0.3 Bq/kg. As reported in previous years, there was no Co-60 or Cs-134 detected in the sample.

PN

The Cs-137 concentrations measured at PN area beaches ranged from 0.3 Bq/kg to 0.8 Bq/kg. As reported in previous years, there was no Co-60 or Cs-134 detected in the samples.

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

5.4 Sewage Sampling

The results for the PN sewage samples and the ash from the WPCP incinerator are provided in Appendix D, Tables D13 and D14, respectively.

PN

The concentrations of I-131 in ash were above the detection level and ranged from 1.1 Bq/kg to 25.4 Bq/kg. 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.

5.4.1 PN Sewage Effluent – HTO and C-14

The average HTO concentration in sewage was 2335 Bq/L, which was lower than in 2008 and 2009. The elevated level in 2009 and partially in 2010 was due to building heating steam entering into the sewage sump via a leak from the Unit 1 inactive drainage system. Investigation and repairs took place during the 2010 Vacuum Building Outage, which addressed the problem. The measured HTO concentration has

a very small dose implication (<0.01 µSv) to the WPCP workers. C-14 was not detected in any of the quarterly composite samples.

5.5 Special Studies and Other Studies

5.5.1 Special Studies

Special Studies are conducted to investigate specific REMP issues or findings. Special Studies exclude development work such as improvement of measurement techniques or instruments.

There are currently no issues in the REMPs that require a special study.

5.5.2 Other Studies

Cesium Bioaccumulation Factor (BAF) for Fish in Lake Ontario

Concentrations of potassium in lake water around PN, DN and Cobourg are monitored annually to support validation of the CSA N288.1-08 [R-14] default cesium bioaccumulation factor (Cs BAF) for fish of 3500, which is used for the calculation of station Derived Release Limits (DRLs). The BAF value is based on an equation recommended by the International Atomic Energy Agency (IAEA) in the TRS-472 report [R-48] which considers the relationship of the Cs BAF to lake water concentrations of potassium.

Figure 5-33 is a graph of the annual Cs BAF as calculated by the TRS-472 equation. The best fit line shows that on average the estimated Cs BAF is below 3500. Therefore usage of the CSA N288.1-08 recommended Cs BAF of 3500 for DRL calculations is valid.

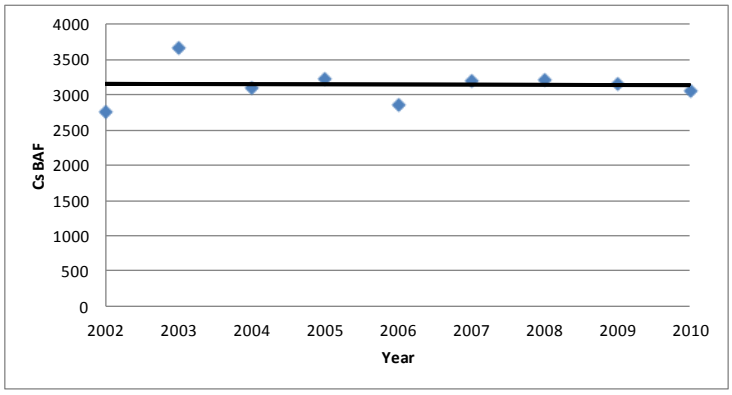


Figure 5-33: Annual Cs BAF (TRS-472)

Furthermore, since the potassium concentration in Lake Ontario has been shown to be relatively constant, the frequency of potassium concentration measurements have been reduced to once every three years. As a result, the next potassium in lake water measurements will take place in 2013 to revalidate the default Cs BAF value.

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 2010 environmental monitoring data. Where measured environmental data is not available, IMPACT calculates the doses from emissions. IMPACT 5.4.0 represents the method of dose calculation described in the CSA N288.1-08 standard [R-14].

The following improvements were made to the IMPACT database and scenarios in 2010:

- To be conservative, ponds are used at the farm and dairy farm critical groups as a surrogate source of irrigation water for generic feed crops.
- Intake fractions for venison and geese are specific for each age class rather than applying the adult intake fraction to all three age classes.
- Intake fractions of fish calculated for DN critical groups have been corrected.
- The recreational water use location for PN has been relocated closer to PN site.

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 there are no local measured values 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 location. 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.

Separate Ka values 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 – 2010

DESCRIPTION	Measured Average Airborne Tritium Concentration (Bq/m^3)	Measured Ka (s/m^3)
INDICATOR SITES:		
D1 – Southeast Fence	0.8	1.7E-07
D2 – East Fence	0.6	1.3E-07
D3 – Maple Grove	0.4	7.5E-08
D4 – Park Road	0.2	3.7E-08
D5 – Knight Road	0.2	4.0E-08
D6 – Provincial Park	0.2	4.3E-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 – 2010

DESCRIPTION	Measured Average Airborne Tritium Concentration (Bq/m^3)	Measured Ka (s/m^3)
INDICATOR SITES:		
P2 – Montgomery Park Rd.	11.1	6.1E-07
P3 – Sandy Beach Rd.	2.3	1.2E-07
P4 – Liverpool Rd.	1.9	1.0E-07
P6 – East Boundary	4.3	2.4E-07
P7 – Central Maintenance – West	4.3	2.3E-07
P8 – Frenchman's Bay	1.3	7.0E-08
P9 – Petticoat Creek	1.4	7.6E-08
P10 – Central Maintenance – East	8.2	4.5E-07
P11 – Alex Robertson Park	1.7	9.1E-08
Average		**2.2E-07**

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

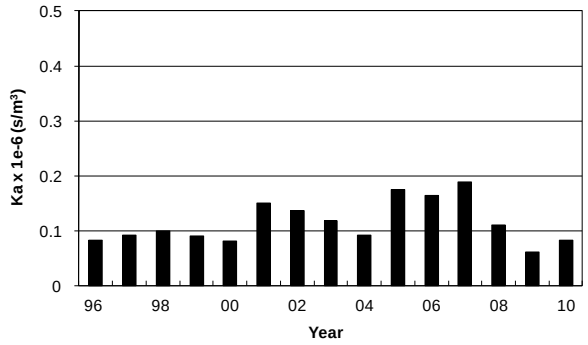


Figure 6-1: Darlington Nuclear Calculated Boundary Average Ka Values

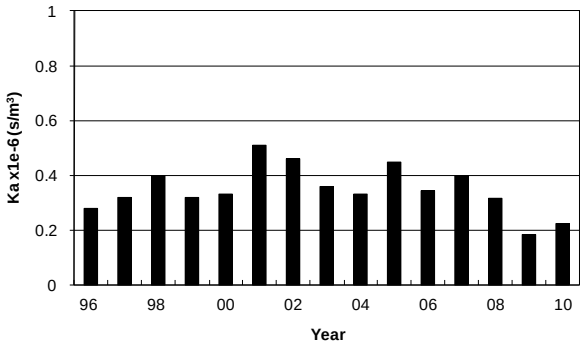


Figure 6-2: Pickering Nuclear Calculated Boundary Average Ka Values

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 2010 for the DN and PN sites are presented in Table 6-3.

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 2010, the wind sectors from which the wind predominantly blew towards the land are 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 – 2010 Annual Average Wind Frequency by Direction (at 10 m height)

Direction From	Darlington Nuclear Wind Frequency (%)	Pickering Nuclear Wind Frequency (%)
N	8.64	9.92
NNE	4.19	6.05
NE	3.39	3.02
ENE	5.35	3.77
E	7.27	6.36
ESE	4.51	3.71
SE	1.97	2.08
SSE	1.80	1.50
S	1.41	2.45
SSW	3.15	9.51
SW	8.52	6.65
WSW	7.12	6.06
W	8.57	5.73
WNW	9.54	9.20
NW	13.43	12.84
NNW	11.13	11.16
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-12]. Assumptions, modeling parameters, and mean intake rates were used in accordance with CSA N288.1-08 [R-14] and the COG DRL Guidance [R-17]. Annual average meteorological data is used along with local intake fractions and representative locations for critical groups as identified in the reviews of the site-specific surveys [R-1] [R-16]. 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-13] [R-15] [R-16].

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-14]. 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 all age classes within each potential critical group.

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 2010 dose estimates for these critical groups have been adjusted to account for this portion of the population.

CSA N288.1-08 recommends a reduction of the building shielding factor to the default value of 0.5 [R-14]. This value was selected to be reasonably conservative and to better represent the type of housing suitable for climate conditions encountered through most of Canada [R-17]. This change results in a decrease in the dose estimates for noble gases, which is more apparent at PN than at DN due to PN having a higher dose contribution from noble gas.

7.1.1 Age Classes

In accordance with CSA N-288.1-08, 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-9].

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 cycle. In 2008, the representative location used for modeling the Dairy Farm critical group was relocated to a location approximately 1 km closer to DN, which provides greater conservatism to the modeled air concentrations. Further, a 2009 review of the representative potential critical group locations determined that the Rural Resident and Industrial/Commercial critical group representative locations should be shifted to the west of DN based on updated meteorological data used for atmospheric dispersion and the construction of a new industrial/commercial site.

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-16] 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 using 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

- Measurements of HTO and C-14 in fruits, vegetables, silage and milk, and C-14 in air were taken from locations around PN and DN. HTO in air was measured at station boundary locations. HTO was measured in WSP drinking water, local well water, and lake water. HTO, C-14 and Cs-137 were measured in fish and Cs-

137 was measured in local beach sand. 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 2010 Darlington Nuclear Public Dose

For 2010, the limiting critical group at DN was the Dairy Farm one-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.

7.3.2.1 Dose Calculation Results

The results of the 2010 DN public dose calculation are presented in Table 7-1.

Table 7-1: 2010 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	0.4	0.4	**0.6**
Farm Residents	0.5	0.4	0.3
Sport Fishers	0.1	0.0	0.0
Bowmanville Residents	0.2	0.2	0.1
Oshawa Residents	0.1	0.1	0.0
Rural Residents	0.3	0.3	0.2
West/East Beach Residents	0.2	0.2	0.1
Industrial/Commercial Workers	0.1		

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

Table 7-2: 2010 Darlington Nuclear Public Dose – Dairy Farm One-Year Old Infant

Radionuclide	Dose (µSv/a)	% Dose Contribution
C-14	4.80E-01	80%
Co-60	1.73E-03	0%
Cs-137+	5.38E-06	0%
HT	1.26E-07	0%
HTO	8.58E-02	14%
NobleGases	9.45E-03	2%
OBT	1.16E-02	2%
I (mfp)	9.13E-03	2%
Total	5.98E-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. Hypothetical Individual dose was reported as the site official dose up to 2002, and thereafter, the official dose has been based on the site Critical Group. A description of Hypothetical Individual dose calculation methodology can be found in previously published annual reports.

The DN dose remained essentially unchanged over the last five years and was significantly below 1% of the legal limit.

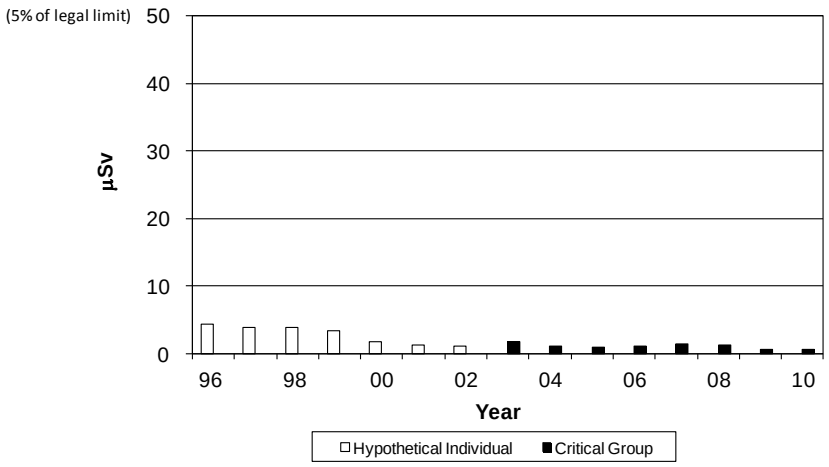


Figure 7-1: Darlington Nuclear Public Dose Trend

7.3.2.2 Discussion of Results

The 2010 DN site public dose of 0.6 µSv, as represented by the Dairy Farm one-year old infant, is about 0.1% of the 1000 µSv/a legal limit for a member of the public. The DN dose for 2010 is about the same as the site public dose of 0.7 µSv for the Dairy Farm one-year old infant reported in 2009.

Any difference in the 2010 dose, when compared with 2009, is attributed to the following:

- C-14 is the primary source of dose for the Dairy Farm critical group and total dose from C-14 increased by 3% in 2010. This is attributed to a very small increase in the C-14 concentration measured in Dairy Farm produce.

- Total dose from HTO decreased by 34% from 2009, mainly as the result of lower HTO levels measured in Dairy Farm milk and produce. In addition, a small reduction was seen in HTO in air concentrations measured for the Dairy Farm dose, which is likely the result of slightly lower HTO and HT in air emissions in 2010.

The DN dose for 2010 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.

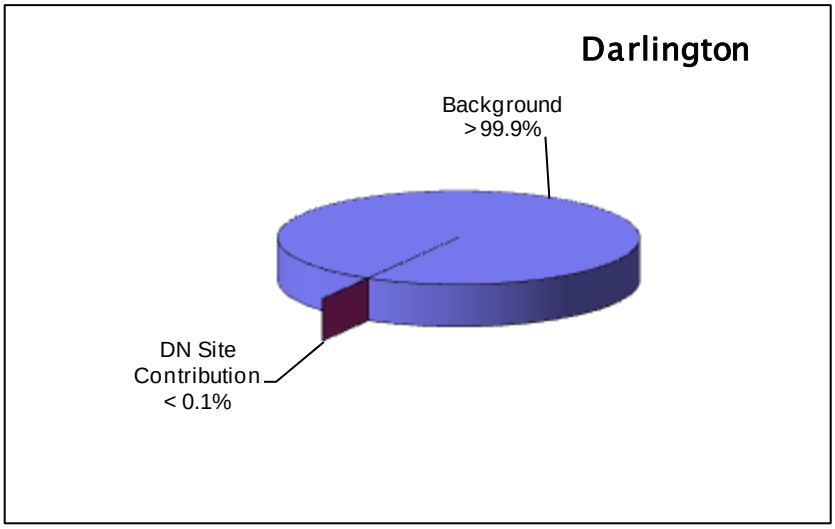


Figure 7-2: Comparison of Darlington Nuclear Public Dose to Background Dose

7.3.3 2010 Pickering Nuclear Public Dose

For 2010, the limiting critical group at PN was the Urban Resident Adult with a dose of 1.0 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 2010 PN public dose calculation are presented in Table 7-3.

Table 7-3: 2010 Pickering Nuclear Critical Group Doses

Potential Critical Group	Dose per Age Class (microsieverts)		
	Adult	Child (10-year old)	Infant (One-year old)
Farm Residents	0.4	0.3	0.3
Dairy Farm Residents	0.4	0.3	0.4
Sport Fishers	0.5	0.5	0.4
Urban Residents	1.0	0.9	0.8
C2 Correctional Institution	0.8	0.8	
Industrial Workers	0.9		

Table 7-4 illustrates the dose by radionuclide for the Industrial/Commercial Adult and the percent contribution to the total dose. HTO, Cs-137+ and noble gases contribute more than 90% of the total dose.

Table 7-4: 2010 Pickering Nuclear Public Dose – Urban Resident Adult

Radionuclide	Dose (µSv/a)	% Dose Contribution
C-14	1.89E-02	2%
Co-60	9.70E-03	1%
Cs-137+	1.74E-01	18%
HTO	4.15E-01	43%
NobleGases	3.39E-01	35%
OBT	1.60E-03	0%
I (mfp)	4.58E-05	0%
Total	9.59E-01	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. Dose from Cs-137+ is largely based on concentrations in drinking water and soil which are modeled from waterborne emissions.

The public dose trend for PN is presented in Figure 7-3. Hypothetical Individual dose was reported as the site official dose up to 2002, and thereafter, the official dose has been based on the site Critical Group. A description of Hypothetical Individual dose calculation methodology can be found in previously published annual reports.

The PN dose remains below 1% of the legal limit.

One step change is observed in the PN trend over the last five years. The decrease in 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.

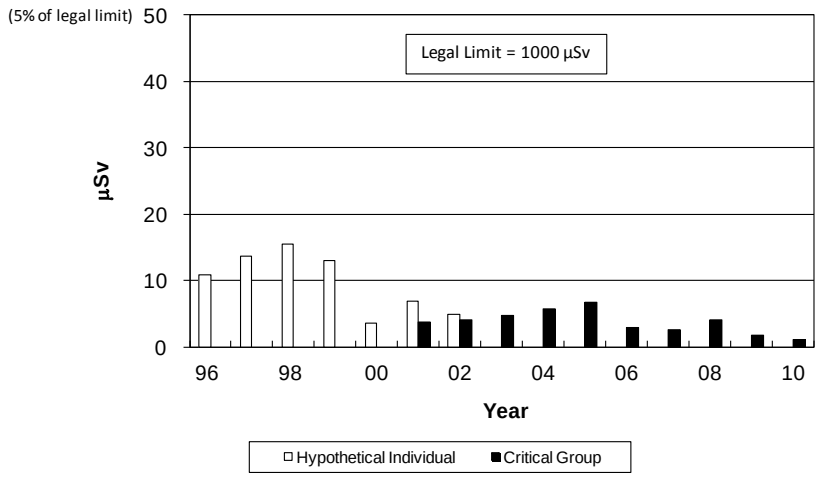


Figure 7-3: Pickering Nuclear Public Dose Trend

7.3.3.2 Discussion of Results

The 2010 PN site public dose of 1.0 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 is lower than the 2009 reported site public dose value of 1.8 µSv, represented by the Industrial/Commercial Adult, and is attributed to the following:

- There was a decrease in dose received by the Industrial/Commercial group from HTO inhalation and external exposure to noble gas, their two primary exposure pathways, due to a reduction in HTO airborne emissions, discontinuation of passive samplers, and lower noble gas dose resulting from a lower building shielding factor as discussed in Section 7.1. This rationale is also applicable to the Correctional Institution group, which previously received a higher dose than the Urban Residents.

- In addition, the Urban Resident Adult dose exceeds the Industrial/Commercial dose in 2010 for two main reasons:

    - The adjustment of the critical group dose estimate to account for the portion of urban residents who work within 5 km of PN resulted in an increase in the noble gas dose (see Appendix E for more detail).

    - There was an increase in Cs-137+ concentrations modeled for drinking water and soil as a result of the increased gross beta/gamma emissions to water in 2010. Drinking water is used to irrigate soil in the dose model leading to an increase in soil external dose for the urban resident that would not apply to the industrial/commercial group. Although the model shows an increase in dose from Cs-137+, it is extremely conservative since no increase was seen in the 2010 measured gross beta results for drinking water. A third-party review is underway to investigate the gross beta/gamma emissions as per Section 3.3.1.

The PN dose for 2010 was equivalent to about 0.1% of the total public background dose. The estimated background dose around PN is 1400 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.

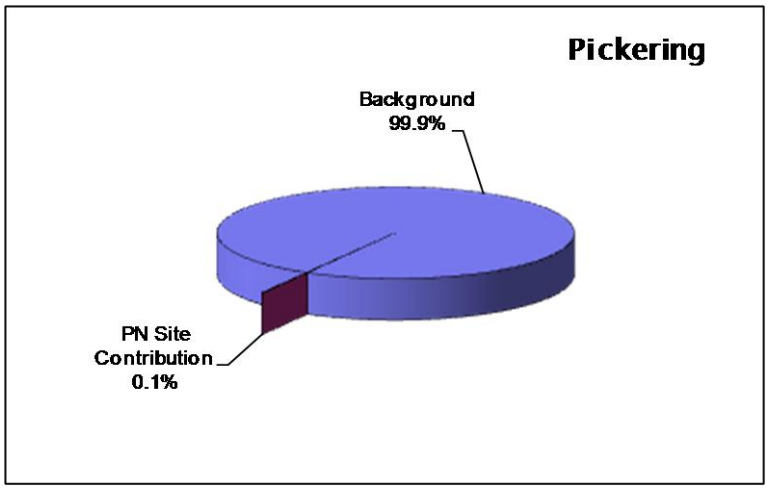


Figure 7-4: Comparison of Pickering Nuclear Public Dose to Background Dose

7.4 Natural and Anthropogenic Dose 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-49]	4
Chest X-Ray (single film) [R-50]	10
Airplane Travel (two hour flight) [R-51]	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-28] [R-29]. 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-30]

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 objective is to ensure the accuracy of REMP samples and their analytical results 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-31].

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 ± 10-20% of the known/expected values, depending on the analysis type.

For 2010, 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 2010 [R-32]. 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, gross beta, and gamma in water/drinking water, 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 2010 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 – 2010

Sample Types	Relative Difference (%)		Relative Precision (%)	
	High	Low	High	Low
Tritium in Water	+2	-6	3	2
Gross Beta in Water	+6	-5	10	7
Gamma in Milk	+15	-14	11	1
Gamma in Water	+26	-10	21	2
Gamma in Soil	+33	-15	8	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-32]

All testing met performance requirements.

8.2 Audits and Self Assessments

In 2010, Environment Programs Department (EPD) performed two self assessments on different elements of the REMPs. Furthermore, an audit was performed by Performance Improvement and Nuclear Oversight (PINO).

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

8.2.1 Audits

PINO performed an audit of the REMP (NO-2010-059). One finding identified was inconsistent compliance for review of REMP documents. This finding was based on the fact that several REMP documents were not reviewed within the review cycles assigned to them in OPG's document control system. However, following the audit's conclusion, this issue was further investigated and it was discovered that the review cycles for all but one of the REMP documents were entered in error by Controlled

Documents personnel. A plan to address this issue has been developed by Controlled Documents and is currently being implemented. Corrective actions have been initiated to address the one document N-TQD-405-00001, Nuclear Health Physics Technologist Training and Qualification Description, that was past its review period.

8.2.2 Self Assessments

(a) C-14 Laboratory Analysis and Noble Gas Detector Sensitivity Checks

The objective of self assessment NO10-00300 was for the EPD to assess procedural compliance and adequacy of procedures for laboratory C-14 analysis performed by HPL, and for noble gas detector sensitivity checks performed by Health Canada. There were no adverse conditions identified by this self assessment. Findings were of minor nature and mainly involved recommendations for improvements to written procedure quality.

(b) Environmental Health Physics Training Course

Self assessment NO10-000291 was carried out by the EPD to provide feedback and evaluation on the Environmental Health Physics Training pilot course initiated by COG.

Conclusions of the assessment were that although most training objectives were addressed, the organization of presentation topics and flow of material need improvement. In addition, the course should be conducted with a more hands-on/instructional approach tailored to suit the needs of the end user. COG has been informed of the findings from this assessment.

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.

9.0 PROGRAM PERFORMANCE

9.1 Sample Unavailability

A total of 2,354 laboratory analyses were performed for the 2010 REMPs. The analyses covered HTO, gross beta, C-14, I-131, TLD gamma, OBT, and gamma scan. The DN site accounted for 46% of these sample analyses, while the PN and Provincial programs accounted for 40% and 14% 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, 1,130 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 campaign 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-45], 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 REMPs separately.

The unavailability limits for samples used in the dose calculation are provided in Table 9-1 and range from 10-25%. 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 REMPs were 2%, 1% and 17%, respectively. For 2010, all unavailability limits for individual analyses used in dose calculations were met, with the exception of the fish sample analyses for the Provincial REMP.

The unavailability of provincial background fish samples exceeded the 25% limit in 2010 due to problems with obtaining a sufficient quantity of Lake Ontario far field fish. The average C-14 and Cs-137 analytical results for the available Lake Ontario far field fish samples were slightly lower than in the past five years, resulting in a more conservative dose estimate. Alternative actions to ensure the collection of adequate Lake Ontario far field fish samples are being evaluated for the 2011 sampling season.

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
		Number of Locations	Plan	Actual	Unavailability	Number of Locations	Plan	Actual	Unavailability	Number of Locations	Plan	Actual	Unavailability	
Tritium														
Tritium in Air (Molecular Sieve)	Monthly/Quarterly	7	84	79	6%	6	72	66	8%	2	19	18	5%	10%
Water Supply Plants	Weekly Composite	1	48	48	0%	2	96	96	0%					15%
Residential Wells	Monthly	5	60	60	0%	15	180	180	0%					15%
Milk	Monthly Composite	2	24	24	0%	5	60	60	0%					25%
Milk	Quarterly									2	8	8	0%	25%
Lake Water	Monthly [a]	2	18	18	0%	3	27	27	0%					25%
Fruits	Annual	8	8	8	0%	18	18	18	0%					20%
Vegetables	Annual	13	13	11	15%	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	16	16	0%	2	20	20	0%					25%
Carbon-14														
Carbon-14 in Air	Quarterly	8	32	32	0%	13	52	52	0%	6	24	24	0%	25%
Milk	Monthly Composite	2	24	24	0%	5	60	60	0%					10%
Milk	Quarterly									2	8	8	0%	10%
Fruits	Annual	8	8	8	0%	18	18	18	0%					20%
Vegetables	Annual	13	13	11	15%	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	16	16	0%	2	20	20	0%	1	16	4	75%	25%
Noble Gases														
External Gamma (Noble Gas Monitors) [b]	Continuous	4	NA	NA	1%	5	NA	NA	1%					25%
Gamma														
Fish	Annual	1	16	16	0%	2	20	20	0%	1	16	4	75%	25%
Beach Sand	Annual	3	3	3	0%	2	3	3	0%	1	2	2	0%	25%
Overall dose sample Unavailability [c]			385	376	**2%**		684	676	**1%**		103	78	**17%**	

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 OF 2010 REMP

10.1 Overall Program Performance

The results of OPG's 2010 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.

- For the REMP designs, the major change in 2010 was the discontinuation of passive tritium-in-air samplers from PN, DN and Provincial REMPs. For DN, lake water sampling at St. Mary's Cement plant was replaced with lake water and beach sand sampling at West/East beach to better represent the dose to members of the pubic using the beach area.

- There were no significant deficiencies in sample collection and sample analyses this year. 2,354 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 with the exception of the Lake Ontario far field fish samples. The overall unavailabilities were 2%, 1%, and 17% for the PN, DN, and Provincial REMPs, respectively.

- An audit and two self assessments were completed this year for the REMPs. Findings included one document being overdue for review, minor improvements recommended for procedures, and improvements needed for the Environmental Health Physics Training Course by COG.

10.2 Darlington

10.2.1 Summary of Sampling Results

- There were minor reductions in HTO, HT, and C-14 emissions to air, and in HTO emissions to water. 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. HTO and gross beta-gamma activity in well water remained about the same as the previous year.

- 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, and C-14 in milk and vegetation were in line with results seen over the last five years. HTO measured in milk and vegetation were lower than results seen in the last five years.

10.2.2 Summary of Site Public Dose

The 2010 public dose for the DN site was 0.6 µSv and was represented by the one-year old infant of the Dairy Farm critical group. This dose is essentially the same as the dose of 0.7 µSv reported for the same receptor in 2009. The 2010 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 to water were lower than the previous year. C-14 emissions to air was slightly higher, with a minimal effect on concentrations measured in milk and produce. There was a notable increase in gross beta/gamma emissions to water resulting in an increase in the modeled Cs-137+ dose.

- The average dose measured by environmental noble gas monitors at the boundary locations showed a small increase as a result of increased wind frequency to certain landward wind sectors during times when noble gas was emitted.

- Annual average tritium concentrations in drinking water from the nearby water supply plants were below 10 Bq/L. HTO and gross beta-gamma activity in well water remained the same as the previous year.

- 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, and C-14 in air, milk and vegetation were in line with results seen over the last five years. HTO measured in air, milk and vegetation were lower than results seen in the last five years.

10.3.2 Summary of Site Public Dose

The 2010 public dose for the PN site was 1.0 µSv and was represented by adult members of the Urban Resident group. This dose is lower than the PN 2009 dose of 1.8 µSv for the Industrial/Commercial adult. The decrease is due primarily to lower HTO airborne emissions, discontinuation of passive tritium–in-air samplers, and lower dose from noble gas.

11.0 OUTLOOK FOR 2011

- CSA N288.4-10, Environmental Monitoring at Class I Nuclear Facilities and Uranium Mines and Mills was published in May 2010. In addition to the scope of the existing REMPs, which involves monitoring and assessing of radiological dose to humans, the standard encompasses monitoring for non-human biota as well as for conventional contaminants, and will result in future changes to OPG's environmental monitoring programs.

  OPG conducted a gap analysis of the existing REMPs to identify any areas requiring further development or improvement. The gap analysis showed that OPG's existing REMPs are in compliance with N288.4-10. Some minor areas of improvement were identified, including the need to update documentation, and several recommendations shall be evaluated for implementation. A CSA N288.4-10 implementation plan is being developed in 2011.

- A reduction in the frequency to once every five years for sample collection of honey, which is not utilized in the dose calculation, will be evaluated in 2011.

- As discussed in Section 4.2.2.1, new active tritium-in-air samplers will be installed in 2011 to replace the previous aging models.

- Options to acquire a sufficient number of replicate fish samples from the Lake Ontario background locations are being evaluated for the 2011 sampling season.

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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
Bi-214	Bismuth-214
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
E	East wind sector
ECI	Emergency Coolant Injection

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
PN-A	Pickering A
PN-B	Pickering B
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
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
TSS	Total Suspended Solids
TWh	Terawatt Hour
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, 2011

- 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 Ait 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

OSHAWA/COURTICE RESIDENT

RURAL RESIDENT

CAMPER

INDUSTRIAL/ COMMERCIAL

NON-DAIRY FARM

DAIRY FARM

FISHER

BOWMANVILLE RESIDENT

WEST/EAST BEACH RESIDENT

DN

Oshawa WSP

Bowmanville WSP

Newcastle WSP (13 km ENE of DN site)

DF9 (13 km ENE of DN site)

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

Figure C2 Pickering Nuclear Site Critical Groups and Environmental Monitoring Locations

0 1 2 3 4 km

LEGEND Data as of February, 2011

- 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) R11 discontinued July 2010.
6) Sediment sampling performed every five years.

DF3 (18 km NW of PN site)

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

5.0 km

1 km

PN

URBAN RESIDENTIAL

INDUSTRIAL COMMERCIAL

CORRECTIONAL INSTITUTION 2

DAIRY FARM

NON-DAIRY FARM

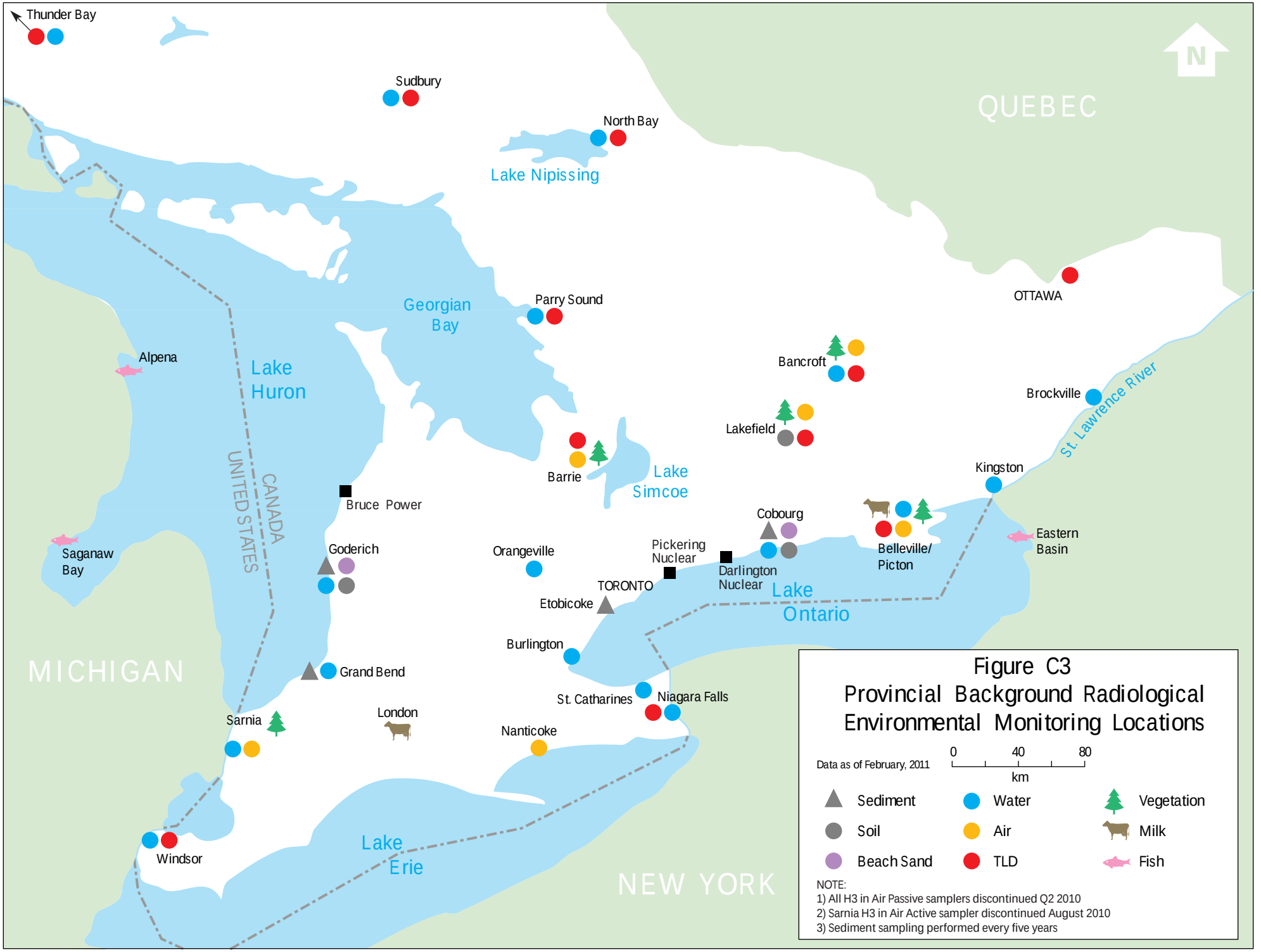
FISHER

R.C. Harris WSP (22 km WSW of PN site)

F.J. Horgan WSP

Ajax WSP

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
Eastern Basin
Saganaw Bay
Goderich
Orangeville
Pickering Nuclear
Belleville/ Picton
Darlington Nuclear
TORONTO
Lake Ontario
Etobicoke
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, 2011
0
40
80
km
Sediment
Water
Vegetation
Soil
Air
Milk
Beach Sand
TLD
Fish
NOTE:
1) All H3 in Air Passive samplers discontinued Q2 2010
2) Sarnia H3 in Air Active sampler discontinued August 2010
3) Sediment sampling performed every five years

Appendix D: Environmental Monitoring Data

Table D1: TLD External Gamma Measurements – 2010

DN REMP Locations			PN REMP Locations			Background Locations		
Boundary Locations	Annual Average Dose Rate in Air (nGy/h)	Annual Dose in Air (μGy/yr)	Boundary Locations	Annual Average Dose Rate in Air (nGy/h)	Annual Dose in Air (μGy/yr)	Site Description	Annual Average Dose Rate in Air (nGy/h)	Annual Dose in Air (μGy/yr)
D1	55.1	483	P2	53.3	467	Bancroft	64.3	563
D2	56.9	498	P3	54.3	476	Belleville	66.8	585
D3	61.3	537	P4	54.3	476	Windsor	50.7	444
D4	55.6	487	P6	63.2	554	Niagara Falls	44.7	391
D5	56.7	497	P7	46.8	410	North Bay	63.2	554
D6	61.3	537	P8	48.7	427	Barrie	59.8	524
			P9	57.8	506	Ottawa	51.4	451
			P10	44.0	385	Parry Sound	54.9	481
			P11	59.7	523	Sudbury	65.6	574
						Thunder Bay	69.3	607
						Lakefield	63.2	554
Average	57.8	507	Average	53.6	469	Average [(a)]	57.8	506
CRITICAL GROUP LOCATIONS			CRITICAL GROUP LOCATIONS					
D7	60.5	530	C2	62.0	543			
D8	57.9	507						
R275	63.4	556						
DF5	61.9	542						

NOTES:
(a) 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-34].

Table D2: Noble Gas, Skyshine and I-131 Dose in Air – 2010

Boundary Locations	Total Measured Air Kerma Rates (nGy/yr) [a]				
	Xe-133	Xe-135	Ar-41	Ir-192 Skyshine	I-131 [b]
DN REMP					
D1	< 3	**9**	**46**	< 24	**19**
D2	< 4	< 9	**38**	< 26	**19**
D3	< 5	< 10	< 37	< 30	< 19
D4	< 4	< 9	< 36	< 28	< 18
D5	< 4	< 9	< 34	< 28	< 16
D6	< 4	< 9	< 39	< 25	< 14
D8	**6**	< 9	**68**	< 28	**20**
Average[c]	< 4	< 9	< 37	< 27	< 16
PN REMP					
P2	54	132	3073	**31**	< 18
P3	25	28	1422	< 27	< 18
P4	8	**17**	662	< 26	< 17
P6	33	82	1773	< 28	< 18
P7	39	55	2841	< 24	< 17
P8	9	**12**	538	< 26	< 14
P9	**6**	< 10	352	< 31	< 18
P10	69	60	3791	< 21	< 12
P11	**9**	20	878	< 33	**19**
Average[c]	28	46	1703	< 27	< 17

Notes:
(a) Bolded values are greater than Lc but less than Ld. "<" indicates less than the Lc.
(b) In this context, dose means the air immersion effective dose from gamma radiation.
(c) Annual averages are calculated from monthly measurements and compared with the average Lc or Ld to determine how they will be reported.

Table D3: Tritium-in-Air Concentrations – 2010

DN REMP Locations		PN REMP Locations		Background Locations	
Boundary Locations	**Molecular Sieve Tritium-in-Air (Bq/m^3) (a)**	**Boundary Locations**	**Molecular Sieve Tritium-in-Air (Bq/m^3) (a)**	**Site Description**	**Molecular Sieve Tritium-in-Air (Bq/m^3) (a)**
D1	0.8	P2	11.1	Lambton[d]	< 0.1
D2	0.6	P3	2.3	Nanticoke	< 0.1
D3[b]	0.4	P4[c]	1.9		
D4	0.2	P6[c]	4.3		
D5[c]	0.2	P7[b]	4.3		
D6[b]	0.2	P8	1.3		
		P9	1.4		
		P10[b]	8.2		
		P11	1.7		
Average	0.4	Average	4.1	Average	< 0.1
CRITICAL GROUP LOCATIONS		**CRITICAL GROUP LOCATIONS**			
D7	**0.1**	Ajax Hospital[c]	0.9		
D8[c]	0.2				

NOTES:
NR = Not Required by Program
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) Annual average based on 10 monthly samples due to sampler component failures.
(c) Annual average based on 11 monthly samples due to sampler component failures.
(d) Annual average based on six monthly samples due to one sampler component failure and discontinuation of the sampler in August 2010.

Table D4: Carbon-14 in Air Concentrations – 2010

DN REMP		PN REMP		Background Locations	
Boundary Locations	**Passive Sampler C-14 in Air (Bq/kg-C) [(a)]**	**Boundary Locations**	**Passive Sampler C-14 in Air (Bq/kg-C) [(a)]**	**Site Description**	**Passive Sampler C-14 in Air (Bq/kg-C) [(a)]**
D1	271	P2	492	Lambton	239
D2	270	P6	402	Lakefield	246
D6	242	P10	479	Bancroft	241
Average	261	Average	458	Barrie	245
CRITICAL GROUP LOCATIONS		**CRITICAL GROUP LOCATIONS**		Belleville	245
R2	262	DF1	242	Picton	235
R27	247	DF8	257	Average	242
R275	252	C2	309		
F1	246	F31	251		
R329	240	R145	248		
DF12	233				
DF5	232				
DF7	233				
DF8	246				
DF9	242				

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

Table D5: Tritium in Precipitation and Gross Beta in Wet/Dry Fallout – 2010

DN REMP Locations			PN REMP Locations		
Boundary Locations	**Average Tritium Concentration in Precipitation (Bq/L)[(a)]**	**Average Gross Beta Deposition Rate (Bq/(m^2·month))**	**Boundary Locations**	**Average Tritium Concentration in Precipitation (Bq/L)[(a)]**	**Average Gross Beta Deposition Rate (Bq/(m^2·month))**
D1	30	14.5	P6	130	14.9
D3	13	14.8	P8	113	17.9
D4	12	16.5	P10	280	14.3
			P11	74	16.1
Average	18	15.3	Average	149	15.8
CRITICAL GROUP LOCATIONS			**CRITICAL GROUP LOCATIONS**		
F1	40	NR	F31	17	NR
DF12	7	NR	F10	14	NR
DF8	5	NR			

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.

Table D6: Tritium and Gross Beta Activity Concentrations in Drinking Water and Lake Water – 2010

DN REMP			PN REMP		
Site Description	**Annual Average Tritium Concentration (Bq/L) [a]**	**Annual Average Gross Beta Activity Concentration (Bq/L) [b]**	**Site Description**	**Annual Average Tritium Concentration (Bq/L) [a]**	**Annual Average Gross Beta Activity Concentration (Bq/L) [b]**
Bowmanville WSP	4.8	0.11	Ajax WSP	5.5	0.11
Newcastle WSP	4.6	0.10	Scarborough Horgan WSP	**4.2**	0.11
Oshawa WSP	5.8	0.12	Toronto Harris WSP	**4.3**	0.12
			Whitby WSP	5.4	0.11
CRITICAL GROUP LOCATIONS (Well Water)			**CRITICAL GROUP LOCATIONS (Well Water)**		
DF12	5.3	0.35	R11 (Deep) [c]	81.5	0.14
DF5	< 2.3	0.20	R11 (Shallow) [c]	81.2	0.17
DF7	< 2.3	0.07	F10	12.7	NR
DF8	< 2.3	0.10	DF8	12.7	NR
DF9	< 2.3	0.08	F25	< 2.3	NR
F1	< 2.3	0.04	R143	16.9	NR
R329	13.3	1.25	F31	18.9	NR
F15	12.7	0.30			
R2	22.5	2.69			
R29	< 2.3	0.07			
R47	8.6	0.11			
R279	< 2.3	0.08			
R294	13.0	0.10			
R316	9.8	0.05			
R320	9.5	0.05			
LAKE WATER LOCATIONS			**LAKE WATER LOCATIONS**		
Darlington Provincial Park[d]	5.9	0.11	Frenchman's Bay[d]	25.3	NR
McLaughlin Bay[d]	21.5	0.21	Beachpoint Promenade[d]	14.8	NR
West East Beach[d]	**4.1**	0.11	Squire's Beach[d]	9.8	NR

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) Annual average does not include February to April because the participant was not available to provide a sample. These samples were not a requirement of the program. In addition, this location was discontinued in July 2010 due to the participant selling the property.
(d) Annual average based on nine to 11 monthly samples because sampling is not required during the winter months when the lake/shoreline is frozen.

Table D6: Tritium and Gross Beta Activity Concentrations in Drinking Water and Lake Water – 2010 (Continued)

Background Locations			
Site Description	**Water Source**	**Annual Average Tritium Concentration (Bq/L) [a]**	**Annual Average Gross Beta Activity Concentration (Bq/L) [b]**
Bancroft [c]	Clarke Lake	< 2.3	0.04
Belleville [c]	Bay of Quinte	**2.6**	0.08
Brockville	Lake Ontario	**2.6**	0.10
Burlington	Lake Ontario	**3.7**	0.10
Cobourg	Lake Ontario	**3.4**	0.12
Goderich	Lake Huron	**2.9**	0.08
Kingston	Lake Ontario	**3.1**	0.09
London	Lake Huron	**2.9**	0.09
Niagara Falls	Niagara River	< 2.3	0.10
North Bay	Trout Lake	< 2.3	0.07
Orangeville	Well Water	< 2.3	0.09
Parry Sound[c]	Georgian Bay	**2.8**	0.06
Sarnia	Lake Huron	**2.7**	0.10
St. Catherines[c]	Lake Moodie/Gibson	**2.6**	0.09
Sudbury	Ramsay Lake	< 2.3	0.04
Thunder Bay	Lake Superior	< 2.3	0.05
Windsor	Lake St. Clair	**3.0**	0.10

NOTES:
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) Annual average is based on three quarterly samples.

Table D7: Lake Sediment – 2010

DN REMP[d]						
Site Description		C-14 Composites (Bq/kg-C ± 2σ)[c]	Gamma Analysis Bq/kg dw ± 2σ[b]			
			Cs-137	Cs-134	Co-60	K-40
Darlington Provincial Park	-A	134 ± 27	0.5 ± 0.1	< 0.1	< 0.1	343.5 ± 4.3
	-B		0.5 ± 0.1	< 0.2	< 0.2	319.5 ± 5.7
	-C		0.4 ± 0.1	< 0.1	< 0.1	351.5 ± 5.0
	-D		0.5 ± 0.1	< 0.2	< 0.2	354.2 ± 5.1
Port Darlington	-A	153 ± 28	0.3 ± 0.1	< 0.1	< 0.2	376.5 ± 5.5
	-B		0.3 ± 0.1	< 0.2	< 0.2	406.1 ± 6.6
	-C		0.3 ± 0.1	< 0.2	< 0.2	399.3 ± 6.6
	-D		0.3 ± 0.1	< 0.1	< 0.1	408.3 ± 5.6
DN Diffuser	-A	193 ± 27[a]	0.8 ± 0.1	< 0.1	< 0.2	392.0 ± 6.3
	-B		0.5 ± 0.1	< 0.1	< 0.1	363.8 ± 5.1
	-C		1.3 ± 0.1	< 0.1	< 0.2	472.9 ± 5.6
	-D		0.8 ± 0.1	< 0.2	< 0.2	408.6 ± 6.4

NOTES:
(a) The total organic carbon content of the DN Diffuser composite sediment samples was 5,100 ppm.
(b) For gamma analysis "<" indicates less than Ld.
(c) Ld for C-14 = 40 Bq/kg-C.
(d) 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.

Table D7: Lake Sediment – 2010 (Continued)

PN REMP[e]						
Site Description		C-14 Composites (Bq/kg-C ± 2σ)[d]	Gamma Analysis (Bq/kg dw ± 2σ) [c]			
			Cs-137	Cs-134	Co-60	K-40
PN "A" Discharge	-A	281 ± 31 [a]	1.4 ± 0.1	< 0.1	< 0.1	396.7 ± 4.8
	-B		1.7 ± 0.1	< 0.1	< 0.1	406.9 ± 5.6
	-C		1.3 ± 0.2	< 0.2	< 0.2	340.1 ± 5.9
	-D		1.4 ± 0.1	< 0.1	< 0.1	383.2 ± 4.7
PN "B" Discharge	-A	204 ± 30 [b]	1.8 ± 0.1	< 0.2	< 0.1	410.5 ± 4.7
	-B		1.3 ± 0.1	< 0.1	< 0.1	377.4 ± 5.3
	-C		1.5 ± 0.1	< 0.1	< 0.1	414.0 ± 4.9
	-D		1.3 ± 0.2	< 0.1	< 0.2	367.8 ± 6.1
Liverpool Road Beach	-A	195 ± 28	1.6 ± 0.2	< 0.1	< 0.1	409.7 ± 5.5
	-B		1.8 ± 0.2	< 0.2	< 0.2	411.1 ± 6.5
	-C		1.6 ± 0.2	< 0.2	< 0.2	401.0 ± 6.5
	-D		1.6 ± 0.2	< 0.2	< 0.2	421.4 ± 5.6
Duffin's Creek	-A	104 ± 26	0.3 ± 0.2	< 0.2	< 0.2	382.0 ± 6.3
	-B		< 0.2	< 0.1	< 0.2	401.6 ± 5.6
	-C		0.3 ± 0.1	< 0.2	< 0.1	372.6 ± 6.1
	-D		0.3 ± 0.1	< 0.1	< 0.2	385.4 ± 5.3

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

Table D7: Lake Sediment – 2010 (Continued)

Background Locations[d]						
Site Description		C-14 Composites (Bq/kg-C±2σ)[c]	Gamma Analysis (Bq/kg dw ± 2σ) [b]			
			Cs-137	Cs-134	Co-60	K-40
Cobourg	-A	190 ± 27 [a]	0.9 ± 0.1	< 0.1	< 0.1	503.4 ± 5.7
	-B		0.7 ± 0.1	< 0.2	< 0.2	468.5 ± 6.1
	-C		1.0 ± 0.2	< 0.2	< 0.2	464.6 ± 7.5
	-D		1.0 ± 0.1	< 0.1	< 0.2	473.0 ± 6.4
Marie Curtis Park	-A	NR	0.7 ± 0.1	< 0.1	< 0.2	574.0 ± 6.1
	-B		0.5 ± 0.1	< 0.2	< 0.2	504.3 ± 7.4
	-C		0.6 ± 0.1	< 0.2	< 0.1	528.9 ± 6.7
	-D		0.4 ± 0.1	< 0.2	< 0.1	485.3 ± 5.3

NOTES:
NR = Not required by the program.
(a) The total organic content of the Cobourg composite sediment samples was 7,200 ppm.
(b) For gamma analysis "<" indicates less than Ld.
(c) Ld for C-14 = 40 Bq/kg-C.
(d) 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.

Table D8: Beach Sand – 2010

Site Description	Gamma Analysis (Bq/kg dw ± 2σ) [(a)]			
	Cs-137	Cs-134	Co-60	K-40
DN REMP				
Darlington Provincial Park	< 0.1	< 0.2	< 0.1	422.9 ± 5.0
Darlington Provincial Park	0.2 ± 0.1	< 0.2	< 0.1	335.1 ± 5.1
West East Beach	0.3 ± 0.1	< 0.2	< 0.1	284.8 ± 5.5
PN REMP				
Beach Point Promenade	0.8 ± 0.1	< 0.1	< 0.1	439.8 ± 4.9
Squires Beach	0.4 ± 0.2	< 0.2	< 0.2	339.5 ± 5.9
Liverpool Road Beach	0.3 ± 0.1	< 0.1	< 0.1	219.5 ± 3.6
Background Locations				
Cobourg – A	0.4 ± 0.1	< 0.2	< 0.2	312.1 ± 5.9
Cobourg – B	< 0.2	< 0.2	< 0.2	299.9 ± 5.6

NOTES:
(a) For gamma analysis "<" indicates less than Ld.

Table D9: Lake Fish – 2010

DN REMP									
Site Description	Fish Type Composites		HTO (Bq/L ± 2σ)[a]	C-14 (Bq/kg-C ± 2σ)[a]	Gamma Analysis (wet weight) (Bq/kg ± 2σ) [b]				OBT Composites (Bq/L [water equivalent (w.e.)] ±2σ)
					Cs-137	Cs-134	Co-60	K-40	
Darlington Diffuser	White Sucker	-A	**2.7 ± 2.4**	226 ± 19	0.2 ± 0.1	< 0.1	< 0.1	141.0 ± 3.0	18 ± 3
		-B	**3.0 ± 2.4**	219 ± 19	0.2 ± 0.1	< 0.1	< 0.1	139.5 ± 3.4	
		-C	**4.1 ± 2.4**	212 ± 19	0.2 ± 0.1	< 0.1	< 0.1	144.0 ± 3.4	
		-D	4.6 ± 2.5	229 ± 19	0.2 ± 0.1	< 0.1	< 0.1	133.5 ± 3.8	
		-E	**4.4 ± 2.5**	245 ± 20	< 0.1	< 0.1	< 0.1	139.7 ± 3.0	
		-F	4.8 ± 2.5	254 ± 21	< 0.1	< 0.1	< 0.1	133.2 ± 2.9	
		-G	**3.4 ± 2.4**	237 ± 20	0.2 ± 0.1	< 0.1	< 0.1	126.8 ± 3.7	
		-H	6.7 ± 2.5	217 ± 18	0.2 ± 0.1	< 0.1	< 0.1	138.3 ± 3.4	
Darlington Diffuser	Round Whitefish	-A	5.3 ± 2.4	237 ± 19	0.3 ± 0.1	< 0.1	< 0.1	131.9 ± 3.8	12 ± 3
		-B	**4.4 ± 2.4**	243 ± 19	0.2 ± 0.1	< 0.1	< 0.1	145.1 ± 3.1	
		-C	5.0 ± 2.4	241 ± 18	0.2 ± 0.1	< 0.1	< 0.1	140.9 ± 2.9	
		-D	6.0 ± 2.5	227 ± 18	0.3 ± 0.1	< 0.1	< 0.1	141.1 ± 3.4	
		-E	**4.2 ± 2.4**	218 ± 18	0.2 ± 0.1	< 0.1	< 0.1	140.2 ± 4.0	
		-F	5.4 ± 2.4	257 ± 20	0.3 ± 0.1	< 0.1	< 0.1	150.2 ± 3.1	
		-G	4.9 ± 2.4	241 ± 19	0.3 ± 0.1	< 0.1	< 0.1	130.7 ± 3.8	
		-H	6.0 ± 2.4	246 ± 20	0.3 ± 0.1	< 0.1	< 0.1	135.0 ± 3.4	
Average			4.7	234	0.2	<0.1	<0.1	138	15
McLaughlin Bay	Assorted Pan Fish	-A	19.2 ± 3.1	221 ± 18	< 0.1	< 0.1	< 0.1	< 5.3	35 ± 3
		-B	19.2 ± 3.1	223 ± 19	< 0.1	< 0.1	< 0.1	53.2 ± 3.4	
		-C	19.3 ± 3.1	212 ± 19	< 0.1	< 0.1	< 0.1	91.6 ± 3.2	
		-D	20.3 ± 3.2	238 ± 19	< 0.1	< 0.1	< 0.1	93.0 ± 3.3	
Average			19.5	224	<0.1	<0.1	<0.1	61	

NOTES:
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) For gamma analysis "<" indicates less than Ld.

Table D9: Lake Fish – 2010 (Continued)

PN REMP								
Site Description	Fish Type Composites	HTO (Bq/L ± 2σ) [a]	C-14 (Bq/kg-C ± 2σ)[c]	Gamma Analysis (wet weight) (Bq/kg ± 2σ) [b]				OBT Composites (Bq/L (w.e.) ± 2σ)
				Cs-137	Cs-134	Co-60	K-40	
Pickering 5-8 Outfall	White Sucker -A	7.8 ± 2.6	229 ± 18	0.2 ± 0.1	< 0.1	< 0.1	136.6 ± 2.9	17 ± 3
	-B	**4.3 ± 2.4**	270 ± 20	0.3 ± 0.1	< 0.1	< 0.1	132.9 ± 3.8	
	-C	5.3 ± 2.4	253 ± 19	0.2 ± 0.1	< 0.1	< 0.1	141.3 ± 3.1	
	-D	5.8 ± 2.4	227 ± 19	0.1 ± 0.1	< 0.1	< 0.1	134.3 ± 3.4	
	-E	7.1 ± 2.5	275 ± 20	0.1 ± 0.1	< 0.1	< 0.1	140.2 ± 3.0	
	-F	7.7 ± 2.6	237 ± 19	0.2 ± 0.1	< 0.1	< 0.1	126.4 ± 2.8	
	-G	6.6 ± 2.5	252 ± 20	0.2 ± 0.1	< 0.1	< 0.1	136.2 ± 3.4	
	-H	7.0 ± 2.5	245 ± 19	0.3 ± 0.1	< 0.1	< 0.1	133.7 ± 3.7	
Pickering 5-8 Outfall	Round Whitefish -A	4.5 ± 2.4	244 ± 19	0.3 ± 0.1	< 0.1	< 0.1	143.8 ± 3.2	22 ± 3
	-B	**3.0 ± 2.3**	264 ± 20	0.3 ± 0.1	< 0.1	< 0.1	139.1 ± 3.0	
	-C	4.5 ± 2.4	247 ± 19	0.1 ± 0.1	< 0.1	< 0.1	137.9 ± 3.1	
	-D	6.0 ± 2.5	246 ± 19	0.3 ± 0.1	< 0.1	< 0.1	139.8 ± 3.8	
	-E	5.1 ± 2.5	242 ± 19	0.4 ± 0.1	< 0.1	< 0.1	148.1 ± 3.5	
	-F	6.5 ± 2.5	246 ± 19	< 0.1	< 0.1	< 0.1	143.9 ± 3.0	
	-G	6.0 ± 2.5	242 ± 19	0.3 ± 0.1	< 0.1	< 0.1	131.0 ± 3.9	
	-H	**3.1 ± 2.2**	249 ± 19	0.4 ± 0.1	< 0.1	< 0.1	139.4 ± 3.4	
Average		5.6	248	0.2	<0.1	<0.1	138	20

NOTES:
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) For gamma analysis "<" indicates less than Ld.
(c) Ld for C-14 = 40 Bq/kg-C.

Table D9: Lake Fish – 2010 (Continued)

Background Locations									
Site Description	Fish Type Composites		HTO (Bq/L ± 2σ) [a]	C-14 (Bq/kg-C ± 2σ)[c]	Gamma Analysis (wet weight) (Bq/kg ± 2σ) [b]				OBT Composites (Bq/L (w.e) ± 2σ)
					Cs-137	Cs-134	Co-60	K-40	
Lake Ontario-Far Field	White Sucker	-A	**3.0 ± 2.2**	205 ± 18	0.2 ± 0.1	< 0.2	< 0.1	162.6 ± 4.2	73 ± 5
		-B	**3.3 ± 2.2**	231 ± 19	< 0.1	< 0.2	< 0.2	140.4 ± 3.8	
		-C	(d)	(d)	(d)	(d)	(d)	(d)	
		-D	(d)	(d)	(d)	(d)	(d)	(d)	
		-E	(d)	(d)	(d)	(d)	(d)	(d)	
		-F	(d)	(d)	(d)	(d)	(d)	(d)	
		-G	(d)	(d)	(d)	(d)	(d)	(d)	
		-H	(d)	(d)	(d)	(d)	(d)	(d)	
	Lake Whitefish	-A	**3.4 ± 2.2**	199 ± 18	0.3 ± 0.1	< 0.1	< 0.1	116.3 ± 2.8	14 ± 3
		-B	< 2.3	240 ± 19	0.3 ± 0.1	< 0.1	< 0.1	114.3 ± 3.2	
		-C	(d)	(d)	(d)	(d)	(d)	(d)	
		-D	(d)	(d)	(d)	(d)	(d)	(d)	
		-E	(d)	(d)	(d)	(d)	(d)	(d)	
		-F	(d)	(d)	(d)	(d)	(d)	(d)	
		-G	(d)	(d)	(d)	(d)	(d)	(d)	
		-H	(d)	(d)	(d)	(d)	(d)	(d)	
Average			**2.8**	219	0.2	<0.2	<0.1	133.4	44

NOTES:
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) For gamma analysis "<" indicates less than Ld.
(c) Ld for C-14 = 40 Bq/kg-C.
(d) Sample not available.

Table D10: Terrestrial Biota – 2010

DN REMP							
Site Description	Sample Type Composite [a]	HTO (Bq/L ± 2σ)[c]	C-14 (Bq/kg-C ± 2σ)[d]	Site Description	Sample Type Composite [a]	HTO (Bq/L ± 2σ)[c]	C-14 (Bq/kg-C ± 2σ)[d]
R2	Fruit	12.2 ± 2.7	236 ± 20	R2	Vegetable	16.7 ± 2.8	258 ± 21
R85	Fruit	18.7 ± 3.1	221 ± 19	R19	Vegetable	6.9 ± 2.3	283 ± 23
R122	Fruit	8.7 ± 2.6	235 ± 19	DF2	Vegetable	5.9 ± 2.3	240 ± 21
R19	Fruit	16.5 ± 3.0	229 ± 19	F13	Vegetable	3.7 ± 2.2	250 ± 22
R24	Fruit	11.6 ± 2.8	243 ± 19	F16	Vegetable	8.8 ± 2.4	266 ± 22
DF12	Fruit	11.0 ± 2.7	235 ± 19	DF6	Vegetable	[b]	[b]
R27	Fruit	15.4 ± 3.0	260 ± 20	R335	Vegetable	13.0 ± 2.6	280 ± 23
R35/Loc 1	Fruit	9.3 ± 2.6	222 ± 18	DF7	Vegetable	**3.5 ± 2.2**	254 ± 20
R39	Fruit	13.3 ± 2.9	213 ± 18	R228	Vegetable	7.6 ± 2.4	246 ± 20
F18	Fruit	8.8 ± 2.6	231 ± 19	F25	Vegetable	10.9 ± 2.5	241 ± 19
R335	Fruit	13.9 ± 2.9	234 ± 18	R275	Vegetable	35.9 ± 3.5	250 ± 20
R63	Fruit	9.1 ± 2.6	238 ± 20	R357	Vegetable	5.5 ± 2.2	245 ± 21
DF7	Fruit	5.2 ± 2.4	239 ± 19	R358	Vegetable	7.6 ± 2.4	270 ± 22
R65	Fruit	28.3 ± 3.5	283 ± 20	R356	Vegetable	19.6 ± 2.4	249 ± 21
R228	Fruit	14.4 ± 2.9	232 ± 19	DF12	Silage	17.2 ± 3.0	233 ± 19
F26	Fruit	10.4 ± 2.7	229 ± 19	DF5	Corn	18.5 ± 2.9	245 ± 20
R275	Fruit	30.2 ± 3.6	259 ± 20	DF7	Silage	3.5 ± 2.3	215 ± 19
DF9	Fruit	9.0 ± 2.6	266 ± 20	DF8	Silage	8.4 ± 2.6	235 ± 19
				DF9	Corn	21.7 ± 3.1	229 ± 19
Average (Fruits, Vegetables)		12.3	246	Average (Silage)		13.9	231

NOTES:

(a) 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.

(b) Sample not available.

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

(d) Ld for C-14 = 40 Bq/kg-C.

Table D10: Terrestrial Biota – 2010 (Continued)

PN REMP									
Site Description	**Sample Type Composite [a]**	**HTO (Bq/L ± 2σ)[c]**	**C-14 (Bq/kg-C ± 2σ)[d]**	**OBT (Bq/L (w.e.) ± 2σ)**	**Site Description**	**Sample Type Composite[a]**	**HTO (Bq/L ± 2σ)[c]**	**C-14 (Bq/kg-C ± 2σ)[d]**	**OBT (Bq/L (w.e.) ± 2σ)**
L35	Fruit	166.9 ± 7.2	259 ± 21	NR	P9	Vegetable	44.0 ± 3.8	226 ± 19	NR
R152	Fruit	62.6 ± 4.7	282 ± 21	NR	R144	Vegetable	99.7 ± 5.2	242 ± 20	NR
F10	Fruit	16.0 ± 3.0	238 ± 20	60 ± 4	Location 16	Vegetable	12.5 ± 2.6	231 ± 20	33 ± 3
Location 7	Fruit	94.0 ± 5.6	318 ± 21	NR	DF1	Vegetable	8.1 ± 2.4	260 ± 22	NR
Location 12	Fruit	31.6 ± 3.7	221 ± 19	NR	P11	Vegetable	53.8 ± 4.0	338 ± 22	NR
Location 10	Fruit	147.0 ± 6.8	385 ± 23	NR	F13	Vegetable	5.8 ± 2.3	233 ± 19	NR
Location 22	Fruit	85.7 ± 5.3	310 ± 21	141 ± 5	F40	Vegetable	12.7 ± 2.6	257 ± 21	NR
F31	Fruit	27.7 ± 3.5	213 ± 20	NR	F41	Vegetable	22.0 ± 3.0	232 ± 19	44 ± 3
					F36	Vegetable	[b]	[b]	NR
					DF3	Vegetable	8.9 ± 2.4	259 ± 20	NR
					R156	Vegetable	37.7 ± 3.5	286 ± 21	NR
					R157	Vegetable	28.4 ± 3.2	270 ± 20	NR
					R158	Vegetable	[b]	[b]	NR
DF8	Silage	20.1 ± 3.0	232 ± 19	NR	Average (Fruits, Vegetables)		50.8	298	69

NOTES:
NR = Not Required by Program

(a) Composite vegetables are from the following categories: Above ground (e.g., cucumber, zucchini, tomato, beans and peppers); Below ground (e.g., onions, potato, beet and carrots); 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.

(b) Sample not available.

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

(d) Ld for C-14 = 40 Bq/kg-C.

Table D10: Terrestrial Biota – 2010 (Continued)

Background Locations				
Site Description	**Sample Type Composite [a]**	**HTO (Bq/L ± 2σ) [b]**	**C-14 (Bq/kg-C ± 2σ)[c]**	**OBT (Bq/L (w.e.) ± 2σ)**
Lakefield	Vegetable	5.6 ± 2.4	225 ± 19	32 ± 3
Bancroft	Vegetable	5.4 ± 2.4	222 ± 19	28 ± 3
Barrie	Vegetable	5.4 ± 2.5	234 ± 19	30 ± 3
Picton	Vegetable	**3.6 ± 2.3**	250 ± 20	27 ± 3
Sarnia	Vegetable	< 2.3	220 ± 19	22 ± 3
Average (Vegetables and Fruits)		**4.2**	230	28

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

(a) Composite vegetables are from the following categories: Above ground (e.g., cucumber, zucchini, tomato, beans and peppers); Below ground (e.g., onions, potato, beet and carrots); 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.

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

(c) Ld for C-14 = 40 Bq/kg-C.

Table D10: Terrestrial Biota – 2010 (Continued)

Site Description	Sample Type	HTO (Bq/L ± 2σ)[c]	C-14 (Bq/kg-C ± 2σ)[d]	Gamma Analysis (Bq/kg ± 2σ) [b]				OBT (Bq/L (w.e.) ± 2σ)
				Cs-137	Cs-134	Co-60	K-40	
DN REMP								
F27	Honey	15.6 ± 2.8	223 ± 19	< 0.1	< 0.1	< 0.1	121.8 ± 0.9	NR
R326	Honey	(a)	(a)	(a)	(a)	(a)	(a)	NR
R328	Honey	(a)	(a)	(a)	(a)	(a)	(a)	NR
R327	Honey	(a)	(a)	(a)	(a)	(a)	(a)	NR
R32	Honey	29.6 ± 3.5	258 ± 20	< 0.1	< 0.1	< 0.1	16.7 ± 1.2	NR
PN REMP								
R148	Honey	39.7 ± 3.8	274 ± 19	< 0.1	< 0.1	< 0.1	21.0 ± 1.5	NR
R150	Honey	26.0 ± 3.3	220 ± 19	< 0.1	< 0.2	< 0.1	15.0 ± 1.8	26 ± 3
R154	Honey	54.1 ± 4.3	221 ± 19	< 0.1	< 0.1	< 0.1	33.3 ± 1.9	NR

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

Table D11: Inland Soils and Garden Soils – 2010

Site Description	Sample Type	Gamma Analysis (Bq/kg dw ± 2σ) [a]			
		Cs-137	Cs-134	Co-60	K-40
DN REMP					
F1	Soil (open area – not irrigated)	4.0 ± 0.2	< 0.3	< 0.2	732.3 ± 7.2
F16	Soil (open area – not irrigated)	8.7 ± 0.4	< 0.4	< 0.3	729.1 ± 10.0
F16	Garden soil (irrigated – shallow well water)	8.5 ± 0.3	< 0.4	< 0.3	679.0 ± 9.9
R2	Garden Soil (irrigated – deep well water)	5.2 ± 0.2	< 0.3	< 0.1	657.3 ± 6.8
R316	Garden Soil (irrigated – deep well water)	2.8 ± 0.2	< 0.2	< 0.2	731.4 ± 7.4
PN REMP					
P11	Soil (open area – not irrigated)	5.0 ± 0.2	< 0.2	< 0.2	700.8 ± 7.4
P11	Soil (irrigated)	3.0 ± 0.2	< 0.3	< 0.2	579.2 ± 7.3
Background Locations					
Lakefield – A	Inland Soil	5.8 ± 0.2	< 0.3	< 0.2	738.7 ± 8.2
Lakefield –B	Inland Soil	5.7 ± 0.3	< 0.2	< 0.2	709.9 ± 9.4
Cobourg - A	Inland Soil	3.7 ± 0.2	< 0.2	< 0.1	593.6 ± 6.4
Cobourg - B	Inland Soil	3.9 ± 0.2	< 0.3	< 0.2	587.0 ± 7.4
Goderich – A	Inland Soil	2.4 ± 0.1	< 0.2	< 0.2	349.3 ± 5.0
Goderich – B	Inland Soil	3.4 ± 0.2	< 0.4	< 0.1	380.0 ± 5.3

NOTES:
(a) For gamma analysis "<" indicates less than Ld.

Table D12: Tritium, I-131, and C-14 Annual Average Concentrations in Milk – 2010

Site Description	Distance and Direction from Station (km)	HTO [a] [b] (Bq/L)	I-131 [c] (Bq/L)	C-14 [a][b] (Bq/kg-C)	OBT (Bq/L – w.e.)
DN REMP					
DF12	15 km NW	8.5	[c]	240	NR
DF5	3 km N	**3.5**	[c]	242	NR
DF7	9 km NNE	< 2.3	[c]	238	NR
DF8	10 km NE	**4.0**	[c]	244	NR
DF9	13 km ENE	**3.6**	[c]	244	NR
Average		**4.3**	< 0.1	242	-
PN REMP					
DF1	12 km WNW	13.5	[c]	246	NR
DF8	10 km NNE	20.4	[c]	249	27
Average		17.0	< 0.1	247	-
Background Locations					
Belleville		**3.3**	< 0.1	233	NR
London		< 2.3	< 0.1	223	NR
Average		< 2.3 [d]	< 0.1	228	-

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

(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.
(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.
(d) The background average tritium concentration is calculated from the actual measurements and then compared to the Lc and Ld.

Table D13: Pickering Nuclear Sewage Effluent H-3, C-14 and Gamma Scan Results – 2010

Date	I-131 (Bq/kg) (a) (b)	Cs-137 (Bq/kg) (a) (b)	Cs-134 (Bq/kg) (a) (b)	Co-60 (Bq/kg) (a) (b)	K-40 (Bq/kg) (a) (b)	Date [c]	H-3 (Bq/L) [d] [e]	C-14 (Bq/L) [d] [e]
January	< 0.2	< 0.2	< 0.2	< 0.1	9.5	Quarter 1	3754 ± 31	< 2.3
February	< 0.2	< 0.2	< 0.2	< 0.1	9.7			
March	< 0.3	< 0.2	< 0.2	< 0.1	9.2			
April	< 0.2	< 0.2	< 0.2	< 0.1	6.4	Quarter 2	1130 ± 18	< 2.3
May	< 0.2	< 0.3	< 0.2	< 0.1	6.9			
June	< 0.2	< 0.2	< 0.2	< 0.2	6.6			
July	< 0.2	< 0.7	< 0.2	0.2	6.8	Quarter 3	1741 ± 21	< 2.3
August	< 0.1	< 0.2	< 0.2	< 0.1	8.0			
September	< 0.2	< 0.2	< 0.2	< 0.1	6.3			
October	< 0.2	< 0.2	< 0.2	< 0.2	6.7	Quarter 4	2714 ± 27	< 2.3
November	< 0.2	< 0.2	< 0.2	< 0.1	7.1			
December	< 0.2	< 0.2	< 0.2	< 0.2	7.1			

NOTES:
(a) For gamma analysis "<" indicates less than Ld.
(b) Monthly average of PN Site Sewage Effluent weekly sample results. The sewage stream is treated at the Duffin Creek WPCP.
(c) Quarterly composite samples are prepared from weekly samples.
(d) 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.
(e) Bolded values are greater than Lc but less than Ld. "<" indicates less than Lc.

Table D14: Duffin Creek Water Pollution Control Plant Ash Gamma Scan Results – 2010 [(a)]

Month	I-131 (Bq/kg±2σ)	Cs-137 (Bq/kg±2σ) [(b)]	K-40 (Bq/kg±2σ)	Co-60 (Bq/kg±2σ)	Cs-134 (Bq/kg±2σ)
January	1.1 ± 0.3	0.4 ± 0.2	146.4 ± 5.9	< 0.2	< 0.3
February	5.8 ± 0.3	0.3 ± 0.2	178.1 ± 5.1	< 0.2	< 0.3
March	4.4 ± 0.3	< 0.3	179.2 ± 5.5	< 0.2	< 0.4
April	8.1 ± 0.4	< 0.3	204.8 ± 6.1	< 0.2	< 0.3
May	5.3 ± 0.4	< 0.4	271.5 ± 7.4	< 0.4	< 0.6
June	14.3 ± 0.6	0.8 ± 0.4	296.4 ± 9.4	< 0.3	< 0.7
July	10.9 ± 0.5	0.9 ± 0.3	297.2 ± 7.8	< 0.3	< 0.6
August	4.5 ± 0.4	0.8 ± 0.4	228.7 ± 7.5	< 0.2	< 0.6
September	17.5 ± 0.7	< 0.5	229.3 ± 8.5	< 0.3	< 0.6
October	17.8 ± 0.6	0.7 ± 0.3	246.4 ± 7.4	< 0.3	< 0.6
November	25.4 ± 0.7	2.7 ± 0.4	285.3 ± 7.9	< 0.3	< 0.7
December	8.3 ± 0.6	< 0.5	261.5 ± 9.2	< 0.4	1.7 ± 0.4

NOTES:
For gamma analysis "<" indicates less than Ld.
(a) The ash samples contain elevated concentrations of natural background and medical source radionuclides.
(b) 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 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-16], 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-12]. Where there was a deviation from this methodology that deviation is listed below:

- 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.

- Dose calculation parameters align with CSA N288.1-08 [R-14]

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-17] provides a description of each pathway.

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

Pathway	Radionuclide	Modeled[1]	Measured
Air Inhalation	HTO	✓(Fisher)	✓
	HT	✓[2]	
	C-14	✓[2]	✓
	I(mfp)	✓[2]	
	Co-60	✓[2]	
Air External Exposure	Noble Gas		✓[3]
	C-14	✓[2]	✓
	I(mfp)	✓[2]	
	Co-60	✓[2]	
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	✓[4]	
Terrestrial Plants Ingestion	HTO		✓
	C-14		✓
	I(mfp)	✓	
	Cs-137+, Co-60	✓	
	OBT	✓[4]	
Aquatic Animals Ingestion	HTO		✓
	C-14		✓
	I(mfp)	✓	
	Cs-137+		✓
	OBT	✓[4]	
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.

(1) Modeling is based on emissions or from local air measurements where they are available.
(2) Concentrations are modeled from emissions and adjusted using empirical Ka determined for each critical group location.
(3) 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.
(4) 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:

(a) **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 minitored 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.

(b) **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, as calculated for natural and weapons fallout contributions only from the Great Lakes Time-Concentration Tritium Model [R-7], is used. 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-7], are subtracted.

(c) **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.

(d) **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.

(e) **Silage** – Silage is a dry animal feed (e.g. hay, corn) used at farms and dairy farms and is usually harvested from the previous year. In Pickering, one silage 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 silage obtained at these locations. Therefore, a silage sample taken at one location is applied to both the Farm and Dairy Farm critical groups. Background values are subtracted. At Darlington, silage 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 silage for the DN Farm is modeled from concentrations in air.

(f) **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.

(g) **Fish** – The radionuclide concentrations used for locally caught fish is the maximum measured in the fish samples with the background tritium in water value, as calculated from the Great Lakes Time-Concentration Tritium Model [R-7], subtracted.

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-25] and standard occupancy and shielding factors for air immersion dose as described in CSA N288.1-08 [R14].

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-26]. 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-27]). 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-37][R-38], 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-35].

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 – 2010

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	6.01E-05	6.91E-08	9.46E-07	1.39E-11	0.00E+00	0.00E+00	3.86E-11	2.47E-12	0.00E+00	6.45E-04	1.29E-01	4.52E-02	1.75E-01
	Co-60	uSv/a	1.30E-05	4.93E-07	2.83E-07	3.83E-08	1.26E-08	1.31E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E-04	5.41E-06	1.32E-02
	Cs-137+	uSv/a	0.00E+00	0.00E+00	2.98E-05	4.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.32E-04	0.00E+00	0.00E+00	2.66E-04
	HT	uSv/a	7.36E-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	7.36E-07
	HTO	uSv/a	7.51E-02	0.00E+00	9.62E-02	2.28E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.83E-05	1.59E-02	1.19E-02	2.01E-01
	NobleGases	uSv/a	0.00E+00	4.77E-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	4.77E-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	7.87E-06	2.31E-03	8.25E-03	1.06E-02
	I (mfp)	uSv/a	6.84E-05	5.43E-06	5.66E-07	2.96E-09	3.52E-10	1.55E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.77E-03	6.31E-04	2.49E-03
	Total	uSv/a	7.52E-02	4.77E-02	9.62E-02	2.29E-03	1.30E-08	1.31E-02	3.86E-11	2.47E-12	0.00E+00	9.03E-04	1.49E-01	6.60E-02	4.50E-01
Child-10y	C-14	uSv/a	8.57E-05	6.91E-08	6.71E-07	1.39E-11	0.00E+00	0.00E+00	2.13E-10	2.47E-12	0.00E+00	3.81E-04	9.47E-02	2.96E-02	1.25E-01
	Co-60	uSv/a	1.85E-05	4.93E-07	4.71E-07	3.83E-08	1.63E-07	1.31E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E-04	9.87E-06	1.33E-02
	Cs-137+	uSv/a	0.00E+00	0.00E+00	1.18E-05	4.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.65E-05	0.00E+00	0.00E+00	9.25E-05
	HT	uSv/a	8.75E-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	8.75E-07
	HTO	uSv/a	8.93E-02	0.00E+00	6.18E-02	1.90E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.82E-06	1.07E-02	6.56E-03	1.70E-01
	NobleGases	uSv/a	0.00E+00	4.77E-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	4.77E-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	4.62E-06	1.76E-03	4.91E-03	6.67E-03
	I (mfp)	uSv/a	1.55E-04	5.43E-06	6.87E-07	2.96E-09	3.33E-09	1.55E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-03	1.04E-03	3.30E-03
	Total	uSv/a	8.96E-02	4.77E-02	6.18E-02	1.91E-03	1.67E-07	1.31E-02	2.13E-10	2.47E-12	0.00E+00	4.72E-04	1.09E-01	4.22E-02	3.66E-01
Infant_1y	C-14	uSv/a	5.85E-05	6.91E-08	0.00E+00	4.21E-12	0.00E+00	0.00E+00	4.26E-10	2.47E-12	0.00E+00	2.24E-04	7.12E-02	2.65E-02	9.80E-02
	Co-60	uSv/a	1.36E-05	6.41E-07	0.00E+00	4.98E-08	4.01E-07	1.70E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.31E-04	1.53E-05	1.73E-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	2.70E-05	0.00E+00	0.00E+00	2.70E-05
	HT	uSv/a	6.00E-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	6.00E-07
	HTO	uSv/a	6.12E-02	0.00E+00	0.00E+00	5.13E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.13E-06	1.13E-02	5.78E-03	7.88E-02
	NobleGases	uSv/a	0.00E+00	5.86E-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	5.86E-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	2.81E-06	1.69E-03	4.00E-03	5.69E-03
	I (mfp)	uSv/a	1.81E-04	7.05E-06	0.00E+00	3.85E-09	1.17E-08	2.02E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.89E-03	2.93E-03	6.03E-03
	Total	uSv/a	6.15E-02	5.86E-02	0.00E+00	5.13E-04	4.13E-07	1.70E-02	4.26E-10	2.47E-12	0.00E+00	2.60E-04	8.73E-02	3.92E-02	2.64E-01

Table G2: Darlington Nuclear – Dairy Farm Critical Group Doses – 2010

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	5.65E-05	6.50E-08	1.30E-06	1.33E-11	0.00E+00	0.00E+00	3.86E-11	2.47E-12	0.00E+00	1.28E-04	6.11E-02	2.29E-01	2.90E-01
	Co-60	uSv/a	2.34E-06	8.86E-08	0.00E+00	0.00E+00	1.19E-09	1.23E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.26E-05	6.05E-06	1.29E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	4.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.62E-05	0.00E+00	0.00E+00	5.04E-05
	HT	uSv/a	1.55E-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	1.55E-07
	HTO	uSv/a	1.58E-02	0.00E+00	5.39E-02	1.96E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.65E-06	6.17E-03	2.15E-02	9.94E-02
	NobleGases	uSv/a	0.00E+00	7.70E-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	7.70E-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	1.57E-06	9.03E-04	4.73E-03	5.63E-03
	I (mfp)	uSv/a	1.44E-05	1.09E-06	0.00E+00	0.00E+00	7.22E-11	3.21E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-04	1.00E-03	1.69E-03
	Total	uSv/a	1.59E-02	7.70E-03	5.39E-02	1.96E-03	1.26E-09	1.23E-03	3.86E-11	2.47E-12	0.00E+00	1.80E-04	6.89E-02	2.56E-01	4.06E-01
Child-10y	C-14	uSv/a	8.07E-05	6.50E-08	9.26E-07	1.33E-11	0.00E+00	0.00E+00	2.13E-10	2.47E-12	0.00E+00	7.58E-05	4.49E-02	2.41E-01	2.86E-01
	Co-60	uSv/a	3.33E-06	8.86E-08	0.00E+00	0.00E+00	1.54E-08	1.23E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.53E-05	1.86E-05	1.34E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	4.19E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-05	0.00E+00	0.00E+00	1.94E-05
	HT	uSv/a	1.84E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.84E-07
	HTO	uSv/a	1.88E-02	0.00E+00	3.47E-02	1.63E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.95E-06	4.15E-03	2.83E-02	8.75E-02
	NobleGases	uSv/a	0.00E+00	7.70E-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	7.70E-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	9.18E-07	6.86E-04	5.30E-03	5.99E-03
	I (mfp)	uSv/a	3.27E-05	1.09E-06	0.00E+00	0.00E+00	6.82E-10	3.21E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.96E-04	2.33E-03	3.16E-03
	Total	uSv/a	1.89E-02	7.70E-03	3.47E-02	1.64E-03	1.60E-08	1.23E-03	2.13E-10	2.47E-12	0.00E+00	9.38E-05	5.06E-02	2.77E-01	3.92E-01
Infant_1y	C-14	uSv/a	5.51E-05	6.50E-08	0.00E+00	3.92E-12	0.00E+00	0.00E+00	4.26E-10	2.47E-12	0.00E+00	4.46E-05	3.47E-02	4.45E-01	4.80E-01
	Co-60	uSv/a	2.44E-06	1.15E-07	0.00E+00	0.00E+00	3.77E-08	1.60E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.28E-05	4.57E-05	1.73E-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	5.38E-06	0.00E+00	0.00E+00	5.38E-06
	HT	uSv/a	1.26E-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	1.26E-07
	HTO	uSv/a	1.29E-02	0.00E+00	0.00E+00	2.96E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-06	4.31E-03	6.83E-02	8.58E-02
	NobleGases	uSv/a	0.00E+00	9.45E-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	9.45E-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	5.58E-07	6.52E-04	1.10E-02	1.16E-02
	I (mfp)	uSv/a	3.83E-05	1.42E-06	0.00E+00	0.00E+00	2.39E-09	4.17E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-03	7.99E-03	9.13E-03
	Total	uSv/a	1.30E-02	9.46E-03	0.00E+00	2.96E-04	4.01E-08	1.60E-03	4.26E-10	2.47E-12	0.00E+00	5.18E-05	4.08E-02	5.32E-01	5.98E-01

Table G3: Darlington Nuclear – Bowmanville Critical Group Doses – 2010

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	1.40E-04	1.61E-07	3.41E-07	8.54E-12	1.06E-13	1.97E-12	3.76E-11	2.40E-12	0.00E+00	7.40E-05	4.27E-02	4.36E-03	4.73E-02
	Co-60	uSv/a	6.62E-06	2.51E-07	0.00E+00	0.00E+00	3.50E-09	3.63E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.52E-05	5.53E-07	3.68E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	4.42E-04	9.51E-06	5.27E-08	3.44E-03	0.00E+00	0.00E+00	0.00E+00	2.67E-05	9.83E-06	0.00E+00	3.93E-03
	HT	uSv/a	3.75E-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	3.75E-07
	HTO	uSv/a	3.83E-02	0.00E+00	2.59E-02	1.85E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-06	5.73E-03	1.62E-03	7.34E-02
	NobleGases	uSv/a	0.00E+00	4.11E-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	4.11E-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	9.04E-07	8.09E-04	1.06E-03	1.87E-03
	I (mfp)	uSv/a	3.50E-05	2.72E-06	0.00E+00	0.00E+00	1.75E-10	7.76E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.59E-04	5.18E-05	6.57E-04
	Total	uSv/a	3.84E-02	4.11E-02	2.63E-02	1.86E-03	5.63E-08	7.08E-03	3.76E-11	2.40E-12	0.00E+00	1.04E-04	4.99E-02	7.09E-03	1.72E-01
Child-10y	C-14	uSv/a	1.90E-04	1.53E-07	2.40E-07	8.77E-12	5.99E-13	2.03E-12	2.13E-10	2.47E-12	0.00E+00	4.49E-05	3.22E-02	2.83E-03	3.53E-02
	Co-60	uSv/a	9.24E-06	2.46E-07	0.00E+00	0.00E+00	4.28E-08	3.43E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.51E-05	9.81E-07	3.51E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	1.74E-04	9.75E-06	1.66E-07	3.53E-03	0.00E+00	0.00E+00	0.00E+00	9.01E-06	4.10E-06	0.00E+00	3.73E-03
	HT	uSv/a	4.36E-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	4.36E-07
	HTO	uSv/a	4.45E-02	0.00E+00	1.65E-02	1.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.16E-06	3.95E-03	9.00E-04	6.75E-02
	NobleGases	uSv/a	0.00E+00	4.10E-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	4.10E-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	5.44E-07	6.29E-04	6.32E-04	1.26E-03
	I (mfp)	uSv/a	7.75E-05	2.65E-06	0.00E+00	0.00E+00	1.62E-09	7.59E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E-04	8.91E-05	8.53E-04
	Total	uSv/a	4.48E-02	4.10E-02	1.67E-02	1.59E-03	2.11E-07	6.96E-03	2.13E-10	2.47E-12	0.00E+00	5.56E-05	3.76E-02	4.45E-03	1.53E-01
Infant_1y	C-14	uSv/a	1.30E-04	1.53E-07	0.00E+00	1.30E-12	1.20E-12	2.03E-12	4.26E-10	2.47E-12	0.00E+00	2.64E-05	2.44E-02	2.45E-03	2.70E-02
	Co-60	uSv/a	6.77E-06	3.19E-07	0.00E+00	0.00E+00	1.05E-07	4.45E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.44E-05	1.21E-06	4.54E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	1.88E-06	1.99E-07	4.60E-03	0.00E+00	0.00E+00	0.00E+00	3.18E-06	2.00E-06	0.00E+00	4.61E-03
	HT	uSv/a	2.99E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.99E-07
	HTO	uSv/a	3.05E-02	0.00E+00	0.00E+00	1.80E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.21E-07	4.39E-03	8.72E-04	3.59E-02
	NobleGases	uSv/a	0.00E+00	5.01E-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	5.01E-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	3.30E-07	6.36E-04	5.95E-04	1.23E-03
	I (mfp)	uSv/a	9.07E-05	3.45E-06	0.00E+00	0.00E+00	5.66E-09	9.86E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.53E-04	1.79E-04	1.24E-03
	Total	uSv/a	3.07E-02	5.01E-02	0.00E+00	1.82E-04	3.10E-07	9.06E-03	4.26E-10	2.47E-12	0.00E+00	3.07E-05	3.04E-02	4.10E-03	1.25E-01

Table G4: Darlington Nuclear – Industrial/Commercial Critical Group Doses – 2010

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	1.31E-04	1.50E-07	1.88E-07	2.30E-12	2.84E-14	5.30E-13	1.01E-11	6.46E-13	0.00E+00	1.99E-05	1.15E-02	1.17E-03	1.28E-02
	Co-60	uSv/a	4.51E-06	1.71E-07	0.00E+00	0.00E+00	3.43E-09	3.55E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-05	1.48E-07	3.57E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	2.43E-04	2.55E-06	1.41E-08	9.24E-04	0.00E+00	0.00E+00	0.00E+00	7.16E-06	2.64E-06	0.00E+00	1.18E-03
	HT	uSv/a	2.55E-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	2.55E-07
	HTO	uSv/a	2.60E-02	0.00E+00	1.43E-02	4.97E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.65E-07	1.54E-03	4.36E-04	4.28E-02
	NobleGases	uSv/a	0.00E+00	2.11E-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	2.11E-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	2.43E-07	2.17E-04	2.84E-04	5.01E-04
	I (mfp)	uSv/a	2.38E-05	1.87E-06	0.00E+00	0.00E+00	1.21E-10	5.34E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-04	1.39E-05	1.95E-04
	Total	uSv/a	2.62E-02	2.11E-02	1.45E-02	5.00E-04	1.77E-08	4.48E-03	1.01E-11	6.46E-13	0.00E+00	2.79E-05	1.34E-02	1.90E-03	8.21E-02

Table G5: Darlington Nuclear – West/East Beach Critical Group Doses – 2010

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	1.42E-04	1.64E-07	1.69E-06	2.59E-11	2.96E-14	5.53E-13	3.81E-11	2.43E-12	0.00E+00	1.45E-03	3.94E-02	2.61E-03	4.36E-02
	Co-60	uSv/a	1.00E-05	3.80E-07	1.70E-07	1.71E-08	3.86E-09	4.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.59E-05	4.45E-07	4.05E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	8.62E-05	4.36E-06	1.47E-08	9.63E-04	0.00E+00	0.00E+00	0.00E+00	5.23E-04	8.90E-07	1.91E-07	1.58E-03
	HT	uSv/a	5.67E-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	5.67E-07
	HTO	uSv/a	5.79E-02	0.00E+00	7.25E-02	2.23E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.13E-05	6.76E-03	2.63E-04	1.40E-01
	NobleGases	uSv/a	0.00E+00	1.09E-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	1.09E-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	1.77E-05	9.73E-04	1.65E-04	1.16E-03
	I (mfp)	uSv/a	5.29E-05	3.87E-06	8.51E-07	3.33E-09	2.63E-10	1.17E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.62E-04	2.64E-05	6.58E-04
	Total	uSv/a	5.81E-02	1.09E-02	7.26E-02	2.23E-03	1.89E-08	4.97E-03	3.81E-11	2.43E-12	0.00E+00	2.03E-03	4.77E-02	3.06E-03	2.02E-01
Child-10y	C-14	uSv/a	1.98E-04	1.59E-07	1.21E-06	2.63E-11	1.66E-13	5.60E-13	2.13E-10	2.47E-12	0.00E+00	8.70E-04	2.93E-02	1.60E-03	3.19E-02
	Co-60	uSv/a	1.42E-05	3.79E-07	2.87E-07	1.74E-08	4.86E-08	3.89E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.54E-05	6.43E-07	3.98E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	3.15E-05	4.42E-06	4.60E-08	9.77E-04	0.00E+00	0.00E+00	0.00E+00	1.75E-04	3.53E-07	5.88E-08	1.19E-03
	HT	uSv/a	6.72E-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	0.00E+00	6.72E-07
	HTO	uSv/a	6.86E-02	0.00E+00	4.70E-02	1.88E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.24E-05	4.58E-03	1.44E-04	1.22E-01
	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	1.05E-05	7.43E-04	9.70E-05	8.51E-04
	I (mfp)	uSv/a	1.20E-04	3.86E-06	1.05E-06	3.38E-09	2.47E-09	1.16E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.71E-04	4.05E-05	8.48E-04
	Total	uSv/a	6.89E-02	1.05E-02	4.70E-02	1.89E-03	9.71E-08	4.88E-03	2.13E-10	2.47E-12	0.00E+00	1.08E-03	3.53E-02	1.89E-03	1.71E-01
Infant_1y	C-14	uSv/a	1.35E-04	1.59E-07	0.00E+00	8.61E-12	3.32E-13	5.60E-13	4.26E-10	2.47E-12	0.00E+00	5.12E-04	2.22E-02	1.25E-03	2.41E-02
	Co-60	uSv/a	1.04E-05	4.92E-07	0.00E+00	2.26E-08	1.19E-07	5.06E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.48E-05	7.41E-07	5.15E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	3.02E-07	5.52E-08	1.27E-03	0.00E+00	0.00E+00	0.00E+00	6.18E-05	1.78E-07	2.96E-08	1.33E-03
	HT	uSv/a	4.61E-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	4.61E-07
	HTO	uSv/a	4.70E-02	0.00E+00	0.00E+00	4.84E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-05	4.92E-03	1.45E-04	5.26E-02
	NobleGases	uSv/a	0.00E+00	1.28E-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	1.28E-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	6.41E-06	7.29E-04	9.50E-05	8.30E-04
	I (mfp)	uSv/a	1.40E-04	5.01E-06	0.00E+00	4.40E-09	8.66E-09	1.51E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.47E-04	6.81E-05	1.18E-03
	Total	uSv/a	4.73E-02	1.28E-02	0.00E+00	4.84E-04	1.83E-07	6.35E-03	4.26E-10	2.47E-12	0.00E+00	5.94E-04	2.88E-02	1.56E-03	9.79E-02

Table G6: Darlington Nuclear – Rural Resident Critical Group Doses – 2010

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	2.91E-04	3.35E-07	3.02E-06	4.83E-11	1.03E-14	1.91E-13	3.79E-11	2.42E-12	0.00E+00	4.33E-04	5.66E-02	1.28E-02	7.01E-02
	Co-60	uSv/a	1.22E-05	4.62E-07	3.18E-07	2.43E-08	1.10E-08	1.14E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.55E-05	2.07E-06	1.15E-02
	Cs-137+	uSv/a	0.00E+00	0.00E+00	9.70E-05	4.33E-06	5.11E-09	3.34E-04	0.00E+00	0.00E+00	0.00E+00	1.56E-04	2.98E-06	1.53E-07	5.94E-04
	HT	uSv/a	6.90E-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	6.90E-07
	HTO	uSv/a	7.05E-02	0.00E+00	9.99E-02	2.09E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.23E-05	8.83E-03	1.92E-03	1.83E-01
	NobleGases	uSv/a	0.00E+00	4.54E-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	4.54E-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	5.28E-06	1.30E-03	1.23E-03	2.54E-03
	I (mfp)	uSv/a	6.46E-05	5.33E-06	6.81E-07	2.05E-09	3.30E-10	1.48E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.83E-04	1.00E-04	8.69E-04
	Total	uSv/a	7.08E-02	4.54E-02	1.00E-01	2.10E-03	1.64E-08	1.18E-02	3.79E-11	2.42E-12	0.00E+00	6.06E-04	6.75E-02	1.60E-02	3.14E-01
Child-10y	C-14	uSv/a	4.12E-04	3.32E-07	2.18E-06	4.93E-11	5.77E-14	1.95E-13	2.13E-10	2.47E-12	0.00E+00	2.60E-04	4.25E-02	8.53E-03	5.17E-02
	Co-60	uSv/a	1.74E-05	4.62E-07	5.38E-07	2.48E-08	1.42E-07	1.14E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.17E-05	3.56E-06	1.15E-02
	Cs-137+	uSv/a	0.00E+00	0.00E+00	3.50E-05	4.41E-06	1.60E-08	3.40E-04	0.00E+00	0.00E+00	0.00E+00	5.23E-05	1.23E-06	5.59E-08	4.33E-04
	HT	uSv/a	8.21E-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	8.21E-07
	HTO	uSv/a	8.38E-02	0.00E+00	6.50E-02	1.78E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.71E-06	6.04E-03	1.02E-03	1.58E-01
	NobleGases	uSv/a	0.00E+00	4.54E-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	4.54E-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	3.16E-06	1.01E-03	7.12E-04	1.72E-03
	I (mfp)	uSv/a	1.46E-04	5.34E-06	8.43E-07	2.09E-09	3.11E-09	1.48E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.21E-04	1.77E-04	1.16E-03
	Total	uSv/a	8.44E-02	4.54E-02	6.51E-02	1.78E-03	1.61E-07	1.18E-02	2.13E-10	2.47E-12	0.00E+00	3.23E-04	5.05E-02	1.04E-02	2.70E-01
Infant_1y	C-14	uSv/a	2.81E-04	3.32E-07	0.00E+00	1.73E-11	1.15E-13	1.95E-13	4.26E-10	2.47E-12	0.00E+00	1.53E-04	3.45E-02	8.42E-03	4.34E-02
	Co-60	uSv/a	1.28E-05	6.01E-07	0.00E+00	3.22E-08	3.49E-07	1.48E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.91E-05	5.33E-06	1.49E-02
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	2.88E-07	1.92E-08	4.43E-04	0.00E+00	0.00E+00	0.00E+00	1.85E-05	6.44E-07	3.34E-08	4.62E-04
	HT	uSv/a	5.63E-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	5.63E-07
	HTO	uSv/a	5.74E-02	0.00E+00	0.00E+00	4.13E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.19E-06	6.25E-03	1.36E-03	6.54E-02
	NobleGases	uSv/a	0.00E+00	5.57E-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	0.00E+00	0.00E+00	5.57E-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	1.92E-06	9.49E-04	9.06E-04	1.86E-03
	I (mfp)	uSv/a	1.71E-04	6.94E-06	0.00E+00	2.72E-09	1.09E-08	1.92E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-03	5.60E-04	1.90E-03
	Total	uSv/a	5.79E-02	5.57E-02	0.00E+00	4.14E-04	3.80E-07	1.53E-02	4.26E-10	2.47E-12	0.00E+00	1.78E-04	4.30E-02	1.12E-02	1.84E-01

Table G7: Darlington Nuclear – Provincial Park Camper Critical Group Doses – 2010

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	1.44E-04	1.66E-07	2.30E-07	6.43E-12	0.00E+00	0.00E+00	3.86E-11	2.47E-12	0.00E+00	4.68E-03	2.63E-02	5.27E-03	3.64E-02
	Co-60	uSv/a	5.55E-06	2.11E-07	0.00E+00	0.00E+00	5.09E-09	5.27E-03	0.00E+00	0.00E+00	0.00E+00	7.51E-07	2.99E-05	1.06E-06	5.31E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	2.98E-04	7.15E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-03	0.00E+00	0.00E+00	1.43E-03
	HT	uSv/a	3.14E-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	3.14E-07
	HTO	uSv/a	3.21E-02	0.00E+00	2.16E-02	1.69E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.12E-04	3.22E-03	9.30E-04	6.00E-02
	NobleGases	uSv/a	0.00E+00	3.45E-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	3.45E-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	1.77E-04	4.69E-04	5.98E-04	1.24E-03
	I (mfp)	uSv/a	2.94E-05	2.38E-06	0.00E+00	0.00E+00	1.50E-10	6.71E-06	0.00E+00	0.00E+00	0.00E+00	3.17E-07	3.61E-04	5.64E-05	4.56E-04
	Total	uSv/a	3.23E-02	3.45E-02	2.19E-02	1.70E-03	5.24E-09	5.28E-03	3.86E-11	2.47E-12	0.00E+00	6.39E-03	3.04E-02	6.86E-03	1.39E-01
Child-10y	C-14	uSv/a	2.06E-04	1.66E-07	1.63E-07	6.43E-12	0.00E+00	0.00E+00	2.13E-10	2.47E-12	0.00E+00	2.76E-03	1.93E-02	3.31E-03	2.55E-02
	Co-60	uSv/a	7.92E-06	2.11E-07	0.00E+00	0.00E+00	6.58E-08	5.27E-03	0.00E+00	0.00E+00	0.00E+00	1.04E-06	4.83E-05	1.72E-06	5.33E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	1.18E-04	7.15E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.69E-04	0.00E+00	0.00E+00	4.94E-04
	HT	uSv/a	3.74E-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	3.74E-07
	HTO	uSv/a	3.81E-02	0.00E+00	1.39E-02	1.41E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.20E-04	2.16E-03	4.86E-04	5.63E-02
	NobleGases	uSv/a	0.00E+00	3.45E-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	3.45E-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	1.04E-04	3.56E-04	3.36E-04	7.95E-04
	I (mfp)	uSv/a	6.66E-05	2.38E-06	0.00E+00	0.00E+00	1.42E-09	6.71E-06	0.00E+00	0.00E+00	0.00E+00	3.21E-07	4.24E-04	9.92E-05	5.99E-04
	Total	uSv/a	3.84E-02	3.45E-02	1.40E-02	1.41E-03	6.72E-08	5.28E-03	2.13E-10	2.47E-12	0.00E+00	3.46E-03	2.23E-02	4.23E-03	1.24E-01
Infant_1y	C-14	uSv/a	1.41E-04	1.66E-07	0.00E+00	6.91E-13	0.00E+00	0.00E+00	4.26E-10	2.47E-12	0.00E+00	1.63E-03	1.45E-02	2.75E-03	1.90E-02
	Co-60	uSv/a	5.81E-06	2.74E-07	0.00E+00	0.00E+00	1.62E-07	6.85E-03	0.00E+00	0.00E+00	0.00E+00	7.52E-07	4.70E-05	1.94E-06	6.91E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	1.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.31E-04	0.00E+00	0.00E+00	1.32E-04
	HT	uSv/a	2.56E-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	2.56E-07
	HTO	uSv/a	2.61E-02	0.00E+00	0.00E+00	1.19E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E-04	2.27E-03	6.08E-04	2.93E-02
	NobleGases	uSv/a	0.00E+00	4.23E-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	4.23E-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	6.30E-05	3.41E-04	4.10E-04	8.14E-04
	I (mfp)	uSv/a	7.79E-05	3.10E-06	0.00E+00	0.00E+00	4.97E-09	8.72E-06	0.00E+00	0.00E+00	0.00E+00	3.31E-07	5.88E-04	2.21E-04	8.99E-04
	Total	uSv/a	2.64E-02	4.23E-02	0.00E+00	1.20E-04	1.67E-07	6.86E-03	4.26E-10	2.47E-12	0.00E+00	1.96E-03	1.78E-02	3.99E-03	9.94E-02

Table G8: Darlington Nuclear – Oshawa Critical Group Doses – 2010

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-05	4.39E-08	3.84E-07	9.01E-12	1.15E-13	2.14E-12	3.82E-11	2.44E-12	0.00E+00	1.40E-03	1.96E-02	4.94E-05	2.11E-02
	Co-60	uSv/a	1.78E-06	6.76E-08	0.00E+00	0.00E+00	1.69E-09	1.75E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.07E-05	8.46E-09	1.77E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	4.97E-04	1.00E-05	5.70E-08	3.73E-03	0.00E+00	0.00E+00	0.00E+00	5.05E-04	8.07E-06	0.00E+00	4.75E-03
	HT	uSv/a	1.01E-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	1.01E-07
	HTO	uSv/a	1.03E-02	0.00E+00	3.60E-02	2.08E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.98E-05	2.99E-03	6.15E-05	5.15E-02
	NobleGases	uSv/a	0.00E+00	6.54E-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	6.54E-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	1.71E-05	4.30E-04	4.07E-05	4.88E-04
	I (mfp)	uSv/a	9.36E-06	6.71E-07	0.00E+00	0.00E+00	4.82E-11	2.11E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.49E-04	1.26E-07	2.62E-04
	Total	uSv/a	1.03E-02	6.55E-03	3.65E-02	2.09E-03	5.88E-08	5.48E-03	3.82E-11	2.44E-12	0.00E+00	1.96E-03	2.33E-02	1.52E-04	8.64E-02
Child-10y	C-14	uSv/a	4.95E-05	3.99E-08	2.72E-07	9.09E-12	6.39E-13	2.16E-12	2.13E-10	2.47E-12	0.00E+00	8.35E-04	1.45E-02	2.85E-05	1.55E-02
	Co-60	uSv/a	2.40E-06	6.39E-08	0.00E+00	0.00E+00	2.07E-08	1.66E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.39E-05	1.15E-08	1.69E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	1.96E-04	1.01E-05	1.77E-07	3.76E-03	0.00E+00	0.00E+00	0.00E+00	1.68E-04	3.32E-06	0.00E+00	4.14E-03
	HT	uSv/a	1.13E-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	1.13E-07
	HTO	uSv/a	1.16E-02	0.00E+00	2.32E-02	1.75E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.15E-05	2.03E-03	3.22E-05	3.86E-02
	NobleGases	uSv/a	0.00E+00	6.19E-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	6.19E-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	1.01E-05	3.30E-04	2.33E-05	3.63E-04
	I (mfp)	uSv/a	2.01E-05	6.30E-07	0.00E+00	0.00E+00	4.31E-10	1.99E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.97E-04	1.25E-07	3.20E-04
	Total	uSv/a	1.16E-02	6.19E-03	2.34E-02	1.76E-03	1.98E-07	5.42E-03	2.13E-10	2.47E-12	0.00E+00	1.03E-03	1.72E-02	8.42E-05	6.68E-02
Infant_1y	C-14	uSv/a	3.38E-05	3.99E-08	0.00E+00	1.38E-12	1.28E-12	2.16E-12	4.26E-10	2.47E-12	0.00E+00	4.92E-04	1.10E-02	3.64E-05	1.16E-02
	Co-60	uSv/a	1.76E-06	8.31E-08	0.00E+00	0.00E+00	5.08E-08	2.16E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.35E-05	1.80E-08	2.19E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	2.00E-06	2.13E-07	4.90E-03	0.00E+00	0.00E+00	0.00E+00	5.93E-05	1.60E-06	0.00E+00	4.96E-03
	HT	uSv/a	7.78E-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	0.00E+00	7.78E-08
	HTO	uSv/a	7.93E-03	0.00E+00	0.00E+00	2.37E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.34E-05	2.19E-03	4.35E-05	1.04E-02
	NobleGases	uSv/a	0.00E+00	7.60E-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	7.60E-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	6.15E-06	3.23E-04	3.08E-05	3.60E-04
	I (mfp)	uSv/a	2.35E-05	8.19E-07	0.00E+00	0.00E+00	1.51E-09	2.59E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.19E-04	2.79E-07	4.46E-04
	Total	uSv/a	7.99E-03	7.60E-03	0.00E+00	2.39E-04	2.65E-07	7.06E-03	4.26E-10	2.47E-12	0.00E+00	5.71E-04	1.40E-02	1.11E-04	3.75E-02

Table G9: Darlington Nuclear – Fisher Critical Group Doses – 2010

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	1.09E-04	1.26E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-02	0.00E+00	0.00E+00	1.26E-02
	Co-60	uSv/a	5.31E-06	2.01E-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	5.51E-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	4.49E-03	0.00E+00	0.00E+00	4.49E-03
	HT	uSv/a	3.00E-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	3.00E-07
	HTO	uSv/a	3.09E-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	3.54E-04	0.00E+00	0.00E+00	3.13E-02
	NobleGases	uSv/a	0.00E+00	2.40E-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	2.40E-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	1.52E-04	0.00E+00	0.00E+00	1.52E-04
	I (mfp)	uSv/a	2.79E-05	1.86E-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	2.98E-05
	Total	uSv/a	3.10E-02	2.40E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.74E-02	0.00E+00	0.00E+00	5.09E-02
Child-10y	C-14	uSv/a	1.56E-04	1.26E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.35E-03	0.00E+00	0.00E+00	7.51E-03
	Co-60	uSv/a	7.57E-06	2.01E-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	7.77E-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	1.48E-03	0.00E+00	0.00E+00	1.48E-03
	HT	uSv/a	3.57E-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	3.57E-07
	HTO	uSv/a	3.67E-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	1.89E-04	0.00E+00	0.00E+00	3.69E-02
	NobleGases	uSv/a	0.00E+00	2.40E-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	2.40E-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	8.91E-05	0.00E+00	0.00E+00	8.91E-05
	I (mfp)	uSv/a	6.34E-05	1.86E-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	6.52E-05
	Total	uSv/a	3.70E-02	2.40E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.11E-03	0.00E+00	0.00E+00	4.85E-02
Infant_1y	C-14	uSv/a	1.06E-04	1.26E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.33E-03	0.00E+00	0.00E+00	4.44E-03
	Co-60	uSv/a	5.55E-06	2.62E-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	5.81E-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	5.22E-04	0.00E+00	0.00E+00	5.22E-04
	HT	uSv/a	2.45E-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	2.45E-07
	HTO	uSv/a	2.52E-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	1.18E-04	0.00E+00	0.00E+00	2.53E-02
	NobleGases	uSv/a	0.00E+00	2.94E-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	2.94E-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	5.42E-05	0.00E+00	0.00E+00	5.42E-05
	I (mfp)	uSv/a	7.41E-05	2.41E-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	7.65E-05
	Total	uSv/a	2.54E-02	2.94E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.02E-03	0.00E+00	0.00E+00	3.33E-02

Table G10: Pickering Nuclear – Farm Critical Group Doses – 2010

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	1.31E-04	1.51E-07	5.42E-06	7.03E-10	4.82E-13	8.98E-12	6.88E-09	4.40E-10	0.00E+00	8.62E-04	4.74E-02	3.01E-02	7.85E-02
	Co-60	uSv/a	2.90E-06	1.10E-07	2.59E-08	3.12E-09	1.33E-09	1.38E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.51E-05	8.71E-07	1.40E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	4.67E-03	6.93E-04	2.19E-07	1.43E-02	2.93E-06	1.48E-03	0.00E+00	4.93E-04	4.35E-04	6.55E-05	2.21E-02
	HTO	uSv/a	8.91E-02	0.00E+00	1.04E-01	1.65E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.02E-05	2.44E-02	3.56E-03	2.23E-01
	NobleGases	uSv/a	0.00E+00	7.42E-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	7.42E-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	8.69E-06	3.68E-03	2.23E-03	5.93E-03
	I (mfp)	uSv/a	4.30E-06	2.92E-07	3.02E-08	1.39E-10	2.16E-11	9.40E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.22E-05	2.48E-05	1.03E-04
	Total	uSv/a	8.93E-02	7.42E-02	1.09E-01	2.34E-03	2.20E-07	1.57E-02	2.93E-06	1.48E-03	0.00E+00	1.38E-03	7.60E-02	3.60E-02	4.05E-01
Child-10y	C-14	uSv/a	1.88E-04	1.51E-07	3.84E-06	7.03E-10	2.66E-12	8.98E-12	3.80E-08	4.40E-10	0.00E+00	5.09E-04	3.49E-02	1.92E-02	5.48E-02
	Co-60	uSv/a	4.14E-06	1.10E-07	4.32E-08	3.12E-09	1.72E-08	1.38E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.45E-05	1.46E-06	1.41E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	1.85E-03	6.93E-04	6.73E-07	1.43E-02	9.00E-06	1.48E-03	0.00E+00	1.62E-04	1.77E-04	2.22E-05	1.87E-02
	HTO	uSv/a	1.06E-01	0.00E+00	6.71E-02	1.38E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-05	1.64E-02	1.97E-03	1.93E-01
	NobleGases	uSv/a	0.00E+00	7.42E-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	7.42E-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	5.10E-06	2.81E-03	1.33E-03	4.14E-03
	I (mfp)	uSv/a	9.76E-06	2.92E-07	3.66E-08	1.39E-10	2.04E-10	9.40E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.50E-05	3.84E-05	1.34E-04
	Total	uSv/a	1.06E-01	7.42E-02	6.90E-02	2.07E-03	6.90E-07	1.57E-02	9.04E-06	1.48E-03	0.00E+00	6.88E-04	5.43E-02	2.25E-02	3.46E-01
Infant_1y	C-14	uSv/a	1.28E-04	1.51E-07	0.00E+00	1.91E-11	5.32E-12	8.98E-12	7.60E-08	4.40E-10	0.00E+00	3.00E-04	2.78E-02	1.47E-02	4.29E-02
	Co-60	uSv/a	3.04E-06	1.43E-07	0.00E+00	4.05E-09	4.22E-08	1.79E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.36E-05	1.49E-06	1.82E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	1.57E-05	8.07E-07	1.86E-02	1.08E-05	1.93E-03	0.00E+00	5.74E-05	9.58E-05	1.03E-05	2.07E-02
	HTO	uSv/a	7.27E-02	0.00E+00	0.00E+00	4.27E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.77E-06	1.60E-02	1.85E-03	9.09E-02
	NobleGases	uSv/a	0.00E+00	9.04E-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	9.04E-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	3.10E-06	2.52E-03	1.22E-03	3.74E-03
	I (mfp)	uSv/a	1.14E-05	3.80E-07	0.00E+00	1.80E-10	7.14E-10	1.22E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-04	6.33E-05	1.94E-04
	Total	uSv/a	7.28E-02	9.04E-02	0.00E+00	4.43E-04	8.50E-07	2.04E-02	1.09E-05	1.93E-03	0.00E+00	3.67E-04	4.65E-02	1.78E-02	2.51E-01

Table G11: Pickering Nuclear – Dairy Farm Critical Group Doses – 2010

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	2.10E-04	2.42E-07	3.50E-06	7.06E-10	0.00E+00	0.00E+00	6.88E-09	4.40E-10	0.00E+00	0.00E+00	5.15E-02	1.04E-01	1.55E-01
	Co-60	uSv/a	1.57E-06	5.97E-08	0.00E+00	5.62E-10	8.61E-10	8.92E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.84E-06	1.87E-06	9.04E-04
	Cs-137+	uSv/a	0.00E+00	0.00E+00	5.81E-04	6.81E-04	0.00E+00	0.00E+00	2.93E-06	1.48E-03	0.00E+00	0.00E+00	0.00E+00	2.73E-06	2.75E-03
	HTO	uSv/a	5.55E-02	0.00E+00	8.57E-02	1.34E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.00E-03	1.95E-02	1.67E-01
	NobleGases	uSv/a	0.00E+00	5.34E-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	5.34E-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	8.16E-04	5.18E-03	5.99E-03
	I (mfp)	uSv/a	2.43E-06	1.34E-07	0.00E+00	2.21E-11	1.23E-11	5.36E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.15E-05	5.68E-05	1.01E-04
	Total	uSv/a	5.57E-02	5.34E-02	8.63E-02	2.03E-03	8.73E-10	8.92E-04	2.93E-06	1.48E-03	0.00E+00	0.00E+00	5.74E-02	1.28E-01	3.86E-01
Child-10y	C-14	uSv/a	3.00E-04	2.42E-07	2.49E-06	7.06E-10	0.00E+00	0.00E+00	3.80E-08	4.40E-10	0.00E+00	0.00E+00	3.79E-02	9.96E-02	1.38E-01
	Co-60	uSv/a	2.25E-06	5.97E-08	0.00E+00	5.62E-10	1.11E-08	8.92E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-05	4.65E-06	9.13E-04
	Cs-137+	uSv/a	0.00E+00	0.00E+00	2.30E-04	6.81E-04	0.00E+00	0.00E+00	9.00E-06	1.48E-03	0.00E+00	0.00E+00	0.00E+00	8.10E-07	2.40E-03
	HTO	uSv/a	6.60E-02	0.00E+00	5.51E-02	1.12E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.33E-03	2.40E-02	1.50E-01
	NobleGases	uSv/a	0.00E+00	5.34E-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	5.34E-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	6.24E-04	5.08E-03	5.70E-03
	I (mfp)	uSv/a	5.54E-06	1.34E-07	0.00E+00	2.21E-11	1.16E-10	5.36E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.87E-05	1.14E-04	1.69E-04
	Total	uSv/a	6.63E-02	5.34E-02	5.53E-02	1.80E-03	1.13E-08	8.92E-04	9.04E-06	1.48E-03	0.00E+00	0.00E+00	4.19E-02	1.29E-01	3.50E-01
Infant_1y	C-14	uSv/a	2.05E-04	2.42E-07	0.00E+00	1.42E-11	0.00E+00	0.00E+00	7.60E-08	4.40E-10	0.00E+00	0.00E+00	2.86E-02	1.70E-01	1.99E-01
	Co-60	uSv/a	1.65E-06	7.76E-08	0.00E+00	7.30E-10	2.73E-08	1.16E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.33E-05	1.06E-05	1.19E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-05	1.93E-03	0.00E+00	0.00E+00	0.00E+00	7.24E-07	1.94E-03
	HTO	uSv/a	4.52E-02	0.00E+00	0.00E+00	2.29E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.66E-03	5.64E-02	1.04E-01
	NobleGases	uSv/a	0.00E+00	6.50E-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	6.50E-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	4.81E-04	9.56E-03	1.00E-02
	I (mfp)	uSv/a	6.48E-06	1.74E-07	0.00E+00	2.87E-11	4.06E-10	6.97E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-05	4.01E-04	4.73E-04
	Total	uSv/a	4.54E-02	6.50E-02	0.00E+00	2.29E-04	2.77E-08	1.16E-03	1.09E-05	1.93E-03	0.00E+00	0.00E+00	3.18E-02	2.37E-01	3.82E-01

Table G12: Pickering Nuclear – Industrial/Commercial Critical Group Doses – 2010

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	8.62E-04	9.91E-07	5.77E-06	5.60E-11	3.27E-13	6.09E-12	4.24E-10	2.71E-11	0.00E+00	7.89E-07	1.16E-03	3.74E-07	2.03E-03
	Co-60	uSv/a	1.54E-05	5.83E-07	1.14E-295	3.98E-11	5.97E-10	6.19E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.20E-07	4.29E-11	6.35E-04
	Cs-137+	uSv/a	0.00E+00	0.00E+00	6.80E-03	5.67E-05	1.48E-07	9.68E-03	1.80E-07	9.13E-05	0.00E+00	4.51E-07	2.22E-05	5.04E-10	1.66E-02
	HTO	uSv/a	4.75E-01	0.00E+00	1.14E-02	1.03E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-08	6.56E-04	1.40E-07	4.87E-01
	NobleGases	uSv/a	0.00E+00	4.18E-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	4.18E-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	7.96E-09	1.02E-04	8.16E-08	1.02E-04
	I (mfp)	uSv/a	2.29E-05	1.64E-06	0.00E+00	8.73E-13	4.70E-12	2.08E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.48E-06	3.47E-09	2.63E-05
	Total	uSv/a	4.75E-01	4.18E-01	1.82E-02	1.60E-04	1.49E-07	1.03E-02	1.81E-07	9.13E-05	0.00E+00	1.27E-06	1.94E-03	6.00E-07	9.24E-01

Table G13: Pickering Nuclear – Correctional Institute (C2) Critical Group Doses – 2010

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	9.63E-04	1.11E-06	2.05E-05	6.16E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.85E-04
	Co-60	uSv/a	1.09E-05	4.13E-07	0.00E+00	0.00E+00	5.76E-09	5.97E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.98E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	2.42E-02	6.25E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-02
	HTO	uSv/a	3.89E-01	0.00E+00	4.02E-02	2.54E-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	4.30E-01
	NobleGases	uSv/a	0.00E+00	3.42E-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	3.42E-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	1.72E-05	1.18E-06	0.00E+00	0.00E+00	8.55E-11	3.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.22E-05
	Total	uSv/a	3.90E-01	3.42E-01	6.45E-02	3.16E-04	5.84E-09	5.97E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.03E-01
Child-10y	C-14	uSv/a	1.37E-03	1.11E-06	1.45E-05	6.16E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.39E-03
	Co-60	uSv/a	1.56E-05	4.13E-07	0.00E+00	0.00E+00	7.45E-08	5.97E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.98E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	9.57E-03	6.25E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.63E-03
	HTO	uSv/a	4.63E-01	0.00E+00	2.59E-02	2.11E-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	4.89E-01
	NobleGases	uSv/a	0.00E+00	3.42E-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	3.42E-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	3.90E-05	1.18E-06	0.00E+00	0.00E+00	8.08E-10	3.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.40E-05
	Total	uSv/a	4.64E-01	3.42E-01	3.55E-02	2.74E-04	7.53E-08	5.97E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.48E-01

Table G14: Pickering Nuclear – Fisher Critical Group Doses – 2010

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	6.13E-04	7.05E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.83E-02	0.00E+00	0.00E+00	1.89E-02
	Co-60	uSv/a	9.22E-06	3.50E-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	9.57E-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	1.05E-02	0.00E+00	0.00E+00	1.05E-02
	HTO	uSv/a	2.84E-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	4.30E-04	0.00E+00	0.00E+00	2.85E-01
	NobleGases	uSv/a	0.00E+00	1.38E-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	1.38E-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	1.85E-04	0.00E+00	0.00E+00	1.85E-04
	I (mfp)	uSv/a	1.37E-05	8.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E-05
	Total	uSv/a	2.85E-01	1.38E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.94E-02	0.00E+00	0.00E+00	4.52E-01
Child-10y	C-14	uSv/a	8.75E-04	7.05E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-02	0.00E+00	0.00E+00	1.17E-02
	Co-60	uSv/a	1.32E-05	3.50E-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	1.35E-05
	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	3.45E-03	0.00E+00	0.00E+00	3.45E-03
	HTO	uSv/a	3.38E-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	2.30E-04	0.00E+00	0.00E+00	3.38E-01
	NobleGases	uSv/a	0.00E+00	1.38E-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	1.38E-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	1.08E-04	0.00E+00	0.00E+00	1.08E-04
	I (mfp)	uSv/a	3.11E-05	8.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E-05
	Total	uSv/a	3.39E-01	1.38E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E-02	0.00E+00	0.00E+00	4.92E-01
Infant_1y	C-14	uSv/a	5.97E-04	7.05E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.37E-03	0.00E+00	0.00E+00	6.97E-03
	Co-60	uSv/a	9.64E-06	4.55E-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	1.01E-05
	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	1.22E-03	0.00E+00	0.00E+00	1.22E-03
	HTO	uSv/a	2.32E-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	1.44E-04	0.00E+00	0.00E+00	2.32E-01
	NobleGases	uSv/a	0.00E+00	1.69E-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	1.69E-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	6.58E-05	0.00E+00	0.00E+00	6.58E-05
	I (mfp)	uSv/a	3.64E-05	1.17E-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	3.75E-05
	Total	uSv/a	2.32E-01	1.69E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.80E-03	0.00E+00	0.00E+00	4.09E-01

Table G15: Pickering Nuclear – Urban Resident Critical Group Doses – 2010

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	7.69E-04	8.84E-07	1.72E-05	8.75E-10	5.11E-12	9.52E-11	6.63E-09	4.24E-10	0.00E+00	1.23E-05	1.81E-02	5.85E-06	1.89E-02
	Co-60	uSv/a	1.20E-05	4.54E-07	1.78E-294	6.22E-10	9.34E-09	9.68E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.57E-06	6.71E-10	9.70E-03
	Cs-137+	uSv/a	0.00E+00	0.00E+00	2.02E-02	8.87E-04	2.32E-06	1.51E-01	2.82E-06	1.43E-03	0.00E+00	7.06E-06	3.47E-04	7.88E-09	1.74E-01
	HTO	uSv/a	3.68E-01	0.00E+00	3.50E-02	1.61E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-07	1.03E-02	2.19E-06	4.15E-01
	NobleGases	uSv/a	0.00E+00	3.39E-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	3.39E-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	1.24E-07	1.60E-03	1.28E-06	1.60E-03
	I (mfp)	uSv/a	1.78E-05	1.40E-06	0.00E+00	1.36E-11	7.35E-11	3.26E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.32E-05	5.42E-08	4.58E-05
	Total	uSv/a	3.69E-01	3.39E-01	5.52E-02	2.50E-03	2.33E-06	1.61E-01	2.82E-06	1.43E-03	0.00E+00	1.98E-05	3.03E-02	9.38E-06	9.59E-01
Child-10y	C-14	uSv/a	9.45E-04	7.61E-07	1.21E-05	9.09E-10	2.93E-11	9.88E-11	3.80E-08	4.40E-10	0.00E+00	7.57E-06	1.38E-02	7.29E-06	1.48E-02
	Co-60	uSv/a	1.42E-05	3.78E-07	3.07E-294	6.46E-10	1.25E-07	1.00E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-05	2.03E-09	1.01E-02
	Cs-137+	uSv/a	0.00E+00	0.00E+00	7.94E-03	9.21E-04	7.40E-06	1.57E-01	9.00E-06	1.48E-03	0.00E+00	2.41E-06	1.45E-04	3.04E-09	1.68E-01
	HTO	uSv/a	3.65E-01	0.00E+00	2.24E-02	1.40E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.61E-07	7.10E-03	1.54E-06	3.96E-01
	NobleGases	uSv/a	0.00E+00	2.86E-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	2.86E-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	7.58E-08	1.26E-03	8.92E-07	1.27E-03
	I (mfp)	uSv/a	3.37E-05	1.19E-06	0.00E+00	1.42E-11	7.21E-10	3.38E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.83E-05	1.21E-07	6.67E-05
	Total	uSv/a	3.66E-01	2.86E-01	3.03E-02	2.32E-03	7.52E-06	1.67E-01	9.04E-06	1.48E-03	0.00E+00	1.02E-05	2.24E-02	9.85E-06	8.75E-01
Infant_1y	C-14	uSv/a	6.45E-04	7.61E-07	0.00E+00	6.13E-11	5.85E-11	9.88E-11	7.60E-08	4.40E-10	0.00E+00	4.46E-06	1.14E-02	1.51E-05	1.20E-02
	Co-60	uSv/a	1.04E-05	4.91E-07	0.00E+00	8.39E-10	3.08E-07	1.31E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-05	5.25E-09	1.31E-02
	Cs-137+	uSv/a	0.00E+00	0.00E+00	0.00E+00	7.97E-05	8.88E-06	2.05E-01	1.08E-05	1.93E-03	0.00E+00	8.53E-07	7.14E-05	2.16E-09	2.07E-01
	HTO	uSv/a	2.50E-01	0.00E+00	0.00E+00	2.78E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-07	6.40E-03	2.29E-06	2.57E-01
	NobleGases	uSv/a	0.00E+00	3.48E-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	3.48E-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	4.60E-08	1.06E-03	1.12E-06	1.06E-03
	I (mfp)	uSv/a	3.94E-05	1.55E-06	0.00E+00	1.84E-11	2.53E-09	4.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.85E-05	4.49E-07	8.43E-05
	Total	uSv/a	2.51E-01	3.48E-01	0.00E+00	3.58E-04	9.19E-06	2.18E-01	1.09E-05	1.93E-03	0.00E+00	5.46E-06	1.89E-02	1.90E-05	8.37E-01

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