Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

CMD 18-H6.155B

File / dossier: 6.01.07
Date: 2018-05-30
Edocs: 5554443

Supplementary Information

Written submission from Frank R. Greening

In the Matter of

Ontario Power Generation Inc., Pickering Nuclear Generating Station

Request for a ten-year renewal of its Nuclear Power Reactor Operating Licence for the Pickering Nuclear Generating Station

Commission Public Hearing – Part 2

June 2018

Renseignements supplémentaires

Mémoire de Frank R. Greening

À l'égard de

Ontario Power Generation Inc., centrale nucléaire de Pickering

Demande de renouvellement, pour une période de dix ans, de son permis d'exploitation d'un réacteur nucléaire de puissance à la centrale nucléaire de Pickering

Audience publique de la Commission – Partie 2

Juin 2018

From: Frank Greening
Sent: Wednesday, May 30, 2018 12:42 PM
To: Interventions (CNSC/CCSN); Levert, Louise (CNSC/CCSN)
Cc: Mendoza, Melissa (CNSC/CCSN); gerry.frappier@canad.ca; Rinker, Michael (CNSC/CCSN); Elder, Peter (CNSC/CCSN); Media relations / Relations avec les médias (CNSC/CCSN)
Subject: Supplementary Submission
Attachments: PINTERVEN2018.docx

To: The Senior Tribunal Officer

Secretariat of the Canadian Nuclear Safety Commission (CNSC)
280 Slater Street, P.O. Box 1046, Station B Ottawa, ON K1P 5S9

Tel: 1-800-668-5284 or 1-613-996-9063 Fax: 613-995-5086
Email: Interventions@cnsc-ccsn.gc.ca

Re: Supplemental material for my submission to the CNSC Public Hearing to consider Ontario Power Generation's (OPG's) application to renew its Nuclear Power Operating Licence for the Pickering Nuclear Generating Stations, A and B, for a period of 10 years, Hearing Number Ref. 2018-H-03

To whom it may concern:

In my original submission, dated May 4th 2018, for the upcoming Pickering Hearings, I included the following data request:

3. Airborne radionuclide emissions data (*on a weekly basis*) for all contaminated and non-contaminated stacks at Pickering A and Pickering B. This should include data for tritium (HTO), Carbon – 14, Noble Gases, Radioiodine, Gamma/Beta- emitting particulate and alpha-emitting particulate for the period 2013-2017.

N.B. Monthly or annual averaged data are *not* acceptable for the calculation of doses to critical groups since the airborne emissions from CANDU reactors are spiked, not continuous, and should be evaluated under CSA N288.2,
(*not CSA N288.1*). CSA N288.2 deals with *short-term* emissions which are well represented by weekly data.

I now wish to provide supplementary material to support my claim that CSA N.288.1 is *not* valid for CANDU station's off-site dose calculations because of the intermittent nature of these emissions. Thus, please find as an attachment to this email, a WORD file (PINTERVEN2018) that contains emissions data for typical CANDU plant – not including data for Pickering A or Pickering B, which I have requested.

Please include this email and its attachment as supplementary material to my original submission.

Thank you,

Sincerely,

Dr. F. R. Greening

Airborne Radionuclide Emissions from CANDU Reactors in Ontario:

CANDU stations operating in Ontario have significant airborne emissions of tritium, carbon-14, radioiodine, noble gases and α/β particulates. These radionuclide emissions are generally *not* continuous but consist of short-term emission "spikes". This is because these emissions are caused by facility-specific events such as heavy water spills, moderator cover gas and annulus gas system purges, failed or defective fuel discharges, maintenance outages, etc. Nevertheless, the associated radiation doses to members of the public residing in the vicinity of Pickering, Bruce and Darlington have traditionally been determined based on a Gaussian plume dispersion model that implicitly assumes that the radioactive discharges are relatively uniform and continuous – as described by the Standard CSA N288.1. This standard takes annual average station's emissions data and assigns a dose to critical groups based on annual average wind speed and direction data. However, as described in a COG Report on the derivation of Derived Release Limits, (which uses the same computational methodology), this averaging approach is only valid for relatively uniform and continuous radionuclide emissions - as described in the following extract from the report:

COG-06-3090-R2-I: Derived Release Limits Guidance

D. Hart

November 2008

6.0 APPLICATION GUIDES

6.1 Source Averaging Times for Monitoring

6.1.1 Airborne Releases

The calculation of DRLs for releases to the atmosphere assumes a uniform source emission rate and is based on the use of long-term average atmospheric conditions. In practice, neither emission rates nor weather are constant, and emissions may be intermittent. Therefore, it is important to monitor emissions on a frequent basis for the purpose of tracking performance relative to the DRL.

Adverse weather conditions (poor dispersion), sufficient to produce critical group doses up to 15 times those of average weather conditions, have a 10% chance of occurring for one week in a year (Barry, 1971, 1978). If such a weather event actually occurred, and if a facility was releasing at the DRL rate at the time, then during this period the critical group could receive a dose as high as 30% of the annual dose limit: (15 x 7 days) x 100 = 30% of dose limit for 365 days

6.2.1 Release Duration: General Considerations

The methods described for calculating DRLs are designed for routine, continuous, low-level emissions at a constant rate under steady-state environmental conditions. These circumstances are rarely met in practice. Releases at most nuclear facilities fluctuate with time, and environmental conditions vary diurnally and seasonally.

6.2.2 Intermittent Releases

The performance of the models may deteriorate at sites with intermittent releases and may cease to apply altogether if the releases become too infrequent or too short. This Standard can be used to calculate DRLs for intermittent releases if they are routine and controlled, if the release rate is roughly the same from event to event, and if the release duration and frequency satisfy the conditions described below.

6.2.3 Airborne Releases

The methods described in this Standard are not meant to be applicable in the case that more than about 1% of the annual DRL is released in a matter of a few hours (CSA 1987). This implies that the methods are applicable if at least 100 releases occur per year, each with a duration of at least 3 or 4 hours, for a total release duration of 400 hours. Individual release durations of 3 to 4 hours mean that the release will be seen by most critical groups as a plume rather than a puff, which is a requirement for the dispersion model to be valid.

6.2.5 Alternative Approaches

The discussion in Sections 6.2.3 provides general guidance in determining the applicability of the Standard to periodic, short-term releases. The responsibility is on the user to ensure that the methods described in this Guidance are valid for his or her particular application. Airborne releases that do not meet these conditions may be treated by other methods such as those described in CAN/CSA-N288.2.

The above extract is from a document that was prepared for Ontario Power Generation (OPG) in 2002, which was itself an update of an existing standard, CSA N288.1, and guidance at the time. The 2002 OPG Guidance was approved by staff of the Canadian Nuclear Safety Commission (CNSC). However, in view of the caveats noted above with regard to the applicability of CSA N288.1 for the calculation of off-site doses from the operation of CANDU plants, *it is of vital importance to verify that radionuclide emissions from these plants satisfy the duration requirements listed in Section 6.2.3, above*, or would in fact be better described by CSA N.288.2. To this end, representative examples of airborne emissions data from Bruce NGS are provided below. These examples clearly demonstrate that CSA N288.1 is inappropriate for the calculation of off-site doses from these CANDU stations, and it appears likely that Pickering emissions would show similar intermittent behavior that is not well described by CSA N288.1.

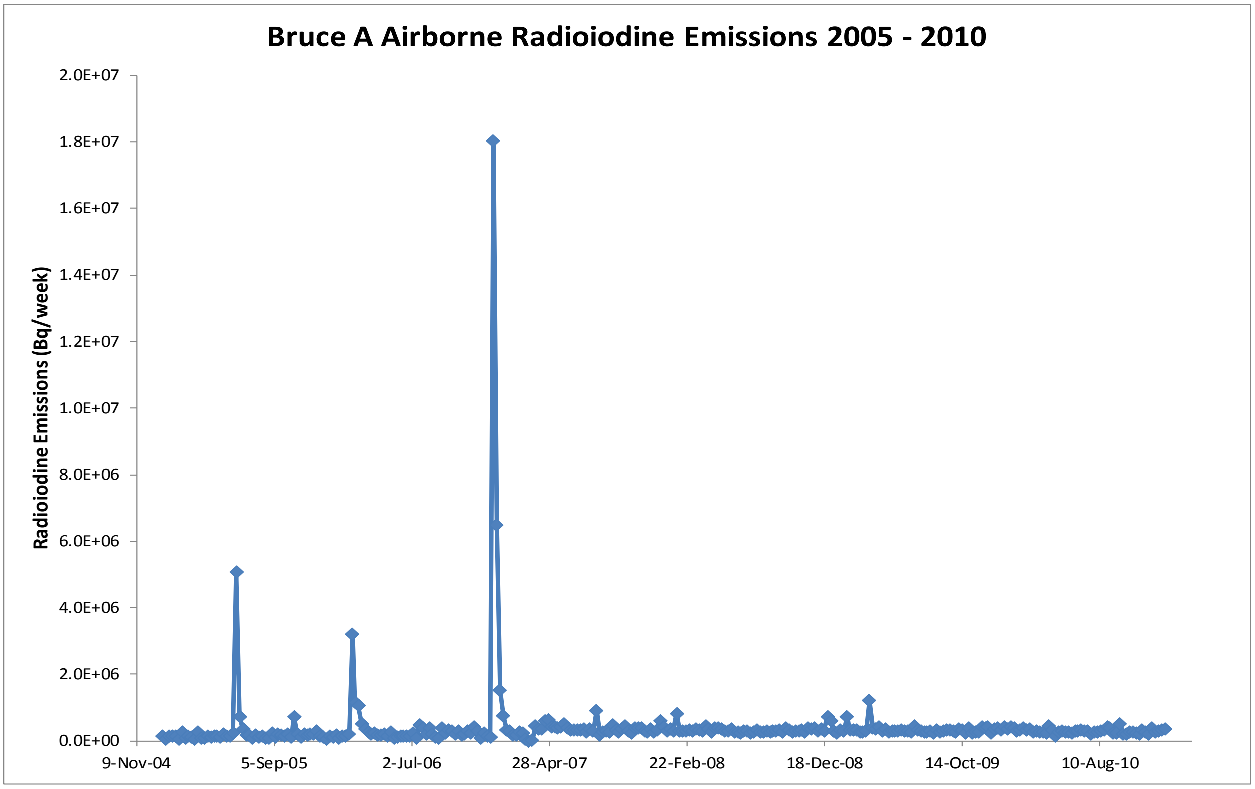
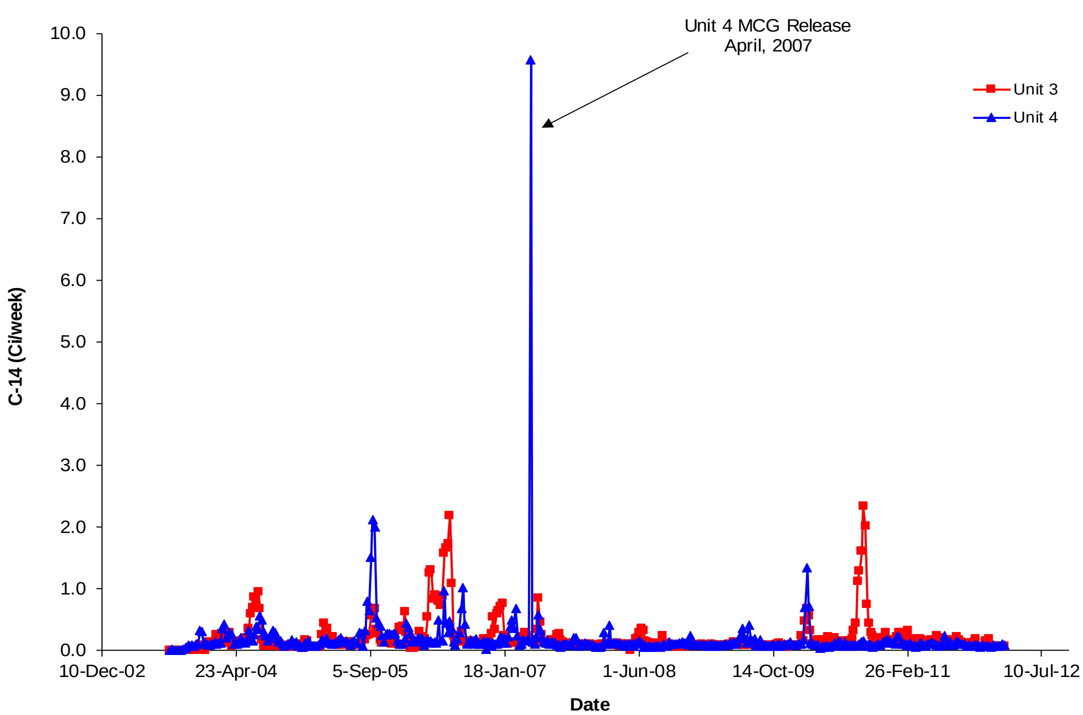


Figure 1: Bruce A Airborne Carbon-14 Emissions 2003 - 2011



Bruce B Airborne Tritium Emissions: 2005 - 2006

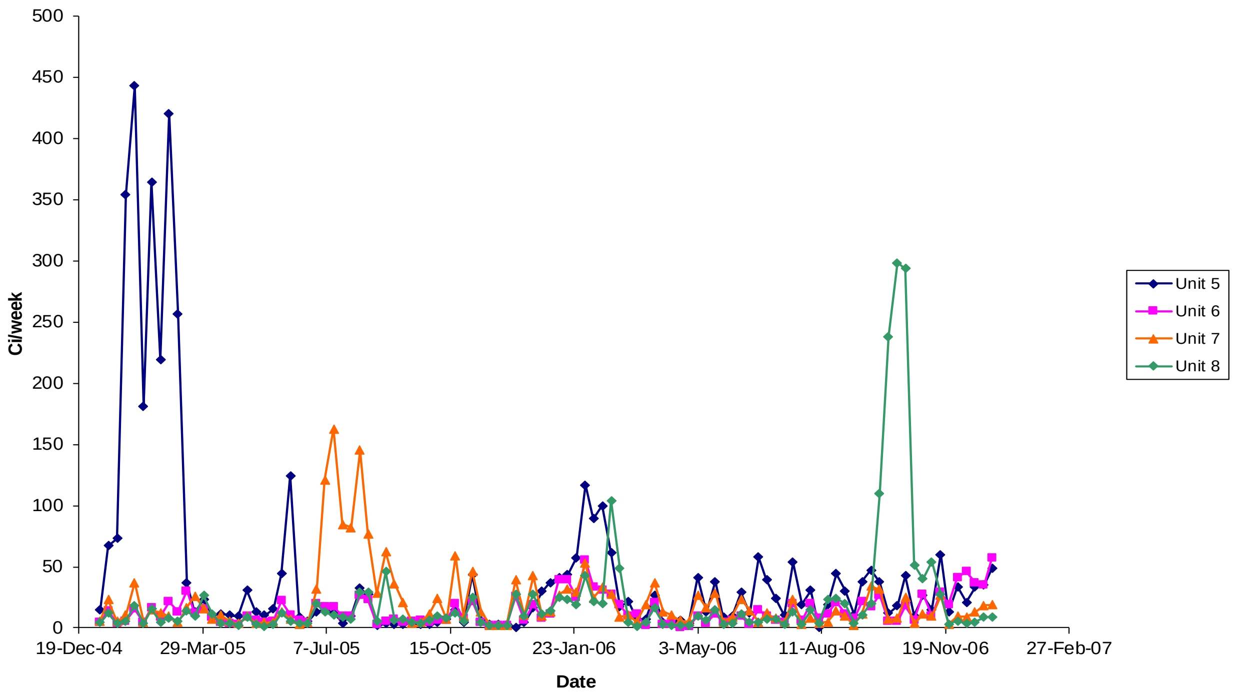
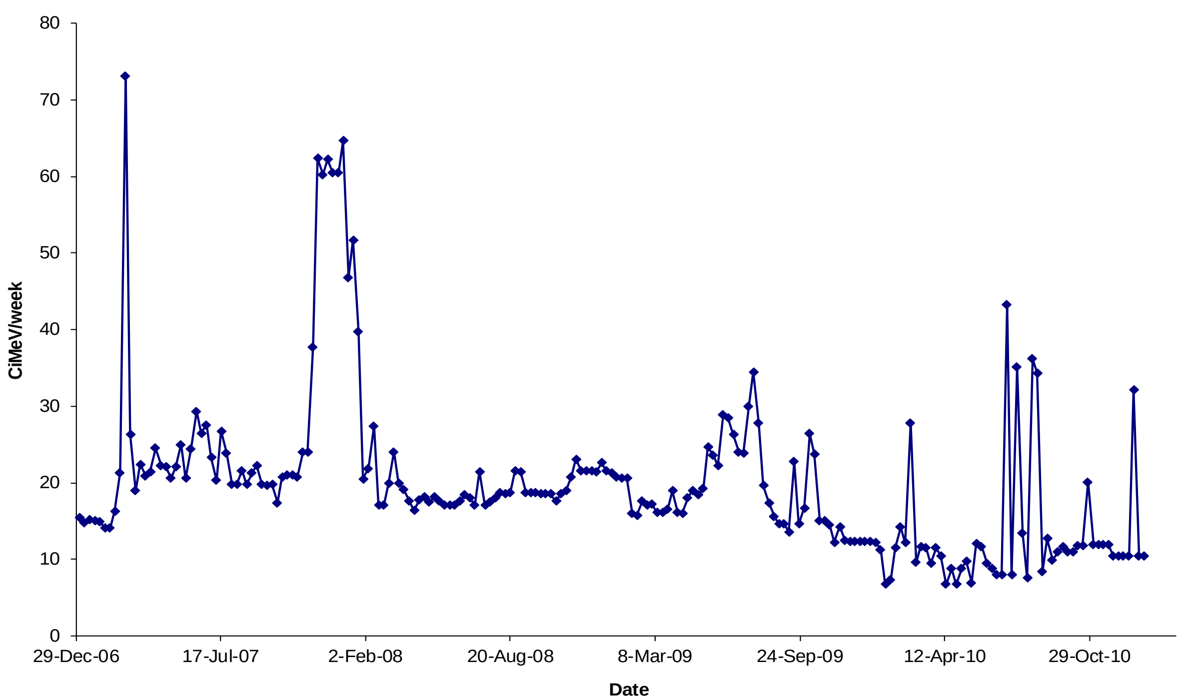


Figure 8: Bruce B Airborne Noble Gas Emissions: 2007 - 2010



In conclusion, it is important to add that dose calculations using the CSA N288.2 methodology will result in considerably *higher* dose estimates than those derived using CSA N288.1. This is because the averaging over all possible wind directions and speeds used in CSA N288.1 effectively dilutes the airborne concentration of a radionuclide emission.

The inhalation dose *per year* from the release of a radioactive species such as tritium is given by:

Inhalation Dose (Sv/year) =

***Release* (Bq/year) × *DCF* (Sv/Bq) × *BR*(m^3/s) × *(X/Q)* (s/m^3)** .... Eqn. 1

Here ***DCF*** is the dose conversion factor (in Sv/Bq), **BR** is the receptor's breathing rate (in m^3/s), ***Q*** is the release rate of the radionuclide (in Bq/s), and ***X*** is the concentration (in Bq/m^3). The **(X/Q)** term is an atmospheric dispersion factor that drops off rapidly with distance from an emission source. Thus, for example, at a station's "regulatory site boundary", generally taken to be about 1 km from the emission source, **(X/Q)** is in the range 10^{-6} to 10^{-5} s/m^3, while at 10 km from the site boundary **(X/Q)** is generally less than 10^{-7} s/m^3. However, the precise value of an atmospheric dispersion factor depends on the time scale of the release.

For short-term releases the maximum downwind concentration of a radionuclide of interest occurs along the plume centerline and the atmospheric dispersion factor is given by:

$$(X/Q)_{short}\ (s/m^3) = \mathrm{Exp}\{-h^2/2\sigma_z^2\} / (\pi\sigma_y\sigma_z u) \quad \text{.... Eqn. 2}$$

Where,

σ_y is the standard deviation in the concentration in the crosswind direction in meters

σ_z is the standard deviation in the concentration in the vertical direction in meters

u is the average wind speed in meters per second

h is the stack height in meters

For long-term releases the wind does not always blow with the same speed or in the same direction so that a correction factor must be applied to the short-term release equation to allow for these variabilities. This is accomplished by dividing all possible wind directions into *n* sectors and replacing σ_y in the short- term release equation by the sector width at a distance *x* from the emission source, or $2\pi x$ divided by the number of sectors. This is typically taken to be the sixteen 22.5° compass directions – N, NNE, NE, etc. In addition, the concentration in each sector is weighted by the fraction of time, f_i, that the wind blows into sector *i*. And this is further weighted by a factor F_{jk} which is the fraction of time during which a Pasquill-Gifford atmospheric stability class, *j*, is observed for a wind class *k*. The resulting, so-called "triple-frequency", atmospheric dispersion factor is given by:

$$\mathbf{(X/Q)_{long}\ (s/m^3) = 2.032\ f_i / x\ .\ \Sigma_{jk}\ F_{jk} / (u_k\ \sigma_{zj})\ .\ Exp\{-\ h^2/2\ \sigma_{zj}^2\}} \quad \text{…. Eqn. 3}$$

Frequencies of occurrence of the atmospheric stability classes, mean wind speeds and wind directions for the Bruce, Pickering and Darlington NPPs have been published in the AECL report: S. L. Chouhan et al. "*Testing the Atmospheric Dispersion Model of CSA N288.1 with Site-Specific Data*", AECL Report No: AECL -12099, January 2001. These frequencies may be used to calculate typical long-term atmospheric dispersion factors for the hypothetical case of a critical group located ***x*** km from a ground level source.

An illustration of the magnitude of the difference between short-term and long-term (X/Q)s may be found in the Bruce Power Report: "*Updated Site Specific Atmospheric Dilution Factors for Use in Safety Analysis*" Report No. B-Rep-03611-00001, issued in June 2004. Here we find "*Recommended Atmospheric Dilution Factors or (X/Q)s for the Bruce Site*" as follows:

$$\text{Short-Term ADF} = 86 \times 10^{-6}\ s/m^3$$

$$\text{Long-Term ADF} = 1.7 \times 10^{-6}\ s/m^3$$

Thus, we see that doses from short-term releases are about 50 times higher than doses from the same total releases delivered continuously over a long-term interval, e.g. 1 year. However, an intermittent release of tritium may also be accompanied by periods of heavy precipitation leading to so-called washout and wet deposition of tritium and even higher doses.