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Supplementary Information

Oral Presentation

Submission from Swim Drink Fish / Lake Ontario Waterkeeper

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

Exposé oral

Mémoire de Swim Drink Fish / Lake Ontario Waterkeeper

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

Canada

Submissions of Swim Drink Fish Canada/Lake Ontario Waterkeeper

Re: Relicensing hearing before the Canadian Nuclear Safety Commission (CNSC) for the Pickering Nuclear Generating Station

Notice of Public Hearing, Ref. 2018-H-03

May 18, 2018

Submitted to:
Participant Funding Program Administrators cnsc.pfp.ccsn@canada.ca and the CNSC Secretariat cnsc.interventions.ccsn@canada.ca
CC: Adam Zenobi adam.zenobi@canada.ca

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Executive Summary

Swim Drink Fish Canada/Lake Ontario Waterkeeper ("Waterkeeper") is a grassroots environmental organization that uses research, education, and legal tools to protect and restore the public's right to swim, drink, and fish in Lake Ontario.

The current power reactor operating licence for the PNGS is set to expire in August 2018. Ontario Power Generation (OPG) is currently applying for a licence renewal that would include a new licence period of ten years, from 2018 to 2028. This requested licence term is at least two times longer than any past licence the PNGS has been granted to date.

Waterkeeper has received participant funding to intervene in this matter, which requires the organization to prepare and deliver both written and oral submissions concerning the impacts of the PNGS to local water quality and aquatic ecosystems, as well as the adequacy of OPG's public information policies and practices for the facility.

Waterkeeper was provided with participant funding from the CNSC in order to retain three experts to examine the PNGS and make recommendations for improvements to its operations:

- **Pippa Feinstein, JD,** counsel and case manager for Waterkeeper;
- **Peter Henderson, BCs, PhD**, an experienced fisheries biologist and international leading expert on the impacts of nuclear cooling water systems; and
- **Wilf Ruland, P. Geo**., an experienced hydrogeologist and recognized leading expert on the impacts of industrial facilities on local groundwater and surface water.

Waterkeeper ultimately submits that there is currently insufficient information on the public record upon which the Commission Tribunal could even consider OPG's current request for a renewal of its licence for any term. Further, what limited information is available seems to indicate that there are significant environmental risks posed by the continued operation of the PNGS that require immediate investigation.

As such, Waterkeeper recommends a temporary licence of no longer than two years to allow for OPG, CNSC staff, the Department of Fisheries and Oceans (DFO), and Environment and Climate Change Canada (ECCC) to collect and publicly present more information to allow OPG's application to be properly considered and assessed on its merits.

Background

About Swim Drink Fish Canada/Lake Ontario Waterkeeper

Swim Drink Fish Canada/Lake Ontario Waterkeeper ("Waterkeeper") is a grassroots environmental organization that uses research, education, and legal tools to protect and restore the public's right to swim, drink, and fish in Lake Ontario. As a non-political registered charity, Waterkeeper focuses on research and justice issues in the public interest. It is dedicated to protecting and celebrating the Lake Ontario watershed, including the wetlands, streams, rivers, and creeks that flow into the lake.

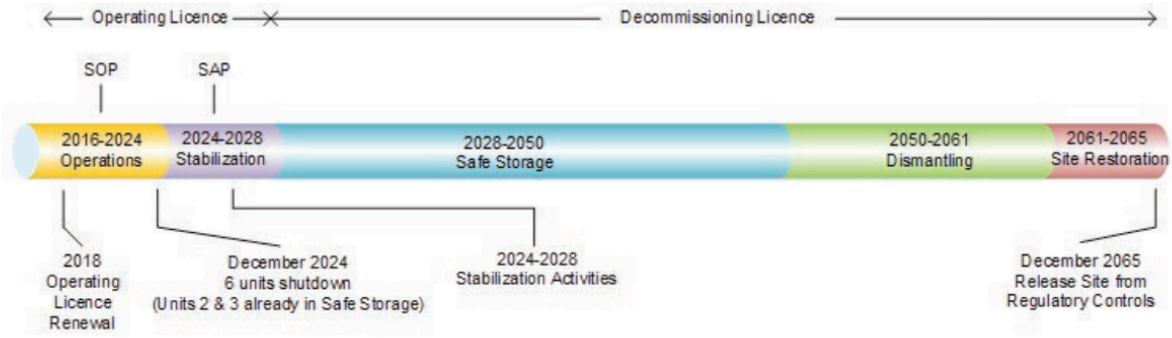
Waterkeeper also works with communities to facilitate the use of environmental laws to protect their rights to swim, drink, and fish. The organization participates in legal processes to help ensure that environmental decisions are made on the basis of sound and tested scientific evidence by independent decision-makers and in the public interest. Waterkeeper is participating in the current Pickering Nuclear Generating Station (PNGS) relicensing process in order to ensure the Commission Tribunal considers the public's need for a swimmable, drinkable, fishable Lake Ontario when determining whether to renew the PNGS licence and add any additional licence terms.

About the Pickering Nuclear Generating Station and the current relicensing application

The current power reactor operating licence for the PNGS is set to expire in August 2018. Ontario Power Generation (OPG) is currently applying for a licence renewal that would include a new licence period of ten years, from 2018 to 2028. This requested licence term is at least two times longer than any past licence the PNGS has been granted to date.

OPG's current relicensing application also includes a request that the power generation limit for PNGS Units 5-8, currently set at 247,000 Effective Full Power Hours (EFPH), be increased to 295,000 EFPH.

As the figure below shows, OPG is currently planning to end the facility's commercial operations in 2024. Between 2024 and 2028, OPG plans to 'stabilize' the site, removing fuel bundles and reactor components for cooling in irradiated fuel bays and removing heavy water from the reactors. Then, from 2028, OPG is planning to transition the facility to a 'safe storage' state until approximately 2050, at which time it hopes to dismantle and restore the Pickering site.



The current long-term operating and decommissioning plan for the PNGS. Source: OPG CMD at p 8.

However, OPG has been incrementally extending its commercial operating period, pushing its design limit, and increasing its power generation limit over the last decade. Thus, while it asserts it will soon wind down its operations, this may not in fact be the case.

The currently proposed new licence for the facility requires the Canadian Nuclear Safety Commission (CNSC) to be notified by December 2022 of any intention by OPG to extend the PNGS operating life past 2024, thus leaving open the possibility of further extending the commercial operations of the facility. Should OPG apply to extend the site's commercial operations past 2024, a decision would be rendered at that time by the CNSC, based primarily on a safety assessment of the reactors.[1] It is uncertain whether that decision would automatically require public input via written or oral hearing, or whether it would only proceed to be considered by CNSC staff internally. Either way, the extent to which public participation and considerations of environmental factors during that future decision-making process remains unclear.

Given the potential for the current hearing to be the last PNGS-specific opportunity for public input into the facility's operations and environmental impacts for a decade – and given the fact that the PNGS operations may be extended over that time – the CNSC must ensure a rigorous review of all relevant evidence concerning the PNGS' safety and environmental performance.

Waterkeeper's submissions

Waterkeeper has received participant funding to intervene in this matter, which requires the organization to prepare and deliver both written and oral submissions concerning the impacts of

[1] Pickering Nuclear Generating Station Relicensing "Day 1" Hearing, April 4, 2018, Official transcripts, at 61, online: <http://www.nuclearsafety.gc.ca/eng/the-commission/pdf/TranscriptofPickeringHearing-April4,2018.pdf>.

the PNGS to local water quality and aquatic ecosystems, as well as the adequacy of OPG's public information policies and practices for the facility.

Waterkeeper was provided with participant funding from the CNSC in order to retain three experts to examine the PNGS and make recommendations for improvements to its operations:

- **Pippa Feinstein, JD,** counsel and case manager for Waterkeeper. Ms. Feinstein was retained to assess and make recommendations concerning the PNGS' regulatory compliance as well as the adequacy of its public information-sharing policies and practices;
- **Peter Henderson, BCs, PhD**, an experienced fisheries biologist and international leading expert on the impacts of nuclear cooling water systems. Dr. Henderson was retained to assess the PNGS cooling water system and make recommendations for its improvement; and
- **Wilf Ruland, P. Geo**., an experienced hydrogeologist and recognized leading expert on the impacts of industrial facilities on local groundwater and surface water. Mr. Ruland was retained to assess the PNGS' impacts on groundwater and surface water and make recommendations for improvements.

However, when Waterkeeper's experts began their reviews, they found that there was insufficient publicly available information to inform their work. As such, Waterkeeper requested additional information from CNSC staff and OPG, and requested a site visit of the PNGS. Despite these requests, there was still insufficient information for Waterkeeper's experts to do the work they have been retained to do by the original May 7th due date for written submissions, and no site visit by that time had proven possible.

Waterkeeper requested, and was subsequently granted, an extension by the CNSC Secretariat. The Secretariat required Waterkeeper to submit preliminary written submissions to meet the May 7th deadline, and permitted Waterkeeper to submit more fulsome submissions by May 18, 2018.

On May 10th Ms. Feinstein and Mr. Ruland were provided a site visit of the PNGS, and on May 14th, 15th, and 16th, Waterkeeper received additional information disclosures from OPG. While Waterkeeper is appreciative of this new information, it still falls short of what is needed for Waterkeeper to prepare and provide the fulsome review it had planned on presenting.

To ensure its submissions would be as helpful as possible to the Commission Tribunal, Waterkeeper requested CNSC staff assistance in obtaining sufficient information from OPG to inform these final submissions. It remains unclear whether, or to what extent, CNSC staff assisted with this.

These final written submissions include the expert testimony of Dr. Henderson and Mr. Ruland, as well as Ms. Feinstein's legal arguments concerning the regulatory compliance of the PNGS with regard to its impacts on the swimmability, drinkability, and fishability of Lake Ontario. It also contains an assessment of the PNGS public information sharing policies and practices and include recommendations from all three experts for their improvement. However, these submissions are still unfortunately limited due to OPG's continuing lack of disclosure. The persisting information deficit is a significant concern and does the current hearing proceeding a disservice, frustrating Waterkeeper's ability to help ensure OPG's application is considered on its merits.

Concerns about the requested 10-year licence term

The Commission Tribunal can only renew the PNGS licence, if it finds the legal test in section 24(4) of the *Nuclear Safety and Control Act* (*NSCA*) is met. This section specifies:

> No licence shall be issued, renewed, amended or replaced — and no authorization to transfer one given — unless, in the opinion of the Commission, the applicant or, in the case of an application for an authorization to transfer the licence, the transferee
>
> (a) is qualified to carry on the activity that the licence will authorize the licensee to carry on; and
>
> (b) will, in carrying on that activity, make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed.

Section 24(5) of the *NSCA* also provides the Commission with the authority to impose any conditions on licence approvals it considers necessary:

> A licence may contain any term or condition that the Commission considers necessary for the purposes of this Act, including a condition that the applicant provide a financial guarantee in a form that is acceptable to the Commission.

The requested ten-year licence term for the PNGS would be twice as long as any licence the facility has had in the past. OPG's arguments in favour of such an extended licence term are that it would:

1. Allow OPG to expedite post-shut down activities;
2. Provide regulatory certainty for OPG shareholders and rate payers;
3. Not impact the effectiveness of separate (i.e. non-hearing) CNSC mechanisms to ensure site compliance, or preclude reviews and ongoing scrutiny of plant performance;
4. Be consistent with the recently-granted ten-year licence for the Pickering Waste Management Facility (PWMF); and

5. Be consistent with CNSC practices to extend licence periods to ten years, relying more on periodic safety reviews (PSRs) in lieu of relicensing processes as the primary oversight mechanism.[2]

However, Waterkeeper has several concerns with these arguments. First and foremost, they betray OPG's troubling attitudes toward public processes: that they are an inconvenience to the company, and that they cannot offer assistance to the CNSC or lead to improvements in OPG's operations by being held at more regular intervals. Waterkeeper insists on the significant value of meaningful public engagement opportunities, especially public hearings, to ensure OPG and CNSC's accountability and transparency.

Waterkeeper also stresses the potential for regular hearings, especially those in which experts can conduct proper reviews of applications, to add valuable insights and contribute to the body of knowledge on which Commissioners and CNSC staff members can draw to ensure comprehensive and effective regulation of the nuclear industry. It should be noted that the CNSC's own Participant Funding Program recognizes the importance of value-added information provided by qualified individuals and organizations representing diverse public interests.[3]

Further, fewer hearings would not necessarily result in more regulatory certainty for OPG. Rather, regulatory certainty depends on PNGS performance and compliance with applicable regulations. Provided OPG operates the PNGS in keeping with its licence terms and applicable law, public participation in regular hearings should not cause any uncertainty.

Additionally, the PWMF licence was only granted three months ago, almost a year after the PWMF's hearing. At last year's PWMF hearing, Waterkeeper submitted arguments that the Commission Tribunal should have waited for the current PNGS hearing so that the PWMF licence could be considered along-side that of the PNGS, as their facilities and operations are interconnected, and their separation is essentially a legal fiction.[4] As such it is extremely problematic to use the new PWMF licence at this time to support a longer PNGS licence period.

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[2] *Ibid* at 45-46.
[3] See PFP description: Canadian Nuclear Safety Commission, Participant Funding Program Eligibility Criteria, online: < http://nuclearsafety.gc.ca/eng/the-commission/participant-funding-program/eligibility-criteria.cfm>.
[4] See: Submissions of Lake Ontario Waterkeeper, Re: Relicensing hearing before the Canadian Nuclear Safety Commission (CNSC) for the Pickering Waste Management Facility, March 13, 2017, online: < http://www.waterkeeper.ca/blog/2017/4/11/waterkeepers-submission-for-the-pickering-waste-management-facility-relicensing-hearing>.

Finally, Waterkeeper has been consistently expressing concern at the recent CNSC practice of granting ten-year licence terms. The organization has explained in numerous past hearings for facilities including the Darlington Nuclear Generating Station (DNGS) and Port Hope Conversion Facility, and devoted an entire intervention concerning the SRB Technologies facility to this issue. Public disclosure of PSRs and Environmental Risk Assessments (ERAs) cannot come close to providing the same opportunities for public review and input that licence renewal hearings have the potential to offer.[5]

Apart from the arguments above concerning the general problems of ten-year licences, Waterkeeper also submits that there is currently insufficient information on the public record upon which the Commission Tribunal could even consider OPG's current request for a renewal of its licence. Further, what limited information is available seems to indicate that there are significant environmental risks posed by the continued operation of the PNGS that require immediate investigation.

For this reason, Waterkeeper recommends a temporary licence of no longer than two years to allow for OPG, CNSC staff, the DFO, and ECCC to collect and publicly present more information to allow OPG's application to be properly considered and assessed on its merits.

This would be consistent with a precautionary approach which is affirmed and codified in Canadian law as well as several international law instruments to which Canada is a signatory.[6]

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[5] For more information on this issue, please see Waterkeeper's SRBT submissions: Lake Ontario Waterkeeper and Ottawa Riverkeeper, Nuclear Substance Processing Facility Operating Licence Renewal Hearing for SRB Technologies Ltd. (Canada) Inc., April 10, 2015.

[6] The precautionary principle in both domestic Canadian and international law refers to the duty to prevent possible environmental harm, even if available evidence cannot yet prove its complete inevitability. It is included in the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity, both of which are binding on Canada. Canada's House of Commons Standing Committee on Environment and Sustainable Development has emphasized the importance of the precautionary principle in federal environmental legislation. The principle also informs the preventative nature of provisions in the *Fisheries Act* (see: Margot Venton, "Fisheries Act Review - Protection of Fish Habitat and Associated Provisions", online: <https://ecojustice.ca/wp-content/uploads/2016/11/Ecojustice-Fisheries-Act-brief-for-FOPO-Commitee-FINAL-2016-11-30.pdf>. Also, note the currently proposed changes to the Act include more explicit requirements for decision-makers to include a precautionary approach to applying the Act: Fisheries and Oceans, "Overview of the Proposed Changes to the Fisheries Act, February 2018, at s 2.5, online: <http://www.dfo-mpo.gc.ca/campaign-campagne/fisheries-act-loi-sur-les-peches/proposed-changes-modifications-proposees-eng.html>). This principle has seven core elements: 1) the need for proactive measures to prevent environmental harm before it gets to severe; 2) a proportional response taking into account the benefits and costs of responses to potential environmental harms; 3) the need to consider ecological margins of error, recognizing that ecosystems are dynamic and their ability to absorb harms can be difficult to predict exactly; 4) the intrinsic value of non-human ecological components and the impacts of harms on non-human entities; 5) a shift in the burden of proof, which does not require harms to be absolutely proven and predicted beyond doubt in order to merit action

Recommendation 1: *That OPG be granted a licence under the terms of its current licence, for no longer than two years, during which time OPG, CNSC staff, the DFO and ECCC can monitor and publicly report on the PNGS impacts to Lake Ontario's water quality and local aquatic environments, and ensure a future hearing to consider a longer PNGS licence benefits from a more comprehensive evidentiary record.*

The lack of Information-sharing during the current hearing process

OPG's application, which is 376 pages long, contains fewer than five pages concerning the PNGS' impacts on local surface water, groundwater, and the impacts of its cooling water system on aquatic biota.[7] The Commission Member Document (CMD) provided by CNSC staff fails to do much better, devoting fewer than 25 of its 472 pages to assessments of the PNGS' impacts on the health and wellbeing of local aquatic ecosystems, surface and groundwater.[8] Additional sources of information, including the Independent Environmental Monitoring Program (IEMP), the 2014 and 2017 Environmental Risk Assessments (ERAs), and quarterly or annual compliance reports from OPG, similarly fail to provide sufficiently detailed or consistent information to allow for Waterkeeper's experts to fully understand and assess the PNGS' environmental performance.

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to address a potential ecological threat; 6) concern for future generations; and 7) payment for ecological debts and ensuring the accountability of polluters. See: Hugh Benevides and Theresa McClenaghan, "Implementing Precaution: An NGO Response to the Government of Canada's Discussion Document *A Canadian Perspective on the Precautionary Approach/Principle*", April 2002, at 3, online: <http://www.cela.ca/sites/cela.ca/files/uploads/419precautionary.pdf>.

[7] Approximately one page of information (on pp 48 and 89) concerns fish impingement at the PNGS, though no data is included or referenced in this discussion. Virtually no discussion of fish entrainment is included in the document. One paragraph on p 90 concerns thermal impacts of the PNGS cooling water system, again unaccompanied by any data or references to publicly available data. Approximately one and a half pages of information concern groundwater quality below the PNGS (pp 47, 72, and 84), again unaccompanied by any data or references to publicly available data – despite the fact that Units 5-8 irradiated fuel bay areas were found to have been leaking. Surface water impacts of the PNGS are discussed in a single page (pp 91-92) generally lacking any data or references to data: stormwater is not mentioned once, one sentence is devoted to all liquid effluent from the site, simply asserting all effluent streams met regulatory and licence conditions (p 83). Written submission from Ontario Power Generation Inc., CMD 18-H6.1.

[8] This information is included in pp 37-37, 94-5, 128-9 of the main document, and pp 19, 29, and 37-47 of CNSC staff's Environmental Assessment Report (EAR). However, the discussions of PNGS impacts on aquatic biota and local surface and groundwater are not accompanied by sufficient data. Only annual impingement averages are provided and no entrainment data is provided. Virtually no data is provided concerning groundwater, stormwater, thermal, or effluent discharges. Written submission from CNSC staff, CMD 18-H6.

While it may appear upon first glance that the abovementioned sources provide several publicly accessible platforms for information-sharing, this is not the case. Closer examination shows that all of these sources repeat assertions that the PNGS is operating within its licence conditions and that any exceedances are not environmentally significant. However, insufficient data is provided to demonstrate the veracity of these claims. These documents include virtually no disaggregated data concerning any environmental monitoring on the PNGS site itself. What limited data is reported concerning impacts of the PNGS site on its surroundings, is often provided in annual or quarterly averages, and even then, it is not consistently reported from year to year. Further, the monitoring methodologies OPG uses are not comprehensively explained, frustrating attempts to assess the significance and adequacy of any provided sampling results.

Waterkeeper has included a summary of correspondence with OPG and CNSC staff as Appendix III these submissions. This evidences the significant delays in receiving any requested information from OPG and documents the amount and quality of information received so far. OPG is still denying Waterkeeper's requests for monitoring and event reports, and in many areas continues to refuse to provide more detailed information than that which is already available in publicly posted materials. This is discussed further in subsequent sections of this report and informs Waterkeeper's recommendations.

The lack of OPG cooperation during this hearing process is almost unprecedented. While obtaining information from the company can often be challenging, Waterkeeper has never experienced this degree of obfuscation before.

Public access to information during the last PNGS licence renewal hearings

During the 2013 licence renewal hearing, in response to concerns Waterkeeper raised at that time regarding the limited amount of publicly available data concerning PNGS operations, Commissioners asked OPG why it refused to make data (including its monitoring results) available to the public.[9] OPG and CNSC staff responded by offering examples of the limited information that was publicly available, including OPG's compliance reports and the Independent Environmental Monitoring Program (IEMP) and asserting their sufficiency. However, Waterkeeper has long expressed concerns over the limitations of both the reports and IEMP.

Ultimately, the Commission Tribunal recommended more proactive disclosure by OPG:

[9] Canadian Nuclear Safety Commission, Record of Proceedings, Including Reasons for Decision In the Matter of Ontario Power Generation Inc. Application to Renew the Power Reactor Operating licence for the Pickering Nuclear Generating Station, August 9, 2013, at para 228, online: <http://nuclearsafety.gc.ca/eng/the-commission/pdf/2013-05-29-Decision-OPG-Pickering-e-Edocs4177096.pdf>.

> The Commission acknowledges the intervenors' concerns regarding the availability of monitoring data. The Commission recommends that OPG make **environmental monitoring data** accessible to the public on a more frequent basis.[10] [emphasis added]

Waterkeeper wishes to draw the Commission Tribunal's attention to emphasized wording above. During the 2013 hearing, OPG's disclosure appears to be largely the same as it is now. It was sharing annual and quarterly monitoring reports, as well as event reports for planned and unplanned releases at the site. However, all these source lacked the inclusion of actual monitoring data. As such, the Commission's recommendation above should be understood as one requiring more meaningful data disclosure than that which was being provided at the time – something which OPG has yet to do.

Public access to information during the 2017 Pickering Waste Management Facility relicensing hearing

It is important to note that the amount of information available during this current hearing process is more than it would have been were it not for Waterkeeper's intervention in last year's Pickering Waste Management Facility's (PWMF) hearing.

In the Commission Tribunal's written decision to relicense the PWMF it expressed concern over the lack of public access to environmental data during the hearing process. In its decision, the Commission Tribunal addressed deficiencies in both CNSC staff and OPG's information disclosure and a lack of transparency during the hearing process.

Commissioners expressed concerns over CNSC staff's use of "ambiguous terminology: such as 'very minor percentages' in reference to contaminant releases", and supported Waterkeeper's recommendations that CNSC characterizations of environmental effects be supported by publicly available data in order to ensure greater transparency.[11] Further, the Commission Tribunal supported a more active role by CNSC staff in future hearing processes,should intervenors find it difficult to acquire information from regulated facilities.[12]

In its decision, the Commission Tribunal also encouraged OPG to publicly release more information about its contaminants of primary concern in future annual CNSC facility compliance reports,[13] and expressed dissatisfaction that ERAs for the Pickering site were not made publicly

[10] *Ibid* at para 229.
[11] Canadian Nuclear Safety Commission, Record of Decision in the Matter of Ontario Power Generation Application to Renew the Waste Facility Operating Licence for the Pickering Waste Management Facility, February 6, 2018, at para 169, online: <http://nuclearsafety.gc.ca/eng/the-commission/pdf/2017-04-13-Decision-OPG-PickeringWasteManagementFacility-e.pdf>.
[12] *Ibid* at para 234.
[13] *Ibid* at para 15.

available for the PWMF hearing.[14] In fact, the Commission extended the hearing from April to July 2017 to allow for OPG's disclosure of its 2014 and 2017 ERAs and to facilitate Waterkeeper's comments on them.

Thus, it is due to Waterkeeper's intervention last year that OPG's ERAs are even a part of the public record in the present PNGS relicensing hearing, assisting Waterkeeper and the other intervenors during the current process. At the same time, as Waterkeeper's submissions during the PWMF hearing demonstrated, ERAs are still a significantly limited source of disaggregated data or environmental monitoring methodologies.[15]

Ultimately, in its PWMF decision, the Commission Tribunal recognized there could be instances in which the need for future public information disclosure may be broader than the reporting requirements specified in CNSC RD/GD-99.3 (the Commission's policy concerning public information and disclosure).[16] Waterkeeper submits that the current PNGS hearing constitutes such a circumstance.

Troublingly, during the current hearing process, when Waterkeeper notified CNSC staff of its difficulties in obtaining information or arranging a site visit with OPG, staff explained that they require OPG's consent before sharing any information in their files concerning the PNGS operations. CNSC staff subsequently directed Waterkeeper to focus instead on obtaining information from OPG directly. It is unclear to date whether (or to what extent) CNSC staff have been discussing this issue of minimal disclosure with OPG, or encouraging further disclosure.

Waterkeeper is deeply concerned over CNSC staff's deference to OPG (the regulatee) in these circumstances, and their approach to data concerning the local swimmability, drinkability, and fishability of Lake Ontario, treating it as the private property of this company. Such an approach infringes on members of public's right to know about the quality of their environment, and appears to be inconsistent with the legislated role of the CNSC to protect the public interest.

Section 9(b) of the *NSCA* specifies that the CNSC's objectives include:

> disseminat[ing] objective scientific, technical and regulatory information to the public concerning the activities of the Commission and the effects, on the environment and on the health and safety of persons, of the development, production, possession and use [of nuclear substances].

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[14] *Ibid* at para 167.
[15] See: Lake Ontario Waterkeeper comments on the 2014 and 2017 Environmental Risk Assessments for the Pickering Nuclear Generating Station and Pickering Waste Management Facility, July 21, 2017, online: <http://www.waterkeeper.ca/blog/2017/7/31/waterkeeper-comments-on-environmental-risk-assessment-for-pickering-waste-management-facility?rq=pickering>.
[16] *Supra* note 11 at para 71.

To date, the lack of public disclosure of objective scientific and technical information is glaring. This continues to be a deeply problematic failure of the CNSC to use its authority to protect the integrity of the current hearing process and ensure intervenors are able to perform the analysis they were provided Commission funding to undertake.

Moving forward, Waterkeeper hopes that the current hearing will provide an opportunity for the Commission Tribunal to intervene and not only recommend or urge OPG and CSNC staff to ensure more proactive public information and data disclosure, but use its authority to *require* it. Specific areas in which more disclosure is required are discussed in more detail in later sections of these submissions, and submitted as specific recommendations below.

However, before discussing those issues, Waterkeeper hopes to provide some important context for these current proceedings.

The PNGS and its local environment

The PNGS is located in an ecologically stressed, but resilient part of the northern shoreline of Lake Ontario. The City of Pickering has more than 220 hectares of parks, trails, and conservation areas.[17] Over the last several years, this area has been the focus of increasing remediation and conservation efforts. These include efforts to promote the health of the Rouge River, and Duffins Creek, as well as the Petticoat Creek Conservation Area.


Pictures from the Toronto Region Conservation authority, TRCA.ca

The PNGS site is surrounded by parks to the west and north, wetlands to the east, and by Lake Ontario to the South. Conservation areas, beaches, fishing and paddling spots, and trails are all

[17] Taylor Alicia Lena Marquis, “Re-Imagine Pickering Here: A Vision for Pickering Nuclear Park”, A Major Research Project presented to Ryerson University in partial fulfillment of the requirements for the degree of Master of Planning in Urban Development, 2016, at 16, online: <http://digital.library.ryerson.ca/islandora/object/RULA%3A4870/datastream/OBJ/view>.

located close to the site. As such, it is imperative that the facility be held to high standards that protect the swimmability, drinkability, and fishability of this local area.

Local parks include:

- Dunmoore Park;
- Rotary Frenchman's Bay West Park, which is a TRCA-designated Environmentally Sensitive Area due to vegetation diversity and other significant natural features, and a provincially designated significant wetland and coastal lagoon;[18]
- Bruce Hanscombe Memorial Park;
- Glen Ravine Park;
- Douglas Park;
- Alderwood Park;
- Beachfront Park and neighbouring Great Lake Nautical Village and Millennium Square;
- Alex Robertson Park, which "has become a demonstration site for restoring open spaces to a more natural state as well as numerous stewardship activities";[19]
- Bay Ridges Kinsmen Park;
- And Rouge Park, one of the largest urban parks in North America.

[18] *Ibid* at 20.
[19] *Ibid* at 19.

Natural features in Pickering Ajax, and Rouge Park. Source: Marquis, “Re-Imagine Pickering Here: A Vision for Pickering Nuclear Park”, drawing data from Election Canada and the Ontario Ministry of Natural Resources

Local waterbodies that provide popular paddling and fishing spots include Lake Ontario, Duffins Creek, Frenchman's Bay which is also a provincially significant coastal lagoon, and Hydro Marsh which has been designated as provincially significant wetlands.[20] Local beaches include the Frenchman's Bay West and East Beaches.[21] Many of these recreational areas are connected by the Waterfront Trail.

Local water quality is being addressed in the Watershed Plan for Duffins Creek and Carruthers Creek,[22] and Frenchman's Bay Stormwater Management Master Plan.[23] The Frenchman's Bay Plan was a priority area for Pickering's five-year plan to revitalize and restore the waterfront.

Of the 90 fish species found in Lake Ontario, 60 have been found in historical sampling at the Pickering site.[24] Benthic invertebrates, emerald shiner, and white sucker[25] in particular have been identified around the site, as well as species at risk and of concern such as sturgeon, American eel,[26] and salmon.

Water in Lake Ontario has an average residence time of approximately six years before flowing out through the St. Lawrence River. This is especially important given the half-life of tritium, which is a little over 12 years. Tritium is a major contaminant of local lake water around the Pickering site. It is present in high concentrations at the PNGS, and is also present at the PWMF. Recent Independent Environmental Monitoring Plan (IEMP) results also show tritium levels of around 20 Bq/L at the Frenchman's Bay beaches – a result of Pickering water contamination.[27]

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[20] City of Pickering, "Measuring Sustainability Report", 2017, at 20, online: <https://www.pickering.ca/en/living/resources/2017-measuring-sustainability-report.pdf<. See also: N Eyles, M Meriano, & P Chow-Fraser, "Impacts of European Settlement (1840-present) in a Gret Kale watershed lagoon: Frenchman's Bay, Lake Ontario, Canada", *Environmental Earth Sciences*, April 19, 2012, online: <http://greatlakeswetlands.ca/wp-content/uploads/2012/10/Eyes-et-al.-2012.pdf> for information about historical impacts of the PNGS to the Bay.

[21] Where beaches are closed due to unsafe water conditions between 21% and 11% between 2012 and 2016. See *Ibid* "Measuring Sustainability Report" at 9.

[22] "A Watershed Plan for Duffins Creek and Caruthers Creek: A Repor of the DUffins Creek and Carruthurs Creek Watershed Task Forces", August 2003, online: <http://trca.on.ca/dotAsset/25961.pdf>.

[23] City of Pickering, "Frenchman's Bay Stormwater Management Masterplan", April 2009, online: <https://www.pickering.ca/en/city-hall/FrenchmansBaySMMP.aspx>.

[24] CNSC staff, PWMF Phase II: Final Environmental Assessment Study Report (92896-REP-07701-00002 R01), 2003, at 5-18.

[25] *Ibid* at 5-19.

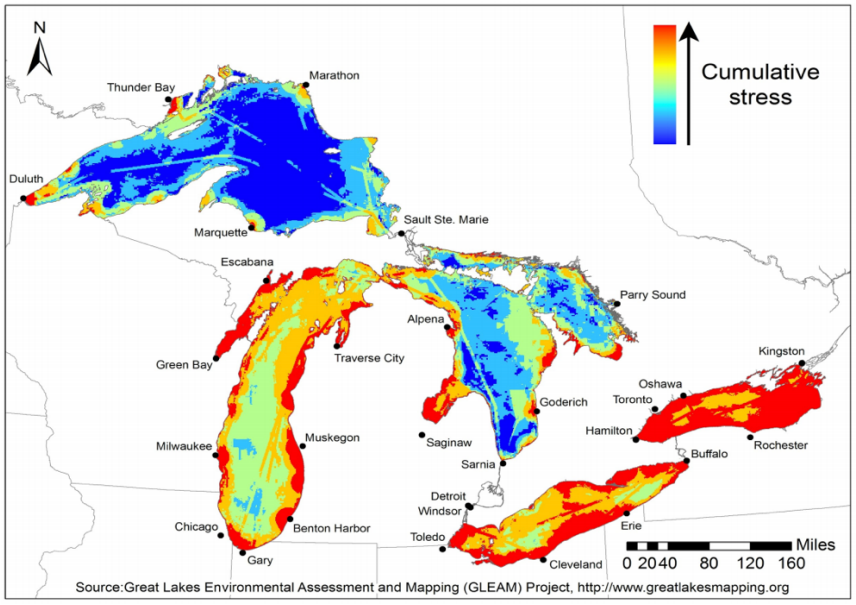
[26] CNSC staff CMD 17-H.5, Appendix A: Environmental Assessment Report: Ontario Power Generation Pickering Waste Management Facility Licence Renewal (e-Doc: 5164324 PDF), 2017, at 21.

[27] Independent Environmental Monitoring Program (IEMP) results reported online: http://nuclearsafety.gc.ca/eng/resources/maps-of-nuclear-facilities/iemp/pickering.cfm#sample_map. The Ontario Drinking Water Advisory Council (ODWAC) has recommended that Ontario's drinking water limits

The fact that lake water residency is half the period of tritium's half-life means that tritium emissions can accumulate in local lake water. The impacts of tritiated water are felt throughout Lake Ontario, and may also result in a contamination legacy felt beyond the lake.[28] As such, understanding and mitigating the environmental impacts of nuclear facilities, including the Pickering site, on Lake Ontario's health is of the utmost importance.

Current ecological stressors in Lake Ontario

Lake Ontario has a changing, severely stressed ecosystem. The Commission Tribunal must consider the fragility of Lake Ontario's ecosystem when making its decision in this matter. The degraded state of the environment in Lake Ontario also makes it more important to protect and restore the lake. Greater caution is required when assessing the continued impact of fish mortality and pollution on this stressed ecosystem.



The lake is threatened by a number of stressors, most linked to a failure to respect and nurture it as a finite and essential resource.

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for tritium be reduced to 20 Bq/L. See: ODWAC Report and Advice on the Ontario Drinking Water Standard for Tritium, May 21, 2009.

[28] Dr. Ekaterina Markelova, Independent Review of Environmental Impact of the Pickering Waste Management Facility on Lake Ontario within the Scope of Relicensing Procedure for 2018 – 2028, March 13, 2017, at 2, *Supra* note 4.

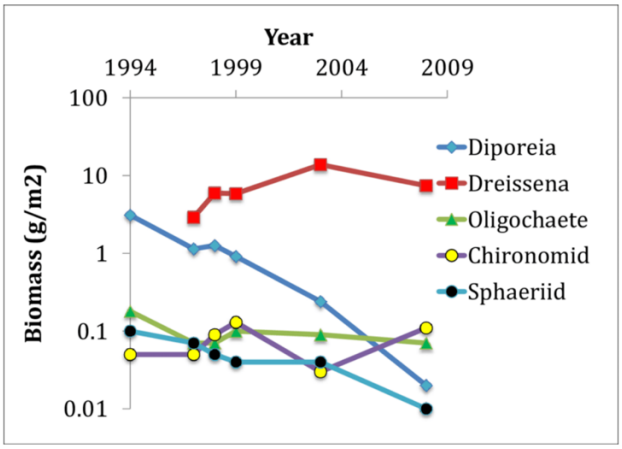
Ecologically speaking, the lake's shoreline is its most biodiverse area. Dr. Henderson explains "[l]akes depend on their shores and shallows for their productivity".[29] Lake Ontario is a deep lake, with a particularly small area of shoreline habitat (compared to other North American lakes). This limited habitat area has also unfortunately borne the brunt of human development as most of the province's densest development has occurred along its north shore. Given the artificial shoreline created along much of the GTA and beyond, extensive and water-intensive industrial facilities built along the lake, oand increasingly dense housing, the impacts of the PNGS on the shoreline ecology of Lake Ontario must be considered within this context of environmental stressors.

Historic and ongoing abuse and pollution of this ecosystem have drastically altered nutrient dynamics, hydrological rhythms, coastal habitats, water quality, and biological diversity. Many of these changes have occurred rapidly, and the lake continues to respond to these changes in unpredictable ways.

The Great Lakes have been experiencing significant ecological upheaval and serve as a continental crossroads for addressing ecological decline.[30] To illustrate this, Dr. Henderson points to the increasing populations of invasive species, including zebra mussels, quagga mussels, sea lamprey, and alewife, as well as the contemporaneous decline in native populations of fish, like the slimy sculpin, and of amphipod crustaceans, like *Diporeia*.

Diporeia once generated more than 80% of total benthic production of Lake Ontario and was a critical component of the diets of most benthic fishes.[31] It's decline has very significant impacts on the stability of Lake Ontario's food web and efforts should be undertaken to reduce harm, not further aggravate its decline and threaten the continuation of the species.

[29] P A Henderson, "Comments on Aquatic Ecology Issues Relating to the Pickering Nuclear Generating Station (PNGS) License Renewal", May 2018, at 25. ["Henderson Report"] This report is included as Appendix I to these submissions.
[30] John L Riley, *The Once and Future Great Lakes Country*, (2014: McGill-Queens University Press, Montreal).
[31] Henderson Report at 15.



Time trend of major benthic invertebrate groups from 1994 to 2008 in Lake Ontario. Source: Analysis of Lake Ontario Lower Aquatic food web Assessment (LOLA 2003 and 2008) within the context of long-term ecological change.[32]

Further, as the lake's water clarity changes, there is increased plant growth, including beds of Cladophora (or green algae) along the shore by the Pickering site.

Lake Ontario's ecological instability means that predictions about the PNGS's future impact must be treated with caution. Dr. Henderson notes that climate change models have predicted that by 2041-2070 the maximum water temperature could be 2.5°C above the 1970-2000 norm,[33] and that the PNGS already impacts fish behaviour in the vicinity of the site.[34] This information indicates that neither the Lake Ontario ecosystem, nor the PNGS's impact on it, can be treated as static.

Predicted changes in Durham Region and the Greater Toronto Area

Durham Region will not look the same 10 years from now. Ontario's Growth plan for the Golden Horseshoe designated downtown Pickering as an urban growth centre, with the city expected to grow from 94,510 residents in 2013 to 190,00 by 2031. According to the Ontario government's

[32] Lars Rudstam, et al, "Analysis of Lake Ontario Lower Aquatic food web Assessment (LOLA 2003 and 2008) within the context of long-term ecological change", 2012, at 53, online: <https://www.researchgate.net/publication/313632952_Analysis_of_Lake_Ontario_Lower_Aquatic_food_web_assessment_LOLA_2003_and_2008_within_the_context_of_long-term_ecological_change>.
[33] Henderson report at 24.
[34] *Ibid* at 19.

growth forecasts, there will be an additional 350,000 people living in the broader Durham region by 2031.[35]

As Pickering continues to grow and urbanize, Lake Ontario's role will change in response to its inhabitants. More people will come to depend on the shoreline near the PNGS as a source of recreation and natural beauty. The lake will also provide drinking water to all of these new inhabitants. The revitalization of Pickering's waterfront is evidence of the community's growing connection to the lake – and this will only continue to increase over time. As Pickering grows, the importance of Lake Ontario to the community will grow as well.

The same is true for those living in the Greater Toronto Area (GTA). Scarborough borders on Durham region, and has also proven to be a particularly significant area of population growth in the latest Canada census results.[36] This, when paired with Pickering's growth, increases both the social and cultural significance as well as the ecological vulnerability of the Lakeshore along and around the PNGS.

[35] Ontario Ministry of Infrastructure, "Growth Plan for the Greater Golden Horseshoe, 2006", (June 2013, Office Consolidation) at 61.
[36] Alex Ballingall, "Census shows big population gains in Toronto, Milton, and Brampton", *The Toronto Star*, February 8, 2017, online: <https://www.thestar.com/news/canada/2017/02/08/census-shows-big-population-gains-in-toronto-milton-and-brampton.html>.

Growth in the GTA and Durham region will place further stress on the lake. Sewage and stormwater runoff are already two of the most common sources of water pollution in Canada, and both are bound to increase as local populations increase. In nearby Ajax, water quality has already been degraded by massive summer blooms of Cladophora (a type of algae), which may be linked to phosphorus in effluent from the Duffin Creek wastewater treatment plant.[37] The algae is a significant ecological problem, and is capable of impeding the public's enjoyment of the lakeshore.

[37] See: Town of Ajax, "Duffin Creek Water Pollution Control Plant Outfall Environmental Assessment - Part II Order Request", (10 February, 2014).

Thus, increased population growth along the northern shore of Lake Ontario can result in increased ecological stressors on the Lake, but also increased dependence on a swimmable, drinkable, fishable Lake Ontario. This underscores the crucial need for regulators to ensure that further adverse impacts to the local environment are managed in as responsible a way as possible. The Commission Tribunal must take this into account when examining the impact of the PNGS on the lake.

Recommendation 2: *When considering the current licence renewal application, the Commission Tribunal must do so while keeping in mind the growing importance of the lake for swimming, drinking, and fishing as well as cumulative adverse environmental impacts of lake water quality and the health of local aquatic ecosystems.*

Adverse environmental impacts of the PNGS

In 2013, the CNSC and DFO signed a Memorandum of Understanding (MOU), which states:

> The Parties will work together in the development of work plans and protocols to improve the efficiency and effectiveness of regulatory reviews of applications and decision-making related to the roles and responsibilities of each Party for: (i) [.....] (ii) Ensuring that CNSC's assessment of applications considers the intent and requirements of the Nuclear Safety and Control Act, the Fisheries Act, and the Species at Risk Act.[38]

and

> THE CNSC agrees to: (i) Conduct reviews of licence applications for potential impacts to fish and fish habitats, to ensure that the assessment process considers the intent and requirements of the Fisheries Act, SARA, and their associated regulatory and policy frameworks;[39]

The MOU requires the Commission to take a holistic approach when assessing the PNGS's impact on fish populations and endangered species. It requires the Commission to consider the intent of the *Fisheries Act* and SARA, and ask whether there is a risk that the PNGS will frustrate the overarching goals of either Act, namely protecting the health of Canada's fish populations and protecting species of conservation concern from further harm. These requirements ultimately apply to CNSC staff as well as the Commission Tribunal.

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[38] Memorandum of Understanding between Fisheries and Oceans Canada and Canadian Nuclear Safety Commission for Cooperation and Administration of the *Fisheries* Act and the *Species at Risk* Act Related to Regulating Nuclear Materials and Energy Developments, December 16, 2013, at s 3(a), online: <http://nuclearsafety.gc.ca/eng/pdfs/MoU-Agreements/2014-02-27-mou-cnsc-fisheries-oceans-eng.pdf>.
[39] *Ibid* at s 4(c).

Impacts of the once-through cooling water system on aquatic biota

The PNGS operations are incredibly water-intensive. The facility was built along the shoreline of Lake Ontario, in part because its design requires access to a tremendous amount of water to support its operations. The PNGS uses a "once-through" cooling water system to prevent its nuclear reactors from overheating. This once-through system sucks in surface water directly from the lake, feeds it through channels around the nuclear reactors where the water absorbs the heat generated by the reactors, thus cooling them down. The warmed water is then released back into the lake.

Waterkeeper's expert Dr. Henderson explains that the PNGS cooling water system, with all six Pickering Units operating, extracts and discharges on average between 190 and 220 m^3 per second. This is equivalent to the flow of 4.6 to 5.3 Olympic-size swimming pools every minute. He characterizes the water use at PNGS as "equivalent to the flow of a small river" and that "[e]ven by power station standards of water use, it is an unusually large rate of water extraction for a single site".[40]

There are four main ecological concerns associated with this water use:

1. **The impingement of fish by the cooling water intake.** When surface water is drawn into the cooling water system, the current draws in fish as well. Water intake points often have screens to prevent fish over a certain size from being sucked into the cooling system itself – however, fish can be crushed and killed against these screens due to the suction. Fish killed in this way are referred to as "impinged" fish.
2. **The entrainment of fish by the cooling water intake.** The smaller fish, fish larvae, and eggs that pass through intake screens and nets are referred to as "entrained" fish. The entrainment of these smaller aquatic organisms can prove fatal: either due to the increased temperature of the water as they pass round the reactors, or else due to the disruption of the strong current and collision of organisms.
3. **Thermal pollution from the cooling water outfall.** When cooling water is released from the system's outfall, having absorbed heat from the reactors, it is at a higher temperature than ambient lake water temperatures. Many aquatic organisms are sensitive to temperature, and the released warm water can impair their health.
4. **Chemical pollution from the cooling water outfall.** Mussels and other organisms are prone to grow along the inside of the cooling water system, this referred to as "biofouling". To prevent biofouling of the cooling water system, chlorine or copper is mixed in with cooling water. When this water is released back into the lake, it can contain elevated concentrations of residual chlorine or copper which can prove hazardous to local aquatic life.

[40] Henderson Report at 7.

Each of these four specific impacts of the PNGS' cooling water system will be further discussed below.

The impingement of fish by the PNGS

In 2008, the CNSC ordered OPG to reduce its impingement rate by at least 80%.[41] In 2009, OPG installed its Fish Diversion System (FDS), a net comprising of three connecting panels that span the width of the intake channel from the west side to the east side. The bottom of the net is weighed down along the lake bed and the top of the net is lifted up along the surface of the water by buoys.

While the FDS is an important improvement to the PNGS's cooling water system, the efficacy of this net is limited in several ways. First, it is designed to partially submerge when algae or fish obstruct the water flow through the net. Second, the net is only required to remain in the water between April and November of each year. Third, nets may permit fish to swim under the net if it is not consistently anchored along the lake bed. Finally, small, young, and long fish may swim through the mesh gaps.

In fact, upon reviewing impingement data the performance of the FDS is very variable. Dr. Henderson has found that out of the seven years in which FDS effectiveness has been monitored, only three years achieved the 80% impingement reduction requirement.

Year	2003/4	2010	2011	2012	2013	2014	2015	2016
Total biomass impinged	18,214	4616.5	4011.8	1706	2926	3953	8517	1035
Percentage reduction relative to 2003/4		**74.65**	**77.97**	**90.63**	**83.94**	**78.30**	**53.24**	**94.32**
Kg/ million m3	4.35	0.95	0.79	0.35	0.6	0.82	1.69	

Table 1 Observed annual impingement at PNGS for the years 2010-2016 when the FDS was installed compared to the year 2003-4 prior to FDS installation.[42]

Further, a 2014 study found that the effectiveness of the PNGS FDS can vary over the course of a single year and that 80% reduction in impingement was not achieved during the spring

[41] *Supra* note 9, at para 236. Note, this paragraph also seems to suggest limits were set referencing to US Environmental Protection Agency limits under s 316(b) of the *Clean Water Act*, 33 USC, ss1251 et seq, (1972) which at that time had required 80%-90% impingement reduction and 60%-90% entrainment reduction for all industrial facilities operating open cooling water systems in the US.
[42] Henderson Report, at 8.

months.[43] The study failed to observe and measure the FDS's actual effectiveness in summer or winter months.

While measured reductions in impingement are positive developments, Waterkeeper also urges caution when assessing the effectiveness of impingement reduction rates that use the 2003/4 year as a baseline against which current impingement data is compared. This is because 2003/4 baseline data excludes the round goby, a fish that has become increasingly common in Lake Ontario over the last decade. As a result, impingement of round goby is effectively removed from current impingement assessments for the facility. Further, using a single year as a baseline is also highly problematic given the significant variability of certain species of fish populations around the PNGS from year to year. As such, exclusively relying on 2003/4 as the baseline on which to assess the effectiveness of impingement mitigation is inappropriate: it fails to take into account the contemporary characterization of Lake Ontario's aquatic ecosystem, effectively excluding the consideration of round goby impingement, and it fails to take into account annual variation in fish populations and how these variations may affect measured impingement values.[44]

Finally, Waterkeeper has concerns about the extent to which measured impingement rates at the PNGS comply with regulatory permits. On January 11, 2018, OPG obtained its first permit from the DFO for its cooling system to kill fish.[45] This permit allows the PNGS to kill approximately 6,300 kg Age 1 Equivalent fish (excluding Species at Risk and species listed under the Aquatic Invasive Species Regulations) per year, provided certain offsetting activities are undertaken by OPG to promote fish populations and fish habitat elsewhere in the Lake Ontario watershed. The terms of this permit also stipulate that should the PNGS impinge more than 3619 kg of fish on average in two consecutive years, OPG and the DFO must discuss necessary follow-up requirements.[46]

Dr. Henderson's review of PNGS impingement data shows that it is highly likely that this 3,619 kg will be exceeded for two consecutive years, as shown by impingement levels in 2010/11 and 2014/2015.[47] Neither OPG's application, nor CNSC staff's review of it contains any information regarding the need for follow-up discussions between OPG and the DFO concerning the ability of the PNGS to comply with its current licence requirements.

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[43] Henderson Report at 13.
[44] *Ibid* at 9 – 13.
[45] This permit will be discussed in further detail in this submission below.
[46] Fisheries and Oceans Canada, "Paragraph 35(2)(b) *Fisheries Act* Authorization", PATH No: 15-HCAA-00256, January 11, 2018, online: <https://www.opg.com/generating-power/nuclear/stations/pickering-nuclear/Documents/PickeringFisheriesAct_Authorization.pdf>.
[47] Henderson Report at 8.

Recommendation 3: *that CNSC staff and the DFO review the use of 2003/4 data as the benchmark against which impingement mitigation is measured, instead selecting a broader period of time that also takes into account the current characteristics of Lake Ontario's ecosystem.*

Recommendation 4: *that OPG, CNSC staff, and the DFO examine the likelihood of the PNGS exceeding the 3,619 kg threshold for two consecutive years and publicly report their findings, including any proposed follow-up activities.*

Recommendation 5: *that OPG make publicly available its monitoring reports concerning impingement rates and net performance, including net failure events.*

The entrainment of fish by the PNGS

Entrainment of aquatic organisms in the PNGS cooling water system is extremely high. In 2007, measured annual entrainment losses included 51,994,686 fish eggs, and 11,388,876 larvae.[48] In addition, the PNGS entrains large number of invertebrates and planktonic plants which are crucial to the lake's ecosystem, but not measured at all in any publicly available sources.[49]

The US Environmental Protection Agency (EPA) has enacted a policy in which it assumes the mortality of all entrained species. Other studies also confirm high mortality rates of invertebrates resulting from entrainment.[50]

In 2008, the CNSC ordered OPG to reduce entrainment at the PNGS.[51] From available documentation, it does not appear as though OPG has instituted any mitigation measures or otherwise made any progress on reducing entrainment to date.

OPG asserts in its 2017 Environmental Risk Assessment for the PNGS that entrainment in the facility's once-through cooling system is "more than offset" by the company's participation in fish restocking and habitat improvement projects elsewhere in the Lake Ontario watershed. However, this assertion is not supported by available evidence. Recognizing any equivalency between entrainment at the PNGS and other OPG offsetting measures is extremely problematic for several reasons. First, round goby is completely excluded from the calculations determining the fish loss that needs to be compensated. Due to the increasing population of round goby in the lake, excluding this species from entrainment calculations will necessarily and significantly

[48] Henderson Report at 14.
[49] Dr. Henderson has assessed the entrainment data from the Darlington Nuclear Generating Station (DNGS), noting elevated levels of entrainment of certain species at the DNGS may be similar to those at the PNGS.
[50] Henderson Report at 15.
[51] *Supra* note 41.

underestimate the impacts of PNGS entrainment.[52] Second, offsetting activities by OPG assists populations of Northern pike and salmon, which fails to have any impact on round goby or alewife which are the species especially impacted by the PNGS cooling water system.[53] Third, offsetting activities do nothing to address the entrainment of invertebrates such as *Diporeia*, which is already experiencing a severe decline, and is particularly vulnerable to entrainment and threatened by thermal effluent.[54]

The issue of offsetting is discussed further in the section concerning the PNGS DFO section 35 permit below.

Recommendation 6: *that entrainment monitoring commence immediately, rather than 2021.*

OPG has committed in the past to considering other impingement and entrainment mitigation measures, including sonar diversion.[55] Waterkeeper has been advocating for closed cycle cooling at the facility for at least a decade.[56] Dr. Henderson also advocates for the adoption of closed cycle cooling.[57] It is important to note two things in relation to closed-cycle cooling, in particular: 1) partial closed cycle systems can be constructed to assist plants in mitigating fish kills (i.e. it need not be an all-or-nothing measure); and 2) the construction of closed cooling systems is generally economical if in operation for at least ten or so years. As such, there has been sufficient time since Waterkeeper first began raising concerns about fish kills at the site, to explore and at least partially adopt some form of closed cycle cooling to minimize the facility's impact on local aquatic biota. OPG has repeatedly asserted that it is committed to ensuring that the PNGS operates each year at a higher standard than the last. In order to do this consistently, Waterkeeper recommends that the company take further measures to ensure that fish kills at the site are better mitigated using appropriate best technologies.

Recommendation 7: *that OPG and CNSC staff immediately develop entrainment mitigation measures to decrease entrainment rates at the PNGS.*

[52] Henderson Report at 14.
[53] *Ibid.*
[54] *Ibid* at 15.
[55] Canadian Nuclear Safety Commission, Record of Proceedings, Including Reasons for Decision In the Matter of Ontario Power Generation Inc. Screening Environmental Assessment of the Pickering Nuclear Generating Station B Refurbishment and Continued Operations Project, Pickering Ontario, January 23, 2009, at para 31, online: <http://www.suretenucleaire.gc.ca/eng/the-commission/pdf/2008-12-10-Decision-PickeringB-e-Edocs3330500.pdf>.
[56] For example, see *Ibid* at paras 35-36.
[57] Henderson Report at 25-26.

Impingement and entrainment of Species at Risk

With the Lake Ontario Atlantic Salmon Restoration project, and provincial American eel recovery strategy, populations of these species will hopefully grow over the next decade.

While OPG currently asserts the cooling water system has not and will not impact protected species, this is subject to changing ecosystemic conditions. Predictions about future lake conditions must be treated cautiously, especially when data are limited. Such an approach would be consistent with the precautionary principle. Further, it is of utmost importance that the Commission Tribunal properly consider certain data trends that may be inconsistent with OPG's assertion that changes in impingement and entrainment rates will not occur.

Recommendation 8: *that OPG, CNSC staff, and the DFO consider and implement measures to ensure that offsetting activities more effectively compensate for actual species impinged and entrained at the PNGS.*

Thermal pollution by the PNGS

Thermal discharges in waterbodies are a recognized form of pollution and can have significant impacts on planktonic life and many species of fish. Dr. Henderson warns that the thermal pollution from the PNGS necessarily changes the behaviour of local fish, and depending on the species and thermal discharge, results in lasting adverse impacts on their wellbeing. Thermal discharges can also change the local ecology over time, encouraging invasive species adapted to warmer water.

The PNGS is subject to an Environmental Compliance Approval (ECA) permit, which among other things, sets limits for the allowable thermal releases from the PNGS. These limits generally permit cooling water releases between 11°C and 16°C warmer than ambient lake

water temperatures.[58] However, there are occasions in which these limits are exceeded, including circumstances in which algae or ice builds up on the screenhouse travelling screens, requiring certain cooling water system pumps to be turned off, and resulting in increased discharge temperatures.[59]

Due to thermal pollution from the PNGS once-through cooling water system, there is a large area of lake water around the PNGS with a consistently elevated temperature - referred to as a "thermal plume". According to OPG's 2017 ERA, the thermal plume with water over 2°C above ambient lake water temperature spans approximately 1.5-8km^2 from the PNGS at the water's surface year-round, and approximately 0.5-3km^2 at the bottom of the lake during colder weather conditions. Further, data from 2006/7 indicates that the PNGS thermal plume has been as large as 62.6km from the Pickering site along the surface of the lake and 12.8km along the lake bottom.[60]

Elevated temperatures, such as those in the PNGS thermal plume, have been shown to negatively impact phytoplankton productivity, adversely impact macro invertebrate growth, result in a significant loss in diversity, and can adversely impact fish migrations.[61] PNGS thermal discharges during algal impact events in the summer are also close to the thermal death point for many larger fish species in Lake Ontario.[62]

No mention is made in either OPG's application nor CNSC staff's CMD of any follow-up or enforcement measures taken to address PNGS thermal discharge exceedances.

Importantly, thermal impacts of the PNGS on local lake water will only increase with continued climate change, which in and of itself is expected to increase Lake Ontario ambient temperatures by 2.5°C by as early as 2041.[63] This increase in lake temperature on its own would significantly impair certain aquatic species such as the round whitefish. The thermal impacts of the PNGS must be considered in light of this context, and must be understood as a significantly aggravating factor in local aquatic species' vulnerability to heat-related threats. Waterkeeper is concerned that no publicly available materials (including OPG's application, as well as CNSC staff's review of it in their CMD) includes any reference to cumulative impacts of climate change and the PNGS' thermal discharges in Lake Ontario.

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[58] Ontario Ministry of Environment, Environmental Compliance Approval No 4881-5MHQ9F, June 27, 2015, at s 9.
[59] Henderson Report at 16.
[60] *Ibid* at 16-17.
[61] *Ibid* at 18-19 and 22-23.
[62] *Ibid* at 20-21.
[63] *Ibid* at 23.

Recommendation 9: *that OPG, CNSC staff, and the DFO consider and implement measures to mitigate thermal pollution by the PNGS, taking into account the projected impacts of climate change on lake water temperature in Lake Ontario.*

Recommendation 10: *that OPG makes its ECA compliance reports public, by posting them to the OPG webpage with its other compliance reports.*

Chemical pollution by the PNGS

Chlorination of the once-through cooling system at the PNGS appears to occur between May and November of each year, and generally targets zebra and quagga mussels, ensuring they do not grow along the insides of the cooling water infrastructure. While its use can vary depending on water temperature and the extent of mussel growth, the PNGS attempts to ensure maximum total residual chlorine in discharges remains at 0.002 mg/L via a sodium bisulphate dosing system fitted at the facility. This maximum value constitutes the chronic toxicity threshold for aquatic life. However, this threshold cannot be realistically measured and has been derived from mixing calculations. As such, it should be approached with caution.

As Dr, Henderson explains, "Chlorine is a broad-spectrum poison which is highly reactive and reacts with almost every constituent in natural waters, including man-made pollutants, yielding products having varying degrees of persistence and toxicity".[64] In addition to potential adverse impacts of the release of chlorine from the PNGS, chlorination of the cooling water system contributes to the mortality of entrained organisms at the facility: few planktonic organisms would survive chlorination, and microorganisms (including bacteria and fungi), which are particularly vulnerable to chlorine, would not survive. Dr. Henderson explains, "[t]he result is that the warm, chlorinated, discharge will be returning a steady rain of dead and dying organisms to the lake".[65]

Again, OPG's application, and CNSC staff's review of it contains virtually no information concerning chlorine discharges from the PNGS, nor are there any other publicly available sources assessing the cumulative environmental impacts of chlorine emissions from the PNGS and other contaminants in the lake.

Recommendation 10 above would also ensure more information concerning chlorine emissions are made publicly available.

As illustrated above, Dr. Henderson has been able to put together an expert review of PNGS operations, despite limited disclosures by OPG. This was in part due to Dr. Henderson's extensive experience and expertise in this area and his ability to find external scientific peer

[64] *Ibid.*
[65] *Ibid.*

reviewed assessments of the PNGS cooling water system. Dr. Henderson has been denied disaggregated data concerning its performance, as well as any significant disclosure concerning the methodologies used to arrive at whatever findings OPG has disclosed or asserted. This has made it more difficult for him to conduct the review he was retained to provide.

During the Day One hearings for this matter before the Commission Tribunal on April 4, 2018, ECCC staff also expressed concerns over the lack of available information from OPG and CNSC staff noting four areas of concern for which additional information was being requested:

1. the impacts of average thermal pollution from the cooling water discharges on thermally sensitive species other than round whitefish. OPG conducted a round whitefish study a number of years ago, but has not examined other species in the same degree of detail. ECCC noted that certain thermally sensitive species congregate around bluffs, in areas like that in which the PNGS is located, so a better understanding how they are being impacted by the plant is important;
2. the impacts of specific thermal exceedance events to smallmouth bass and emerald shiner species. OPG had not yet provided 'precision information' about how past thermal exceedance events specifically affected these species;
3. more information was generally requested by the ECCC concerning stormwater runoff from the site; and
4. more information about identified species at risk in proximity to the site.

As such, OPG's opacity with regards to data concerning actual measured impacts of the PNGS cooling system on local water quality and aquatic biota does a disservice to members of the public as well as other government bodies.

Recommendation 11: *That OPG and CNSC staff make public their responses to the four ECCC areas in which more information was required concerning potential adverse impacts of the PNGS on local water quality and aquatic biota.*

<u>The DFO s. 35 permit</u>

The *Fisheries Act* specifies in section 35(1) that:

> No person shall carry on any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery.[66]

Such activity is strictly prohibited by the Act and any contravention of this provision can result in fines of up to $100.000 or $500,000 and/or a prison sentence of up to one or two years.[67]

[66] *Fisheries Act*, RSC 1985, c F-14, at s 35.

Further, the Act specifies that for any contravention lasting longer than a single day, each subsequent day on which the offence continues constitutes a separate offence.[68]

Of course, this section does not apply to facilities that receive a special permit by the DFO to undertake activities that would result in serious harm to fish. When such permits are granted, they generally contain provisions for the mitigation or offsetting of harm caused by the licensed activity.

On January 11, 2018, the PNGS received its first s.35 permit from the DFO. Terms of the permit include the following:

- The authorization permits the impingement of 6,300 kg Age 1 Equivalent fish (excluding Species at Risk and species listed under the Aquatic Invasive Species Regulations). It also permits 150m^2 of habitat destruction to allow for infilling of Simcoe Point Wetland for the levee and fish and water control structure installation. It does not permit any release of a deleterious substance to waters frequented by fish;
- The authorization only requires the FDS to be installed and functioning between June 1 and November 1 of each year;
- If any failure in the FDS is detected it must be repaired as soon as possible, and its functionality must be verified the following week;
- OPG must provide annual permit compliance reports to the DFO. These must include dated photographs and inspection reports demonstrating compliance with the permit. They must also include contingency measures that were followed in instances where impacts to fish are greater than that allowed by the permit;
- The permit requires annual impingement monitoring reports. If the annual reported biomass of impinged fish is greater than 3619 kg over two consecutive years, OPG must discuss follow-up requirements with the DFO which may require additional mitigation or offsetting measures;
- The authorization seems to permit modeling of Age 1 Equivalent biomass, based on annual impingement monitoring results;
- The authorization only requires an entrainment sampling work plan by 2020 with monitoring to occur between 2021 and 2022; and
- Conditions of required offsetting measures are specified in the licence for all three offsetting projects (described below), including required monitoring regimes to ensure that the biomass of fish and quality of fish habitat in these three projects effectively replaces exactly what is lost around the PNGS due to their cooling water system[69]

Any failure to comply with the terms of the permit constitutes an offence under the *Fisheries Act*.

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[67] *Ibid* at s 78.
[68] *Ibid* at s 78.1.
[69] *Supra* note 55 at para 46.

In response to Waterkeeper's first round of information requests in March, OPG confirmed that the January 11th, permit is the only DFO authorization the PNGS has received to operate its once-through cooling water system. It remains unclear from publicly available information, how Ontario Hydro/OPG could have been operating the PNGS for all these decades without such a permit and without its operations constituting an offence under the *Fisheries Act*. This is of particular concern as the PNGS appears to have had been impinging approximately 800,000 adults fish before the FDS was installed, and entraining an additional 62 million fish eggs and larvae every year.[70]

Recommendation 12: *that an explanation from the DFO concerning the PNGS's historical compliance with the* Fisheries Act *be shared with Waterkeeper, and put on the record of the current proceedings, in advance of the public hearings from June 25 – 29th, 2018, including references to any regulations or Ministerial Orders exempting the PNGS from the application of the Fisheries Act.*

Waterkeeper is also concerned that the DFO permit's exclusion of aquatic invasive species, including but not limited to alewife, appears to be inconsistent with section 35 of the *Fisheries Act*. Again, the actual wording of that section protects against "any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery". While it is debatable whether alewife or round goby would constitute a commercial, recreational, or Aboriginal fishery, there is ample evidence that both species support such fisheries. Dr. Henderson explains that round goby are a significant fish of prey to many species in Lake Ontario, representing 86% of the food by weight consumed by Lake Sturgeon. Similarly, alewife is "so fundamental a part of the ecosystem that removing them now could potentially do unforeseen damage along all trophic levels".[71]

Recommendation 13: *that all species impinged and entrained by the PNGS be considered and added to the DFO s. 35 permit for the PNGS, including but not limited to alewife and round goby. This approach would be more consistent with the* Fisheries Act.

Further, as briefly mentioned above, Waterkeeper is concerned about the supposed equivalency of offsetting initiatives required by the DFO to compensate for fish kills at the PNGS. The permit includes reference to three such initiatives: 1) assisting with habitat restoration at the Big Island Wetland complex, 2) restoring the Simcoe Point Wetland, and 3) contributing to Lake Ontario Atlantic Salmon restocking initiatives. These initiatives appear to focus on Northern Pike spawning habitat and salmonid population restoration, however this should not be considered sufficient or suitable offsets as neither address losses of any other species, including alewife, round goby, or any invertebrate populations which are especially

[70] *Supra* note 55 at para 29.
[71] Henderson Report at 13.

adversely impacted by the PNGS cooling water system.[72] It is hard to understand how such an approach would be consistent with any conceptualization of equivalency, or reasonable requirements for offsetting activities to compensate for ecosystem disruptions and species-specific losses.[73]

Ultimately, there does not appear to have been any public engagement process, including any opportunity for public comments concerning the DFO authorization. Had such an opportunity existed, Waterkeeper would have been able to provide input to improve the scope and effectiveness of the permit.

Recommendation 14: *that the DFO s. 35 permit itself be amended to ensure that offsetting activities properly compensate for actual species killed by the PNGS. This approach would also be more consistent with the* Fisheries Act*.*

Recommendation 15: *that OPG be required to publicly disclose the annual compliance reports required by the DFO permit by posting them to the OPG webpage with all other PNGS compliance reports.*

Impacts of the PNGS on local surface and groundwater quality

Like Dr. Henderson, Waterkeeper's expert Mr. Ruland was challenged to prepare his review by the lack of publicly available information and OPG's and CNSC staff's refusal to provide what was requested. Waterkeeper's information requests and responses are included in Appendix III to these submissions and more discussion concerning the deficits in publicly available information concerning groundwater and stormwater can be found in Mr. Ruland's Report, included as Appendix II to these submissions. Ultimately. Mr. Ruland's significant expertise and experience led him to find external sources and make determinations concerning the Pickering site's topography, allowing him to prepare the high quality report he has provided.

In particular, the following information was denied to Mr. Ruland:

- a complete set of borehole logs and monitor installation details for OPG's full network of groundwater monitoring wells and sampling points;
- up to date and useable groundwater level and groundwater quality monitoring data for the full network of groundwater wells and sampling points;

[72] Henderson Report at 14-15.
[73] See: K D Clarke and Michael J Bradford, A Review of Equivalency in Offsetting Policies, DFO Canadian Science Advisory Secretariat, Research Document 2014/109, December 2014, online: <https://www.researchgate.net/publication/272086382_A_Review_of_Equivalency_in_Offsetting_Policies>.

- recent annual groundwater monitoring reports for the PNGS; and
- a map and inventory of storm sewer lines for the site, including estimates of flows and a list of how many of these lines are being monitored on a regular basis and the monitoring results (for radiological and non-radiological contaminants).

Waterkeeper is disturbed by the lack of public disclosure of actual data and other information concerning contaminant pathways from the PNGS into Lake Ontario.

Recommendation 16: *That OPG and CNSC staff immediately release the following information on the public record in this hearing process:*

- *a complete set of borehole logs and monitor installation details for OPG's full network of groundwater monitoring wells and sampling points;*
- *up to date and useable groundwater level and groundwater quality monitoring data for the full network of groundwater wells and sampling points;*
- *recent annual groundwater monitoring reports for the PNGS; and*
- *a map and inventory of storm sewer lines for the site, including estimates of flows and a list of how many of these lines are being monitored on a regular basis and the monitoring results (for radiological and non-radiological contaminants).*

Despite these limitations, Mr. Ruland was still able to piece together some information that gives cause for concern.

There are three main pathways by which contaminants from the PNGS an enter Lake Ontario:

1. **Releasing contaminants from the PNGS into groundwater.** At the PNGS, groundwater contamination appears to be primarily due to a series of leaks and spills of contaminants from several of the Station's facilities. Contaminated groundwater at the site ultimately makes its way to Lake Ontario via a number of pathways.
2. **Stormwater runoff from the PNGS.** The PNGS collects stormwater runoff via a series of drainage ditches, swales, culverts, and sewers which all direct this stormwater directly into Lake Ontario without receiving treatment for any contamination. While stormwater runoff can be a significant ecological stressor on the local shoreline, stormwater infrastructure at the site can also mobilize and transport untreated contaminated groundwater into the lake.
3. **Effluent releases from the PNGS facility** (including cooling water and other liquid effluent discharges from the site). Due to deficits in OPG disclosure, Waterkeeper's experts have effectively been prevented from examining the potential environmental impacts of this pathway and (apart from the cursory discussion of chlorine pollution in the discussion on cooling water above), cannot be discussed further in these submissions.

Groundwater contamination from the PNGS

Contaminants spilled or leaking from the site are absorbed into the ground where they will ultimately make their way into Lake Ontario. The PNGS has impacted groundwater flows in several ways, due to large areas of infill along the lakeshore, as well as the weight and depth of foundations holding the reactor buildings.[74] Depending on the location of the contaminated groundwater, its concentration can vary and the speed with which it would make its way to the lake also varies. For example, the reactor buildings depress groundwater in their vicinity thus collecting more water from surrounding areas and diluting contaminants picked up by the groundwater collection system.

Groundwater underneath the PNGS contains both radionuclides as well as potentially hazardous industrial chemicals. Tritium, a radioactive byproduct of reactor operations, appears to be the most significant groundwater contaminant. However, there are also several non-radiological contaminants of potential concern (COPC) that can be found in groundwater below the PNGS. These include:

- Polycyclic aromatic hydrocarbons (PAHs);
- Petroleum hydrocarbons (PHCs);
- Benzene, toluene, ethylbenzene, and xylenes (BTEX compounds); and
- Inorganics such as chloride, iron, and sodium.

Mr. Ruland would add copper and zinc to this list as well.[75]

Recommendation 17: *If not already included, Waterkeeper recommends that coper and zinc be included as COPCs for groundwater below the PNGS.*

There have been at least two major leaks at the PNGS, causing significant contamination which is still adversely affecting the quality of groundwater below the PNGS. The first, in 1979 involved the release of 666 trillion Bq of tritium, resulting in tritium concentrations in groundwater of

[74] During the 2008 PNGS relicensing hearings and the Commission Tribunal's review of the Environmental Assessment of the then proposed Pickering B refurbishment, Commission members expressed concerns about contaminant concentrations in groundwater around the Turbine Auxiliary Bay and that it was making its way directly into Lake Ontario. CNSC staff noted they were aware of this concern and committed to capturing and treating the contaminated groundwater. The Commission Tribunal at that time insisted that this issue be included in EA follow-up programs to ensure the capture and treatment of this contaminated groundwater before being discharged into the lake. *Supra* note 55 at paras 52-54.

[75] Wilf Ruland, P Geo, Independent Report on Hydrogeological Issues Pertaining to the Application for a 10-year Licence Extension for the Pickering Nuclear Generating Station, May 18, 2018, at 8. [Ruland Report] This report is included as Appendix II to these submissions.

2,150,000 Bq/L. Another leak in 1994 resulted in tritium groundwater contaminations of 700,000 Bq/L.[76] Such significant incidents will mean significant legacy groundwater contamination at the PNGS site.

OPG's application confirms extremely elevated levels of tritium in groundwater below the PNGS site as high as 3.96 million Bq/L (over 565 times the already problematic Ontario Drinking Water Quality standard of 7000Bq/L), much of which is likely being picked up in foundation drains which appear to flow directly to Lake Ontario without receiving any treatment.[77] Mr. Ruland warns that these elevated levels cannot just be explained by the two spills mentioned above, meaning that other spills have occurred of which the public has not been notified.[78]

In fact, Mr. Ruland found a reference confirming that there was a pattern of behaviour at the PNGS in which a number of releases and/or leaks circumvented containment systems due to a lack of facility maintenance and/or repairs. An independent report of the cumulative impacts of tritium contamination of groundwater below the PNGS found that the groundwater contaminant plume between 2001 and 2005 contained tritium levels above 30 million Bq/L - over 4285 times the ODWQ limit.[79]

Of just as grave concern is CNSC staff's apparent reaction to these elevated tritium concentrations in PNGS groundwater: Rather than requiring immediate and comprehensive measures to remediate this historical contamination, it appears as though CNSC staff have instead approved a site-specific contamination limit of 3 million Bq/L for tritium non-potable groundwater.[80] If this is the case, it is alarming that there is no mention of any such provision or special dispensation in OPG's current Licence Conditions Handbook (LCH), or the new LCH CNSC staff are currently proposing.

Recommendation 18: *that OPG and CNSC staff publicly confirm whether a site-specific groundwater tritium limit of 3 million Bq/L is in effect for the PNGS.*

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[76] *Ibid* at 10.
[77] Note the 2017 ERA includes measurements of groundwater contamination at 3 million Bq/L, *Ibid*.
[78] This included: "On August 1, 1983, Pickering reactor 2 had a loss of coolant accident after a pressure tube suffered a metre-long rupture. The station was shut down and the four reactors at Pickering A were eventually retubed at a cost of about $1 billion. On November 22, 1988, an operator error damaged 36 fuel bundles. The cooling system was contaminated by radioactive iodine that was vented into the environment over several weeks following the accident. On September 25, 1990, Pickering reactor 2 experienced large power shifts in the reactor core. Staff spent two days trying to stabilize it before shutting it down. The AECB later criticized the utility for not shutting down immediately. On August 2, 1992, Pickering reactor 1 had a heavy water leak from a heat exchanger that resulted in a release of 2,300 trillion becquerels of radioactive tritium into Lake Ontario. On April 15, 1996, Pickering reactor 4 had a heavy water leak from a heat exchanger that resulted in a release of 50 trillion becquerels of tritium into Lake Ontario." Ruland Report at 22.
[79] *Ibid* at 11.
[80] *Ibid.*

Recommendation 19: *that if there is a site-specific groundwater tritium limit of 3 million Bq/L for the PNGS, OPG and CNSC staff must publicly report: 1) when and how it was developed; the scientific basis for its development; the extent to which it has been formally adopted by the CNSC and reasons for its exclusion from the current and proposed licence and Licence Conditions Handbook for the PNGS; and 4) whether any public consultation was conducted prior to establishing this elevated contamination limit.*

With such high concentrations of tritium below the PNGS, Mr. Ruland predicts there are likely highly elevated concentrations of other radioactive and non-radioactive contaminants in groundwater.[81] However, OPG has denied access to recent groundwater monitoring reports, effectively denying public access to the list of contaminants that are being monitored, current monitoring frequency and methodologies, as well as the sampling results from current groundwater monitoring programs.

Throughout most publicly available materials prepared by both OPG and CNSC staff, groundwater contamination below the PNGS is downplayed in three ways: 1) unsupported blanket assertions that groundwater contamination does not pose significant risks; 2) unsupported blanket assertions that even if groundwater is contaminated it would not make its way to Lake Ontario; and 3) the absence of any significant and accessible public disclosure of measured contaminants.

The only clearly accessible and available groundwater monitoring data that has been provided by OPG is that of several perimeter wells, all of which indicate less than 6000Bq/L, under the Ontario Drinking Water Quality standard. These levels pale in comparison to the two hidden references in OPG's ERA and licence application indicating tritium levels exceed 3,000,000 Bq/L – and even that data is incomplete.

Northwatch and Greenpeace had also requested access to groundwater monitoring reports in February 2018 and only received a response from OPG the week before interventions were due in May, denying their request without giving reasons.[82]

<u>Stormwater releases from the PNGS</u>

Stormwater releases from the site are also a significant pathway by which contaminants end up in Lake Ontario. The PNGS collects stormwater runoff via a series of drainage ditches, swales,

[81] *Ibid* at 12.
[82] Northwatch, Comment on Ontario Power Generation's Application for the renewal of its Nuclear Power Reactor Operating Licence (PROL) for the Pickering Nuclear Generating Station (NGS), May 7, 2018, at 4, online: < http://www.nuclearsafety.gc.ca/eng/the-commission/hearings/cmd/pdf/cmd18-h6/CMD18-H6-55.pdf>.

culverts, and sewers which all appear to direct this stormwater directly into Lake Ontario without receiving treatment for any contamination.

Subsurface pipes tend to be installed in beds of sand or fine gravel, both of which have high permeability compared to other groundwater layers beneath the PNGS. Stormwater infrastructure is also guaranteed to develop cracks over time. The result of both of these factors is the inflow of contaminated groundwater through the sand and gravel and into stormwater pipes, where it is discharged directly into the lake.[83] Contamination concentrations and locations will vary over the course of a year, and be influenced by storm events. This requires frequent monitoring for OPG to understand, identify, track, and remediate contaminant pathways. However, it does not appear as though this is being done at the PNGS.

Mr. Ruland has found that stormwater monitoring is sporadic: since 1990 there have been monitoring gaps of between three and eight years; when monitoring is done it does not appear to be performed at all stormwater discharge lines; and when monitoring is done, it often fails to take into account seasonal variation or include follow-up monitoring in instances in which elevated contaminant levels are discovered. All of this has led Mr. Ruland to warn "this infrequent and sporadic monitoring of stormwater quality is unacceptable for a modern nuclear power generating station".[84]

Only stormwater monitoring results from 2002/2006 and 2015/2016 are publicly available. Further, this limited disclosure appears to exclude the detailed results of toxicity testing which was conducted. Testing data for "MH211" which failed toxicity testing in 2001, again in 2002, and in 2006 have not been provided.[85] This is especially significant as it appears to be the only location at which toxicity testing was done, raising the question of how many other catchments might have failed toxicity testing over that time had they been tested. Further, no other stormwater testing appears to have occurred after 2006 for almost another decade, resuming again in 2015.

Recommendation 20:

a) *OPG must conduct quarterly monitoring of every stormwater collection line which is discharging to the forebay, the outfalls, or directly into Lake Ontario,*
b) *As a first step, an inventory of stormwater collection lines needs to be developed and flows of water in those lines need to be metered. Particular attention needs to be paid to any lines which are always flowing, as this should not be occurring in a system which is collecting only stormwater.*

[83] Ruland Report at 13.
[84] *Ibid* at 14.
[85] *Ibid.*

c) *Toxicity testing should be done on every line for every sampling event. For lines which are consistently showing zero mortality, the frequency of toxicity testing can be stepped down to annually after 3 years of passing test results.*
d) *The parameter lists being used for stormwater monitoring are reasonable, however in the event of failed toxicity testing results the scope of the testing should be increased to include:*
   - *volatile organic chemicals(VOCs);*
   - *polynuclear aromatic hydrocarbons (PAHs);*
   - *hydrazine and morpholine;*
   - *additional radionuclides.*
e) *Adverse test results and in particular failed toxicity tests should prompt immediate further investigation, with the goal of remediation of the issue(s) which are allowing contaminated and/or toxic stormwater to be discharged to Lake Ontario via the stormwater collection system.*
f) *This information (including disaggregated data showing the results of this testing) should be made publicly available in OPG's quarterly or annual compliance reports.*

Toxicity testing involves assessing the length of time in which aquatic species are able to survive in the water being tested for contamination. Details of testing protocols have not been provided, but the failure of water tested in MH211 to pass toxicity testing most likely means that species were not able to survive for more than 48 hours in a sample of water from the PH211 location. The filed test proves that the tested water is lethal to aquatic life. That same location also has had zinc levels up to 17 times higher, and copper over eight times higher, as well as cadmium levels higher than Provincial Water Quality Guidelines.[86] No publicly available documents indicate any follow-up measures to address the toxicity of these stormwater catchments, nor does it appear as though the DFO was contacted to assess impacts of the PNGS stormwater system and its compliance with the *Fisheries Act*.

In addition to failed toxicity tests, what limited stormwater monitoring data is available appears to confirm that contaminated groundwater is being discharged into Lake Ontario via the PNGS stormwater infrastructure. Tritium levels in the stormwater collection system were as high as 39,600 Bq/L, again at MH211.[87] Such elevated contaminant concentrations cannot be explained

[86] *Ibid* at 16.
[87] Catchments at MH211 and MH20 seem to contain especially concentrated contamination levels. Those of MH211 have been discussed in the body of this submission, however, MH20 contains alarmingly high levels of zinc, at 12 times the PWQO, and copper at four times PWQO limits. OPG asserted in its 2017 ERA that the toxic water in MH20 was "redirected to the station" and thus did not need to be considered as a concern. However, there is no evidence to suggest that this water would be treated before being discharged from the station to the lake. *Ibid* at 16.

be precipitation alone. Further, contaminant concentrations appear to be increasing over time: the highest concentration levels between 2002 and 2006 were 14,430Bq/L, half of those measured in 2015.

Despite all of this deeply concerning evidence, OPG's 2014 ERA asserted stormwater was not toxic and did not require any additional examination.[88]

In order to determine whether this is the case, and ensure that OPG, CNSC staff, other regulatory bodies and the public understand real and measured impacts of the PNGS to local surface and groundwater quality, further environmental monitoring should occur.

Recommendation 21:

a) *Additional water quality sampling of Lake Ontario is recommended, with samples to be taken at Beachfront Park, Frenchman's Bay West Park, and Squires Beach and tested as follows:*

   -quarterly testing for copper, zinc, morpholine, and hydrazine;
   - annual testing for the full list of parameters presented on Table F.1 of the 2017 ERA Report.

b) *If not being done, then it is recommended that tritium and gross beta/ gamma be added as parameters in the weekly testing of the PNGS outfall water quality. It is also recommended that the outfall water quality testing should be done at a point downstream of all inputs from the PNGS.*

c) *Table A.3 of the Quarterly Environmental Emissions Data reports indicates that waterborne radionuclide releases from the PNGS are analyzed monthly for Tritium, Gross Beta/Gamma, Carbon-14, and Gross Alpha. It is recommended that the quarterly reports should provide a transparent explanation for how the data being presented in Table A.3 are obtained.*

d) *It is recommended that the CNSC order OPG to provide full public disclosure of historic and current PNGS groundwater monitoring data (including provision of full copies of Annual Monitoring Reports if requested), commencing immediately.*

e) *It is recommended that OPG be required to fund a full, independent Peer Review of the historic and current results of its PNGS groundwater monitoring program. The Peer Reviewer should report to the CNSC, and their report should provide:*

   - *an overview of historic groundwater quality monitoring results and their implications;*
   - *recommendations on how to improve the groundwater monitoring program on a go-forward basis;*

[88] *Ibid.*

- *recommendations on how to optimize the provision of transparent and publicly accessible reporting of the results of the groundwater monitoring program.*

f) *This information (including disaggregated data showing the results of this testing, and additional explanations of how this data was obtained) should be made publicly available in OPG's quarterly or annual compliance reports.*

Possible *Fisheries Act* s. 36 offence

The *Fisheries Act* specifies in section 36(3) that:

> … no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any other deleterious substance that results from the deposit of the deleterious substance may enter any such water.

Again, such activity is strictly prohibited by the Act and any contravention of this provision can result in significant penalties that can increase exponentially throughout extended periods of non-comliance. Of course, this section does not apply to facilities that receive a special permit by the DFO to undertake activities that would result in serious harm to fish. When such permits are granted, they generally contain provisions for the mitigation or offsetting of harm caused by the licensed activity.

The Act defines a "deleterious substance" as:

> **(a)** any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water, or
>
> **(b)** any water that contains a substance in such quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water…[89]

Significantly, this language specifies that the toxicity of a substance must be determined prior to discharge or dilution into receiving waterbodies. Further, the Act defines a "deposit" as:

[89] Supra note 66 at s 34(1).

> any discharging, spraying, releasing, spilling, leaking, seeping, pouring, emitting, emptying, throwing, dumping or placing[90]

Given the available evidence, it appears as though any direct discharge of toxic water via stormwater drains directly into the lake would constitute an offence under the Act. The section 35 DFO permit discussed above explicitly states that it cannot be interpreted to permit activity otherwise prohibited by section 36 of the Act, thus cannot be construed to permit any discharges of deleterious substances by the PNGS.

Recommendation 22: *The DFO and ECCC should immediately investigate the potential for stormwater outfalls at the PNGS to be releasing deleterious substances into waters frequented by fish in contravention of the Fisheries Act. The results of this investigation must be publicly disclosed.*

Public information sharing inadequacies concerning the PNGS

The public has a right to a healthy Lake Ontario and information concerning the health of the lake. The preamble of the Great Lakes Protection Act (GLPA) states that "all Ontarians have an interest in the ecological health of the Great Lakes-St. Lawrence River Basin".[91] Ontario's Environmental Bill of Rights acknowledges that Ontarians have the right to a healthful environment.[92] However, inadequate access to information concerning the ecological footprint of the PNGS prevents the public from being able to assess how it affects their right to a healthful environment, or whether such an impact can be acceptable.

Further, OPG is a public company, answerable to its sole shareholder the Government of Ontario. Its mandate is to provide the public with a service - the generation of electricity. How this electricity is produced, including its relative benefits and risks, are public issues. The public should be engaged and informed enough to meaningfully contribute to decision-making processes concerning public energy producing facilities and the impact they can have on local waterbodies used for swimming, drinking, and fishing.

Further, the federal government has been developing an open data strategy for almost a decade. It's most recent Plan on Open Government notes:

> Openness and transparency are fundamental to ensuring Canadians' trust in their government and in democracy overall. Citizens expect their government to be open,

[90] *Ibid.*
[91] *Great Lakes Protection Act*, SO 2015, c 24, Preamble.
[92] *Environmental Bill of Rights*, SO 1993, c 28, Preamble.

> transparent, and accountable... The Government of Canada's commitment to openness is intended to foster greater transparency and accountability, and to help create a more cost-effective, efficient, and responsive government for all Canadians.[93]

Several Commitments from this plan are especially relevant to these submissions, including Commitment 3 to expand and improve open data across the country. The commitment recognizes:

> Open data has the potential to transform how government officials make decisions and how citizens interact with government… The Government of Canada is committed to ensuring that its data is open by default. Data must be discoverable, accessible, and reusable without restriction so as to enhance transparency, enable better services to Canadians, facilitate innovation, and inform public participation.

Commitment 6 requires all federal public servants to change how they design and deliver programs to support Canada's commitments to transparency and public engagement. It asserts "an openness mindset needs to be integrated into their day-to-day business activities". Further, Commitment 13 undertakes to increase the availability and usability of geospatial data, and Commitment 14 undertakes to make the science performed in support of Government of Canada programs and decision-making open and transparent to Canadians.

The CNSC recently amended its own internal regulatory document concerning public information and disclosure requirements for all regulated facilities. This policy (and its predecessor released in 2012) state the "primary goal of a public information and disclosure program… is to ensure that information related to health, safety and security of persons and the environment, and other issues associated with the lifecycle of the nuclear facilities are effectively communicated to the public."[94]

OPG shared its Public Information and Disclosure protocol with Waterkeeper for review as part of its PWMF intervention. During that intervention Waterkeeper expressed several concerns with the PID and recommended measures to improve it. As part of this current intervention, Waterkeeper has confirmed that the PNGS PID has not changed since last year, and none of Waterkeeper's recommendations appear to have been adopted.

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[93] Government of Canada, Canada's New Plan on Open Government 2016-2018, online: < https://open.canada.ca/en/content/canadas-new-plan-open-government-2016-2018>.

[94] REGDOC-3.2.1 *Public Information and Disclosure*, s 2.1, online: <http://nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc3-2-1/index.cfm>. Note, this was the same in the previous *Public Information and Disclosure*, Regulatory Document 99.3, March 2012, s 2.1.

The following discussion mirrors the one in Waterkeeper's PWMF intervention, for the benefit of new members of the Commission Tribunal, and to ensure it is included in the public record for these current proceedings.

OPG's Public Information and Disclosure protocol consists of a Public Information Program (PIP) and a Public Disclosure Protocol (PDP). Upon examining the language of both documents, there appear to be several significant inconsistencies concerning mandatory and discretionary reporting requirements under the PIP and its PDP. Further, OPG's implementation of its PIP is not as effective as it could be in ensuring transparency and safe and open communication between the facility and the public.

OPG's Public Information Program

The PIP specifies that OPG's target audiences include residents, the general public, non-governmental organizations, Industry, and OPG staff.[95] OPG's strategies for communication include electronic communications and notices, website, social media, and "reporting and communicating reports and regulatory information relating to health, safety and environment".[96] Waterkeeper finds the PIP's identified audiences to be comprehensive and also finds these methods for public communication to be appropriately diverse and current.

However, there appears to be a significant discrepancy between the discretionary and mandatory provisions of OPG's PIP and PDP. The discretionary provisions throughout the PIP tend to suggest a fairly high degree of disclosure, while mandatory provisions provide for a much more limited degree of disclosure, especially concerning the disclosure of incidents that may have environmental impacts.

First, the PIP specifies that "[i]nformation *should* be communicated on an ongoing and timely basis, and *should* be respective of both the public's perception of risk and the level of public interest of station operations, activities, and anticipated effects on environment and the health and safety of persons".[97] Waterkeeper would agree that these are good principles to include in a PIP, however it does not appear from the language of these provisions that they are mandatory.

Second, Appendix A to OPG's PIP is a Public Information Disclosure and Transparency Protocol which is meant to guide the development of annual plans for the communication of information to the public. Appendix A notes OPG is committed to: publicly posting its quarterly compliance reports (prepared for the CNSC) on its website; communicating unplanned events

[95] Ontario Power Generation, Nuclear Public Information and Disclosure (N-STD-AS-0013, R007), s 1.1.2.
[96] *Ibid*, s 1.4.2(c)
[97] *Ibid*, s 1.1.1(d).

exceeding regulatory limits or offsite effects or which could result in public or media interest or concern; reporting quarterly or annually "various emissions and spills" that require notification by municipal and provincial agencies; annual posting and communications of Environmental Monitoring Programs detailing emissions and spills. While this is a comprehensive list, it does not appear to be mandatory either. Rather it is merely a guideline that *may* be used.

Third, the PIP suggests that notifications *should* include (but not be limited to), "events with off-site effects which could result in public of media interest or concern", "unplanned events, including those exceeding regulatory limits", "abnormal tritium liquid emissions below notification requirements", and "issues related to Significant Environmental Aspects". This discretionary provision also appears to support the one directly above.

When examining mandatory provisions in the PIP and PDP, in contrast to the discretionary provisions discussed above, it appears as though much less is required of OPG. While the PIP requires OPG to publicly post "significant regulatory events" on a quarterly basis on its website (and requires these reports to be archived on its website),[98] these "significant regulatory events" do not appear to include the types of events listed above which could impact the local environment.

Second, while the PIP requires unplanned events and all events exceeding regulatory limits to be reported within 72 hours of a planned event and as soon as possible for unplanned events, it also notes this must be done in a way that adheres to Appendix B of the PIP (OPG's Public Interest Notification Procedure for Pickering and Darlington Nuclear Generating Stations). Both of these sections are drafted making it clear that they are mandatory. However, Appendix B only explicitly requires reporting of work-related injuries, steam releases or odours, significant changes in reactor status, possible contaminations of workers, or scheduled station emergency preparedness. While there is one vague term providing for the release of information concerning "events or a change in station conditions [that]… may constitute public concern or media interest",[99] this does not explicitly include any of the environmental events mentioned above.

During its intervention in the PWMF's relicensing hearing last year, Waterkeeper inquired about this issue with OPG, asking what kind of environmental incident reporting is done in practice at the PNGS. The response we received did not clarify this issue, as OPG staff merely stated that actual reporting "may not" be confined to the list provided in Appendix B, and "may" include events from the discretionary lists.

***Recommendation 23**: OPG should better distinguish between mandatory and discretionary reporting in its PIP and PDP and disclose the types of events that are reported in practice.*

[98] *Ibid*, s 1.2.1(a)
[99] *Ibid*, Appendix B, Part B.

Recommendation 24: *OPG should undertake to make all environmental reporting mentioned in the PIP and PDP mandatory for the PNGS.*

The need for better monitoring data sharing

There is no section in the current PIP that requires the public dissemination of monitoring data for the facility, however, there are numerous examples in OPG's application in which it asserts it shares performance information with the public via annual and quarterly reports.

In practice, OPG has posted annual Environmental Monitoring Plan (EMP) reports from 2011 to 2015 on its website.[100] However, the amount of actual monitoring data provided in these reports is very low. These EMP annual reports concern both the DNGS and the PNGS. Generally, when data is provided, it is provided as annual averages, sometimes including both the DNGS and PNGS. No regular or disaggregated data reporting is provided for the PWMF specifically in these reports.

OPG also posts quarterly Environmental Emissions Data Reports on the same webpage as the EMP reports. The reports available on the webpage date from the second quarter of 2015 to the second quarter of 2016. However, none of these reports contain any disaggregated data nor do they contain monitoring results for all parameters at all locations.

This same webpage also includes quarterly Nuclear Waste Management Performance Reports, however none of these reports contain *any* data or discussion of what is being monitored at the PWMF. Further, while these reports indicate whether a spill occurred in that quarter, they do not provide an explanation of the spill threshold that requires public reporting, or any measurements of spilled substances or other descriptions of the spill.

The contents of all the reports discussed above illustrate how limited the environmental performance-related data is in OPG's public reports. The available monitoring data in OPG's reports are also insufficient to adequately demonstrate to the public OPG's assertions of the PWMF's safe operation and high performance. While actual fulsome monitoring data may establish the facility is completely safe, it would be impossible for members of the public to currently verify this based on publicly available data.

Since OPG's PIP requires the disclosure of information to be commensurate to the public *perception of risk* as well as actual risks, Waterkeeper submits OPG's assertions of PNGS's high performance must be demonstrated in its monitoring data and shared with the public for review.

[100] Ontario Power Generation, online: http://www.opg.com/news-and-media/Pages/reports.aspx.

Recommendation 25*: The Commission Tribunal must require more proactive disclosure of environmental data collected at the PNGS. CNSC staff should work with OPG to create a timeline for OPG ultimately posting comprehensive data in machine-readable formats in real time.*

The need for better release event reporting

The PNGS is required to notify off-site authorities of accidental releases of radioactive contaminants during and/or immediately after their occurrence.[101] For releases of radioactive contaminants that exceed ALs or DRLs, the CNSC must be informed according to draft licence condition 10.2.[102]

The Ontario MOECC also requires that releases of non-radioactive contaminants to be reported to it, as well as the municipality in which the spill occurs.[103] Generally, the party responsible for the spill must report the date and time of the incident, identity of pollutant released, quantity of pollutant released, a description of any conditions (including weather) that may mitigate or aggravate the effects of the spill, the cause of spill, description of clean-up efforts and their success, as well as any adverse effects observed as a result of the spill.[104] These reporting requirements comprise a high standard the CNSC should consider applying to OPG for spills reportable under its own legislation.

OPG archives incident reports on one of its webpages entitled "Special Interest Station Updates" – a link to which was provided upon request to Waterkeeper by OPG staff.[105] The webpage is difficult to find on OPG's website, and does not come up via online searches for event or release reports on google.com or opg.com. As such this page appears hidden in the larger OPG website. No reported events on this webpage were identified as originating from the PNGS. No events included any measurements of planned or unplanned releases, nor did they contain relevant reporting thresholds or applicable regulatory release limits. [106]

OPG maintains another webpage of incidents between 2010 and 2016[107] and only reports from 2015 can be found via a google search for PNGS reportable events. This archive contains

[101] *Class I Nuclear Facilities Regulations*, SOR 2000, s 6(k) (ii) and (iii). *General Nuclear Safety and Control* Regulations, SOR 2000-202, s 29(1)(c).
[102] Draft Licence Conditions Handbook, p 91.
[103] *Environmental Protection Act*, RSO 1990, c E 19, s 92(1)(a) and (b).
[104] *Classification and exemptions of spills and reporting of discharges*, O 1998, 675, ss 12 and 13.
[105] Ontario Power Generation, online: http://www.opg.com/generating-power/nuclear/stations/Documents/StationUpdateArchives.pdf.
[106] Ontario Power Generation, online: http://www.opg.com/generating-power/nuclear/stations/Pages/Station-Reporting.aspx
[107] All reportable events (i.e. unplanned releases of potential contaminants) are listed in the following reports: 2010-2014, online: http://www.opg.com/generating-power/nuclear/nuclear-waste-

events from the PNGS specifically, many of which concern instances in which routine environmental monitoring was not conducted, despite being required. Again, reported unplanned or planned release events at the facility fail to contain any measurements of the released substance(s), or any relevant reporting thresholds or applicable regulatory release limits.

Recommendation 26*: The webpage for reporting incidents at the PNGS should be included as a shortcut tab on the PNGS's homepage on opg.com.*

Recommendation 27*: Each incident report must include the incident date, reporting date, an exact description of the event including actual data of any measured releases, and any applicable DRLs or ALs so that members of the public can understand the severity of the reported incidents.*

Conclusion

Lake Ontario is precious and irreplaceable. It's ecosystems are very dynamic, ecologically stressed but resilient, and internationally significant. It is the drinking water supply for millions of people, and an increasingly important place for recreation. As such, it is essential that the Commission's consideration of OPG's application to relicense the PNGS for another ten years be based on a thorough and reliable factual record. At this time such a record does not exist.

Waterkeeper ultimately submits that there is currently insufficient information on the public record upon which the Commission Tribunal could even consider OPG's current request for a renewal of its licence for any term. Further, what limited information is available seems to indicate that there are significant environmental risks posed by the continued operation of the PNGS that require immediate investigation.

Waterkeeper is deeply concerned about the PNGS's potential non-compliance with the *Fisheries Act*, the continued ecological damage caused by the PNGS open-cycle cooling water system, and the lack of information being collected on entrainment and stormwater impacts in particular.

As such, Waterkeeper recommends a temporary licence of no longer than two years to allow for

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management/Documents/NuclearWaste_2010-2014_ReportableEvents.pdf; 2015 online: http://www.opg.com/generating-power/nuclear/nuclear-waste-management/Documents/NuclearWaste_2015_ReportableEvents.pdf; and 2016 online: http://www.opg.com/generating-power/nuclear/nuclear-waste-management/Documents/NuclearWaste_2016_ReportableEvents.pdf

OPG, CNSC staff, the Department of Fisheries and Oceans (DFO), and Environment and Climate Change Canada to collect and publicly present more information to allow OPG's application to be properly considered and assessed on its merits.

Summary of Recommendations:

Recommendation 1: *That OPG be granted a licence under the terms of its current licence, for no longer than two years, during which time OPG, CNSC staff, the DFO and ECCC can monitor and publicly report on the PNGS impacts to Lake Ontario's water quality and local aquatic environments, and ensure a future hearing to consider a longer PNGS licence on a more comprehensive evidentiary record.*

Recommendation 2: *When considering the current licence renewal application, the Commission Tribunal must do so while keeping in mind the growing importance of the lake for swimming, drinking, and fishing as well as cumulative adverse environmental impacts of lake water quality and the health of local aquatic ecosystems.*

Recommendation 3: *that CNSC staff and the DFO review the use of 2003/4 data as the benchmark against which impingement mitigation is measured, instead selecting a broader period of time that also takes into account the current characteristics of Lake Ontario's ecosystem.*

Recommendation 4: *that OPG, CNSC staff, and the DFO examine the likelihood of the PNGS exceeding the 3,619 kg threshold for two consecutive years and publicly report their findings, including any proposed follow-up activities.*

Recommendation 5: *that OPG make publicly available its monitoring reports concerning impingement rates and net performance, including net failure events.*

Recommendation 6: *that entrainment monitoring commence immediately, rather than 2021.*

Recommendation 7: *that OPG and CNSC staff immediately develop entrainment mitigation measures to decrease entrainment rates at the PNGS.*

Recommendation 8: *that OPG, CNSC staff, and the DFO consider and implement measures to ensure that offsetting activities more effectively compensate for actual species impinged and entrained at the PNGS.*

Recommendation 9: *that OPG, CNSC staff, and the DFO consider and implement measures to mitigate thermal pollution by the PNGS, taking into account the projected impacts of climate change on lake water temperature in Lake Ontario.*

Recommendation 10: *that OPG makes its ECA compliance reports public, by posting them to the OPG webpage with other compliance reports.*

Recommendation 11: *That OPG and CNSC staff make public their responses to the four ECCC areas in which more information was required concerning potential adverse impacts of the PNGS on local water quality and aquatic biota.*

Recommendation 12: *that an explanation from the DFO concerning the PNGS's historical compliance with the* Fisheries Act *be shared with Waterkeeper, and put on the record of the current proceedings, in advance of the public hearings from June 25 – 29th, 2018, including references to any regulations or Ministerial Orders exempting the PNGS from the application of the Fisheries Act.*

Recommendation 13: *that all species impinged and entrained by the PNGS be considered and added to the DFO s. 35 permit for the PNGS, including but not limited to alewife and round goby. This approach would be more consistent with the* Fisheries Act.

Recommendation 14: *that the DFO s. 35 permit itself be amended to ensure that offsetting activities properly compensate for actual species killed by the PNGS. This approach would also be more consistent with the* Fisheries Act.

Recommendation 15: *that OPG be required to publicly disclose the annual compliance reports required by the DFO permit by posting them to the OPG webpage with all other PNGS compliance reports.*

Recommendation 16: *That OPG and CNSC staff immediately release the following information on the public record in this hearing process:*

- *a complete set of borehole logs and monitor installation details for OPG's full network of groundwater monitoring wells and sampling points;*
- *up to date and useable groundwater level and groundwater quality monitoring data for the full network of groundwater wells and sampling points;*
- *recent annual groundwater monitoring reports for the PNGS; and*
- *a map and inventory of storm sewer lines for the site, including estimates of flows and a list of how many of these lines are being monitored on a regular basis and the monitoring results (for radiological and non-radiological contaminants).*

Recommendation 17: *If not already included, Waterkeeper recommends that coper and zinc be included as COPCs for groundwater below the PNGS.*

Recommendation 18: *that OPG and CNSC staff publicly confirm whether a site-specific groundwater tritium limit of 3 million Bq/L is in effect for the PNGS.*

Recommendation 19: *that if there is a site-specific groundwater tritium limit of 3 million Bq/L for the PNGS, OPG and CNSC staff must publicly report: 1) when and how it was developed; the scientific basis for its development; the extent to which it has been formally adopted by the CNSC and reasons for its exclusion from the current and proposed licence and Licence Conditions Handbook for the PNGS; and 4) whether any public consultation was conducted prior to establishing this elevated contamination limit.*

Recommendation 20:

g) *OPG must conduct quarterly monitoring of every stormwater collection line which is discharging to the forebay, the outfalls, or directly into Lake Ontario,*
h) *As a first step, an inventory of stormwater collection lines needs to be developed and flows of water in those lines need to be metered. Particular attention needs to be paid to any lines which are always flowing, as this should not be occurring in a system which is collecting only stormwater.*
i) *Toxicity testing should be done on every line for every sampling event. For lines which are consistently showing zero mortality, the frequency of toxicity testing can be stepped down to annually after 3 years of passing test results.*
j) *The parameter lists being used for stormwater monitoring are reasonable, however in the event of failed toxicity testing results the scope of the testing should be increased to include:*
   - *volatile organic chemicals(VOCs);*
   - *polynuclear aromatic hydrocarbons (PAHs);*
   - *hydrazine and morpholine;*
   - *additional radionuclides.*
k) *Adverse test results and in particular failed toxicity tests should prompt immediate further investigation, with the goal of remediation of the issue(s) which are allowing contaminated and/or toxic stormwater to be discharged to Lake Ontario via the stormwater collection system.*
l) *This information (including disaggregated data showing the results of this testing) should be made publicly available in OPG's quarterly or annual compliance reports.*

Recommendation 21:

g) *Additional water quality sampling of Lake Ontario is recommended, with samples to be taken at Beachfront Park, Frenchman's Bay West Park, and Squires Beach and tested as follows:*

-quarterly testing for copper, zinc, morpholine, and hydrazine;
- annual testing for the full list of parameters presented on Table F.1 of the 2017 ERA Report.

h) *If not being done, then it is recommended that tritium and gross beta/ gamma be added as parameters in the weekly testing of the PNGS outfall water quality. It is also recommended that the outfall water quality testing should be done at a point downstream of all inputs from the PNGS.*

i) *Table A.3 of the Quarterly Environmental Emissions Data reports indicates that waterborne radionuclide releases from the PNGS are analyzed monthly for Tritium, Gross Beta/Gamma, Carbon-14, and Gross Alpha. It is recommended that the quarterly reports should provide a transparent explanation for how the data being presented in Table A.3 are obtained.*

j) *It is recommended that the CNSC order OPG to provide full public disclosure of historic and current PNGS groundwater monitoring data (including provision of full copies of Annual Monitoring Reports if requested), commencing immediately.*

k) *It is recommended that OPG be required to fund a full, independent Peer Review of the historic and current results of its PNGS groundwater monitoring program. The Peer Reviewer should report to the CNSC, and their report should provide:*
   - *an overview of historic groundwater quality monitoring results and their implications;*
   - *recommendations on how to improve the groundwater monitoring program on a go-forward basis;*
   - *recommendations on how to optimize the provision of transparent and publicly accessible reporting of the results of the groundwater monitoring program.*

l) *This information (including disaggregated data showing the results of this testing, and additional explanations of how this data was obtained) should be made publicly available in OPG's quarterly or annual compliance reports.*

Recommendation 22: *The DFO and ECCC should immediately investigate the potential for stormwater outfalls at the PNGS to be releasing deleterious substances into waters frequented by fish in contravention of the Fisheries Act. The results of this investigation must be publicly disclosed.*

Recommendation 23*: OPG should better distinguish between mandatory and discretionary reporting in its PIP and PDP and disclose the types of events that are reported in practice.*

Recommendation 24: *OPG should undertake to make all environmental reporting mentioned in the PIP and PDP mandatory for the PNGS.*

***Recommendation 25**: The Commission Tribunal must require more proactive disclosure of environmental data collected at the PNGS. CNSC staff should work with OPG to create a timeline for OPG ultimately posting comprehensive data in machine-readable formats in real time.*

***Recommendation 26**: The webpage for reporting incidents at the PNGS should be included as a shortcut tab on the PNGS's homepage on opg.com.*

***Recommendation 27**: Each incident report must include the incident date, reporting date, an exact description of the event including actual data of any measured releases, and any applicable DRLs or ALs so that members of the public can understand the severity of the reported incidents.*

Appendix I

P A Henderson, “Comments on Aquatic Ecology Issues Relating to the Pickering Nuclear Generating Station (PNGS) License Renewal”

Comments on Aquatic Ecology Issues Relating to the Pickering Nuclear Generating Station (PNGS) License Renewal.

P. A. Henderson

May 2018

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Summary

- Pickering Nuclear Generating Station (PNGS) renewal license application is based on the continued use of once-through cooling. PNGS condenser cooling water system with all six units operating extracts on average from 190 to 220 m^3/s.
- In October of 2008 the CNSC issued a directive to OPG to reduce impingement of all species of fish at PN by 80%. To meet this requirement a Fish Diversion System (FDS) was installed.
- The efficiency of the FDS is based on comparison with a 2003/4 impingement baseline. This baseline is inappropriate for two reasons. First, it relates to ecological conditions which no longer apply as round goby has become a dominant member of the fish community. Second, the baseline is based on a single year of impingement data and does not adequately reflect temporal variation in fish abundance.
- The impact of entrainment and impingement on round goby is not adequately considered or assessed. It is not correct to assert that because it is a recent invasive species it should not be considered. It is an integrated and key member of the lake community. It is proven to be an important food for large predatory fish.
- There are strong reasons to believe that the 80% impingement reduction required of the FDS cannot be consistently achieved.
- It has been concluded that entrainment mortality which is in the order of tens of millions of fish eggs and larvae per year cannot be practically reduced. It is argued that the loss can be compensated by a fish stocking program. However, this program aims to improve the stocks of species different from those entrained and therefore does not truly compensate for the loss.
- The discharge plume causes local thermal pollution which can change fish distribution and harm lake plankton and bottom living invertebrates. No measures to address this issue have been taken or are proposed.
- The cooling water system also has to be chlorinated to control bivalve fouling. This chlorination will reduce entrainment survival probability and harm lake organisms in the vicinity of the discharge.

Introduction

This report considers the impacts on the aquatic ecology of Lake Ontario relating to the Pickering Nuclear Generating Station (PNGS) application for a operating license renewal.

At present, the plant uses a once-through condenser cooling system which requires considerable volumes of water to be extracted from Lake Ontario. The use of once-through cooling has three key areas of impact on the aquatic environment which are usually discussed under the heading of impingement, entrainment and thermal pollution.

- Impingement is used here to describe the capture of fish and other organisms on the filter screens of a water intake system.
- Entrainment is used here to describe the drawing of small organisms via the water intake structure into the cooling system of the power station, through which they pass to be discharged back to the lake.
- Thermal pollution arises from the need to discharge cooling water, the maximum weekly average temperature (MWAT) modelled for the Pickering discharge canal is as high as 34°C over the July to September period.

All three areas of impact have the potential to be important ecological issues with respect to PNGS.

A summary of the present circulating water system

The PNGS uses a once-through cooling water system. While water for a variety of purposes other than domestic use is drawn from Lake Ontario, the greatest use relates to condenser cooling. The PNGS condenser cooling water (CCW) system with all six units operating extracts and discharges on average from 190 to 220 m^3/s. CCW flows make up the largest proportion of the water pumped with a combined flow of approximately 170 m^3/s (50 m^3/s on the PN U1-4 side and 120 m^3/s on the U5-8 side). This is equivalent to the flow of a small river and has the potential to influence the local flora and fauna of the lake. Even by power station standards of water use it is an unusually large rate of water extraction for a single site.

Impingement

This has previously been recognized as an important ecological impact and the FDS barrier net is an attempt to greatly reduce this impact. The efficacy of this approach is discussed below. In October of 2008 the CNSC issued a directive to OPG to reduce impingement of all species of fish at PNGS by 80%. To meet this requirement, PN installed the barrier net, termed a Fish Diversion System (FDS), covering the entire intake channel in 2009.

The effectiveness of the barrier net to reduce impingement

The FDS barrier net places a 0.5-in (1.27 cm) mesh around the intake structure on Lake Ontario. The FDS comprises of a series of connected net panels with a total length of 600 m. It has three distinct sides orientated east, south, and west. The top of the net is attached to a float line and the bottom to an anchoring system. The aim is to net the entire vertical column of the water. The structure has a designed height of 110% of the high-water depth to accommodate extreme water levels. The design of the FDS also incorporates a top skirt section of netting held afloat by a secondary float line. The FDS is designed to partially submerge when clogged in order to maintain adequate cooling water flow to the station.

The net is not deployed for the entire year and is used only for the ice-free months of April to November.

The observed gross reduction

Table 1 summarises the observed annual impingement when the FDS was deployed together with data for the year 2003/4 which has been used as a baseline against which to assess effectiveness.

Table 1 Observed annual impingement at PNGS for the years 2010-2016 when the FDS was installed compared to the year 2003-4 prior to FDS installation. The data are from the annual reports of the Environmental Monitoring Programs and for the years 2010-2012 from Patrick et al (2014)[1] and the Environmental Risk Assessment Report P-Rep-07010-10012-R000.

Year	2003/4	2010	2011	2012	2013	2014	2015	2016
Total biomass impinged	18,214	4616.5	4011.8	1706	2926	3953	8517	1035
Percentage reduction relative to 2003/4		**74.65**	**77.97**	**90.63**	**83.94**	**78.30**	**53.24**	**94.32**
Kg/ million m3	4.35	0.95	0.79	0.35	0.6	0.82	1.69	

Table 1 shows that for 4 of the 7 years for which I have data the system did not achieve the required 80% reduction. Further the Fisheries act authorization includes the following text:

"*Should the annual reported biomass of fish impinged have two consecutive years where average annual weight of fish is above 3619 Kg, then the OPG shall engage DFO in discussions to determine potential follow up requirements*."

The value of 3619 Kg represents the 80% requirement (100 x (1-3619/18214) = 80.1%).

The available results indicate that there is a high likelihood that 3619 Kg will be exceeded for 2 consecutive years as it was for 2010/11 plus 2014/15. It is unclear what potential follow up requirements would be as no alternative measures for impingement reduction have been identified. The only fully proven approach which could be taken would be to reduce the rate of water extraction (see the Section Alternatives to once through cooling below).

Reasons for the impaired effectiveness of the FDS barrier net

There are a number of clearly identified reasons why the FDS will often not achieve > 80% annual reductions in impingement losses.

1. The FDS is only deployed between April and November. Fish can be impinged during the winter and some species are far more likely to be impinged during the winter. One such fish is the Northern pike for which impingement has found to increase above that in the baseline year. As the Environmental Risk assessment report (P-REP-07701-00001 R0) states on p 2.77 "*Smallmouth Bass and Northern Pike are more likely to overwinter within coastal marshes and, possibly, in the PN discharge and intake channels*." Further, on page 4.116 it is stated that "*The loss of Northern Pike has not been reduced overall by the FDS, likely because this species is prevalent in the winter when the FDS is not in place.*"
2. The net can become blocked and sink allowing fish to swim over the top. While this is reported as a particular problem in the spring, but it has been observed at other times. For

[1] Patrick, P. H., Mason, E., Powell, J., Milne, S., & Poulton, J. S. (2014). Evaluating the Effectiveness of the Pickering Nuclear Generating Station Fish Diversion System Barrier Net. *North American journal of fisheries management*, *34*(2), 287-300.

example, Patrick et al (2014)[2] report the following "*However, there were instances where fish passage was observed over the FDS when it was degraded in the water column due to large mats of algae. For example, fish behavioral observations were made with the imaging sonar on the inside of the FDS from September 3 to 7, 2010, when net degradation occurred. On September 3–4, 2010, the FDS was degraded up to 1 m. During this period, large Alewife schools were observed in the vicinity of the FDS (on the inside),…*"

3. Nets do not always sit tightly on the lake bed and bottom living fish such as eels may burrow under the bottom line or find holes where the flow has tunnelled under the lower edge.
4. Some elongate, small and young fish, such as gobies and eels. may pass across a 0.5 inch mesh.

The inadequacy of the 2003/4 baseline for the assessment of FDS efficiency

One of the most important requirements for a successful assessment of the effectiveness of the FDS is the baseline against which it is to be compared. Unfortunately, the 2003/4 period is both a completely inappropriate time period to act as a baseline and also far too short in temporal extent to cover a fair range of fish abundances.

The year 2003/4 is inappropriate because it is prior to the huge increase in round goby abundance and therefore does not adequately reflect the actual fish abundances for the period post 2009. As shown in Table 2, the 2003/4 impingement baseline includes no round goby. The problems inherent in using a single year baseline are also demonstrated by the negative reductions shown for some species, for example Rainbow smelt. This is because rainbow smelt abundance shows high between year variability and thus a single year baseline is of little value.

Table 2 Abundances of the main fish taxa impinged on the screens at PNGS. The data are from the annual reports of the Environmental Monitoring Programs and for the years 2010-2012 from Patrick et al (2014) and the Environmental Risk Assessment Report P-Rep-07010-10012-R000. The percentage reductions are only for the period of FDS deployment and would be lower on an annual basis.

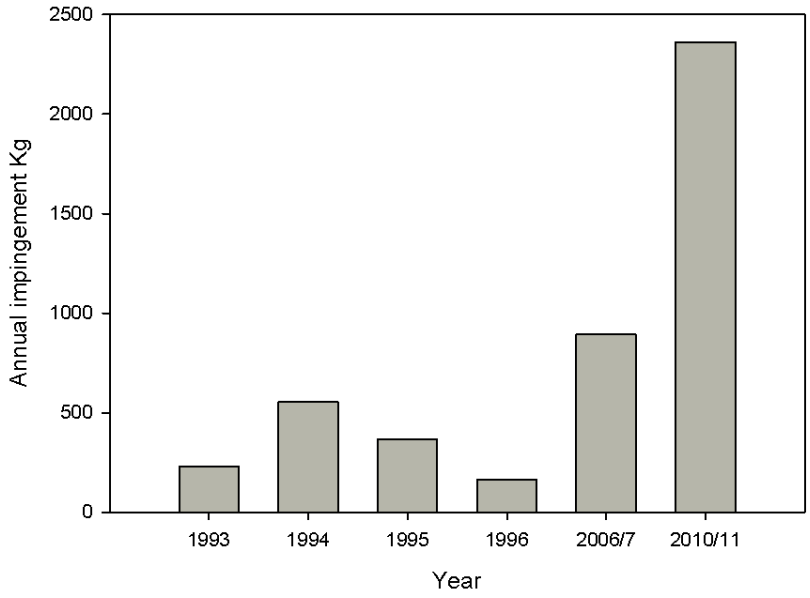
Taxa	2003/4	2010	2011	2012	% reduction 2010	% reduction 2011	% reduction 2012
Freshwater Drum	4,803.40	128.9	204.1	95.1	99.4	98.4	99.6
Brown Bullhead	3,287.20	48.7	46	11.4	99.4	99.3	99.9
Alewife	3,134.60	2,591.90	1,912.10	165.3	19.4	47.7	95.3
Common Carp	2,621.70	347.3	462.5	263	94.1	94.1	98.8
Gizzard Shad	1,702.00	393.1	327.2	528.2	78.1	76.6	98.6
Salmonids,	717.8	260.5	449.49	155.3	71.9	36.3	90.6
Walleye	617.8	27.8	0	3.5	98.9	100	99.4
White Sucker	608.3	77.9	94.9	33.5	86.2	90.7	97.3
3-spined stickleback	279	0.6	0.3	0.2	100	100	100
Emerald Shiner	136	23.7	4.1	7.5	79.5	96.4	96.1
Smallmouth Bass	84.2	11.2	17.8	8.9	96.7	93	96.7

[2] Patrick, P. H., Mason, E., Powell, J., Milne, S., & Poulton, J. S. (2014). Evaluating the Effectiveness of the Pickering Nuclear Generating Station Fish Diversion System Barrier Net. *North American journal of fisheries management*, *34*(2), 287-300.

Northern Pike	66.9	51.2	120.4	132.9	100	38.3	66.4
Rainbow Smelt	41.7	124.5	132.5	4.7	−153.7	−141.6	98.1
American Eel	38.5	0.51	12.3	53.6	98.7	90.3	72.6
Yellow Perch	16.6	15.3	18.1	23.2	16.3	28.3	79.6
Sea Lamprey	4.4	36.1	14.7	7.2	−651.1	−216.0	67.4
Round Goby	0	287.5	155.6	120.8	NA	NA	NA
Others		189.99	54.8				
Total	18,160.10	4,616.70	4,026.89	1,614.30	74.57778	77.82562	91.11073

We can gain some insight into the huge increase in round goby abundance from studies at the Darlington Nuclear Generating Station (DNGS). Recent impingement sampling at DNGS was conducted over a one-year period from May 4, 2010 to April 26, 2011. Based on this sampling, estimated annual impingement was 274,931 individual fish with a weight of 2362 kg (SENES, 2011)[3]. As is shown graphically below, the latest estimates of number and biomass are considerably higher than totals reported from earlier years.

The annual weight of fish estimated impinged at the DNGS (from Table 3.6 ,SENES, 2011)



SENES (2011) discusses the recent increase in impingement and identifies a number of reasons, itemised below.

[3] SENES (2011) Fish Impingement sampling at the Darlington Nuclear Generating Station. NK38-REP-07730-10020-R000

- There has been a recent rise in round goby abundance, which accounted for over 50% of the total impingement in 2010-11. In 2006-07, goby only represented about 8.5% of total impingement.
- More efficient travelling screens were installed in 2010-11.
- Recent changes in the lake population dynamics of alewife with increased numbers of age-1 fish.

An examination of the reasons presented by SENES (2011) for this increase indicates that the major changes observed are likely to continue in future years.

First, there is no indication that round goby numbers are likely to decline in the future, and there is every possibility that they will increase further. Figure 1 is reproduced from Weidel and Walsh (2014)[4] and shows the change in round goby abundance in US waters of Lake Ontario since 2002, when no gobies were recorded in the regular sampling program (the species was first found in Lake Ontario in 1998). The population shows characteristics typical of a successful invader. After a phase when numbers are low and the species is rarely observed, an exponential rise occurred (2002-2008). This was followed by a period of wild fluctuations as the species disperses, fills the available niches, and responds to the local carrying capacity. There are no indications that round goby density in the vicinity of the PNGS has yet reached the maximum obtainable.

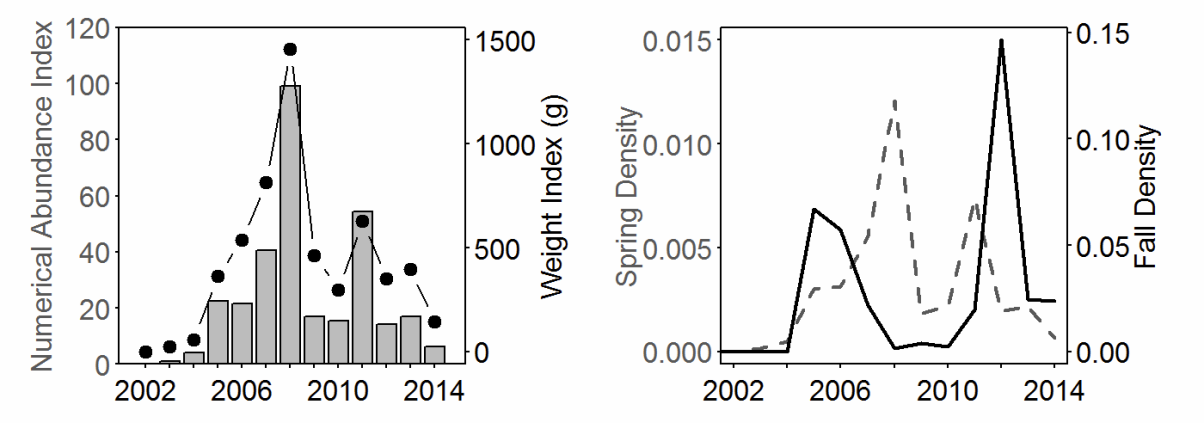


Figure 1 The recent change in abundance of round goby. From Weidel & Walsh (2014).

The second reason for increased impingement relates solely to DNGS and so will not be discussed further here. The third reason given for increased impingement in 2010/11 related to changes in alewife abundance. Alewife populations are notably variable and evidence exists that the population in Lake Ontario is increasing. Walsh *et al* (2012) note the influence of climatic conditions on alewife numbers: "*The number of spawners increased from 2010 and the winter of 2011-2012 has been milder than average, so the predicted 2011year-class will likely be above average. Because of moderate year classes in 2007-2008 and above average year classes in 2009-2010, we expect adult alewife abundance and biomass to increase in 2012.*"

The considerable between year variation in alewife recruitment is illustrated in Figure 2 which shows 1 year old alewife abundance in the US parts of Lake Ontario. Note that alewife yearling numbers

[4] Weidel and Walsh (2014) Lake Ontario Benthic Prey Fish Assessment, 2014. NYSDEC Annual Lake Ontario Report 2014.

were not high in the baseline period of 2003/4 and would be inappropriate for assessing impingement reduction in years with notably higher or lower abundance such as 2013 or 2007.

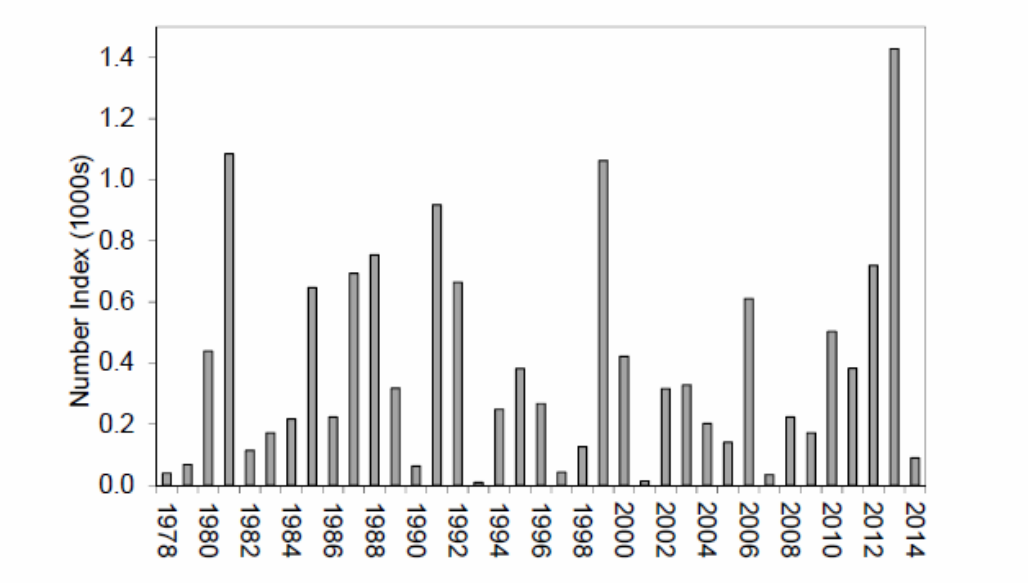


Figure 2 The abundance index of yearling alewife in the US water of Lake Ontario from trawling undertaken in April to May. Taken from Walsh et al (2014)[5] Section 12 page 5

In summary, the impingement data for 2003/4 cannot be used as a baseline against which to test for an 80% reduction in impingement.

Should round goby be considered in impingement assessments?

The impacts of the PNGS on round goby perfectly highlight the problems facing the use of past data to assess subsequent impacts. Round goby is an invasive species which has only become abundant since 2004. It is clear that it is now a major component in the lake ecosystem and regularly impinged at PNGS. As it states in the Environmental Risk Assessment 2017, "*Impingement monitoring for the 5-year period from 2011 to 2015 identified 52 species of fish which may occupy the intake forebay (OPG, 2016b, 2015c, 2014, 2013e, 2012h). Of these species, the most commonly impinged fish species are Alewife, Gizzard Shad, Round Goby, Three-Spine Stickleback, Emerald Shiner, and Rainbow Smelt.*" (p2.76).

Irrespective of the abundance and ecological importance of round goby, no assessment has been undertaken of the reduction in goby impingement produced by the FDS barrier net. As stated on p 4.115 of the Environmental Risk Assessment 2017 "*The Round Goby was not impinged in the baseline year, thus a reduction in goby impingement cannot be calculated. This is an invasive species that has recently extended its range into the Pickering area and may still be undergoing rapid population growth here*."

It is clear that round goby has become a key component of the Lake Ontario ecosystem. Several native fish species prey upon round goby. The restoration of lake trout has been aided by the fact that they prey heavily on round goby. Similarly, round goby represented 86% of the food by weight

[5] Walsh, Weidal and Connerton (2014) Status of Alewife in the U.S. Waters of Lake Ontario, 2014. NYSDEC annual Lake Ontario report 2014.

consumed by Lake Sturgeon in the Niagara River and Lake Ontario[6]. The available evidence indicates that round goby are now an important forage fish and as they cannot be removed from the lake this is likely to continue to be so into the foreseeable future.

Lakes in North America have undergone tremendous change with the invasion of zebra (*Dreissena polymorpha*) and quagga mussels (*Dreissena bugensis*). These Dreissenid mussels have altered the physically environment and created the niche for the round goby. It is simply not tenable to discount the round goby as an invasive species which should not be considered. It has to be considered as an integral part of the lake ecosystem because it has made itself so, and there is no realistic possibility that it will disappear. In future years it will likely play a major role in the ecosystem because it feeds on zebra mussel and is itself preyed upon by larger predatory fish.

Finally, it is completely arbitrary to exclude consideration of the round goby, but, include without question earlier invasive species. For example, the alewife seems to have entered the Great Lakes at about the time of canal building in the late 19th century. Perhaps using the Erie as a mode of transportation, the alewife range increased greatly as they entered the Great Lakes and from there became established in all five lakes; Alewife were first detected in Lake Ontario in 1873. It is now considered that alewife is so fundamental a part of the ecosystem that removing them now could potentially do unforeseen damage along all trophic levels.

It can be concluded that, like alewife, round goby is now such a fundamental part of the ecosystem that it must be considered an integral component and harm could arise if numbers were to be appreciably reduced. It is an important prey to species of conservation concern. It therefore needs to be included in an assessment of the impacts of the PNGS.

Assessment of FDS efficiency without the use of a baseline year

The arbitrary nature of the 2003/4 baseline was recognized in the Environmental Risk Assessment 2017 and hydroacoustic and gill netting studies were also undertaken to compare fish abundances within and outside the barrier net. The results of this study were published by Patrick et al (2014)[7]. The following quotation from their summary illustrates the general conclusions:

"*Analysis of the hydroacoustic data based on the weighted average biomass indicated that FDS effectiveness was 75, 98, and 100% for the spring, summer, and fall periods, respectively, and 98% for the three seasons combined. The summer and fall estimates were based on net performance under optimal net-deployment conditions and if the net degrades, effectiveness is reduced significantly as observed in the spring data.*"

The authors concluded that their study demonstrated that during the spring period the barrier net could not achieve 80% reduction in impingement and further the high potential reductions achievable in summer and fall were only possible when the net was not fouled and effectiveness degraded. The question which is not clearly addressed in their paper is how often is the net degraded in the summer and fall? As the authors state their study was undertaken during optimal net conditions during the summer and fall. I cannot determine how often this is the case from the

[6] Jacobs, G. R., Bruestle, E. L., Hussey, A., Gorsky, D., & Fisk, A. T. (2017). Invasive species alter ontogenetic shifts in the trophic ecology of Lake Sturgeon (Acipenser fulvescens) in the Niagara River and Lake Ontario. Biological invasions, 19(5), 1533-1546.

[7] Patrick, P. H., Mason, E., Powell, J., Milne, S., & Poulton, J. S. (2014). Evaluating the Effectiveness of the Pickering Nuclear Generating Station Fish Diversion System Barrier Net. *North American journal of fisheries management*, *34*(2), 287-300.

published accounts. However, it is known that degradation occurs at times other than the spring. Patrick et al (2014)[8] report the following "*However, there were instances where fish passage was observed over the FDS when it was degraded in the water column due to large mats of algae. For example, fish behavioral observations were made with the imaging sonar on the inside of the FDS from September 3 to 7, 2010, when net degradation occurred. On September 3–4, 2010, the FDS was degraded up to 1 m. During this period, large Alewife schools were observed in the vicinity of the FDS (on the inside),…*"

Entrainment

Entrainment is a term generally used to describe the fate of organisms that are drawn into the cooling water intake structure and enter the cooling system. The organisms pass through fine filter screens via the plant's pipe-work and are discharged back to the environment with the heated effluent water. Of particular concern is the entrainment of fish eggs and larvae, which may be killed in very large numbers during passage through the power plant's condensers. The US EPA assumes 100% mortality for all life stages of fish following passage through a cooling water system. This is considered the best estimate because, even if organisms are released alive, they may be harmed and unable to develop to maturity.

Annual animal numbers entrained at PNGS are high. In the 2007 Golder reported annual entrainment losses at full flow to be 51,994,686 eggs and 11,388,876 larvae. The entrained fish species in decreasing order of relative abundance were Common Carp (48.36%), Alewife (34.91%), Round Goby (16.51%) and Freshwater Drum (0.22%). PNGS also entrains large numbers of invertebrates and planktonic plants. The annual totals for invertebrates are certain to be great but were not presented or discussed in Environmental Risk Assessment for Pickering NGS (2017). Results from the Darlington NGS entrainment study suggests that invertebrates entrained would comprise the following relative abundances 83.5% copepods/cladocerans, 8.1% spiny water fleas, 6.3% rotifers, 1.6% amphipods and <1% mysids.

In October 2008, OPG was ordered by the CNSC to reduce fish entrainment by 60% relative to the baseline year (2003/04). However, no progress has been made on achieving this target. As stated in the Environmental Risk Assessment for Pickering NGS (2017) p 4.111 "*No reasonable technological solution is available to reduce entrainment by 60% (OPG, 2012h), but these losses are more than offset by operation of the FDS and by OPG support for projects to create Northern Pike spawning and nursery habitat (OPG, 2012h), and by OPG participation in the Bring Back the Salmon Program (Lake Ontario Atlantic Salmon Restoration Program, 2011). The latter program is focused on restoration of Atlantic Salmon in Lake Ontario; it includes fish production and stocking, water quality and habitat enhancement, outreach and education, and research and monitoring components.*"

When comparing the actual fish species entrained against the offsetting activities quoted above it is hard to imagine how projects to create Northern pike spawning habitat or salmonid restoration can be suitable offsets. None of the programs would likely have a notable impact on Alewife or Round goby populations. Round goby is not even included in the Age-1 equivalent calculations for fish loss presented in Table 4.52 of the Environmental Risk Assessment for Pickering NGS (2017). Seemingly

[8] Patrick, P. H., Mason, E., Powell, J., Milne, S., & Poulton, J. S. (2014). Evaluating the Effectiveness of the Pickering Nuclear Generating Station Fish Diversion System Barrier Net. *North American journal of fisheries management*, *34*(2), 287-300.

entrainment losses for this species are irrelevant (see the Section on the ecological importance of Round Goby above).

The only technological solutions, of which I am aware, which would reduce entrainment by the desired level of 60% is the reduction of cooling water volume by use, at least in part, of closed cycle cooling. The reductions that could be gained are discussed below in the Section Alternatives to Once Through Cooling.

The health of invertebrate populations is important for the lake ecosystem. Particular concern centres on the fate of the benthic small amphipod crustacean *Diporeia*, which once generated more than 80% of total benthic production of Lake Ontario and was a critical component of the diets of most benthic fishes (GLFC 2007)[9]. This species is vulnerable to entrainment and thermal effluent discharge impacts. While the initial crash in the species is probably linked to major changes in the ecology of the lake (see above) , this does not absolve the power plant of responsibility to act to reduce the level of harm. When a species is in decline, all parties that are contributing to increased mortality need to reduce their impact to aid recovery.

There are many examples of high invertebrate and plankton mortality rates in power plant cooling systems. Information on entrainment survival is available from the US EPA Section 316(b) Phase II Final Rule – Regional Studies, Part A: Evaluation Methods Chapter A7: Entrainment Survival. This gives the following information on invertebrate survival.

Facility	Taxa	Survival
Anclote	Amphipods	29-58%
Fort Calhoun	Ephemeroptera	18-32%
Fort Calhoun	Hydropsychidae	47-56%
Fort Calhoun	Chironomidae	43-66%

In addition, Mayhew *et al* (2000) estimated the entrainment survival of the mysid *Neomysis mercedis*. This ranged from > 90% at a discharge temperature of <30 °C, to zero at > 32 °C. Similarly, highly temperature-sensitive results were found by the US EPA (1977) for *Neomysis americana*. At a discharge temperature of <30 °C survival was 80%, declining to 10% at > 32 °C. All the above studies indicate that a mortality rate of 50% or more can be expected for many taxa, and that at high summer temperatures survival may be negligible. During the summer months, negligible entrainment survival is likely at PNGS as the discharge temperature can exceed 35 °C (see Table 3).

To assess the ecological impact of fish entrainment, emphasis is placed on Age-1 equivalents. Equivalent values are mathematically-derived and use estimated mortality rates. Such calculations should be viewed with caution because they are heavily dependent on the values assumed for the survival of each species. It is far from clear if the values used are appropriate for future conditions. The survival of species such as Alewife varies dramatically between years (see Figure 2) so there is no single survival value from the larval stage to age 1.

In summary, in the past the entrained number of fish and invertebrates has been great. No steps have been taken to reduce entrainment mortality at PNGS. Round goby larvae are known to be present in near-shore waters at significant densities, so their entrainment should be anticipated to

[9] Great Lakes Fishery Commission (GLFC) 2007. State of Lake Ontario in 2003. Special Publication 07-01. Ann Arbor, MI.

occur in large numbers. Future fish entrainment likely will be greater than it was in the past because of the vulnerability of round goby larvae.

Chlorination

Chlorination is used to prevent biofouling. The main biofouling organisms are zebra and quagga mussels. The chlorination regime would typically operate from May to November. The actual dates when it is initiated and stopped are determined by water temperature or the presence of zebra or quagga mussel veligers (planktonic early life stages) in the water. It can therefore vary between years. The maximum total residual chlorine (TRC) in the discharges of Pickering A and B is set at 0.002 mg/l. To ensure this level is maintained the plants are fitted with sodium bisulphite dosing systems.

Chlorine is a broad-spectrum poison which is highly reactive and reacts with almost every constituent in natural waters, including made-made pollutants, yielding products having varying degrees of persistence and toxicity. It forms a wide range of organohalogenated compounds and chloramines depending upon the compounds present in the water. The TRC concentration is set at 2 µg/l (0.002 mg/l) which is the chronic toxicity threshold for aquatic life. However, as pointed out Jenner et al (1998)[10] this level cannot be realistically measured and is derived from mixing calculations.

A key effect of the chlorination regime will be to further ensure the mortality of any entrained organisms. While many would be killed or injured by heat shock and mechanical damage while passing through the cooling water circuits, the presence of a biocide makes it certain that few planktonic organisms will survive. Micro-organisms, including bacteria and fungi are particularly vulnerable to chlorine. The result is that a warm, chlorinated, discharge will be returning a steady rain of dead and dying organisms to the lake.

The thermal discharge

The temperature constraints for PNGS are given in Table 3. The maximum summer temperature in the discharge canal is 36 °C. However, there are reported occasions when these constraints have been breached. *"The thermal impact from the CCW discharge becomes a concern during algae and ice buildup events. These occurrences require some CCW pumps to be turned off to reduce the pressure on the screenhouse travelling screens. This causes the temperature of the water being released at the outfall to be higher than when all the pumps are in operation. At times these algae and ice events have caused the temperature difference to exceed the ECA limit (OPG, 2012e; 2013f; 2014c; 2015g; 2016e)."* p4.35 Environmental Risk Assessment 2017

Table 3 The discharge temperature limits for PNGS. Table 4.12 is reproduced from the Environmental Risk Assessment 2017

Table 4.12: Environmental Compliance Approval Discharge Temperature Limits for Different Operating Conditions (OPG, 2011j)

Operating Conditions	Period of Year	Effluent Temperature Limit	Temperature Difference Limit (ΔT)	Allowed Period of Operation	Total Number of Operating Days Limit Allowed
Normal	Jul 1 to Oct 31	36°C	11°C	continuous	N/A
	Nov 1 to Jun 30	32°C	11°C	continuous	N/A
Algae Impact Event	Jul 1 to Dec 31	37°C	16°C	Not to exceed 24 h for any single event	16
Declared Electrical Supply Emergency	Jul 1 to Oct 31	37°C	11°C	Not specified	15

The extent of the thermal discharge plume in Lake Ontario has been extensively studied. The area of surface water raised by > 2 °C above ambient ranges from 1.5 to 8 km^2. "*The historic data also indicated that thermal plumes in winter were generally larger in extent than thermal plumes in summer. Based on a criterion of 2°C above the ambient water temperature, the area of combined PN thermal plumes ranged from 1.5 to 8 km^2 at the water surface regardless of warm or cold weather conditions, and from 0.5 to 3 km2 at the bottom during cold weather conditions*." p 2.49 Environmental Risk Assessment 2017

The extent of the plume with a temperature > 10 °C above ambient is given in Table 4.

Table 4 The extent of the thermal plume at the PNGS cooling water discharge with a temperature > 10 C above ambient. Copied from Table 2.12 Environmental Risk Assessment 2017

Event		Temperature Contour	
Year	Date	10°C above the PN U5-8 Intake Temperature	
		Depth	Maximum Area (m^2)
2006	October 11-12	Surface	33,425
		Middle	9,750
		Bottom	8,325
2006	October 27-28	Surface	40,800
		Middle	13,325
		Bottom	12,850
2007	August 21-29	Surface	53,475
		Middle	24,000
		Bottom	3,300
2007	October 9-10	Surface	33,975
		Middle	20,100
		Bottom	125
2007	October 26-28	Surface	62,625
		Middle	24,175
		Bottom	11,375

Source:

Tables 9 to 14, Ager *et al.*, 2008.

Heated effluent that will result from the plant's once-through cooling water is a water quality parameter of significant concern. The release of heat into the lake is a form of pollution. Thermal pollution has long been recognised as an important issue, because warm water can alter the local ecology. It is even the subject of an entire book entitled '*Ecological Effects of Thermal Discharges*' by T. E. L. Langford (1990)[11]. In some lakes in the warmer parts of the USA, thermal discharges have even caused the introduction of pathogenic organisms. For example, pathogenic *Acanthamoeba* and *Naegleria* were isolated from cooling water discharges at several coal-fired power stations in the USA (Shapiro *et al*. 1980)[12].

While entrainment normally is used to describe the passage of organisms through the cooling water circuits of the power plant as discussed above, it frequently is forgotten that planktonic life also is entrained into the warm water effluent after discharge. This occurs as the warm water mixes with the water of the lake. The entrained plankton, including fish eggs and larvae, experience sudden temperature change and are likely to be physiologically stressed. Langford (1990) quotes a number of studies in which the zooplankton of heated and unheated lake waters are different. Not all species are disadvantaged by contact with warm water discharges, but the differential response makes it inevitable that the structure of the lake community in the region of impact will be altered to some extent.

[11] Langford, T. E. L. (1990) Ecological Effects of Thermal Discharges. Elsevier Applied Science Ltd., England. 468 pp.

[12] Shapiro, M. A. et al (1980) The role of free-living amoebae occurring in heated effluents as causative agents of human disease, pp 135-149 In: Jenkins & Schodtzhansen (Eds) Cooling water discharges from coal-fired power plants; Water Pollution Problems. Pergamon Press, Oxford.

In many situations, the warm water discharge floats over the cooler receiving waters, so that thermal impacts on bottom-living organisms will be negligible. However, during cold winter periods warm water can sink to the lakebed, resulting in benthic impacts. This is because at temperatures below 4 °C, as temperature declines, water gradually becomes less dense; this is why ice floats. Thus, a situation can develop where the warm water effluent is denser than the receiving water and sinks to the bottom.

Heated discharges can also alter the seasonal pattern of vertical stratification in receiving water bodies. Obviously, the discharge cannot change the vertical stratification of a water body as large as Lake Ontario, but it might change the local regime on a sufficiently large scale to produce detectable changes in the local plankton.

In addition to potential impacts on the lakebed community, heated discharges almost always change the behaviour of the local fish. In some cases, they can attract fish into the warm water, and they often attract predatory fish. To give background information on the importance of thermal issues I summarise information on the impacts on aquatic life and fish in particular in the following section.

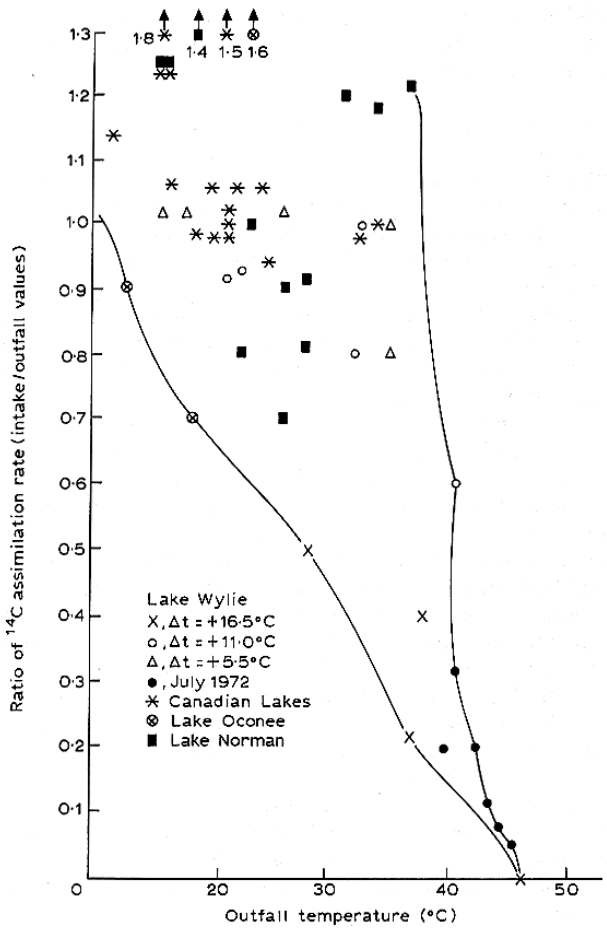
The effects of hot water discharges on aquatic life

Almost all aquatic life is affected by thermal discharges. I will give brief comments on observations of planktonic life in general and then more detailed information on fish.

When warm water is discharged to a lake it mixes with the receiving waters. Any small organisms in the receiving water with which it mixes will be subjected to sudden changes in temperature that are potentially harmful. The importance of these impacts will be, in part, determined by both the temperature and volume of the discharge. Other factors may be important are the duration of the exposure and the presence of biocides such as low levels of copper or chlorine used to control fouling.

Thermal impacts on plants and benthic invertebrates

Several studies have shown that species diversity of phytoplankton decreases in areas consistently heated to over 30 °C. The available data would suggest that phytoplankton productivity as measured by Carbon assimilation rates declines with increasing temperatures above about 20 °C. This temperature is frequently reached over an extensive area within the PNGS discharge plume. The following graph from Langford (1990) shows the rapid decline in phytoplankton photosynthesis in lakes with increasing temperature.



In addition to damage to plants exposed to high temperatures further away from the discharge there is the possibility that phytoplankton blooms will develop. For example, in the Connecticut River near the Haddam Neck nuclear power plant phytoplankton growth increased downstream of the plant. Blooms of *Scenedesmus* and *Microcystis* were associated with the discharge and were increases were detectable 2 km downstream.

From numerous studies it seems likely that changes in macro invertebrate growth and seasonality will occur when temperatures exceed 2°C above ambient, and large changes in community structure, including a significant loss in diversity, are likely to occur when temperatures exceed 8°C above ambient. Changes in the diversity of the invertebrate community associated with the PNGS plume have been observed, "*The diversity of the invertebrate community at sites with a depth of 6 and 10 m were influenced by the thermal plume and diversity was significantly lower than for the reference sites*." p 2.72 Environmental Risk Assessment 2017.

General features of the response of fish to temperature

A fish lives immersed in a liquid (water) of relatively high thermal capacity and will gain heat quite rapidly by conduction across its entire body surface. Moreover, it must pass this fluid over its gills, and in considerable volumes since the concentration of oxygen is comparatively low. Gills are richly supplied with blood and have a substantial surface area to optimize gas exchange. These features

also make for efficient heat exchange and the blood rapidly distributes heat throughout the body (Crawshaw, 1979)[13].

Most organisms can acclimate (i.e. metabolically adjust) to temperatures above or below those to which they are normally subjected. Baldwin and Hochachka (1970)[14] correlated thermal acclimation and the switch to alternative metabolic pathways with changes in the proportions of iso-enzymes. However, as the temperature of the fish rises, coordination in the central nervous system can break down, which eventually manifests itself as "distress" symptoms; ultimately "heat death" will ensue. It was recognised many years ago that various reflexes disappear in a consistent sequence (e.g. Fisher, 1958)[15].

Fish will attempt to avoid stressful temperatures by actively seeking water at the preferred temperature, but this becomes increasingly a matter of chance once coordination begins to break down. If an uncoordinated fish is moved to cooler water it may recover, but the chances of recovery decrease with duration of exposure.

At less than stressful levels, increasing temperatures allow increased rates of metabolism, and (notably with regard to migratory activity) increased swimming speeds but decreased endurance (Turnpenny & Bamber, 1983)[16].

The temperature at which locomotory activity becomes disorganized and thus the fish loses its ability to escape from adverse conditions has been termed the Critical Thermal Maximum (CTM). Once temperatures exceed 40°C, heat death ensues: enzymes are inactivated, proteins denature or coagulate and fats melt. The last comprehensive review of this subject, from the molecular to whole organism level, was that of Rose (1967). Note that the maximum temperature in the PNGS discharge canal in summer during an algal impact event (37 °C see Table 3) is close to the thermal death point for many fish, even those which are warm water adapted such as carp.

The response of fish to temperature is complex. Fish have natural thermal niches (preferenda) and in the temperate zone freshwater species are either:

cold water species, such as salmon, trout, tomcod & smelt;

cool water species;

warm water species, such as carp;

This categorization tends to fall along taxonomic lines in that related species and genera have similar thermal niches. Cherry *et al.* (1975)[17] found that the stenothermal salmonids had the narrowest temperature tolerance ranges of all the teleosts which they studied. This is important given the desire to improve salmonid populations in Lake Ontario.

[13] Crawshaw L.I., 1979. Responses to rapid temperature change in vertebrate ectotherms. *American Zoologist*, **19**; 225-237.

[14] Baldwin J. & Hochachka F.W., 1970. Functional significance of isoenzymes in thermal acclimation. *Biochemical Journal*, **116**; 883-887.

[15] Fisher K.C., 1958. An approach to the organ and cellular physiology of adaptation to temperature in fish and small mammals. *In:* C.L. Prosser (Ed.), *Physiological Adaptation*. American Physiological Society Inc.(Publisher), Washington.

[16] Turnpenny A.W.H. & Bamber R.N., 1983. The critical swimming speed of the sand-smelt (Atherina presbyter Valenciennes) in relation to capture at a power station cooling water intake. J. Fish Biol.; 23; 65-73.

[17] Cherry D.S., Dickson K.L. & Cairns J. Jr, 1975. Temperatures selected and avoided by fish at various acclimation temperatures. *J. Fish. Res. Bd Canada*, **32**; 485-491.

Superimposed upon this thermal selectivity are temporal variations in preferenda that can be correlated with the age or developmental stage of the fish, its physiological condition, or with various environmental variables. Young fish generally have higher thermal preferences and greater tolerances than do older fish. Feeding activity, reproductive or migratory behaviour and stress (anoxia, turbidity, salinity changes and chemical pollutants) might substantially alter normal thermal responses. Some species are better than others at adapting their physiology or behaviour.

For any fish there are temperatures that it prefers, temperatures to which it can acclimate, temperatures that it would seek to avoid but at which it can survive for various periods of time and temperatures that are lethal. Moreover, the ability of individuals to survive is not the same as the ability of the species to continue to prosper; increased temperatures may advance or delay breeding seasons, encourage breeding in the wrong place or inhibit fish migration.

Thermal tolerance of great lakes fish species

The temperature requirements of Great Lakes fishes have been reviewed by a number of authors. Wismer & Cristie (1988)[18] made a general compilation of the available data. Below I tabulate the upper temperature that a range of common N. American fish can tolerate. When no size is given the values are for adults. Generally young and small fish are more vulnerable to elevated water temperatures than adults.

Table 5 The upper temperature that a range of common N. American fish can tolerate

Species	**Latin Name**	**Acclimatization temperature ºC**	**Upper tolerance limit ºC**
Carp	Cyprinus carpio	20	31-34
Large mouth bass	*Micropterus salmoides*	20	32.5
		30	36.4
Blue gill	*Lepomis macrochirus*	15	30.7
3 spined stickleback	*Gasterosteus aculeatus*	25-26	30.6
Yellow perch	*Perca flavescens*	15	27.7
Alewife	*Alosa pseudoharengus*	15	23
Rainbow smelt	*Osmerus mordax*		21
Sea lamprey	*Petromyzon marinus*		34
Common shiner	*Notropis cornutus*	15	30.3
Brown bullhead	*Ictalurus nebulosus*	15	31.8
American shad	*Alosa sapidissima*		28
White perch	*Morone americana*		32-34

[18] Wismer, D.A. and A.E. Christie. 1987. Temperature Relationships of Great Lakes Fishes: A Data Compilation. Great Lakes Fish. Comm. Spec. Pub. 87-3. 165 p.

When considering the effect of a heated outfall we must take into account both the temperature and the exposure time. It is quite likely that larger fish will simply avoid entering the warm water plume and thus will not suffer direct harm. However, these animals will be denied access to warmed area. The thermal impacts will likely be felt by the eggs and weakly swimming early life stages.

North American Studies on the temperature sensitivity of salmonids

Because of their general sensitivity to temperature and their economic importance salmonids are one of the few fish groups about which we have good information on their response to temperature. It is likely that the response of salmon will be indicative of other cold water forms found in the Great Lakes.

Altmann & Dittmer (1966)[19] list, from their review, upper temperature tolerances for salmonids of 28°C (*S. salar* and *S. trutta* prolarvae & postlarvae) and 26°C for *S. trutta* alevins (acclimatized at 20°C); upper temperature tolerances for *Oncorhynchus* species were 24-25°C for both juveniles and adults (acclimatized at 20°C). Generally, their data indicate that North American salmonid adults tolerate slightly higher temperatures than do their juveniles The maximum temperature at which *S. salar* eggs will hatch (in experimental conditions) is 10°C. Bouck (1977)[20] stated "*Perhaps no other single parameter has such a determining effect on a fishery as does its water temperature*". Anadromous salmonids feed very little during their spawning run, so increased temperature leading to increased metabolic rate results in increased weight loss during migration - once fat reserves are used up, muscle is converted for energy.

Lake Ontario once had a thriving Atlantic salmon population. Much effort has made in recent years to restock the lake (eg The Lake Ontario Atlantic Salmon Restoration Program). Three river systems have been chosen for the restocking effort;

1 Duffins Creek - about 25 km to the west of Darlington
2 Cobourg Creek – about 25km east of Darlington
3 Credit River - west of Toronto

Salmon have returned to all the rivers, with the first reported breeding in the Credit River in 2008. In 2009, 80 Atlantic salmon were estimated to run up the Credit River.

Coutant (1968)[21] followed some 70 radio-tagged *Oncorhynchus* species in the Hanford Reach of the Columbia River, where the Hanford Nuclear Reactor discharges a heated plume, and found that the adult fish mostly migrated upstream in shallow water on the opposite side of the river, avoiding any thermal barrier. Johnsen (1980)[22] studied the movement of eight individual tagged migrating salmonids (*S. trutta, Oncorhynchus mykiss, O. tshawytscha* & *O. kisutch*) in a heated discharge plume (ΔT 10°C) in Lake Michigan. On release, fish in the discharge water moved at 0.2 m s^{-1} compared with speeds on leaving the vicinity of the discharge of 1m s^{-1}, and showed frequent turning across the

[19] Altmann P.L. & Dittmer D.S. (Eds),1966. Environmental Biology. Fed. Amer. Soc. Exper. Biol., Bethesda, Maryland, USA.
[20] Bouck G.R., 1977. The importance of water quality to Columbia River salmon and steelhead. Amer. Fish. Soc. Special Publications No.10; 149-154.
[21] Coutant C.C., 1968. Behaviour of adult salmon and steelhead trout migrating past Hanford thermal discharges. In: Thompson R.C., Teal P. & Swezea E.G. (Eds), Pacific Northwest Laboratory Annual Report, 1968, to U.S. AEC Division of Biology and Medicine, Vol.1. Richland, Washington, USA. pp. 9-10.
[22] Johnsen P.B., 1980. The movements of migrating salmonids in the vicinity of a heated effluent determined by a temperature and pressure sensing radio telemetry system. In: Amlaner C.J. & MacDonald D.W. (Eds), A Handbook on Biotelemetry and Radio Tracking. Oxford, Pergamon Press; pp. 781-783.

plume-ambient water interface (ΔT *ca* 5°C). Mean residence time in the plume was 13.08 h, equivalent to a loss of 37.7 km or *ca* 10 hours at normal migration speed (the maximum was 22 h for a *S.trutta*, equivalent to a loss of 63 km or 18 h). Gray *et al.* (1977)[23] during experimental studies found that juvenile chinook salmon avoided a simulated thermal effluent when the ΔT was of 9-11°C; none of their fish passed through plumes of absolute temperature ≥ 24°C. After repeated trials, avoidance conditioning was invariable at "higher plume temperatures", the fish not approaching the discharge. It can be concluded that there is substantial data to indicate that salmonids are influenced by thermal discharge plumes and these can influence their migratory behaviour.

Thermal impacts and climate change

In addition to direct thermal impacts which can lead to the exclusion of species from the impacted zone, thermal discharges can also change the local ecology. For example, invasive species adapted to warmer water will be advantaged over cold water-adapted natives. The Great Lakes are massively troubled by invasive species because man has altered their ecosystems and therefore made the native species more poorly adapted to prevalent conditions.

Climate change predictions

Because of its location Canada is predicted to be greatly affected by climate warming. The Environmental Commissioner of Ontario Annual report Report 2009/10 states the following: "*Increases of average winter temperatures up to 7°C for parts of northern Ontario by the year 2050, as well as increases in winter precipitation up to 39 per cent with more of it falling as rain, are projected. In southern Ontario, projections forecast average summer temperature increases of 2.6°C, but with no real corresponding change in precipitation. These projections are based on "middle of the road" assumptions using moderate greenhouse gas (GHG) emission scenarios.*"

The water temperature of Lake Ontario is predicted to rise appreciably over the coming decades. Trumpickas et al. 2009)[24] predict that by 2041-2070 maximum temperature would be 2.5 °C above the 1970-2000 norm.

There has been extensive analysis of the effectiveness of the diffusers to maintain temperatures suitable for lake round whitefish to reproduce and develop. It is clear that temperatures are close to the upper thresholds for sensitive life stages and can, on occasion, be exceeded. The Draft Screen Report used the warm winter of 2011/2012 to provide "*a snapshot of potentially warmer winters in the future*" (p 89). The analysis presented is not reassuring with respect to the long-term prospects for round whitefish. It is clear that both the short-term acute and long-term chronic temperature criteria of Griffiths (1980) for embryo development were exceeded at some localities. Perhaps the most important point to note is that temperatures are on the threshold of becoming unacceptable and much of the predicted warming is yet to be realized. A rise in lake temperature of 2.5 °C would take temperatures in the region of the discharge above the upper threshold for round whitefish. Given the high likelihood of this occurring within the planned life of the project it is surprising that the effects of climate change on water temperature are not assessed.

[23] Gray R.H., Genoway R.G. & Barraclough S.A., 1977. Behaviour of juvenile chinook salmon (Oncorhynchus tshawytscha) in relation to simulated thermal effluent. Trans. Am. Fish. Soc., 106; 366 370

[24] Trumpickas, J., B. J. Shuter, et al. (2009). "Forecasting impacts of climate change on Great Lakes surface water temperatures." Journal of Great Lakes Research 35(3): 454-463.

Assessing impacts on a local versus lakewide scale

The great size of Lake Ontario leads to the presentation of arguments based on relative scale of the cooling water requirement and impact relative to that of the lake. Such arguments have been universally deployed by those who seek to justify high levels of exploitation or mortality inflicted on local wildlife. Their basic weakness lies in the fact that they are used without fully assessing the in-combination impacts of all the water and resource users. The experience of widespread fisheries collapse and ecosystem damage in huge habitats such as the Great Lakes or the Grand Banks shows such arguments to be fallacious. Underlying such arguments are assumptions that the other areas not affected by the plant are equally valuable to the species impacted. This is clearly not the case. Many species of fish, for example, move seasonally between particular localities which act as overwintering, feeding, reproductive and nursery grounds. The PNGS cooling water system impacts the near-shore ecosystem and it is the importance of this resource that needs to be the focus of the assessment of harm.

Near-shore habitat availability and loss

Lakes are dependent on their shores and shallows for their productivity. Because of their huge size, the Great Lakes have a small proportion of their volume within the productive shallow zones. They are therefore particularly vulnerable to shoreline development and damage to their shallows. To illustrate the point, Lake Ontario has a surface area of 18,960 km^2 and a shore length of 1,146 km giving a length to area ratio of only 0.06. In contrast, Lake St. Clair has an area of 1,114 km^2 and a mainland shore length of 209 km giving a length to area ratio of 0.187. Artificial shoreline hardening and other alterations are a recognized problem in the Great Lakes (see State of Ontario's Biodiversity 2010, p. 62), and loss of shallow water habitat is recognized as a threat to biodiversity.

The PNGS affects the near-shore in a variety of ways. First, there is the inevitable construction of hard structures and lake walls. Second there is the area impacted by the thermal plume the area with a temperature > 2 °C above ambient can reach 8 km^2. Species of fish close to their thermal limits will tend to avoid this zone. It also has the potential to reduce the use of this region as a spawning ground for round whitefish and other coldwater species.

It is easy to assume that because of the great size of Lake Ontario the areas of near-shore affected by the PNGS are insignificant. However, this argument ignores the high level of development along the Canadian shore of the lake and the resulting disturbance to near-shore ecological processes. If all users and occupiers of lakeside property assume they can degrade their local environment because there is plentiful habitat elsewhere, the further decline of the lake is inevitable. The only logical approach is for each lakeside facility or occupier to take responsibility for their near-shore habitat. PNGS undoubtedly has an adverse local impact through impingement, entrainment and thermal discharges. The present proposals make no useful suggestions as to how entrainment and thermal pollution impacts will be reduced in the future.

Alternatives to once through cooling

Over the last 30 years, much has changed in power station design, and it is now widely acknowledged that the minimisation of ecological impacts on aquatic ecosystems caused by once-through cooling water systems is essential if we are to maintain or re-acquire healthy waters. The most important way to minimise the impact of a cooling water system is to reduce as far as possible the volume of water extracted from the environment. This is because impingement, entrainment and thermal pollution all increase with the volume of water pumped.

Widely-used technologies exist to reduce water usage. It is common throughout North America and Europe to use closed-cycle cooling. Such systems can reduce water usage by at least 90% and can reduce impingement, entrainment and thermal impacts to negligible levels. Figure 3 shows the level of reduction in water flow that can be achieved under different thermal regimes and cycles of concentration using evaporative cooling towers. It shows that the percentage reduction is always >70%, and can exceed 95%.

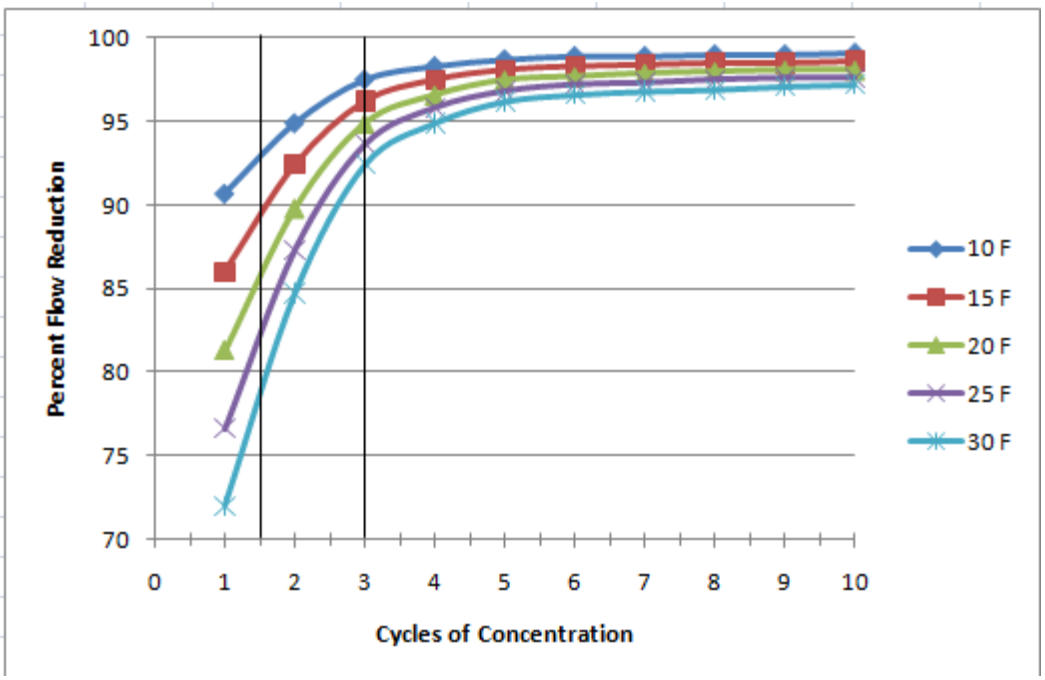


Figure 3: The percent reduction in flow obtained from closed-cycle cooling for various cooling system temperature elevations. Reproduced from p 6-5 316(b) Existing Facilities Proposed Rule Chapter 6 Technologies and Control Measures[25].

This reduction in water usage then results in a great reduction in the mortality of aquatic life:

"*In the 2004 Phase II rule, EPA estimated facilities employing freshwater cooling towers and saltwater cooling towers would achieve flow reductions, and therefore associated entrainment and impingement mortality reductions, of 98 percent and 70-96 percent, respectively.*"
pp. 6-8, 316(b) Existing Facilities Proposed Rule Chapter 6 Technologies and Control Measures[1].

A clear example of the importance of the volume of water extracted on the number of fish impinged is given by Benda *et al*. (1975)[26], in a study of impingement at the Palisades nuclear power plant, Lake Michigan, while operating with both once-through and evaporative cooling tower closed-cycle cooling. The volume of water extracted in each mode was 8,101 and 1,226 gallons/second respectively. Annual estimates of fish impingement were approximately 452,577 for once-through, and 7,488 for closed-cycle cooling.

[25] EPA Technical Development Document for the Proposed Section 316(b) Existing Facilities Rule. EPA-821-R-11-001, March 28 2011.
[26] Benda, R. S., M. John, *et al.* (1975). "Comparison of fish impingement at the Palisades nuclear power plant for once-through and closed cycle cooling." Indiana Academy of Science: 155-160.

Concluding remarks

An assessment of the scale of entrainment, impingement and thermal impacts within the nearshore environment of Lake Ontario indicates that the PNGS has an appreciable impact on the fauna of the lake. The fauna of the lake has changed from when baseline studies were undertaken and round goby are highly vulnerable to impingement and entrainment. In addition, the predicted trend of increasing global temperature makes the scale of the impact of the thermal discharge on native cool water species likely to increase. Given the failure to address entrainment and thermal impacts there is a powerful argument in favor of reducing cooling water requirements and the installation of some closed-cycle cooling should be considered if it is hoped to continue operation of PNGS for anything more than a short additional period of time.

Appendix II

Wilf Ruland, P Geo, Independent Report on Hydrogeological Issues Pertaining to the Application for a 10-year Licence Extension for the Pickering Nuclear Generating Station

Independent Report on Hydrogeological Issues

Pertaining to the Application for a 10-Year License Extension

for the Pickering Nuclear Generating Station

Prepared for:

Swim Drink Fish Canada /
Lake Ontario Waterkeeper

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May 18th, 2018

1) Introduction

I am a hydrogeologist, and I have worked as an environmental consultant for 32 years (2 years for a larger firm in Germany, and 30 years independently in Canada). I am a specialist in groundwater and surface water contamination issues, and have dealt with many such issues over the course of my consulting career.

I have given testimony as an expert witness on hydrogeological issues before various boards and tribunals, including the Environmental Review Tribunal, the Environmental Assessment Board, the Joint Board, the Ontario Municipal Board, the Niagara Escarpment Commission, and the Canadian Nuclear Safety Commission. A copy of my Curriculum Vitae is available upon request.

I have done considerable nuclear-related review work in recent years. This included review of plans for the remediation of the Cameco Nuclear Waste Processing Facility in Port Hope, review of the Environmental Impact Statement for the proposed Darlington 'B' New Nuclear Power Plant Project, review of the proposed Deep Geologic Repository at the Bruce Nuclear Facility, and the proposed surface disposal facilities for low level nuclear waste in Port Hope and Port Granby Ontario. This experience is highly relevant to the issues being considered in this matter.

I have been retained by Swim Drink Fish Canada / Lake Ontario Waterkeeper to review (from a hydrogeological perspective) the technical documentation pertaining to the application for a 10-year license renewal for the Pickering Nuclear Generating Station (PNGS). If approved by the Canadian Nuclear Safety Commission (CNSC) this would allow Ontario Power Generation (OPG) to run the 6 of the original 8 reactors still in operation through to the end of their commercial life in 2024. Following that, the reactors would go into a stabilization phase of about 3-4 years, and work would commence on a longer "safe storage" period which would commence thereafter.

My review of OPG's 10-year license renewal application has been severely hampered by unexpected and unprecedented hindrances and roadblocks in my work on this matter.

For weeks I was refused access to the PNGS site (for a tour of the Pickering facility), though a walk about tour (on May 10, 2018) was finally granted. Unfortunately the staff who accompanied me during the tour while friendly were not at all knowledgeable about water-related technical issues of concern to me.

There were also protracted (weeks long) delays in OPG's response to a request for technical information which was not covered in the application documents (but which is needed in order for me to understand the implications of the requested 10-year site license renewal), and the responses which were finally provided were incomplete and inadequate.

This has left me in the highly problematic position of being asked to comment on a very significant proposal (for the 10-year extension of the site license for the Pickering Nuclear Generating Station) without having sufficient technical information available to me in order to properly provide my comments.

I should note that this situation is entirely unprecedented for me - I have not previously encountered anything like this over the course of a 30+ year consulting career. I apologize in advance to my clients, as I know they were counting on me to provide them with a detailed technical report on the 10-year license extension for the PNGS (to be provided as expert evidence at the upcoming CNSC Hearing).

In the meantime, the process to date and the problems encountered are described in more detail in **Appendix 1** of this report. The net result of OPG's obstructionism and obfuscation has been to make impossible the preparation of a key component of the report which I would normally deliver - namely, a snapshot of current water-related impacts of the PNGS on Lake Ontario.

A variety of critical information is not available to me, including the following:
- a complete set of borehole logs and monitor installation details for OPG's full network of groundwater monitoring wells and sampling points;
- up to date and useable groundwater level and groundwater quality monitoring data for the full network of groundwater wells and sampling points;
- recent annual groundwater monitoring reports for the PNGS;
- an map and inventory of storm sewer lines for the site, including estimates of flows and a list of how many of these lines are being monitored on a regular basis and the monitoring results (for radiological and non-radiological contaminants).

As a result, key parts of my discussion of past and current water-related impacts of the PNGS on Lake Ontario will have to be brief and descriptive in nature, as I have been left to glean what I can from the information provided and to otherwise draw on external reports about the site - many of which focus on historic spills to groundwater and/or Lake Ontario.

In this report I will provide my comments on the following:
- the description of the PNGS site and its surroundings including the local geology, hydrology and hydrogeology;
- the impacts of the PNGS on groundwater and the Lake Ontario environment;
- the adequacy of OPG's public reporting of historical site groundwater and surface water monitoring impacts;
- the adequacy of proposed groundwater and surface water monitoring programs (if the application for a 10-year license renewal is granted based on the current OPG application).

In order to carry out this work, I have reviewed a series of documents and the most important of these are listed as references in **Appendix 2** of this report.

2) Overview of the Pickering Nuclear Generating Station (PNGS) Site

a) Introduction

Basic characterization of the PNGS site and its surroundings is provided in the 2017 OPG Licence Application, and additional information is available in the 2017 Environmental Risk Assessment (ERA) Report.

The PN site is situated in the Regional Municipality of Durham (in the City of Pickering), on the north shore of Lake Ontario about 32 km east of downtown Toronto and 21 km west of Oshawa.

b) Site History and Development

The PN site comprises approximately 240 hectares and accommodates eight CANDU nuclear reactors and a variety of related structures and ancillary service buildings.

Descriptions of the site typically list the reactors in two groups:
- Units 1-4 are located on the west side, and Units 5-8 are on the east side. Units 1-4 and Units 5-8 share the overall PNGS site as well as many services and facilities. Power from the reactor units is delivered to the southern Ontario electrical grid.

Reactor construction started in 1966 for Units 1 to 4 and in 1974 for Units 5 to 8. The in-service dates for Units 1 to 4 ranged from 1971 to 1973, and for Units 5 to 8 ranged from 1983 to 1986. Units 2 and 3 are no longer in operation - they were defueled in 2008 and are now in safe storage. The remaining Units (1, 4, and 5 to 8) are proposed to remain in operation until 2024.

c) Site Topography and Drainage

Although I requested it repeatedly, I have not found or been provided with a proper map showing the site topographical features and drainage network. It is clear that the site topography has been heavily altered in the course of constructing the PNGS and its various supporting facilities.

Overall the ground surface is relatively flat across much of the site, sloping gently from Montgomery Park Road southward toward Lake Ontario. An exception to this is a large hill on the east side of the site known as the East Landfill. There is also a smaller hilly feature on the west side of the site known as the West Landfill.

There are no permanent or intermittent watercourses on-site. Lake Ontario forms the south boundary of the PNGS, and Krosno Creek and the "Hydro Marsh" form the west boundary. Further to the west is Frenchman's Bay, a marsh which is a Provincially Significant Wetland.

On the southeast side of the site there is a small (1/2 hectare) isolated wetland known as the Southeast Wetland, which is located at the foot of Montgomery Park Road. This area was once farmland and the wetland was created as a result of landfilling activities during the construction of the PNGS. The Southeast Wetland receives drainage from the area around the East Landfill. Figure 2.16 of the ERA provides an overview map of the PNGS site, and includes the location of Hydro Marsh, the Southeast Wetland Area, Reactors 1 to 4 (aka Pickering A) and reactors 5 to 8 (aka Pickering B).

Stormwater runoff from the PNGS site is collected by the site stormwater drainage system and directed through various drainage pathways southward toward Lake Ontario. Stormwater drainage occurs via a variety of ditches, swales, culverts and storm sewers - I have requested but not been provided with proper mapping of these features. In any event, the stormwater management system discharges either directly into Lake Ontario, or into the cooling water discharges or the PNGS forebay - it is my understanding that in all instances, the site stormwater is not treated and ultimately ends up in the lake.

Stormwater runoff from a decades-old industrial facility like the PNGS is often a significant pathway by which contaminants can be mobilized and transported into the natural environment off-site (in this case, Lake Ontario). Groundwater contamination at facilities like this one is often heavy, and at the PNGS may include both radionuclides and potentially hazardous industrial chemicals.

Contaminated groundwater may discharge into stormwater ditches and swales at times when the water table is high, but more common is inflow into leaky underground culverts and manholes. Once in the stormwater management system, any contaminants will quickly make their way to Lake Ontario.

An ongoing regular and thorough monitoring program for the stormwater management system of a facility like the PNGS is an essential component of proper and prudent site management. As far as I have been able to discern to date, there is little if any in the way of regular stormwater monitoring being done at the PNGS - this issue is discussed in more detail in **Section 4** of this report.

<u>d) Site Geology</u>

An overview description of the site geology is provided in Section 2.3.2 of the 2017 ERA Report, and I have summarized and interpreted it as follows:

- Pre-construction overburden deposits in the area of the PNGS generally consisted of glacial silt and sand tills up to 24 m thick overlying shale bedrock.

- A considerable amount of the overburden has been excavated and replaced with sand and/or gravel fill in the area of various structures.

- The 2017 ERA Report indicates that "*structures such as the Reactor Buildings and Reactor Auxiliary Buildings were placed on 3 m to 6 m of compacted granular fill*". This fill will be able to rapidly transmit groundwater, as is discussed in more detail in the next section of this review.

- The excavated overburden till materials were deposited elsewhere on site, mainly in the 12 hectare East Landfill.

- The overburden materials can be subdivided into three main layers (starting from the ground surface and working downward):
  - sand/gravel construction fill, which underlies most of the site south of the former Lake Ontario shoreline
  - a recent Upper Till
  - an older Lower Till

- Below the overburden are thick Ordovician shales of the Blue Mountain Formation (about 10 to 20 metres thick), and the underlying Whitby Formation (about 5 to 7 metres thick).

- There are coarser grained interbeds of silt/sand/gravel found at the base of the Upper Till, and found as interbeds within the Lower Till. These interbeds will have the ability to transmit groundwater (and contaminants) more rapidly than the till units.

- The East Landfill (which was in operation from 1971 to 1988) consists of construction waste and of material excavated from elsewhere on-site. The mixed nature of the materials which have gone into the East Landfill will make characterization of its geotechnical and hydraulic properties challenging.

<u>e) Site Hydrogeology</u>

An incomplete and inadequate overview description of the site hydrogeology is provided in Section 2.3.3 of the 2017 ERA Report. My request for up to date hydrogeology-specific data and recent annual monitoring reports was denied by OPG.

The 2017 ERA Report's description of site hydrogeology is all but useless for anyone wanting to understand how and where groundwater is actually moving, and where groundwater contamination is most likely to be found and moving. As such, it is unfortunately a profoundly unhelpful document - but at that, it is still better than any other publicly available document on the PNGS.

To make up for the many gaps in OPG's description of the site hydrogeology I have applied basic hydrogeological principles and a career's worth of experience as a contaminant hydrogeologist to developing a more useful analysis of site hydrogeology, albeit a qualitative/descriptive one.

Based on the information available to me I can provide the following summary and interpretation of site hydrogeology:

- The shale bedrock beneath the site will have a relatively low permeability, and rates of groundwater movement will be slow (perhaps a few metres per year).

- PNGS is situated on the shore of Lake Ontario. At this point in the regional groundwater flow system it is safe to say that groundwater is moving southward in the bedrock, and the vertical component of groundwater movement in the bedrock flow system will be upward. It is unlikely that significant contamination will be found in the bedrock flow system, and it will not be discussed further.

- Past hydrogeologists associated with this site appear to have classified the overburden groundwater flow system into three layers, which correspond to the stratigraphy at the site:

  - A **shallow flow system** is present in the near-surface construction fill and/or Upper Till. Where present the till is likely fractured (with a brown colour due to oxidation of the till caused by groundwater flow in the fractures). It will have a higher permeability and faster rates of groundwater movement than the deeper till layers. Given its proximity to the ground surface, the shallow flow system will be the most badly contaminated groundwater unit at the site.

  - A lower permeability **intermediate flow system** will be present in the lower portions of the Upper Till. Due a relative absence of fractures (and oxidation) the till in this part of the silt/clay Upper Till will be grey in colour. Groundwater movement will be slow, and the primary flow direction will be vertical (either upward or downward, depending on heads in the overlying and underlying higher permeability aquifer layers).

  - A somewhat higher-permeability **deep flow system** can be found in the sandy silt Lower Till. Most of the groundwater movement in this deep overburden flow system will be found in the sand/gravel layer found at the top of the unit and in the silt/sand/gravel interbeds found within the unit.

- Groundwater flow directions on the PNGS property will be dominated by the deep reactor building foundation drains and the deep drains beneath the Turbine Auxiliary Bay, which have depressed groundwater levels in their vicinity to below the Lake Ontario water level. Groundwater flow will be toward these features from their surroundings.

- What this implies is that in the immediate area of the reactors groundwater will be tending to move inland from the lake toward the reactor foundation drains. The fill in the area of the reactors will be high-permeability gravel, which will drain very efficiently. With the lake nearby as a water source, the foundation drains can be expected to collect greater than usual volumes of groundwater.

- These greater than usual volumes of groundwater being collected in the foundation drainage system will have the effect of diluting groundwater contamination being picked up by the system.

- The 2017 ERA Report indicates on page 2.41 that *"Estimated horizontal flow velocities in groundwater across the site range from 0.3 to 11 m/y"*. There is no further explanation of this statement, which I do not consider to be accurate. I believe that there will be considerably higher localized flow velocities in areas where the overburden material is construction fill, and in the bedding for conduits of all kinds which run across the site.

3) Groundwater Contamination at the Pickering Nuclear Generating Station

a) Introduction

The flow of contaminated groundwater is one of the pathways by which contamination from this nuclear site can reach off-site ecological receptors (eg. Lake Ontario, and its aquatic ecosystem).

Groundwater contamination at older facilities is often heavy, and at the PNGS it will include both radionuclides and also potentially hazardous industrial chemicals.

There is almost no groundwater monitoring data or information provided in the 2017 OPG License Application or in the 2017 ERA Report. The sections of these reports discussing radiological and non-radiological COPCs in groundwater are very carefully worded, and provide almost no information of substance.

There are certainly many contaminants of potential concern (or COPCs) in groundwater at the PNGS as alluded to in Sections 3.1.2.4 and 4.1.3.4 of the 2017 ERA Report, including:

- tritium,
- polycyclic aromatic hydrocarbons (PAHs),
- petroleum hydrocarbons (PHCs),
- benzene, toluene, ethylbenzene, and xylenes (aka "BTEX compounds"),
- inorganics (chloride, iron and sodium).

I would also recommend adding metals (in particular copper and zinc) to this list.

Almost no information is provided in the 2017 ERA Report in terms of detailed quantification of the contamination of on-site groundwater by these COPCs. There is likewise almost no information to be gleaned from other OPG or CNSC sources which are publicly available. I expect that OPG's reluctance to transparently provide full access to site groundwater monitoring data may at least in part be because there is massive undisclosed groundwater contamination at the PNGS.

Page 79 of the 2017 OPG Licence Application states that:

> *"Transparency and appropriate public consultations have been upheld and will continue.."*

When it comes to disclosure and honest discussion of the groundwater contamination at the PNGS, I could find no evidence of transparency whatsoever.

Before commencing this report I had requested recent annual groundwater monitoring reports for the site, and was flat-out refused by OPG who took 3 weeks to provide the statement that:

> *"OPG is unable to provide you with the Annual Groundwater Monitoring Reports. However data for our perimeter wells are posted on our public website".*

There is almost no groundwater monitoring information on the OPG website in the "2016 Results of Environmental Monitoring Programs" Report (or in the prior annual reports), and these reports give no sign to indicate that there is any routine groundwater monitoring being done at all at the PNGS.

On the other hand, there is a recent clue that at least minimal groundwater monitoring is being done. I reviewed all of the quarterly Environmental Emissions Data reports available on the OPG website - and there was reference to groundwater monitoring only in the most recent (Q3-2017) report. Table A.7 of the Q3 2017 report provides data - but only for tritium, and only for "perimeter monitoring locations".

The perimeter results are predictably benign, with maximum levels of <6,000 Bequerels per Litre (or Bq/L) reported. By comparison, the Ontario Drinking Water Quality Standard (ODWQS) for tritium is 7,000 Bq/L. These perimeter well monitoring results make sense, given that hot spots are generally not found at the perimeter of an industrial site. But OPG's obstructionism led me to suspect that in fact there is much higher groundwater contamination at the PNGS.

b) The Search for Information on Groundwater Contamination at the PNGS

In the absence of proper disclosure of groundwater quality monitoring information from OPG, I turned to internet searches to see what I could find about groundwater contamination at the PNGS. Several references confirmed that OPG's current obstructionism is nothing new - for example, I learned that in July 1997 it was apparently disclosed that Ontario Hydro (OPG's predecessor) had failed to report tritium contamination of groundwater at the PNGS for a period of 20 years.

In my internet searches I was able to find several relevant reports including a June 2001 Interim Report from the Standing Senate Committee on Energy, the Environment, and Natural Resources; a June 2007 Greenpeace report; and a May 2009 report from the Ontario Drinking Water Advisory Council.

The references which I had found provided some rudimentary information on the checkered history of the PNGS, including reference to two major leaks/spills at the PNGS which caused significant groundwater contamination:

- in 1979, groundwater tritium concentrations reached 2,150,000 Bq/L following a release of 666 trillion Bequerels of tritium at the PNGS;
- in May 1994, Ontario Hydro (OPG's predecessor) found a groundwater tritium concentration of 700,000 Bq/L following a separate leak at Pickering.

Although radioactive decay will have reduced these reported groundwater tritium concentrations significantly (tritium has a half life of about 12 years) since then, there will still be very high levels tritium contamination in groundwater at the PNGS, and these levels will be orders of magnitude higher than the perimeter results of <6,000 Bq/L being reported in the Q3 2017 Report discussed above.

After finding the above references of two spills I combed the 2017 ERA Report and although it contains no specific groundwater monitoring data, on page 4.30 of the 2017 ERA Report I found the following statement:

> *"Based on groundwater data from 2008 to 2012 the only locations where tritium in groundwater exceeds 3E+06 (ie. 3,000,000) Bq/L are around Unit 1 and one well near PN U5-8. Groundwater in the Unit 1 area migrates towards either the IFB A or Vacuum Building Ramp Sump and foundation drains. Groundwater from PN U5-8 flows to the Turbine Auxiliary Bay foundation drains, which is a hydraulic sink (EcoMetrix, 2012). Groundwater originating from these sources is monitored and not discharged directly to Lake Ontario."*

This statement confirms that very high levels of tritium contamination in excess of 3,000,000 Bq/L (even higher than reported by Greenpeace!) are found in groundwater at the PNGS. The subsequent statements confirm that this highly contaminated groundwater is likely being picked up in foundation drains - it is my understanding that water collected from the foundation drains is ultimately discharged to Lake Ontario without treatment.

I also found one additional specific reference to groundwater contamination at the PNGS (in the 2017 OPG Licence Application), which indicated at the bottom of page 84 that:

> *".. elevated tritium concentrations in groundwater were observed at the Pickering 5-8 Irradiated Fuel Bay area, with a maximum tritium concentration of 3.96 x 10_6 (ie. 3,960,000 Bq/L) in 2013 with a downward trend at the end of 2016."*

These very high groundwater tritium levels in excess of 3,000,000 Bq/L are not consistent with the tritium leaks/spills from 1979 and 1994 (referenced at the top of this page) - they are much higher. What this means is that there have been other sources of major tritium contamination to the groundwater flow system at the PNGS.

It is clear that the aforementioned 2 major and publicly known spills are clearly not the only spills/leaks of tritiated water into the groundwater flow system. There have been many other leaks and spills of tritium and other contaminants into the groundwater system at the PNGS. These spills and leaks are apparently not simply due to honest operator error, given that page 89 of a 2007 Report on the PNGS by Golder Associates Ltd. indicated that:

> *"There were historic waterborne releases and/or leaks of radioactivity from the active plant systems that circumvented the associated containment systems that are in place due to lack of maintenance and/or repair of these systems".*

In the same report in Figures 21a through 21e I found groundwater contaminant plume maps for tritium, which revealed that in fact peak tritium levels in groundwater at the PNGS were in excess of 30,000,000 Bq/L throughout the years of 2001 - 2005. Yet all that OPG is reporting publicly on its website are the unconcerning levels of <6,000 Bq/L in selected (perimeter) monitoring locations. I find this troubling from many different perspectives.

The 2007 Golder Hydrogeology Report confirmed my expectation that tritium is the critical contaminant in groundwater at this site - ie. that it is widespread, and present at high levels relative to the drinking water limit (which is 7,000 Bq/L).

I was distressed to also find numerous references in the 2007 Golder Report to a concerning practice on the part of CNSC as the regulator of this and other nuclear sites. The report indicates that apparently the Canadian Nuclear Safety Commission (CNSC) has "approved" a *"tritium in non-potable groundwater"* criterion of 3,000,000 Bq/L, which applies to historical tritium malfunctions and accidents. In essence, the CNSC appears to have provided OPG with a "forgive and forget" criterion which allows the company to shrug off all but the very worst incidents of tritium contamination.

I have searched on-line but not been able to find a CNSC technical document which lists this criterion and provides a rationale for its use at the PNGS (and other nuclear facilities). As far as I can tell the 3,000,000 Bq/L criterion does not appear to have any rational basis - given that it is 428.571 times the drinking water standard for tritium (of 7,000 Bq/L). This leaves me wondering if CNSC staff simply invented a criterion to assist nuclear plant operators by forgiving all but the very worst incidents of tritium contamination at their facilities.

On behalf of my clients I would like to request that the CNSC should please provide full disclosure and all available documentation regarding the aforementioned tritium criterion, including:

- when and how it was developed;
- the scientific basis for its development;
- whether it has been formally adopted by the CNSC; and if so then
- public consultation (if any) which was carried out before it was adopted.

It should be noted that aside from tritium there are other potential groundwater contaminants at the PNGS as well - both radioactive and non-radioactive. In the absence of proper disclosure of groundwater monitoring data by OPG, I also have grave concerns about the current levels of groundwater contamination by other contaminants at the site - it is possible that they are likewise being kept hidden from the public because they are very high.

It is difficult to develop an understanding of the extent or significance of the ongoing groundwater flow system contamination at the PNGS, given OPG's refusal to release current and useable monitoring data. There is no way to determine the dimensions of the contaminant plume(s) or contaminant transport rates in the groundwater flow system in the absence of the information which is being withheld by OPG. But one thing I can say for certain based on basic hydrogeological principles, is that at the PNGS all of the contaminated groundwater eventually ends up in Lake Ontario.

c) Pathways for Groundwater Contamination to Reach Lake Ontario

Interestingly, the 2017 ERA Report does not consider groundwater in its risk assessments. To the extent that there is one, the "rationale" for this astonishing oversight is provided in the discussions in Sections 3.1.2.4, 3.1.2.7, 4.1.3.4, and 4.1.3.10 of the 2017 ERA Report - and it appears to boil down to assertions that there are no pathways by which groundwater contamination could reach the natural environment.

No attempt is made in the 2017 ERA Report to properly list possible pathways, and then explore their potential efficacy in moving groundwater contamination to ecosystem receptors. This replicates the approach taken in the prior 2014 ERA Report.

It is suggested on page 3.18 of the 2017 ERA Report that the groundwater contamination on-site at the PNGS doesn't need to be considered, because groundwater fluxes to Lake Ontario are "small". However this is not a sound argument, as it ignores inflows of groundwater to the site's various foundation drains and the leakage of contaminated groundwater into the site stormwater management system. Both pathways will facilitate much more rapid movement of groundwater (and contaminants) to Lake Ontario than would occur along groundwater flow paths.

4) The PNGS Site Stormwater Management System

a) Introduction

Together with groundwater flow, the flow of stormwater through the PNGS provides a second pathway by which subsurface radiological and non-radiological contaminants (from historical leaks and spills of contamination at the site) can be mobilized and carried into Lake Ontario.

Stormwater runoff from the PNGS site is collected by the site stormwater drainage system, and directed through various drainage paths which all ultimately feed the water into Lake Ontario. Stormwater drainage occurs via a variety of ditches, swales, culverts and storm sewers.

Stormwater runoff from an older industrial facility like the PNGS is often a significant but overlooked pathway by which contaminants can be mobilized and transported into the nearest off-site water body (in this case, Lake Ontario).

The various parts of the site's stormwater management system (especially the subsurface components) will profoundly affect groundwater/contaminant movement at the PNGS. The subsurface pipes and conduits are typically put down in beds of sand or very fine gravel, and this bedding will have a higher permeability than all of the groundwater layers described previously except for the foundation fill.

Over time the subsurface infrastructure of the stormwater management system will have developed leaks, which may allow inflows of contaminated groundwater <u>into</u> parts of the system at times of the year when groundwater levels are higher.

Where it is leaking, the stormwater collection system has the potential to be acting as a series of high-permeability conduits for groundwater contamination captured by the system from affected parts of the PNGS site to rapidly travel to and discharge into Lake Ontario.

Contaminant levels in the storm sewer system will vary across the site and through time. There is a likely a seasonal component to the amount of contaminants being transmitted through various parts of the system, and there will also likely be surges of contamination related to storm events and their aftermath.

Based on the information available to me, I anticipate that OPG does not have a good understanding of the degree to which contaminants at the PNGS are being transported down storm sewer lines and/or through the granular bedding of the lines.

I had requested proper mapping and description of these features from OPGS, but have not been provided with anything allowing a systematic assessment of this pathway for contaminant movement. The 2017 ERA Report provides an overview map of the stormwater catchment areas for the PNGS (in Figure 2.17), but the map does not show the components of the stormwater system or all of the outfalls.

<u>b) Frequency of Sampling, and Availability of Results</u>

As far as I can tell, there is no program of annual monitoring of the PNGS stormwater system for radiological or non-radiological contaminants. Ongoing monitoring of the stormwater management system appears to be minimal or non-existent - instead there are sporadic and inconsistent monitoring campaigns.

Following is a summary of stormwater monitoring done at the PNGS (based on information provided in the 2014 ERA and 2017 ERA Reports):

- there was stormwater monitoring done in 1990/1991
- no monitoring done in 1992
- no monitoring done in 1993
- no monitoring done in 1994
- there was stormwater monitoring done in 1995/1996
- no monitoring done in 1997
- no monitoring done in 1998
- no monitoring done in 1999
- there was stormwater monitoring done in 2000/2001 (at 14 locations)
- there was follow up stormwater monitoring done in 2002
- no monitoring done in 2003
- no monitoring done in 2004
- no monitoring done in 2005
- there was stormwater monitoring done in 2006 (at 6 locations)
- no monitoring done in 2007
- no monitoring done in 2008
- no monitoring done in 2009
- no monitoring done in 2010
- no monitoring done in 2011
- no monitoring done in 2012
- no monitoring done in 2013
- no monitoring done in 2014
- there was stormwater monitoring done in 2015/2016 (at 11 locations)

In my professional opinion, this infrequent and sporadic monitoring of stormwater quality is unacceptable for a modern nuclear power generating station. Stormwater quality monitoring should be done at least 4 times annually, and should be done on every stormwater discharge line for the site.

The stormwater monitoring results which are publicly available are provided in Appendix A of the 2014 ERA Report (for 2002/2006) and in Appendix F of the 2017 ERA Report (for 2015/2016). This is only a fraction of the stormwater monitoring which has actually been done at the site.

From my perspective, not nearly enough stormwater monitoring has been done. But even for the monitoring that has been done, only a fraction of the data are actually publicly available.

Notable by their absence in the publicly available results (in Appendix A of the 2014 ERA Report) are the data for MH211 in Catchment 3 for 2001 - when a sample of stormwater failed a toxicity test. Apparently the failed 2001 toxicity test prompted further testing in 2002 (when 1 of 4 toxicity tests failed), and for 2006 (when 3 of 4 toxicity tests failed). It should be noted that MH211 was the only location to have toxicity testing done in 2002 or 2006.

No further information is provided about the failed toxicity tests for MH211, but usually a failed toxicity test means that a majority of the test organisms (rainbow trout and daphnia magna) did not survive for 48 hours in the water being tested. What this implies is that in multiple testing campaigns the stormwater from Catchment 3 (in MH211) was found lethal to aquatic life. And yet the ERA concluded that there was no need to do anything - and there was no further sampling or toxicity testing after 2006 (when 3 of 4 samples failed the testing) until 2015.

The significance of these failed toxicity testing results is discussed further in the next section of this report.

c) Stormwater Management System Monitoring Results

There was no stormwater monitoring data in OPG's 2017 Licence Application, but I was pleased to find actual stormwater monitoring data from 2002 and 2006 in Appendix A of the 2014 ERA Report, and from 2015/2016 (from the first stormwater monitoring campaign in 9 years) in Appendix F of the 2017 ERA Report.

The 2017 ERA Report provides a very brief description of what is happening in each catchment in Section 3.1.2.2.3 of the report. The description is similar to one provided in the 2014 ERA Report.

There is little in the way of substantive interpretation of the significance of the stormwater collection system monitoring results for this stormwater quality testing in the 2017 ERA Report, or in the 2014 ERA Report (which astoundingly concluded that "*the stormwater is not toxic*" - despite hard evidence to the contrary). However based on my review of the available information I can offer the following observations:

i) **There is solid evidence that contaminated groundwater is getting into parts of the stormwater collection system at the PNGS.** Tritium levels in the stormwater collection system in 2015/2016 were as high as 39,600 Bq/L in MH211 in Catchment 3 - many times higher than the tritium levels found in the rainfall being collected by the system, which implies that significantly contaminated groundwater from the site is getting into the system.

There were also stormwater collection system tritium levels of up to 35,300 Bq/L at MH20 in Catchment 5 - again many times higher than the tritium levels found in the rainfall being collected by the system, and likewise implying that significantly contaminated groundwater at the site is getting into the system.

ii) **The peak levels of contamination in the stormwater collection system are worsening in places.** The highest levels of tritium at MH211 reported in the 2014 ERA Report (for samples taken in 2002 and 2006) were 14,430 Bq/L and 11,433 Bq/L - by 2015 the highest levels were 39,600 Bq/L.

iii) **Of the stormwater collection system lines which were sampled, the key hot spot is at MH211 in Catchment 3.** At MH211, peak tritium levels of 39,600 Bq/L were recorded in 2015. Zinc levels up to 17 times the Provincial Water Quality Objective (PWQO) and copper levels of over 8 times the PWQO were also recorded at MH211. Cadmium was also above the PWQO.

Water at MH211 is toxic, with a failed toxicity test in 2001, apparent failures of 1 of 4 toxicity tests in 2002, and in 2006 (when 3 of 4 toxicity tests failed). Astonishingly, the 2014 ERA Report (which lists the 2002 and 2006 results) reached the general conclusion on page 3.16 that "*the stormwater is not toxic; therefore stormwater is not discussed further in this ERA*".

In the June 11, 2016 monitoring event 30% mortality of rainbow trout was noted for testing at MH211. This means the 30% of the fish would have perished after exposure to the water for 48 hours. It should be noted that the stormwater from MH211 discharges straight into Lake Ontario.

The stormwater collection line being sampled at MH211 offers an obvious target for remediation by OPG. There is no excuse for not doing so. Water quality in this line is unacceptable for discharge into Lake Ontario.

iv) **Stormwater collection system water quality was also poor in Catchment 5.** Peak tritium levels of 35,300 Bq/L were noted in MH20 for October 28, 2015. Zinc levels of over 12 times the PWQO (in MH20) were also recorded at MH20 in 2015, and copper levels of over 4 times the PWQO were recorded at CB70 in Catchment 5.

On the date of the high copper levels at CB70, there was 100% mortality of daphnia magna and rainbow trout for a water sample taken from CB70. The 2017 ERA Report's conclusion with regard to the toxicity test failure was that "*this water is redirected into the station; therefore, it was not considered of concern*".

The rationale behind this conclusion should please be explained in detail by OPG. Stormwater from Catchment 5 discharges into the forebay, and my understanding of the once-through system used at Pickering is that water from the forebay passes through the PNGS without treatment prior to discharge to Lake Ontario.

The stormwater collection system in Catchment 5 offers an obvious target for detailed further investigation, and for remedial action (to be determined depending on the findings of that investigation).

v) **The majority of stormwater monitoring system monitoring results were acceptable.** In the discussion above I have highlighted the problem areas - but the majority of the test results were acceptable with only minor impairment evident.

d) Recommendations for Future Stormwater Monitoring at the PNGS

Stormwater monitoring at the PNGS is inconsistent and inadequate. The years-long gaps between stormwater monitoring campaigns are unacceptable. The inconsistency in the number of stormwater collection system sampling points (14 in 2000/2001, 6 in 2006, 11 in 2015/2016) is also very problematic. Quarterly water quality monitoring should be done on every line which is discharging to the forebay, the outfalls, or directly to Lake Ontario.

As a first step, an inventory of stormwater collection lines needs to be developed and flows of water in those lines need to be metered. Particular attention needs to be paid to any lines which are always flowing, as this should not be occurring in a system which is collecting only stormwater.

Toxicity testing should be done on every line for every sampling event. For lines which are consistently showing zero mortality, the frequency of toxicity testing can be stepped down to annually after 3 years of passing test results.

The parameter lists being used for stormwater monitoring are reasonable, however in the event of failed toxicity testing results the scope of the testing should be increased to include:

- volatile organic chemicals (VOCs);
- polynuclear aromatic hydrocarbons (PAHs);
- hydrazine and morpholine;
- additional radionuclides.

Adverse test results and in particular failed toxicity tests should prompt immediate further investigation, with the goal of remediation of the issue(s) allowing contaminated and/or toxic stormwater to be discharged to Lake Ontario via the stormwater collection system.

5) Issues Pertaining to the PNGS Water-Related Site Monitoring Programs

a) Introduction

There are a large variety of liquid discharge flows from the PNGS. Most of these are monitored to some degree through various monitoring programs (eg. as required by the CNSC Site Licence, MISA, ECA monitoring etc.). While I think more monitoring should be required in many instances, at least the discharge flows have been identified by the regulatory authorities and monitoring is being done.

However there are two interrelated problems of unknown magnitude which I have identified in this report - namely: 1) the heavy groundwater contamination at the PNGS, and 2) the contamination of some stormwater discharge lines, which are most likely due to inflows of contaminated groundwater.

Monitoring of these two interrelated problem areas (groundwater contamination and stormwater discharges to the lake) is my key concern at the present time, but the other water-related monitoring programs are also listed below and discussed.

Following is a list of the various water-related monitoring programs for the PNGS, together with my understanding of the nature and results of the current monitoring and my go-forward recommendations for future monitoring.

I apologize in advance for any factual errors - where such errors crop up, it will be because of the remarkable lack of transparency on the part of OPG in regard to its current water quality monitoring programs at the PNGS. For example, there is no document which I am aware of which lays out in a straight-forward and rational fashion the programs of water quality-related monitoring currently being done at the PNGS.

b) Lake Water Quality Monitoring

The 2016 EMP Report indicates that the only regular lake water quality monitoring being done at the PNGS is done for tritium. There are 2 types of tritium testing of Lake Ontario water being done:

i) Tritium testing of Lake Ontario water is done at nearby water supply plants (WSPs) as follows:

- weekly composites (of daily samples) are taken from 4 nearby WSPs (R.C. Harris, Horgan, Ajax, Whitby) which draw their water from Lake Ontario, and are tested for the presence of tritium only;
- the nearest of these water supply plants is 7 km from the PNGS.

ii) Tritium testing of Lake Ontario water is done at nearby beaches as follows:

- monthly grab samples are taken from 3 nearby beaches (Beachfront Park, Frenchman's Bay, and Squires Beach) and analyzed for tritium only;
- Beachfront Park and Frenchman's Bay Park are immediately to the west of the PNGS, and Squires Beach is immediately to the east of the PNGS.

I support the above testing. It is good that it is being done. But more detailed testing of Lake Ontario water quality in close proximity to the PNGS should be done on a regular basis.

I recommend additional water quality sampling of Lake Ontario, with samples to be taken at Beachfront Park, Frenchman's Bay West Park, and Squires Beach and tested as follows:

- quarterly testing for copper, zinc, morpholine, and hydrazine;
- annual testing for the full list of parameters presented on Table F.1 of the 2017 ERA Report.

The Lake Ontario water quality monitoring data presented in the 2004 and 2007 ERA Reports and in the 2016 EMP Report indicates that Lake Ontario water quality was generally good on the dates sampling was done.

To provide ongoing confirmation that this is the case, I would like to see the changes which I have recommended above implemented on a go-forward basis.

c) Monitoring of Discharges from Final PNGS Pickering A and Pickering B Outfalls

There are two outfalls which convey "inactive" (ie. non-radioactive) water from the PNGS back to Lake Ontario - one for Pickering A, and one for Pickering B. The outfalls have average flows of about 60,000 and 145,000 Litres per second respectively. As a result, there is massive dilution of the PNGS inputs to the outfalls.

Testing of water quality in the outfalls is governed by the Environmental Compliance Approval (ECA) for the site, which is issued by the Ontario Ministry of the Environment and Climate Change (MOECC).

There is weekly testing of the water from each outfall for the following parameters:
- unionized ammonia;
- hydrazine and morpholine;
- pH
- total residual chlorine

I support this testing frequency and the parameters being tested. If not being done, then I recommend that tritium and gross beta/gamma be added as parameters in the weekly testing of the outfall water quality. I also recommend that the outfall water quality testing should be done at a point downstream of all inputs from the PNGS.

I have not been able to access the monitoring data for the outfall testing so I am not in a position to comment on current or historic results

d) Monitoring of Waterborne Radionuclide Releases to Lake Ontario

Table A.3 of the Quarterly Environmental Emissions Data reports indicates that waterborne radionuclide releases from PNGS Units 1-4 are analyzed monthly for:
- Tritium;
- Gross Beta/Gamma.

Table A.3 also indicates that waterborne radionuclide releases from PNGS Units 5-8 only are analyzed monthly for:
- Tritium;
- Gross Beta/Gamma;
- Carbon-14;
- Gross Alpha.

I could not find any details in the quarterly reports or in the License Conditions Handbook on how these analyses are done. I recommend that the quarterly reports should provide a transparent explanation for how the data being presented in Table A.3 are obtained.

The waterborne radionuclide releases from PNGS generally met the discharge criteria in the reports which I was able to review.

e) Groundwater Monitoring Program

The groundwater monitoring program for the PNGS is shrouded in secrecy and mystery. There is no public disclosure of which monitoring wells and monitoring points are being sampled, nor is there disclosure about the frequencies of monitoring at any given location, nor the list of parameters being tested for at any given location.

The current situation is untenable and unacceptable, and raises the question of what OPG may be hiding?

I find it very hard to believe and accept that OPG is being so unreasonably secretive about groundwater contamination at the PNGS, and that CNSC staff are allowing this to occur. As regulator the CNSC has a responsibility to the Canadian public to ensure that nuclear station monitoring program details and monitoring data are publicly accessible and available.

In the almost complete absence of relevant information, I am unable to make any recommendations regarding the specifics of the groundwater monitoring program. I do however have two general recommendations:

i) The CNSC should order OPG to provide full public disclosure of historic and current PNGS groundwater monitoring data (including provision of full copies of Annual Monitoring Reports if requested), commencing immediately.

ii) I recommend that OPG be required to fund a full, independent Peer Review of the historic and current results of its groundwater monitoring program. The Peer Reviewer should report to the CNSC, and their report should provide:

- an overview of historic groundwater quality results and their implications;
- recommendations on how to improve the groundwater monitoring program on a go-forward basis;
- recommendations on how to optimize the provision of transparent and publicly accessible reporting of the results of the groundwater monitoring program.

It should be noted that there is considerable value in regularly testing groundwater quality at a major facility like the PNGS. A properly designed and overseen groundwater quality monitoring can provide warning signs of problems as they are developing, and before they become major issues.

f) Stormwater Quality Monitoring Program

My understanding is that there is currently no annual stormwater quality monitoring program for the PNGS. This is an oversight which is based on poor historic practices and inadequate regulatory oversight, and which should not be allowed to continue.

While most of the monitoring results for the stormwater quality testing which I was able to obtain appear to indicate that much of the system is generally in good condition, there are certainly two areas of significant concern as discussed in **Section 4b**) of this report. My recommendations regarding stormwater quality monitoring were provided in **Section 4c**) of this report.

It is well worthwhile for OPG to take a more proactive and systematic approach to monitoring of the stormwater collection lines at the PNGS. A properly designed and overseen stormwater quality monitoring program can provide warning signs of problems as they are developing, and before they become major issues.

6) Discussion

Working on this Independent Report on hydrogeological issues pertaining to the application for a 10-year license extension for the Pickering Nuclear Generating Station (PNGS) has been a unique and frustrating experience.

Due to the obstructionism and obfuscation of OPG, I have not been able to write the report I was funded to prepare by the CNSC and hired to prepare by my clients.

There are major gaps in my analysis of the water-related issues pertaining to the PNGS - I had been hoping that my analysis would provide a broad overview of the current status of the PNGS, the quality of its discharges to Lake Ontario, and its impacts on the lake. I have done the best I could under the circumstances, and I apologize to my clients that I could not complete the report which I had been intending to write.

The problems I encountered in obtaining technical data and information from OPG have certainly given me a poor impression of this company, and raised significant questions about its ability to responsibly manage Canada's oldest and most accident-prone commercial nuclear power plant.

Through the external research I found myself driven to conduct I learned about two major contaminant releases to the groundwater flow system (as outlined at the top of **page 10** of this report). It is clear from the information which I was subsequently able to glean about groundwater quality at the site, that the PNGS has a long and checkered history of spills and leaks into the on-site groundwater flow system.

Even more concerning for me in my review of external information, were the reports of other major incidents including contaminant releases to Lake Ontario. The 2001 Senate Standing Committee report stated the following about the PNGS:

> *"In 1994, Pickering A was the site of Canada's worst accident at a commercial nuclear station. On December 10, 1994, a pipe break at Pickering reactor 2 resulted in a major loss of coolant accident and a spill of 185 tonnes of heavy water. The Emergency Core Cooling System was used to prevent a meltdown. About 200 workers were involved in the cleanup. The reactor was restarted 14 months later.*
>
> *Throughout its operation, Ontario Hydro reported other significant events at the Pickering station to the AECB. Among them were the following:*
> - *On August 1, 1983, Pickering reactor 2 had a loss of coolant accident after a pressure tube suffered a metre-long rupture. The station was shut down and the four reactors at Pickering A were eventually retubed at a cost of about $1 billion.*
> - *On November 22, 1988, an operator error damaged 36 fuel bundles. The cooling system was contaminated by radioactive iodine that was vented into the environment over several weeks following the accident.*
> - *On September 25, 1990, Pickering reactor 2 experienced large power shifts in the reactor core. Staff spent two days trying to stabilize it before shutting it down. The AECB later criticized the utility for not shutting down immediately.*
> - *On August 2, 1992, Pickering reactor 1 had a heavy water leak from a heat exchanger that resulted in a release of 2,300 trillion becquerels of radioactive tritium into Lake Ontario.*
> - *On April 15, 1996, Pickering reactor 4 had a heavy water leak from a heat exchanger that resulted in a release of 50 trillion becquerels of tritium into Lake Ontario."*

The CNSC is being asked to provide OPG with a 10-year licence renewal. Under the circumstances and given this site's history I believe that granting the requested licence renewal would be a significant mistake.

If one only reads the documents prepared by OPG, then on paper this looks like a model nuclear plant - and one for which a longer-term licence extension could be considered.

One of the very interesting things about the science of hydrogeology is that site-specific hydrogeological water quality monitoring data can provide a long-term and in-depth look at the history of the facility being monitored, and can provide detailed insights into a variety of site design issues and operational practices.

For the PNGS virtually all recent/relevant groundwater monitoring data have been withheld by OPG. It is possible that this may be because of concerns about what the data might reveal about the site's operational history to knowledgeable reviewers.

7) Conclusions

1) Ontario Power Generation (OPG) has submitted an application for a 10-year license renewal for the Pickering Nuclear Generating Station (PNGS).

2) I was funded to conduct a technical review of the OPG licence renewal application, and retained to do so by my clients (Swim Drink Fish Canada / Lake Ontario Waterkeeper). Due to very unfortunate obstructionism on the part of OPG, I have been unable to deliver the report which I had been intending to write. Details of the problems encountered with OPG are discussed throughout this report, and listed in detail in **Appendix 1** of this report.

3a) Stormwater runoff from the PNGS site is collected by the site stormwater drainage system and directed through various drainage pathways southward toward Lake Ontario. Stormwater drainage occurs via a variety of ditches, swales, culverts and storm sewers.

3b) The stormwater management system discharges either directly into Lake Ontario, or into the cooling water outfalls or the PNGS forebay - it is my understanding that in all instances, the site stormwater is not treated and ultimately ends up in the lake.

4a) A shallow groundwater flow system is present in the near-surface overburden materials (construction fill and/or Upper Till) at the site. Given its proximity to the ground surface, the shallow flow system will be the most badly contaminated groundwater unit at the site.

4b) The stormwater collection system for the PNGS is conveyed down pipes and culverts which run through the oft-contaminated shallow overburden materials, and where there are breaks and leaks it may be possible for contaminated groundwater to leak into the system.

5) Groundwater flow directions on the PNGS property will be dominated by the deep reactor building foundation drains and the deep drains beneath the Turbine Auxiliary Bay, which have depressed groundwater levels in their vicinity to below the Lake Ontario water level. Groundwater flow will be toward these features from their surroundings. The fill in the area of the reactors will be high-permeability gravel, which will drain very efficiently.

6a) OPG refused to provide its annual groundwater monitoring reports and other recent hydrogeology-related information, but it is clear through information gleaned from a variety of sources that the groundwater at the PNGS is badly contaminated. Tritium is the critical contaminant, but there are also other potentially hazardous industrial chemicals contaminating parts of the on-site groundwater flow system.

6b) It is difficult to develop an understanding of the extent or significance of the ongoing contamination of the groundwater flow system at the PNGS, given OPG's refusal to release current and useable monitoring data. There is no way to determine the dimensions of the contaminant plume(s) or contaminant transport rates in the groundwater flow system in the absence of the information which is being withheld by OPG. But basic hydrogeological principles dictate that at the PNGS all of the contaminated groundwater eventually ends up in Lake Ontario.

7) Much of the stormwater collection system (at least in those lines which were sampled and reported on in the 2014 and 2017 ERA Reports) appears to be in reasonable shape, with test results showing only minor and insignificant impairment of water quality.

8a) There is solid evidence that contaminated groundwater is getting into parts of the the stormwater collection system, and it appears that the contamination is worsening. Collection lines in 2 catchments (MH211 in Catchment 3, and MH20 and CB70 in Catchment 5) require investigation followed by remediation to stop the flow of contaminated water into Lake Ontario.

8b) There is currently no ongoing program of stormwater quality monitoring at the PNGS. My recommendations regarding stormwater quality monitoring are provided in **Section 4c**) and in **Recommendation 2** of this report.

9) Issues pertaining to the water-related current and proposed PNGS site monitoring programs are discussed in **Section 5** of this report. The available information on lake water quality monitoring which has been done recently suggests that lake water quality is good in the proximity of the PNGS, however it is recommended that additional monitoring measures be added to the site monitoring programs (as outlined in **Section 5**).

10) The CNSC is being asked to provide OPG with a 10-year licence renewal. Under the circumstances and given this site's history I believe that granting the requested 10-year licence renewal would be a significant mistake.

8) Recommendations

Recommendation 1)

A 2007 Golder Associates Ltd. report indicates that apparently the Canadian Nuclear Safety Commission (CNSC) has "approved" a *"tritium in non-potable groundwater"* criterion of 3,000,000 Bq/L, which applies to historical tritium malfunctions and accidents.

The CNSC should provide full public disclosure and all available documentation regarding the aforementioned tritium criterion, including:

- **when and how it was developed;**
- **the scientific basis for its development;**
- **whether it has been formally adopted by the CNSC; and if so then**
- **public consultation (if any) which was carried out before it was adopted.**

Recommendation 2)

a) **Quarterly water quality monitoring should be done on every stormwater collection line which is discharging to the forebay, the outfalls, or directly to Lake Ontario.**

b) **As a first step, an inventory of stormwater collection lines needs to be developed and flows of water in those lines need to be metered. Particular attention needs to be paid to any lines which are always flowing, as this should not be occurring in a system which is collecting only stormwater.**

c) **Toxicity testing should be done on every line for every sampling event. For lines which are consistently showing zero mortality, the frequency of toxicity testing can be stepped down to annually after 3 years of passing test results.**

d) **The parameter lists being used for stormwater monitoring are reasonable, however in the event of failed toxicity testing results the scope of the testing should be increased to include:**
   - **volatile organic chemicals (VOCs);**
   - **polynuclear aromatic hydrocarbons (PAHs);**
   - **hydrazine and morpholine;**
   - **additional radionuclides.**

e) **Adverse test results and in particular failed toxicity tests should prompt immediate further investigation, with the goal of remediation of the issue(s) which are allowing contaminated and/or toxic stormwater to be discharged to Lake Ontario via the stormwater collection system.**

Recommendation 3)

a) **Additional water quality sampling of Lake Ontario is recommended, with samples to be taken at Beachfront Park, Frenchman's Bay West Park, and Squires Beach and tested as follows:**
   - **quarterly testing for copper, zinc, morpholine, and hydrazine;**
   - **annual testing for the full list of parameters presented on Table F.1 of the 2017 ERA Report.**

b) **If not being done, then it is recommended that tritium and gross beta/gamma be added as parameters in the weekly testing of the PNGS outfall water quality. It is also recommended that the outfall water quality testing should be done at a point downstream of all inputs from the PNGS.**

c) **Table A.3 of the Quarterly Environmental Emissions Data reports indicates that waterborne radionuclide releases from the PNGS are analyzed monthly for Tritium, Gross Beta/Gamma, Carbon-14, and Gross Alpha. It is recommended that the quarterly reports should provide a transparent explanation for how the data being presented in Table A.3 are obtained.**

d) **It is recommended that the CNSC order OPG to provide full public disclosure of historic and current PNGS groundwater monitoring data (including provision of full copies of Annual Monitoring Reports if requested), commencing immediately.**

e) **It is recommended that OPG be required to fund a full, independent Peer Review of the historic and current results of its PNGS groundwater monitoring program. The Peer Reviewer should report to the CNSC, and their report should provide:**
   - **an overview of historic groundwater quality monitoring results and their implications;**
   - **recommendations on how to improve the groundwater monitoring program on a go-forward basis;**
   - **recommendations on how to optimize the provision of transparent and publicly accessible reporting of the results of the groundwater monitoring program.**

Recommendation 4)

It is recommended that the CNSC should not approve the requested 10-year licence renewal for the PNGS. The CNSC could consider a much shorter (at most 2-year) renewal to allow OPG sufficient time to get its water-related monitoring programs in order and delivering needed data, before submitting a new longer-term licence renewal application.

9) Signature and Professional Stamp

This independent report has been prepared in its entirety by Wilf Ruland (P. Geo.). It is based on my honest conviction and my knowledge of the matters discussed herein following careful consideration and review of the knowledge and information available to me at this time regarding the Pickering Nuclear Generating Station (PNGS) and the OPG application for a 10-year license renewal for the PNGS

This Review has been prepared for the use of my clients, Swim Drink Fish Canada / Lake Ontario Waterkeeper.

Signed on the 18th day of April, 2018

Wilf Ruland (P.Geo.)

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Dundas, Ont.
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Appendix 1

Summary of Interactions with OPG and CNSC Staff

regarding Provision of Information

and Requested Site Tour and Technical Meeting

Following is a summary of our interactions/requests with OPG and CNSC staff, regarding the provision of requested technical information and the requested site tour and technical meeting.

This was in the matter of Swim Drink Fish Canada's intervention before the CNSC concerning the Pickering Nuclear Generating Station Licence Renewal.

March 7, 2018
Waterkeeper requested:
- the current licence conditions handbook for the PNGS;
- the current *Fisheries Act* authorization to operate the PNGS' once-through cooling water system;
- any plans concerning how the once through cooling water system will be managed during the PNGS' decommissioning process; and
- more information concerning the installation of appropriate emissions monitoring equipment at the facility since 2013 (it appears as though OPG was required to improve its emissions sampling for the site sometime between 2008 and 2010, and that improvements were yet to be implemented by 2013 when Waterkeeper intervened in the last licence renewal hearing for the facility).

March 8, 2018
Waterkeeper received confirmation of receipt from OPG, and a note that should further clarification be required they would be in touch.

March 26, 2018
Sent a follow up email to OPG, noting no responses had been received to date, inquiring about the delay, and offering to provide any further assistance that may be helpful.

March 26, 2018
Waterkeeper received a link from OPG to the DFO permit and an attachment with the PNGS current Licence Condition Handbook.

March 26, 2018
Waterkeeper inquired about whether there had been any other DFO permits.

March 26, 2018
OPG confirmed the sent permit was the facility's first and only one.

March 28, 2018
OPG requested clarification concerning Waterkeeper's request concerning the installation of additional monitoring equipment at the facility since 2013.

March 29, 2018
Waterkeeper undertook to provide clarification the following week.

April 6, 2018
Waterkeeper clarified that additional sampling seemed to have been required by the CNSC after 2008, namely: reactor service water monitoring through radiological and non-radiological samplers (which were expected to be installed in 2013), as well as stack monitors for air emissions, and tritium samplers.
Waterkeeper requested whether any of these additional types of monitoring equipment been installed at the PNGS since 2013, explaining the question was a follow-up item from the organization's last intervention during the 2013 PNGS licence renewal hearing.

April 10, 2018
OPG requested CNSC or OPG pinpoint references to support Waterkeeper's request.

April 10, 2018
Waterkeeper undertook to look into finding pinpoint references.

April 16, 2018
Waterkeeper requested:
- a map showing all stormwater outfalls to the lake
- a list of those outfalls, indicating which are being sampled for water quality and results (or reference to where results may be found)
- a map showing all lines carrying liquid discharges of any kind to the lake (be it for cooling water or other liquid discharges)
- a list of those liquid discharge lines, indicating which are being sampled for water quality and results (or reference to where results may be found)
- annual groundwater quality monitoring reports for the 2 most recent years available

Waterkeeper also requested a site visit of the PNGS for the 24th or 25th of April.

April 16, 2018
OPG asked which parts of the site Waterkeeper would want to see.

April 18, 2018
Waterkeeper noted it was hard to say exactly where on the site Ms. Feinstein and Mr. Ruland needed to go, as Waterkeeper had not yet received the maps requested on the 16th.

However, as the organization was interested in groundwater, surface water and storm water flows, and all liquid discharge flows to the lake, they would want to see:
- general lay of the land around the facility and in particular closest to the lake;
- locations of the monitoring groundwater monitoring wells closest to the lake;
- locations of all storm sewer outfalls;
- locations of all liquid discharge pipes (eg. cooling water and anything else) leading toward or into the lake;
- any waste management facilities on the PNGS property.

April 19, 2018
Waterkeeper requested:
1) More information concerning events when the barrier net has failed. In particular, whether the net is becoming fouled with algae and then getting pulled underwater so fish swim over the top. Please share any event or monitoring reports or other sources containing this information;
2) More information, including any event or monitoring reports. concerning the frequency of events when cooling water flow is reduced resulting in a spike in discharge temperatures; and
3) Copies of, or at least more detailed information concerning, chlorination and other biofouling prevention procedures for the cooling water system at the PNGS.

Waterkeeper also inquired about when it could expect responses to these and the information requests sent on April 16.

April 23, 2018
OPG notified Waterkeeper the PNGS environmental group could not accommodate Waterkeeper's dates and would propose alternative dates

April 23, 2018
Waterkeeper explained the importance of the site visit and requested information, noting both were crucial to ensure its intervention was as helpful as possible to the CNSC, OPG, and general public and requested a site visit later that week or the next

April 25, 2018
Waterkeeper wrote to follow up with OPG as it had not received alternative dates. Waterkeeper proposed its own additional dates to assist with the process. Waterkeeper also reminded OPG of our May 7th deadline, requesting information before this date.

April 26, 2018
Waterkeeper wrote to the CNSC Secretariat expressing concern at not receiving any information from OPG to date and asking whether staff had any of the requested information in their files that they may be able to share.

April 26, 2018
OPG undertook to provide responses to "as many of [Waterkeeper's} questions as possible" by May 2, 2018.

May 2, 2018
OPG provided responses to some of Waterkeeper's information requests.

Waterkeeper followed up about a possible site visit.
Waterkeeper wrote to request an extension from the CNSC Secretariat so as to incorporate OPG responses in its written submissions and to arrange and attend a PNGS site visit.

May 4, 2018
Waterkeeper sent OPG responses to, and expressing concerns with, OPG's initial and problematic May 2 disclosures. In particular, in many cases requested hydrogeology-related information was not provided by OPG and in at least one case incorrect information was provided.

May 7, 2018
OPG confirms receipt of Waterkeeper's concerns about OPG disclosures and undertakes to provide responses in a few days.

May 8, 2018
OPG offered Waterkeeper a site visit on May 10th.
Waterkeeper confirmed and provided the requisite security information and requested itinerary.

May 10, 2018
Site visit at PNGS from 10am – 12:00pm.
Waterkeeper followed-up about when it could expect remaining information from OPG and promised to provide any follow-up questions emerging from the tour.

May 14, 2018
Waterkeeper provided an additional two follow-up questions, namely: confirmation that the PNGS PIPD has not been amended since the PWMF hearing, and whether the chlorine settling basin seen on the site visit contained neutralized chlorine or whether it was the location at which chlorine was being neutralized.

OPG provided additional/more fulsome responses to Waterkeeper's experts initial questions/ information requests. There were still problems with many of the OPG hydrogeology-related disclosures, with some requested information not provided by OPG and in at least one case incorrect information provided..

May 15, 2018
OPG responds to Waterkeeper's PIPD question confirming the document had not been updated since last year's PWMF hearing.

May 16, 2018
OPG responds to Waterkeeper's question noting that dechlorination/neutralization occurs prior to discharge into the setline basin.

Appendix 2

References

References which were considered in the course of preparing this report included the following:

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Standing Senate Committee on Energy, the Environment, and Natural Resources. June 2001. Canada's Nuclear Reactors: How Much is Enough? Interim Report.

Swim Drink Fish Canada / Lake Ontario Waterkeeper. May 7, 2018. Preliminary Submissions of Swim Drink Fish Canada/Lake Ontario Waterkeeper Re: Relicensing Hearing before the Canadian Nuclear Safety Commission (CNSC) for the Pickering Nuclear Generating Station, Notice of Public Hearing, Ref. 2018-H-03.

Appendix III

Summary of correspondences with OPG and CNSC staff

Summary of information requests from Waterkeeper in its intervention before the CNSC concerning the Pickering Nuclear Generating Station Licence Renewal

Below is a record of the interactions between Waterkeeper, OPG, and CNSC staff concerning information requests to date.

March 7, 2018
Waterkeeper requested the current Licence Conditions Handbook from CNSC staff.

March 7, 2018
Waterkeeper requested from OPG:
- the current Licence Conditions Handbook for the PNGS;
- the current *Fisheries Act* authorization to operate the PNGS' once-through cooling water system;
- any plans concerning how the once through cooling water system will be managed during the PNGS' decommissioning process; and
- more information concerning the installation of appropriate emissions monitoring equipment at the facility since 2013 (it appears as though OPG was required to improve its emissions sampling for the site sometime between 2008 and 2010, and that improvements were yet to be implemented by 2013 when Waterkeeper intervened in the last licence renewal hearing for the facility).

March 8, 2018
Waterkeeper received confirmation of receipt from OPG, and a note that should further clarification be required they would be in touch.

March 8, 2018
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March 26, 2018
Waterkeeper sent a follow up email to OPG, noting no responses had been received to date, inquiring about the delay, and offering to provide any further assistance that may be helpful.

March 26, 2018
OPG sent the DFO permit and an attachment with the PNGS current Licence Condition Handbook.

March 26, 2018
Waterkeeper inquired about whether there had been any other DFO permits.

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March 29, 2018
Waterkeeper undertook to provide clarification the following week.

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Waterkeeper clarified that additional sampling seemed to have been required by the CNSC after 2008, namely: reactor service water monitoring through radiological and non-radiological samplers (which were expected to be installed in 2013), as well as stack monitors for air emissions, and tritium samplers. Waterkeeper requested whether any of these additional types of monitoring equipment been installed at the PNGS since 2013, explaining the question was a follow-up item from the organization's last intervention during the 2013 PNGS licence renewal hearing.

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OPG requested CNSC or OPG pinpoint references to support Waterkeeper's request.

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Waterkeeper undertook to look into finding pinpoint references.

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OPG asked which parts of the site Waterkeeper would want to see.

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Waterkeeper noted it was hard to say exactly where on the site Ms. Feinstein and Mr. Ruland needed to go, as Waterkeeper had not yet received the maps requested on the 16th. However, as the organization was interested in groundwater, surface water and storm water flows, and all liquid discharge flows to the lake, they would want to see:
- general lay of the land around the facility and in particular closest to the lake;
- locations of the monitoring groundwater monitoring wells closest to the lake;
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2) More information, including any event or monitoring reports. concerning the frequency of events when cooling water flow is reduced resulting in a spike in discharge temperatures; and

3) Copies of, or at least more detailed information concerning, chlorination and other biofouling prevention procedures for the cooling water system at the PNGS.

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Waterkeeper followed-up about when it could expect remaining information from OPG and promised to provide any follow-up questions emerging from the tour.

May 14, 2018
Waterkeeper provided an additional two follow-up questions, namely: confirmation that the PNGS PIPD has not been amended since the PWMF hearing, and whether the chlorine settling basin seen on the site visit contained neutralized chlorine or whether it was the location at which chlorine was being neutralized.
OPG provides additional/more fulsome responses to Waterkeeper's experts initial questions/information requests.
However, there were still problems with many of the OPG hydrogeology-related disclosures, with some requested information not provided by OPG and in at least one case incorrect information provided. Due to time constraints, Waterkeeper is unable to follow-up with OPG any further.

May 15, 2018
OPG responds to Waterkeeper's PIPD question confirming the document had not been updated since last year's PWMF hearing.

May 16, 2018
OPG responds to Waterkeeper's question noting that dechlorination/neutralization occurs prior to discharge into the setline basin.

Information requests from Peter Henderson, BSc PhD to OPG

Following is a list of information requests from Dr. Henderson to OPG. The original information requests are presented in bold type, the OPG response is below in *italics*, and Dr. Henderson's response is presented below that - again in plain type, and indented. OPG's second responses are below that and indented and italicized again. This document only addresses the first three information requests as subsequent requests were sent from another expert (Mr. Ruland) in this matter.

1) More information concerning events when the barrier net has failed. In particular, whether the net is becoming fouled with algae and then getting pulled underwater so fish swim over the top. Please share any event or monitoring reports or other sources containing this information

OPG annually monitors and reports fish impingement at PNGS to the CNSC. Since 2010, a fish diversion system (FDS) is installed for approximately half the year, from early May to late October, to deter fish from entering the intake and becoming impinged. When deployed, the FDS is highly effective at mitigating fish impingement. The nets that comprise the FDS are cleaned multiple times per week by OPG divers, and the FDS design incorporates a secondary skirt that remains at the surface even if the primary net becomes fouled with algae and begins to sink. One impingement event occurred in May 2015 while the FDS was installed during which approximately 6,000 kg of Alewife were impinged. The cause was a break in the seams between two net panels, which was immediately repaired. A second event occurred in November 2017 after the FDS was removed. During the event, approximately 24,000 kg (1,476 kg of Age-1 equivalent) Alewife were impinged. OPG is investigating the cause of the event.

> **Waterkeeper Response (May 4)**
> This response appears to be denying access to the requested information (namely any monitoring reports or raw data concerning identified types of net failure), merely restating broad and general information than is already provided in the CMDs.
>
> > ***OPG Follow-up Response (May 14)***
> > *The intervener is requesting more data concerning events when the Fish Diversion System has failed. We have interpreted failed as not functioning as intended. The barrier net has failed only once since it was installed. That was the May 2015 event which was referred to and discussed in OPG's May 2 response to the intervener.*
> >
> > *Specific to the portion of the question regarding algae: During day to day operation, algae does come into contact with the Fish Diversion System and due to this weight, portions of the primary or secondary net float line may begin to sink below the surface. The secondary net extends the effective height of the net when the primary net begins to sink. The degree of sinking is monitored through daily visual observations and by depth loggers installed on the net float line. Depth logger results are provided to CNSC in the annual fish impingement reports (see example data below). Depth loggers are located on the main net, primary skirt and secondary skirt on all 3 aspects (East, South and West).*

Table 2
Frequency Distribution of Depth Logger Data

Depth Range (cm below surface)	West			South			East		
	2nd Skirt	1st Skirt	Main Net	2nd Skirt	1st Skirt	Main Net	2nd Skirt	1st Skirt	Main Net
0-30*	94.9%	74.6%	27.9%	92.1%	60.8%	40.3%	98.9%	77.3%	58.0%
30 - 50	4.4%	2.7%	9.6%	7.6%	3.8%	0.3%	0.7%	11.1%	11.7%
50 - 100	0.6%	5.0%	13.7%	0.4%	8.1%	1.3%	0.1%	6.2%	11.2%
>100	0.1%	17.7%	48.8%	0%	27.2%	58.1%	0.2%	5.4%	19.1%

*Note: Due to the position of the depth logger on the net, the logger is always submerged between 10 - 30 cm.

2) More information, including any event or monitoring reports. concerning the frequency of events when cooling water flow is reduced resulting in a spike in discharge temperatures

Section 4.1.3.11.2 in the Environmental Risk Assessment (ERA) outlines discharge limits for cooling water that are regulated by the station's Environmental Compliance Approval (ECA) issued by the Ministry of Environment and Climate Change. Events causing exceedances of the ECA temperature limits occurred due to algae/debris runs, equipment failure and frazil ice. During the period of 2013 to 2015, there were 10 events resulting in the exceedance of ECA temperature limits. In order to minimize the impact and frequency of thermal events, OPG has implemented mitigation and preventative actions as outlined in Section 4.1.3.11.2 of the ERA. As a result, the number of events have declined to one event in 2015 and none occurring in 2016, 2017, or 2018 to date. Reference: Environmental Risk Assessment Report for Pickering Nuclear https://www.opg.com/generating-power/nuclear/stations/pickering-nuclear/Documents/P-REP-07701- 00001.pdf

Waterkeeper Response (May 4)
This response also appears to be denying access to the requested information (namely more detailed event or monitoring reports, or any results, i.e. data, concerning the results of the monitoring program), merely restating broad and general information than is already provided in the ECAs and ERAs.

OPG Follow-up Response (May 14)
The 2016 ECA report is attached.

3) Copies of, or at least more detailed information concerning, chlorination and other biofouling prevention procedures for the cooling water system at the PNGS.

PNGS uses station intake water from Lake Ontario for operating purposes, including the cooling of nuclear reactors, irradiated fuel bays, steam condensers and heat exchangers, fire and emergency water systems and other service water systems. Within the service water systems Dreissenids (Zebra and Quagga mussels) can settle, attach to OPG infrastructure, grow to later life stages and colonize. Accumulations of Dreissenid colonies can cause flow reductions or blockages, particularly in water-bearing pipes, that negatively impact the safe operation of the OPGN reactors, reduce station thermal performance and degrade service water systems. Dreissenid controls are implemented, to reduce and preferably eliminate colonization and protect vulnerable systems,structures and components. The primary

control to deter colonization is chemical treatment of vulnerable service water systems using sodium hypochlorite (i.e. chlorination).

Chlorination controls for Dreissenids are performed in a manner compliant with our Ministry of the Environment and Climate Change (MOECC) Certificate of Approval Industrial Sewage Works (ECA) for Pickering GS (ECA# 4881-5MHQ9F) including ECA specified effluent limits, effluent objectives and the ECA intent. More specific monitoring and control methods, including the timing of applying controls, are contained in OPG environmental, operational and engineering procedures (Control of Dreissenid Mussels N-ED- 07015.061-10000- R006). These procedures are intended to ensure the safety of OPG cooling water systems, protect our workers, deter Dreissenid mussel settlement, monitor treatment effectiveness, and minimize sodium hypochlorite use.

Waterkeeper Response (May 4)
It appears there is a total residual chlorine standard for the discharge canal of 0.002 mg/l maximum concentration. However, this concentration appears to be effectively impossible to actually measure in practice. As no procedures have been shared in response to the original question, the response above is extremely limited. It would be important to know if OPG has some method for actually measuring chlorine concentration, or whether they are instead not able to detect total residual chlorine in the discharge, and thus assume it complies with regulatory/licence/permit limits.

All these three responses are significantly lacking in the disclosure of data and methodology, making expert review especially difficult.

OPG Follow-up Response (May 14)
The ECA referred to in OPG's previous response specifies both effluent objectives and limits for Total Residual Chlorine (TRC). These are summarized in Table 1 below.

Table 1

Station	***ECA Objective or Limit***	***ECA Requirement***
Pickering Nuclear Generating Station	*Objective*	*Total Residual Chlorine concentration in the Pickering A and B Outfalls prior to entering Lake Ontario does not exceed 0.002 mg/L.*
		The chlorination of service water systems at Pickering A and B is carried out in such a manner as to maintain a concentration not exceeding 0.5 mg/L of Total Residual Chlorine, at the furthest point in the service water systems.
		Pickering A and B Inactive Drainage Effluent Concentration does not exceed 0.04 mg/L during active chlorination period. *Sampling point to be taken for effluent from Manhole, MH 89, prior to discharge to the Lake Ontario shoreline via Yard Drainage, or from the Individual Inactive Drainage Sumps to the CCW Intake Ducts if the discharge via the Old Water Treatment Plant is not being used and provided that all chlorination at the Station is stopped during the time of use of the individual Sump discharge route.*

	Limit	*0.01 mg/L at final station discharge in the PNGS A and B outfalls. Sampling point located in the Pickering A and B Outfall.* *Note: TRC concentration may be measured in the PNGS A and B Reactor Building Service Water Ducts and used to calculate the outfall TRC concentration.*

Table 9 of the ECA provides the Final Station Discharge Concentration Limits, Sampling and Analysis Requirements. Table 9 approves TRC concentration to be measured in the Pickering A and B Reactor Building Service Water (RBSW) Ducts and outfall TRC concentrations to be calculated. The outfall calculation assumes a 1:10 ratio of RBSW water to outfall water, by volume.

A second calculation is applied to the RBSW 058 sample point only as studies have demonstrated this sample location is biased high by one order of magnitude due to proximity to the nearby sodium meta- bisulphite addition point. RBSW 058 readings are therefore reduced by a factor of 10.

Both calculations are reported in the Annual ECA Performance Reports submitted to, and approved by, the MOECC.

Information requests from Wilf Ruland (P. Geo.) to OPG

Following is a list of information requests from Mr. Ruland to OPG. The original information requests are presented in bold type, the OPG response is below in *italics*, and Mr. Ruland's response is presented below that - again in plain type, and indented. OPG's second responses are below that in grey and indented and italicized again. The numbering starts with four, as the first three information requests were sent from another expert (Dr. Henderson) in this matter.

4) A map showing all stormwater outfalls to the lake.

Stormwater runoff from the PN site is collected by the stormwater drainage system and directed through drainage pathways south to Lake Ontario. A map of the catchment areas is available in the ERA report (see Figure 2-17). Section 3.1.2.2.3 of the ERA has more details provided on the drainage pattern and the sampling program results. Sample locations are also shown on Figure 2-17 of the ERA.

Reference: Environmental Risk Assessment Report for Pickering Nuclear
https://www.opg.com/generating-power/nuclear/stations/pickering-nuclear/Documents/P-REP-07701-00001.pdf

Waterkeeper Response (May 4)
I am well aware of the overview catchment areas map on Figure 2.17 of the 2017 ERA Report. That is not what I requested. I am trying to get an overview of how many outfalls there are, where they are situated, and how many of them have been sampled.

I am also seeking all water quality data for outfall sampling for the PNGS. If there is more information available than is provided in Appendix F of the 2017 ERA Report then please provide it forthwith.

OPG Follow-up Response (May 14)
The stormwater sampling program focused on outfalls which were sampled under previous assessments in 1996 and 2001 and sample locations which were altered as the result of development (i.e. in the East Complex due to PWMF Phase II expansion). The selected outfalls are considered representative of the catchment area and characterizes the stormwater runoff from the PN site.

Aside from the water quality data that was provided in the ERA, there is also the quarterly stormwater sampling data (collected from catchbasins and sampling stations at the PWMF) available in the "Environmental Emissions Data for Pickering Nuclear" quarterly reports. The reports are available to the public.

For example, see Table A.5 on Page 11 of 2017 Q3 report: (https://www.opg.com/news-and-media/Reports/PN_EmissionsDataReport_2017Q3.pdf).

Note that the runoff from the PWMF is being represented by stormwater sampling location MH-15 in Figure 2-17 of ERA R001.

5) A list of those outfalls, indicating which are being sampled for water quality and results (or reference to where results may be found).

See answer for item 4 above.

Waterkeeper Response (May 4)
The response to 4 above was an unsatisfactory response. Please see my further information request above on this issue.

OPG Follow-up Response (May 14)
See response to item 4 above.

6) A map showing all lines carrying liquid discharges of any kind to the lake (be it for cooling water or other liquid discharges).

Figure 2-5 in the ERA shows the liquid discharge lines. A simplified flow diagram of the radioactive liquid waste management system (RLWMS) is also shown in Figure 2-6 of the ERA. See section 2.2.1.1 of the ERA for more descriptive details of PN Site Drainage and Waterborne Discharge.

Reference: Environmental Risk Assessment Report for Pickering Nuclear
https://www.opg.com/generating-power/nuclear/stations/pickering-nuclear/Documents/P-REP-07701-00001.pdf

Waterkeeper Response (May 4)
Figure 2-5 is useful, but the information is not complete. For example, stormwater runoff catchments are shown on Figure 2.17 of the same report. A total of 17 catchments are shown. Figure 2.5 has three boxes showing stormwater runoffs (with average flows). Please indicate which individual catchments are represented by each of the 3 boxes.

Please also confirm how the average flows were calculated. Are these estimates, or averages of measured flows? How many of the stormwater flows from the site are measured on an ongoing basis with flow meters, and if any of the stormwater outfalls.

Similar questions apply to the other flows shown in Figure 2.5. Which of the other average flows shown are based on measurements, and which are based on estimates.

OPG's Follow-up Response
The water balance figure (figure 2.5 in the ERA) was developed as part of the Pickering A Return to Service EA. Annual runoff estimates for PNGS were prepared using a water budget method. For more details, please refer to section 6.4.8.3 and figure 6.4.13 of the Pickering A Return to Service EA report.

Reference:
Ontario Power Generation (OPG). 2000a. Pickering A Return to Service Environmental Assessment Report Volume 1 Main Report. Report NA44-REP-07730-{372537}. April.

7) A list of those liquid discharge lines, indicating which are being sampled for water quality and results (or reference to where results may be found).

Figure 2-5 in the ERA shows the liquid discharge lines. Aqueous liquid effluent, except for domestic sewage and some stormwater drainage, from PN is discharged into the CCW discharge duct, the outfall structures or the forebay.

The majority of stormwater drainage is directed to Lake Ontario, and domestic sewage is directed to the York-Durham Water Pollution Control Plant. Non-radioactive liquid emissions are controlled in accordance with the provincial Environmental Compliance Approval (ECA) requirements (formerly Certificate of Approval), and with the Municipal Industrial Strategy for Abatement (MISA) program under O. Reg. 215/95 (Effluent Monitoring and Effluent Limits – Electric Power Generation Sector). Under O. Reg 215/95, PN monitors the control points in use for MISA Compliance monitoring. The control points and the parameters monitored at each point are presented in Table 2.4 of the ERA. The locations and parameters monitored for ECA compliance are presented in Table 2.5 of the ERA. Table 3.3 of the ERA shows the radioactive emissions data from PN which included waterborne emissions.

Reference: Environmental Risk Assessment Report for Pickering Nuclear
https://www.opg.com/generating-power/nuclear/stations/pickering-nuclear/Documents/P-REP-07701-00001.pdf

Waterkeeper Response (May 4)
I am familiar with the MISA control points. Where are the water quality testing results for those MISA control points?

I am familiar with the ECA - where are the results for the ECA-required testing?

Is there any other discharge water quality testing done (besides that required by the MISA program and the ECA), and if so where are the results?

OPG's Follow-up Response (May 14)
The 2016 MISA Annual Report is attached.

The 2016 ECA Report is attached.

8) Annual groundwater quality monitoring reports for the 2 most recent years available.

OPG is unable to provide you with the Annual Groundwater Monitoring Reports, However data for our perimeter wells are posted on our public website.

https://www.opg.com/news-and-media/Reports/PN_EmissionsDataReport_2017Q3.pdf

Waterkeeper Response (May 4)
Page 51 of the 2016 Annual Report for Environmental Monitoring Programs indicates that there are 190 groundwater sampling locations on-site.

The data on the link to the quarterly report on the website are for tritium only, for 28 perimeter wells only, and for 2016 only.

Where is other groundwater quality monitoring data to be found, or was the only groundwater quality testing (done in 2015 and 2016) done for tritium only, in 2016?

Also please provide any hydrogeological investigations which have been done for the PNGS. For example, I have seen repeated references to a 2007 report by Golder Associates Ltd. *"Geology, Hydrogeology and Seismicity Technical Support Document Refurbishment and Continued Operation of Pickering B Nuclear Generating Station Environmental Assessment. Report No. NK30-REP-07701-00006."* Please provide this report.

OPG's Follow-up Response (May 14)
On an annual basis, OPG collects groundwater quality data from various monitoring wells on-site in order to meet the objectives for the program. A sub-set of this data is obtained from perimeter locations in order to confirm that there are no adverse off-site impacts from Pickering Nuclear Generating Station (PNGS) groundwater. The perimeter monitoring well locations are sampled for tritium only, given that this the main contaminant of concern. OPG is unable to provide the annual reports; however, we have a mature groundwater program in place to verify our understanding of groundwater flow directions, monitor changes to on-site groundwater quality to ensure timely detection of inadvertent releases, and confirm that there are no off-site impacts (as stated above). Again, we are unable to provide you with the stated 2007 report by Golder. This report was prepared to support the EA for the refurbishment and continued operations of PNGS-B.

The report is attached

9) General lay of the land around the facility and in particular closest to the lake.

See figures below in the ERA:
- *Figure 2-1: PN Site Location and Vicinity*
- *Figure 2-2: Pickering Nuclear Generating Station*
- *Figure 2-16: PN Site Plan*

Reference: Environmental Risk Assessment Report for Pickering Nuclear
https://www.opg.com/generating-power/nuclear/stations/pickering-nuclear/Documents/P-REP-07701-00001.pdf

Waterkeeper's Response (May 4)
These figures are useful, but the information is not complete.

I am seeking a topographic map of the site - the topographic contours provided on such maps give the "lay of the land".

OPG's Follow-up Responses (May 14)
Please see attached topographic map of the site.

10) Locations of the monitoring groundwater monitoring wells closest to the lake.

See figure 4-6 in the ERA as well as attachment.

Reference: Environmental Risk Assessment Report for Pickering Nuclear
https://www.opg.com/generating-power/nuclear/stations/pickering-nuclear/Documents/P-REP-07701-00001.pdf

Waterkeeper's Response (May 4)
This is not helpful. Figure 4.6 shows noise receptors around the site.

The attached figure shows the locations of 6 wells near the lake. Is it OPG's position that of its 190 groundwater monitoring locations, only 6 are located near the lake?

OPG's Follow-up Response (May 14)
Figure 4.6 on Rev 1 of the ERA shows the groundwater monitoring wells near the lake.

Groundwater monitoring well clusters are sampled at each of those perimeter locations, to allow for the collection of data from various depths. Again, OPG has a very good understanding of groundwater flow patterns at the site, with no significant changes noted with respect to the original interpretations. The flow patterns are verified on an annual basis. The groundwater monitoring program has been designed to ensure we collect adequate data to meet our objectives.

11) Locations of all storm sewer outfalls.

See answer for item 4 above.

Waterkeeper's Response (May 4)
The response to item 4 above was an unsatisfactory response. Please see my further information request on item 4 above on this issue.

OPG's Follow-up Response (May 14)
Please see OPG's response to item 4.

12) Locations of all liquid discharge pipes (eg. cooling water and anything else) leading toward or into the lake.

See Figure 2-5 in the ERA.
Reference: Environmental Risk Assessment Report for Pickering Nuclear
https://www.opg.com/generating-power/nuclear/stations/pickering-nuclear/Documents/P-REP-07701-00001.pdf

Waterkeeper's Response (May 4)
This has been covered previously in information requests 4, 6, and 7.

OPG's Follow-up Response (May 14)
No additional information is available at this time.

13) Any waste management facilities on the PNGS property.

OPG operates the Pickering Waste Management Facility on the same site as the Pickering Nuclear Generating Station.

Waterkeeper's Response (May 4)
I understand that the Pickering WMF is a very tightly controlled facility, for storage of used nuclear fuel. I am not anticipating any water-related impacts from this facility, but I am nonetheless interested in water quality sampling which confirms this.

And what about the Eastern Landfill? Please provide any available historic data or reports on groundwater and/or surface water monitoring done at any point in the past at that facility.

OPG's Follow-up Response (May 14)
Quarterly stormwater samples are collected from catchbasins and sampling stations at the PWMF, and analyzed for gross beta gamma. The results can be seen on our public website (reference: Table A.5 on Page 11):

https://www.opg.com/news-and-media/Reports/PN_EmissionsDataReport_2017Q3.pdf

Surface water quality monitoring was previously conducted at the East Landfill as per a Perpetual Care Program, in accordance with the Certificate of Approval. The data collected over numerous years indicated that the landfill does not pose a potential concern to the environment.