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**Supplementary Information**

**Written submission from Swim Drink Fish Canada / Lake Ontario Waterkeeper**

**Regulatory Oversight Report for Canadian Nuclear Power Generating Sites: 2018**

Commission Meeting

**November 6, 2019**

**Renseignements supplémentaires**

**Mémoire de Swim Drink Fish Canada / Lake Ontario Waterkeeper**

**Rapport de surveillance réglementaire des sites de centrales nucléaires au Canada : 2018**

Réunion de la Commission

**Le 6 novembre 2019**

Canada

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# Submissions of Swim Drink Fish Canada/Lake Ontario Waterkeeper

## Re: Commission meeting to consider CNSC Staff Regulatory Oversight Report for Canadian Nuclear Generating Sites: 2018

Notice of Public Meeting, Ref. 2019-M30

October 30, 2019

Submitted to:
Participant Funding Program Administrators cnsc.pfp.ccsn@canada.ca and the CNSC Secretariat cnsc.interventions.ccsn@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.

Waterkeeper has received participant funding to intervene in this current Canadian Nuclear Safety Commission (CNSC) Meeting to review the CNSC staff 2018 Annual Regulatory Oversight Report (ROR) for Canadian Nuclear Generating Sites. Waterkeeper's funding agreement requires the organization to prepare and deliver written submissions concerning groundwater issues at the Pickering Nuclear Generating Station (PNGS) as well as an assessment of more general information disclosure policies and practices by OPG concerning their Darlington Nuclear Generating Station (DNGS) and its Waste Management Facility (DWMF) as well as the PNGS and its Waste Management Facility (PWMF).

Waterkeeper has retained two experts to prepare these submissions:

- **Pippa Feinstein, JD,** counsel and case manager for Waterkeeper, who has also conducted the review in these submissions concerning OPG's and CNSC staff's public engagement activities and information disclosure policies and practices; and
- **Wilf Ruland, P. Geo**., an experienced hydrogeologist and recognized leading expert on the impacts of industrial facilities on local groundwater and surface water, who has focused his review on groundwater issues at the PNGS, following up from his review last year during the PNGS licence renewal hearings.

Waterkeeper ultimately submits that while there have been some positive developments over the last year in terms of increased information and data disclosure of environmental impacts of OPG's nuclear generating stations, significant and concerning deficits remain. In particular, OPG is still refusing to disclose crucial information concerning PNGS groundwater quality and monitoring – despite multiple (and increasingly specific) Commission Tribunal directions to do so over the last three years. This obstruction effectively prevents the public from developing a comprehensive picture of current groundwater conditions at the site.

What little information has been made publicly available indicates that the PNGS may have experienced at least three extremely serious leaks of tritiated water from multiple reactor units, resulting in the highest groundwater contamination concentrations recorded in publicly available sources. There is further evidence to suggest that groundwater contaminant pathways to Lake Ontario from the PNGS are not adequately understood or monitored by OPG, CNSC staff, or other responsible environmental agencies.

As such, Waterkeeper makes a series of recommendations for further investigations and operational improvements at the PNGS, as well as a series of arguments and recommendations for improvements to public disclosure by CNSC staff and OPG concerning its nuclear generation facilities and associated waste management facilities along the northern shore of Lake Ontario.

## 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 intervening before the Canadian Nuclear Safety Commission (CNSC) in the current Regulatory Oversight Report (ROR) Commission Meeting in order to ensure the Commission Tribunal considers the public's need for a swimmable, drinkable, fishable Lake Ontario when reviewing the adequacy and responsibility of nuclear power generating facilities' operations during 2018.

**This current intervention opportunity**

Waterkeeper has received participant funding to intervene in this current Commission Meeting to review the CNSC staff 2018 Annual ROR for Canadian Nuclear Generating Sites. Waterkeeper's funding agreement requires the organization to prepare and deliver written submissions concerning groundwater issues at the Pickering Nuclear Generating Station (PNGS) as well as an assessment of more general information disclosure policies and practices by OPG concerning their Darlington Nuclear Generating Station (DNGS) and Waste Management Facility (DWMF) as well as the PNGS and its Waste Management Facility (PWMF).

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Written submissions were originally due to the Commission on October 7, however, as that date approached, Waterkeeper became aware that OPG refusals to provide requested information meant that there was insufficient information available to inform much of Waterkeeper's expert's work. The Commission was made aware of these disclosure-related difficulties in advance of the October 7 deadline and permitted Waterkeeper to file additional submissions by October 30, 2019.

While the effective extension for providing written submissions was generous of the CNSC Secretariat and Commissioners, and Waterkeeper is very grateful, it put Waterkeeper's experts (and likely CNSC staff and Commissioners) in the uncomfortable position of having to rearrange work schedules to accommodate OPG delays and obfuscation.

While OPG has provided some additional information since October 7, it has still fallen far short of what was requested by Waterkeeper and what was required by Mr. Ruland to provide the analysis he was funded to prepare.

*Recommendation 1: that the Commission Tribunal order OPG to immediately release the remaining information that was requested by Waterkeeper to date.*

*Recommendation 2: that the Commission Tribunal require OPG fund a full, independent, peer review of historic and current results of its PNGS groundwater monitoring data.*

**Waterkeeper's past work in related issues**

This concern over the lack of OPG disclosures is especially frustrating as it is only the most recent installment of a many-years long pattern. For at least the last six years, OPG's refusal to fully respond to Waterkeeper information requests has prevented the public from developing a better understanding of OPG's operations at the Darlington and Pickering sites, as well as CNSC staff's regulation of them. Virtually all the information requested during this current Commission Meeting intervention process had repeatedly been requested during past PWMF and PNGS relicensing hearings. As the following section explains, Commissioners have already directed OPG to provide this information in past Records of Decisions, with increasing specificity and seriousness over the last six years.

Public access to information during the 2018 PNGS licence renewal hearings

In 2018 Waterkeeper intervened in the PNGS licence renewal hearing. At that time, the organization was funded 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. It retained three experts to to examine the PNGS and make recommendations for improvements to its operations: Pippa Feinstein, JD to address PNGS' regulatory compliance as well as the adequacy of its public information-sharing policies and practices; Peter Henderson, BCs, PhD, to assess the PNGS cooling water system and its impacts on aquatic biota; and Wilf Ruland, P. Geo., to assess PNGS impacts on groundwater and surface water.

However, a lack of information disclosure from OPG at that time prevented the experts from completing their reviews by the deadline for written submissions. Waterkeeper was granted an extension and with the additional time was able to organize a site visit at the PNGS and obtain some additional information. However, even by the later filing date, Waterkeeper still lacked crucial information required to prepare the intervention it was funded to present. Access to raw data was of particular concern during that process, as was more general information concerning groundwater conditions at the PNGS site. At that time, Waterkeeper warned the Commission Tribunal that the persisting information deficit was a significant concern. It explained that the lack

of disclosure did the hearing proceeding a disservice, frustrating Waterkeeper's ability to help ensure OPG's application was considered on its merits.[1]

Of particular concern in the context of this current intervention is the fact that the following information was denied to Mr. Ruland in 2018:

- 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).

Waterkeeper requested that OPG be directed by the Commission Tribunal to provide this requested information before any licence was granted for the PNGS. Other intervenors, Northwatch and Greenpeace, had similarly requested (and been denied) groundwater monitoring information. The Commission agreed with the reasonableness of our requests for this information, and while it still ultimately granted OPG a renewed operating licence for the PNGS, the Commission Tribunal also directed OPG to disclose the requested data:

> The Commission notes that on-site groundwater and other environmental monitoring raw data and reports had been requested by Northwatch and the Waterkeeper as part of their interventions. Based on the information provided to the Commission during this hearing, and noting no identified confidentiality or proprietary issues with respect to the on-site raw data and monitoring reports, **the Commission directs OPG to make this information publicly available as soon as practicable**. [emphasis added] [2]

It is especially disheartening that while the Commission Tribunal ordered OPG to provide Waterkeeper with its requested environmental monitoring data in last year's PNGS licence renewal, OPG has again denied virtually all of it during this current intervention.[3]

Waterkeeper's frustration over OPG's lack of public disclosure has been regularly expressed by Waterkeeper since at least 2013 in relation to the Pickering site. It is briefly outlined below to better contextualize and underscore the current situation in which the organization finds itself.

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[1] See Waterkeeper's Submissions RE: Licensing hearing before the Canadian Nuclear Safety Commission (CNCS) for the Pickering Nuclear Generating Station, May 18, 2018, at 6.

[2] See: CNSC Record of Decision, para 408, online: http://www.suretenucleaire.gc.ca/eng/the-commission/pdf/DetailedDecision-OPG-Pickering-2018-e.pdf.

[3] More specifically, information denied to date includes: 1) borehole logs and monitor installation details for OPG's network of groundwater monitoring wells and sampling points; 2) the last 3 years' groundwater level and groundwater quality monitoring data for the full network of groundwater wells and sampling points; 3) the 2014, 2015, 2016 and 2017 groundwater monitoring reports for the PNGS; and 4) 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). See Mr. Ruland's report at 3, which are attached to these submissions as Appendix A. See also: Appendix B to these submissions for a more fulsome account of the timeline and substance of requests for information and responses received from OPG to date.


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Public access to information during the 2013 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 relating to PNGS operations, Commissioners asked OPG why it refused to make data (including its monitoring results) available to the public.[4] OPG and CNSC staff responded by asserting publicly available information was already sufficient at that point, despite Waterkeeper's concerns.

The Commission Tribunal ultimately disagreed, and recommended more proactive disclosure by OPG moving forward, noting:

> 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.[5] [emphasis added]

Despite the Commission Tribunal's recommendation at that time, proactive disclosure by OPG did not noticeably improve by the time Waterkeeper intervened in the relicensing hearing for the PWMF.

Public access to information during the 2017 PWMF licence renewal hearings

In response to Waterkeeper's concerns over the lack of environmental data disclosure over the course of PWMF relicensing hearings, the Commission Tribunal directed CNSC staff characterizations of environmental effects to be supported by publicly available data in order to ensure greater transparency.[6] Further, the Commission Tribunal expressed support for a more active role by CNSC staff in future hearing processes, should intervenors find it difficult to acquire information from regulated facilities.[7]

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,[8] and expressed dissatisfaction that ERAs for the Pickering site were not made publicly available for the PWMF hearing.[9] In fact, the Commission extended the hearing from April to July of 2017 to allow for additional OPG disclosure of its 2014 and 2017 ERAs and to facilitate Waterkeeper's comments on them.

Finally, the Commission Tribunal recognized there could be instances in which the need for future

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[4] 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>.
[5] *Ibid* at para 229.
[6] 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>.
[7] *Ibid* at para 234.
[8] *Ibid* at para 15.
[9] *Ibid* at para 167.

public information disclosure may be broader than the reporting requirements specified in the (then) CNSC RD/GD-99.3 (the Commission's policy concerning licensees' public information and disclosure programs).[10]

Given this history of Waterkeeper's and CNSC Commissioners' continued expressions of concern over the lack of publicly available environmental monitoring data, OPG's lack of disclosure in the current intervention proceeding is particularly glaring. Moving forward, Waterkeeper hopes that the current meeting will constitute the last Commission-funded intervention in which access to information dominates Waterkeeper's intervention submissions, and that future submissions can rather focus on a fulsome assessment of OPG operations and their impacts to the local ecosystems of which they are a part.

## Concerns with current meeting intervention procedures

In addition to more fulsome OPG disclosure moving forward, Waterkeeper recommends amendments to current Commission Meeting intervention procedures. In particular, longer timelines, and a more institutionalized and formalized process for acquiring information would greatly improve the meaningfulness of public intervention opportunities.

**Timelines**

Just under two months were provided as notice for funding applications to intervene in this proceeding, with the notice published on April 10, and funding applications due June 7, 2019. Once applications were submitted, it took another two months to render a funding decision, which was received by Waterkeeper on August 9, 2019. Waterkeeper's written submissions were required by October 7. This left only two months for Waterkeeper to: secure third-party expert consultants; revise the scope of study to reflect actual funding amounts offered; obtain information from OPG and arrange a site visit of the PNGS. This left Waterkeeper's experts with only a couple weeks for understanding, synthesizing, and analysing information received, and drafting legal arguments and scientific/technical findings. Further, the CNSC staff ROR, which is meant to help guide the current Commission Meeting intervention was only made available on September 9, effectively providing a month for its review. While Waterkeeper was ultimately granted an extension to provide full written submissions by October 30, not all of this additional time could be used as the organization was waiting for OPG disclosures for much of October.

At least three months should be afforded by the CNSC to intervenors for their reviews. This period would span from the date on which organizations are notified of the actual granted funding amounts until the date on which written submissions are due. The release of CNSC staff RORs should be made as soon as possible to the funding announcement date to further assist intervenors in preparing their written submissions.

*Recommendation 3: that the CNSC ensure intervenors have at least three months to prepare written interventions for future public meetings. This time period would span from the date on which organizations are notified of the actual granted funding amounts until the date on which written submissions are due.*

[10] *Ibid* at para 71.

*Recommendation 4: that CNSC staff ensure their ROR is available to intervenors at least two months in advance of due dates for intervenor written submissions.*

**Access to information**

Current intervention timelines often mean that interventions focus mainly on obtaining information, and often have to be drafted without having received sufficient responses to information requests. The focus on obtaining information to inform interventions also means there is often insufficient time left for actual synthesis and analysis of information received.

This can constitute not only a waste of Waterkeeper's experts' time and expertise, but a waste of the Commission's time and participant funding as well. Waterkeeper's experts are often already donating much of their time to supplement these intervention processes and contribute what they can to assist the organization in its important public interest work. Ultimately, more formalized information request procedures, spread over longer timeframes would better support intervenors and ensure experts could provide more value-added information.

*Recommendation 5: The CNSC should immediately initiate a comprehensive review of access to information or interrogatory processes for future Commission meetings and hearings in consultation with stakeholders.*

*Recommendation 6: In the meantime, the CNSC should immediately institute the following changes concerning access to information by intervenors for future Commission meetings:*

a. *When notifying organizations of their funding grants, Participant Funding Program officers should also provide contact information for designated individuals representing the nuclear facilities that are subject to the meeting reviews. These representatives should be prepared to field questions and should be made aware of intervenors' timeframes and deadlines; and*
b. *Some CNSC staff time, and industry/proponent staff time must be designated to providing intervenor-requested information and engaging in follow-up information requests and/or site visits.*

## Updated review of PNGS groundwater

As was the case in last year's PNGS relicensing hearing, much of the information required to develop a clear understanding of the Pickering site's hydrogeology was denied by OPG. It is only due to Mr. Ruland's significant expertise concerning industrial facilities and his knowledge of the hydrogeological features of Lake Ontario's shoreline that he could make determinations concerning the Pickering site's hydrogeology, allowing him to prepare the high quality report he has provided.[11]

Mr. Ruland's report was meant to pick up from where his expert report prepared for the PNGS relicensing hearing left off. In particular, he planned to follow-up on his assessment of

[11] Please note that only a cursory summary of Mr. Ruland's findings has been provided in these submissions. For more detailed discussion and explanations of his findings, please see Appendix A to these submissions for his full report.

groundwater conditions at the PNGS site. Despite the limited OPG disclosures over the course of these interventions, Mr. Ruland was able to focus on two important and concerning issues with the PNGS: 1) that several recent groundwater leaks over the last two years have significantly aggravated already existing groundwater quality issues at the PNGS; and 2) that significant groundwater contaminant pathways from the PNGS to Lake Ontario continue to be overlooked by OPG and CNSC staff and other government agencies, namely shallow groundwater and subsurface drains and stormwater infrastructure.

**PNGS leaks, past and present**

In Mr. Ruland's expert report prepared for last year's PNGS licence renewal hearings, he raised concerns over past leaks of tritium below the PNGS reactors, in some areas resulting in concentrations of tritium in groundwater over 30 million Bq/L between 2001 and 2005. These values remained as high as 2 and 3 million Bq/L in the later 2000s and early 2010s.[12]

However, during this current intervention process, Mr. Ruland found that there appears to have been three serious tritium leaks to PNGS groundwater that occurred between 2017 and 2018, resulting in some of the highest tritium concentrations in groundwater ever recorded in publicly available sources.

2018 leak at Reactor Unit 1

Mr. Ruland explains that there is clear evidence of an "extraordinary incident involving leakage of very significant quantities of heavily tritiated water into the groundwater flow system in the vicinity of Reactor Unit 1 in 2018".[13] In fact, values of tritium measured in groundwater around the Unit were the highest ever recorded in searchable and publicly available data for the PNGS, reaching 1.2 and 1.1 billion Bq/L in certain tested locations.[14] Given that the Ontario Drinking Water Quality Standard for tritium is 7000 Bq/L, these most recent measurements for tritium around Reactor Unit 1 are a serious concern.

Despite the scale of this leak, OPG's 2018 Groundwater Monitoring Report actively downplays it by referring to it as "an adverse condition" and "an emerging groundwater matter" rather than the significant spill it is. The source of this substantial release was likely a leaking valve inside the Unit 1 Moderator Purification Room. The room in turn was not able to contain the leak, allowing the heavily tritiated moderator water to flow into underlying groundwater.

[12] A summary of key findings from that report can be found at pages 9-10 of Mr. Ruland's current report.
[13] Ruland report at 10, Appendix A to these submissions.
[14] *Ibid.*

**Table 1 - Peak 2018 Tritium Levels in Groundwater Wells and Sampling Points near Reactor Unit 1, Pickering Nuclear Generating Station**

| Well Designation | Peak 2018 Tritium Levels |
|---|---|
| U1-RBFD-1 | 1.2 billion Bq/L |
| U1-RBFD-2 | 1.1 billion Bq/L |
| U1-RBFD-3 | 367 million Bq/L |
| RBU2-GT-1 | 10 million Bq/L |
| RBU2-GT-4 | 13 million Bq/L |
| MW-262-25 | 55 million Bq/L |
| MW-270-20 | 17 million Bq/L |
| MW-271-20 | 222 million Bq/L |
| MW-273-20 | 9 million Bq/L |
| IFBA-GT-1A | 4 million Bq/L |
| IFBA-GT-2A | 6 million Bq/L |

**Table 1** (above) lists a total of 11 wells at which tritium levels appear to have spiked very significantly in 2018. Other wells near Reactor Unit 1 also saw tritium level increases in 2018, but not as dramatically as the 11 wells featured in **Table 1**. [15]

Absolutely no information has been provided to Waterkeeper concerning the duration of the spill; the volume of leaked moderator water; or the concentration of contaminants in the leaked water.[16] Nonetheless, the significance of the volume of the leak is suggested by the three distinct directions in the flow of leaked tritium from the Unit 1 Moderator Purification Room. This can only happen when the leaked volume is large enough to result in higher groundwater levels at the source of the leak compared to surrounding areas – a condition that requires a pronounced water buildup.[17]

Mr. Ruland explains it is impossible to determine the lateral extent of the groundwater contamination since OPG's 2018 Groundwater Monitoring Report does not contain a map identifying where the leak occurred in relation to groundwater monitoring locations.[18] Still he has been able to find some indication in available monitoring data that there was a pulse of contamination through the system, only lingering in certain areas where it will take longer for

[15] *Ibid* at 11
[16] *Ibid* at 10.
[17] *Ibid* at 12.
[18] *Ibid.*

tritium to dilute and decay to non-radioactive levels.[19] The half-life of tritium is approximately 12 years and there is no way to treat tritium in water. As such, these pockets of particularly concentrated tritium contamination can only be contained to prevent the further contamination of areas beyond the leak. The adequacy of any existing containment efforts is virtually impossible for Waterkeeper to examine or assess at the PNGS given the limited disclosure from OPG.

Given currently available data concerning this event, it appears as though the 2018 Unit 1 leak could have been the worst groundwater contamination event in the facility's history. It is particularly concerning, then, that the public has been denied any further information about it. Despite the alarming data indicating cause for concern and the need for significant regulatory follow-up, the incident was not even mentioned in CNSC staff's ROR which is the main focus of this current Commission Meeting and intervention process.

2017 leak near Reactor Unit 5

A new and separate tritium plume in groundwater below the PNGS also seems to have resulted from a leak from the Moderator Room at Reactor Unit 5 some time in 2017. Contamination resulting from that leak was measured at over 100 million Bq/L in 2017 in five locations, subsiding to a high point of 26 million Bq/L in a monitoring well in the same area in 2018.[20]

This incident was also excluded from CNSC staff's ROR, and OPG has denied Waterkeeper access to its 2017 Groundwater Monitoring Report, which may contain further information and data concerning this leak.

2018 leak near Reactor Unit 6

Still another new tritium plume, this time originating from Reactor Unit 6, was measured to contain between 10 and 30 million Bq/L of tritium at at least three monitoring wells during early 2018. These concentrations subsided to between one and seven million Bq/L by the end of 2018.[21]

The scale of these leaks at Reactor Units 1, 5, and 6 are astronomical. A 2007 report from Golder Associates Ltd concerning past leaks of reactors to groundwater under the PNGS attributed the releases to a lack of maintenance and/or repair of Pickering's active plant systems and associated containment infrastructure.[22] It is unclear to what extent such systemic failures at the PNGS may be responsible for these latest recorded leaks. At the very least, this issue should be investigated further, with any findings made immediately publicly accessible. If continuing lags in repairs and maintenance are responsible for these or any other releases, an immediate work plan for thorough maintenance at Units 1, 5, and 6, and preventative maintenance at Reactor Moderator Rooms 4, 7, and 8 should be carried out.

*Recommendation 7: that OPG and CNSC staff immediately investigate the cause of 2017 and 2018 leaks from Reactor Units 1, 5, and 6.*

*Recommendation 8: that CNSC staff ensure OPG develops and immediately implements a work*

[19] *Ibid* at 12.
[20] *Ibid* at 13.
[21] *Ibid* at 13.
[22] *Ibid* at 10.

*plan for thorough maintenance of Units 1, 5, and 6 if no such plan already exists.*

*Recommendation 9: that CNSC staff ensure OPG develops and immediately implements a work plan for preventative maintenance of Units 4, 7, and 8. If no such plan is deemed necessary, CNSC staff should prepare written rationales for such a decision.*

**Overlooked groundwater contamination pathways**

Neither the 2014 nor the 2017 ERAs for the Pickering site consider groundwater as a contaminant pathway from the PNGS to Lake Ontario, incorrectly assuming natural groundwater fluxes are small and that no human-made features at the Pickering site could affect groundwater contaminant pathways.[23] CNSC staff appear to have accepted these assertions, and as such, their ROR does not comment on either issue.

Mr. Ruland has conducted further analysis of groundwater at the PNGS and found that the movement of contaminated groundwater into Lake Ontario via shallow groundwater flows and subsurface drains and stormwater infrastructure is not sufficiently understood by CNSC staff or OPG. As such, current stormwater monitoring plans and treatment and containment infrastructure at the Pickering site appears to be insufficient.

It is crucial for the protection of the lake that these pathways be better studied and understood. As Mr. Ruland warns in his expert report,

> "… 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. And from my knowledge of the site, I can additionally say that there is no treatment of that contaminated groundwater before it reaches the lake."[24]

<u>Shallow groundwater flow of contaminants</u>

Of particular importance in this intervention is Mr. Ruland's finding that the "vast majority of groundwater contamination at the PNGS is found in the shallow flow system", and that the movement of this groundwater around the site is highly variable depending on whether it is moving through the upper till, construction fill, or various subsurface conduits (such as foundation drains and stormwater infrastructure) around the site.[25] This leads him to find that OPG's current monitoring systems and groundwater flow modelling fails to take into account the dynamism that actually characterizes groundwater movement at the Pickering site.[26]

There is significant evidence, despite the general lack of publicly-available data and OPG's opacity, that contaminated groundwater below the PNGS can travel quite quickly through shallow groundwater, and even faster when it infiltrates stormwater infrastructure. The result is that OPG could be vastly underestimating the impact of groundwater contamination on the water quality of Lake Ontario and health of the lake's aquatic ecosystems.

For example, Mr. Ruland has calculated that the 2018 leaked tritium from Reactor Unit 1 traveled

[23] *Ibid* at 14.
[24] *Ibid* at 14.
[25] *Ibid* at 8.
[26] *Ibid*.

approximately 80m through groundwater below the PNGS over the course of only a few months. This suggests that shallow groundwater at the Pickering site can flow faster than 100m per year, significantly faster than the 0.3–11m annual average asserted by OPG.[27]

Subsurface infrastructure as a conduit for contaminated groundwater

Mr. Ruland explains that OPG's subsurface infrastructure at the Pickering site will likely have developed cracks over the course of its operation, allowing inflows of groundwater contamination into the stormwater system during times of the year when groundwater levels are higher. This means that contaminated groundwater can rapidly flow directly into Lake Ontario via stormwater discharges, though the volume will depend on seasonal variations and precipitation events.[28]

During last year's PNGS licence renewal hearing, Mr. Ruland expressed concern that OPG may not fully understand how stormwater at the site effectively acts as a conduit for discharging contaminated groundwater into the lake (whether it is through the lines themselves or the granular bedding of the lines). At that time, and still during this current intervention, OPG has failed to provide sufficient mapping of these features to allow for a systemic assessment of this potentially significant pathway. However, what data has been made available shows a considerable lack of consistent monitoring of stormwater catchment areas to properly verify whether current stormwater management practices are sufficient at the Pickering site.[29]

The lack of consistent monitoring (with gaps of multiple years) is especially shocking, given the fact that when monitoring has been conducted, several tested locations have failed toxicity tests. Further, existing monitoring results indicate that contamination of stormwater may be worsening over time in several locations.[30]

Waterkeeper's intervention during last year's licence hearing noted that failed toxicity testing in stormwater catchment areas, if they discharge directly into Lake Ontario, would likely constitute a violation of s. 36(3) of the *Fisheries Act.* This section of the Act prohibits the deposit of a "deleterious substance" into water frequented by fish, and clearly specifies that the toxicity of the substance must be measured prior to discharge or dilution into surface waters.[31] At that time, Waterkeeper made a series of recommendations to address these concerns. They are worth repeating at this time, and follow:

*Recommendation 10: OPG must conduct quarterly monitoring of every stormwater collection line which is discharging to the forebay, the outfalls, or directly into Lake Ontario,*

a) *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.*
b) *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*

[27] See *Ibid* at 12 for a more detailed discussion of these issues.
[28] *Ibid* at 15.
[29] *Ibid* at 16
[30] *Ibid* at 17. See also 2018 Ruland expert report prepared for PNGS relicensing hearing for further detail.
[31] See Waterkeeper's intervention prepared for the PNGS relicensing heaing for more detailed analysis and description of legal arguments at 42 - 43.

*stepped down to annually after 3 years of passing test results.*

c) *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.*

d) *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.*

e) *This information (including disaggregated data showing the results of this testing) should be made publicly available in OPG's quarterly or annual compliance reports.*

It should be noted that during last year's PNGS licence renewal hearing, Commissioners inquired about this groundwater/stormwater issue, asking for additional information from OPG and CNSC staff. OPG asserted that it did have a strong understanding of stormwater runoff from the site and that the then provincial Ministry of Environment and Climate Change (MOECC) had approved its stormwater management system and was satisfied with its performance. CNSC staff and Environment and Climate Change Canada (ECCC) asserted that the environment was adequately protected from stormwater emissions at the PNGS.[32] However, no specific sources or examples of actual data were cited by OPG or representatives of any regulatory agencies to support these assertions. To date, Waterkeeper is unable to find any evidence upon which OPG, CNSC staff, the MOECC, or the ECCC can prove that stormwater testing frequency at the Pickering site is sufficient to establish that the passing of groundwater through stormwater infrastructure is adequately understood and mitigated, or that toxicity testing of stormwater catchment basins would not indicate a violation of s. 36(3) the *Fisheries Act*.

*Recommendation 11: that OPG, CNSC staff, and any other applicable government ministries make publicly accessible any evidence (including data) to support their assertions that stormwater management at the PNGS is sufficient to protect Lake Ontario and its ecosystems, and that it does not constitute sufficient cause to suspect a violation of the* Fisheries Act.

## Concerns over lack of publicly-available information

The remainder of this report contains discussions concerning CNSC staff's conceptualization of public engagement in their ROR. It also evaluates the larger regulatory and policy context of public engagement and the importance of environmental information disclosure that includes public access to disaggregated data. Finally, this section ends with an evaluation of OPG disclosures to date, making recommendations for improvements.

[32] See: CNSC Record of Decision at paras 391 – 392.

**The Regulatory Oversight Report's treatment of public engagement and disclosure**

CNSC staff's conceptualization of public engagement in the ROR

OPG's public engagement activities are modest. However, CNSC staff list them in the ROR (e.g. OPG newsletters, maintains Information Centres at the Pickering and Darlington sites, hosts open houses, and presents updates at wider community meetings) and quickly deem them satisfactory.[33] When describing public engagement in the ROR, it is apparent that CNSC staff's conceptualization of what should constitute engagement is too limited. As a result, it is likely their fairly narrow definition of what public engagement means and requires that leads them to find OPG's current engagement practices to be sufficient.

While OPG's presence is felt in Pickering and Ajax communities, and general awareness of the existence of both nuclear sites is high, these are insufficient indicators in and of themselves of adequate public engagement. There are several indicators of robust public engagement that are completely missing from any discussion of this issue in the ROR.

First, the public is not a homogeneous entity. Different segments of the public will have an interest, need, and capacity for different types of information as well as different types of communication between themselves and OPG.[34] Most references to "the public" seem to really be talking about local residents, who again should not be considered a homogenous group. What one local resident may want to know, and the extent to which they may want to interact with OPG, will differ greatly from another resident and be determined by many social and economic factors. Both will differ in a myriad of ways from Civil Society Organizations (CSOs), and CSOs will differ from one another based on their own particular mandates and areas of expertise. To assume that the same engagement exercises will work for all members of an unspecified public body will lead to further inaccurate findings and assertions by CNSC staff examining the success of OPG activities and their satisfactoriness.

Second, all engagement activities undertaken by OPG, and assessed by CNSC staff in the current ROR, focus on one-way communication *from* OPG *to* "the public". No examples are mentioned of any communication or information-sharing *from* members of the public *to* OPG. Nor are any discussions included in the ROR concerning what OPG would do should it receive this information. Significantly, CNSC hearing and meeting processes constitute one of the more structured and meaningful avenues by which communication between OPG and diverse stakeholders can flow both ways. However, as already discussed in this report OPG's lack of responsiveness and information disclosures during these processes often pose a significant barrier to members of the public seeking to make use of these opportunities. Given the many years Waterkeeper and other intervenors have expressed concerns over OPG's communications during these hearings (or the lack thereof), it is surprising that these failings are not addressed at all in the ROR.

Third, no mention is made in the ROR of interactions between OPG and CSOs, especially CSOs that constitute regular interveners during CNSC hearing and meeting processes. As such, these

[33] CNSC staff's 2018 Regulatory Oversight Report of Nuclear Generating Sites at 79.
[34] Note: this point was the focus of the most recent federal Open Government Action Plan, which is discussed more below.

organizations (which include Waterkeeper) are effectively excluded from CNSC staff's definition of "the public" and public engagement. This is a significant oversight that does a disservice to the important work these organizations do to help ensure greater transparency and accountability of OPG operations and CNSC regulation of them.

Finally, while information-sharing is mentioned by CNSC staff in their references to OPG engagement activities, no mention is made of data sharing which is recognized as a crucial aspect of meaningful information disclosure. This final point will be discussed in greater detail below.

Environmental information and data disclosures in the ROR

The ROR itself is not a significant source of environmental information or data. Appendix H to the report only contains annual loadings of tritium, C-14, Noble Gas, Iodine-131, gross beta, gamma, and alpha radiation emitted from the DNGS and PNGS to air and surface water. Annual averages from 2011 to 2018 are provided for only the PNGS, and only for surface water.[35] No disaggregated environmental data is provided at any point in the report. No values are provided for any parameters other than tritium, C-14, Noble Gas, Iodine-131, gross beta, gamma, and alpha radiation. No groundwater information or data is provided. No impingement or entrainment data is provided. Nor is any data provided concerning the DWMF or PWMF.

The ROR notes that the CNSC and the National Pollutant Registry Inventory (NPRI) are working to better coordinate existing disclosures by both on their respective online information-sharing platforms. Downloadable and integrated digital databases of radionuclide releases produced by both sources in collaboration should be publicly available online later in 2019.[36] Waterkeeper looks forward to seeing these developments, though much more collaboration between the CNSC, other environmental agencies and more diverse CSOs and industry representatives, as well as an increased scope of proactive disclosure, is required.

**The regulatory context for public engagement and information disclosure**

The CNSC's provision of environmental information

The CNSC's mandate requires it to provide and ensure the provision of environmental information to members of the public. Section 9(b) of the *Nuclear Safety and Control Act* 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].[37]

Further, the CNSC's own Participant Funding Program recognizes the importance of value-added information provided by qualified individuals and organizations representing diverse public interests.[38]

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[35] CNSC staff's 2018 Regulatory Oversight Report of Nuclear Generating Sites at 278-279.
[36] *Ibid* at 273.
[37] *Nuclear Control and Safety Act*, RSC 1997, c 9, at s 9(b).
[38] 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>.

Underlying these provisions is the recognition that individuals and communities have a right to know how operations at regulated nuclear facilities may impact them, including their health and their environment.

The public has a right to a healthy Lake Ontario and information concerning the health of the lake, which is recognized in other Canadian statutes as well. 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".[39] Ontario's Environmental Bill of Rights acknowledges that Ontarians have the right to a healthful environment.[40] However, inadequate access to information concerning the ecological footprint of nuclear generating sites and their associated waste facilities prevents the public from being able to assess how these sites may affect their right to a healthful environment, or whether such an impact can be considered 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, and all of the impacts of this production (including economic, social, and environmental) are important public issues. Diverse members of 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 – especially their impacts to local waterbodies used for swimming, drinking, and fishing.

<u>The federal government's commitment to open data</u>

The federal government's current Open Government National Action Plan, recognizes that this is "a moment of global importance for the open government movement",

> Rapid digital progress is increasing people's expectations for their governments. Citizens want us to show we are ready and capable, and we will look out for them… Taking action to build public trust in government institutions is of ongoing importance. Open government can be an important way to renew that trust. It can show how governments are working, how they seek to understand citizens' needs, and how they serve those needs. It can also help to keep governments honest and accountable.[41]

The core goal of the plan is to create "a governing culture that fosters greater openness and accountability, enhances citizen participation in policymaking and service design, and creates a more efficient and responsive government".[42] Open Science continues to be a special priority area for the plan, including greater public access to environmental data.

However, nuclear-related data appears to be significantly underrepresented when compared with other industries and other data concerning non radiological or non-nuclear-specific contaminants. The only OPG-specific nuclear data available on the Open Data portal concerns monitoring results from around the DNGS and PNGS collected and published by the Independent

[39] *Great Lakes Protection Act*, SO 2015, c 24, Preamble.
[40] *Environmental Bill of Rights*, SO 1993, c 28, Preamble.
[41] See online: https://open.canada.ca/en/content/canadas-2018-2020-national-action-plan-open-government#toc8.
[42] *Ibid.*

Environmental Monitoring Program (IEMP), and Waterkeeper has regularly expressed concerns with the IEMP's monitoring locations and testing frequencies.

The only other available studies concerning specific nuclear facilities on the Open Data portal date from 1978 and 1982 and concern the Douglas Point and Whiteshell reactors, neither of which are still operational. There are a handful of other studies searchable on the Open Canada Portal with information and data concerning nuclear contaminants including a few by the Canadian Radiological Monitoring Network and a study concerning radioactive content in fish collected along the West Coast of Canada.[43]

The public has a right to know about the quality of the environments of which they are a part, and meaningfully informing the public necessarily requires public access to environmental data.[44] While government and industry representatives can assert that members of the public are safe and that ecosystems are unaffected by nuclear facilities, these assurances need to be supported with publicly accessible data.

The CNSC's REGDOC 3.2.1.

The CNSC recently amended its own internal regulatory document concerning public information and disclosure requirements for all regulated facilities. This policy states 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."[45]

During the PWMF relicensing hearing, Waterkeeper requested but was denied access to the most recent ERAs conducted for the OPG facility. During that hearing, Commissioners directed OPG to make its ERA public and subsequently initiated a public consultation processes concerning proposed amendments to REGDOC 3.2.1 that would require nuclear facilities to publicly post the full text of their ERAs online.[46] On May 7, 2018, these proposed changes to REGDOC were finalized and mandatory disclosure of facilities' ERAs are now mandatory.

Robust public disclosure protocols at regulated nuclear facilities are a cornerstone of ensuring

[43] See online: https://search.open.canada.ca/en/od/?sort=last_modified_tdt%20desc&page=1&search_text=nuclear&od-search-subjects=Science%20and%20Technology|Nature%20and%20Environment

[44] The public Right to Know in environmental contexts has been most developed in the US, constituting a guiding principle in recent federal and state legislation and policy, see: https://19january2017snapshot.epa.gov/www3/epahome/r2k.htm. Also, see generally the work of the Environmental Data & Governance Initiative, online: https://envirodatagov.org/environmental-data-justice/; and the Right2Know Network, online: < https://ourrighttoknow.ca/campaigns/right-to-know-network/ >. See also: Peter H Sand, "The Right to Know: Environmental Information Disclosure by Government and Industry", January 2005.

[45] 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.

[46] See: Lake Ontario Waterkeeper, "Comment on the 2014 and 2017 Environmental Risk Assessments for the Pickering Nuclear Generating Station and Pickering Waste Management Facility", July 21, 2017; and Submissions of Swim Drink Fish/Lake Ontario Waterkeeper concerning the public consultation on proposed changes to REGDOC-3.2.1., September 28, 2017.

the industry's transparency and accountability. They are an important way by which more trusting relationships can develop between industry and the public, not to mention an important way in which facilities can obtain social licenses to operate in communities. Licensees often claim the safe and responsible operation of their nuclear facilities. However, providing sufficient information to the public that supports these claims is vital. Regular, proactive, and comprehensive public information-sharing also supports evidence-based and participatory decision-making processes.

**OPG public engagement and information disclosures concerning the PNGS, PWMF, DNGS, DWMF**

OPG's Public Information Program and Disclosure Protocol (PIPD)

Waterkeeper has been expressing concerns with OPG's PIPD since its intervention in the PWMF's relicensing hearing in 2017. In particular, Waterkeeper has expressed concerns that mandatory information disclosure under the Program was quite limited, and that more comprehensive (and preferable) data disclosure provisions in the Program were only discretionary. The organization recommended that the discretionary provisions already mentioned in the PIPD be made mandatory, especially those concerning unplanned events, events, abnormal tritium liquid emissions below notification requirements, issues related to Significant Environmental Accidents, publicly posting Environmental Monitoring Programs and other information detailing emissions and spills.[47]

Waterkeeper also recommended improvements to OPG event reporting. This included publicly disclosing event duration, volumes released, and concentrations of released contaminants, as well as applicable Action Levels, Derived Release Limits so that the scale of incidents could be better understood in context. Additionally, Waterkeeper urged OPG to commit to more comprehensive disclosure of disaggregated environmental monitoring data.[48] These recommendations are worth repeating in this current intervention:

*Recommendation 12: OPG should to undertake to make all environmental reporting mentioned in its PIP and PDP mandatory for the PNGS. PWMF, DNGS, and DMWF.*

*Recommendation 13: The Commission Tribunal should 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 14: The webpage for reporting incidents at the PNGS. PWMF, DNGS, or DMWF should be included as a shortcut tab on opg.com.*

*Recommendation 15: OPG should ensure that each incident report it posts on its website includes the incident date, reporting date, an exact description of the event including actual data of any measured releases (including duration, volume of contaminants released, and their concentration), as well as all applicable DRLs or ALs so that members of the public can understand the severity of reported incidents.*

[47] See pages 44-48 of Waterkeeper's PNGS relicensing submissions for more detailed discussion of past findings and recommendations.
[48] *Ibid.*

OPG online disclosures

The disclosures of reports on the OPG may not actually constitute significant disclosure of environmental information and data. For example, Mr. Ruland has found that OPG's groundwater reports have almost no description of the Pickering site's hydrogeology, which Mr. Ruland classifies as a major omission in a report claiming to convey groundwater monitoring being conducted at the nuclear facilities. Similarly, the ERAs for the PNGS contain an inadequate overview of the site's hydrogeology, though they constitute the best source currently available. These omissions, when paired with the lack of actual data and specifics concerning the site's organization in both types of report lead Mr. Ruland to find both types of document deficient.

The OPG website contains:

- 2018 and 2017 Environmental Monitoring Program Reports (and archived reports back to 2011);
- 2018 and 2017 Impingement Monitoring Reports for the PNGS;
- Quarterly Environmental Emissions Data Reports for Pickering and Darlington sites (and archived reports back to the second quarter of 2017);
- Pickering Quarterly Performance Reports (and archived reports back to 2013);
- Darlington Quarterly Performance Reports (and archived reports back to 2013);
- Nuclear Waste Management Performance Reports (and archived reports back to 2013).[49]

There are four broad issues with data provided in these sources. First, the same datasets are not consistently updated from year to year. For example, EMP Reports appear to include varying datasets concerning differing parameters or tested areas each year. Further, EMP and other data is reported unevenly for the Pickering and Darlington sites. For example, Impingement Monitoring Reports are posted online for the PNGS, but not for the DNGS. Third, what little data is provided in most OPG reports is expressed in annual averages. Other than some instances in quarterly reports, disaggregated data is wholly excluded, or only partially reproduced in OPG reports. Fourth, disclosed data in OPG reports is rarely comprehensive. For example, maps of monitoring locations provided in EMP appendices do not include all monitoring locations for Darlington or Pickering sites, nor do these appendices provide explanations concerning how and why some monitoring sites were included over others. Further, EMP reports usually exclude any groundwater monitoring data, while Quarterly Emissions Data Reports only provide monitoring results from groundwater wells along the perimeter of OPG properties. Finally, Quarterly Performance Reports are an extremely limited source of information as they are generally two-page summaries with no specific information concerning incidents and no data is included.

Most recent OPG online disclosures concerning groundwater quality at the PNGS

On October 22, Waterkeeper was notified by OPG that it had posted the 2018 Groundwater Monitoring Report to its website. While it is a welcome development, the limited amount of disaggregated data it includes, and the lack of disclosure of previous Groundwater Monitoring Reports makes this isolated instance of disclosure of limited use to Waterkeeper (and likely other CSOs).

[49] More recently, OPG also included 2018 Groundwater Monitoring Report and a groundwater GIS map, both are discussed in further detail below.

At the same time the 2018 Groundwater Monitoring Report was posted to the OPG website, a new interactive GIS map of the Pickering site was also posted. This map allows viewers to select several points on the map that correspond with groundwater monitoring wells and view annual averages of monitoring results from as far back as 2009. The map has several layers or filters, each of which document OPG PNGS ownership boundaries, a satellite birds-eye image of the Pickering facilities, groundwater monitoring wells for on-site and perimeter wells (which are differentiated by colour), and a series of yellow arrows to indicate groundwater flow direction in selected areas of the site.[50] Waterkeeper has had experience designing and creating similar maps in the past as a method for sharing environment and energy-related data in a user-friendly and informative interactive platform.[51] While OPG's creation of this map may become a positive step towards greater transparency at the site in the future, several pressing concerns remain.

First, OPG's GIS map only provides a selected few monitoring wells without ever acknowledging, describing, or explaining the criteria used to determine which monitoring wells would be included in the map and why. Disturbingly, Mr. Ruland has found that no wells that have shown elevated levels of tritium due to either the 2017 or 2018 leaks from Reactor Units 1 and 5 have been included in the map. When data is disclosed, it must either be comprehensive or else provide clear rationales for why only some information has been disclosed, otherwise it risks effectively misinforming the public. The selective disclosure contained in OPG's GIS map has led Mr. Ruland to find that despite this new, OPG "does not appear to be moving meaningfully in the direction of transparency.[52]

Second, all data in the GIS map is expressed as annual averages, thus failing to show seasonal changes in groundwater concentrations, which as explained by Mr. Ruland can be significant over the course of a given year. This averaging effectively prevents the public from seeing any spikes in concentration values.

Third, only tritium is included in the GIS map's data. No other potential contaminant of concern is mentioned, nor is it stated anywhere in the map that tritium is only one of the contaminants tested for in monitoring wells. While it may be the main contaminant of concern, the exclusion of other contaminants should be better explained in the map's text.

Fourth, groundwater flow arrows to not capture the complexity or dynamism of different types or depths of groundwater flow and how this can change over periods of time. From Waterkeeper's past experience creating similar maps, better and more specific filters exist that can show more complex flows of groundwater in various geographic locations and types of sites.

Fifth, while the map has an interesting feature meant to allow users to see the facility's ground plan superimposed on different types of base maps (some with the potential to show basic topography and geographic terrain, for example), these features do not appear to work when clicked on. This leads Waterkeeper to conclude that there is either insufficient detail in the map, or else these features have been arranged not to apply to the PNGS site or immediately surrounding areas.

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[50] See online: https://opgi.maps.arcgis.com/apps/View/index.html?appid=736547b88cc2421daddb5167a9283485
[51] See online: http://www.waterkeeper.ca/case-eastern-mainline-pipeline.
[52] Ruland report at 24, Appendix A to these submissions.

Finally, the map is subject to a disclaimer that,

> The data on this map has been produced and distributed for Ontario Power Generation Inc. purposes only. No part of this map and/or data may be reproduced, published, converted, or stored in any data retrieval system, or transmitted in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise) without the prior written permission of OPG. The information on this map may not be up to date. OPG makes no representations or warranties, either express or implied, regarding this map and/or data. Any third party relies on the information in this map at its own risk and neither OPG nor any agent acting on OPG's behalf assumes any liability with respect to the use by a third party of this map.

As such, the ability for data to be shared and help inform other attempts to pool publicly-available spatial data together for the site is limited if not entirely prevented.

While it is uncertain whether these disclosures are a step towards greater transparency, what they do show, is that OPG has the data as well as the technical means to disclose it in usable formats. The main issue moving forward will be for OPG to focus on the quality of disclosed data in the future.

## Conclusion and summary of recommendations

Waterkeeper ultimately submits that while there have been some positive developments over the last year in terms of increased information and data disclosure of environmental impacts of OPG's nuclear generating stations, significant and concerning deficits remain. In particular, OPG is still refusing to disclose crucial information concerning PNGS groundwater quality and monitoring – despite multiple (and increasingly specific direction to do so over the last three years). This effectively prevents the public from developing a comprehensive picture of current groundwater conditions at the site.

What little information has been made publicly available indicates that the facility may have experienced at least three extremely serious leaks of tritiated water from multiple reactor units, resulting the highest groundwater contamination concentrations recorded in publicly available sources. There is further evidence to suggest that groundwater contaminant pathways to Lake Ontario are not adequately understood or monitored by OPG, CNSC staff, or other responsible environmental agencies.

As such, Waterkeeper makes a series of recommendations for further investigations and operational improvements at the PNGS, as well as a series of arguments and recommendations for improvements to public disclosure by CNSC staff and OPG concerning its nuclear generation facilities and associated waste management facilities along the northern shore of Lake Ontario.

*Recommendation 1: that the Commission Tribunal order OPG to immediately release the remaining information that was requested by Waterkeeper to date.*

*Recommendation 2: that the Commission Tribunal require OPG fund a full, independent, peer review of historic and current results of its PNGS groundwater monitoring data.*

*Recommendation 3: that the CNSC ensure intervenors have at least three months to prepare written interventions for future public meetings. This time period would span from the date on which organizations are notified of the actual granted funding amounts until the date on which written submissions are due.*

*Recommendation 4: that CNSC staff ensure their ROR is available to intervenors at least two months in advance of due dates for intervenor written interventions.*

*Recommendation 5: The CNSC should immediately initiate a comprehensive review of access to information or interrogatory processes for future Commission meetings and hearings in consultation with stakeholders.*

*Recommendation 6: In the meantime, the CNSC should immediately institute the following changes concerning access to information by intervenors for future Commission meetings:*

a. *When notifying organizations of their funding grants, Participant Funding Program officers should also provide contact information for designated individuals representing the industrial facilities that are subject to the meeting reviews. These representatives should be prepared to field questions and should be made aware of intervenors' timeframes and deadlines; and*
b. *Some CNSC staff time, and industry/proponent staff time must be designated to providing intervenor-requested information and engaging in follow-up information requests and/or site visits.*

*Recommendation 7: that OPG and CNSC staff immediately investigate the cause of 2017 and 2018 leaks from Reactor Units 1, 5, and 6.*

*Recommendation 8: that CNSC staff ensure OPG develops and immediately implements a work plan for thorough maintenance of Units 1, 5, and 6 if no such plan already exists.*

*Recommendation 9: that CNSC staff ensure OPG develops and immediately implements a work plan for preventative maintenance of Units 4, 7, and 8. If no such plan is deemed necessary, CNSC staff should prepare written rationales for such a decision.*

*Recommendation 10: OPG must conduct quarterly monitoring of every stormwater collection line which is discharging to the forebay, the outfalls, or directly into Lake Ontario,*

a) *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.*
b) *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.*
c) *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.*

d) *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.*

e) *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 11: that OPG, CNSC staff, and any other applicable government ministries make publicly accessible any evidence (including data) to support their assertions that stormwater management at the PNGS is sufficient to protect Lake Ontario and its ecosystems.*

*Recommendation 12: OPG should to undertake to make all environmental reporting mentioned in its PIP and PDP mandatory for the PNGS. PWMF, DNGS, and DMWF.*

*Recommendation 13: The Commission Tribunal should 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.*

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Appendix A

# Independent Report on Hydrogeological Issues Pertaining to the Pickering Nuclear Generating Station, based on Review of the 2018 Groundwater Monitoring Report and Review of the 2018 Regulatory Oversight Report

**Prepared for:**

**Swim Drink Fish Canada /**
**Lake Ontario Waterkeeper**

**Prepared by Wilf Ruland (P. Geo.)**

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**October 30th, 2019**

## 1) Introduction

I am a hydrogeologist, and I have worked as an environmental consultant for 33 years (2 years for a larger firm in Germany, and 31 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. Also, in 2018 I reviewed the application for a 10-year license extension for the Pickering Nuclear generating Station. 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 provide an independent report on hydrogeological issues pertaining to the Pickering Nuclear Generating Station (PNGS), based primarily upon my review of 2 reports:

- the report on "2018 Pickering Nuclear Groundwater Monitoring Program Results", which is hereafter referred to as the "2*018 Groundwater Report*";
- the "Regulatory Oversight Report for Canadian Nuclear Power Generating Sites: 2018", which is hereafter referred to as the "2*018 ROR Report*".

My review of these reports and the overall hydrogeological impacts of the Pickering Nuclear Generating Station (PNGS) has been impeded by an unfortunate lack of cooperation by various OPG staff. This follows my experience in 2018, when my review of hydrogeological issues pertaining to the PNGS 10-year license renewal application was severely impeded by OPG staff.

Following the problems in obtaining required information from OPG staff in 2018, the CNSC provided the following direction in its Record of Decision regarding the 10-year license extension application:

*"408. The Commission notes that on-site groundwater and other environmental monitoring raw data and reports had been requested by Northwatch and the Waterkeeper as part of their interventions. Based on the information provided to the Commission during this hearing, and noting no identified confidentiality or proprietary issues with respect to the on-site raw data and monitoring reports, the Commission directs OPG to make this information publicly available as soon as practicable."*

Notwithstanding the above direction from the CNSC, I find myself in a similarly problematic position as in 2018.

My clients' legal counsel submitted a request for the last 5 years' groundwater monitoring reports on August 22, 2019. After waiting 4 weeks, OPG staff released only one of the five requested reports (the 2018 Groundwater Report) and I have been waiting since then for the other (2014-2017) reports. The other reports are required in order to put the 2018 results into a longer-term context.

Overall, with regard to many of our information requests the OPG responses amounted to a mixture of inadequate responses, evasions and outright refusals to provide the information sought or to answer questions which had been asked.

The failures by OPG staff to provide requested information have made it impossible for me to write the report which I was funded by the CNSC to produce for my clients.

I am left in the highly problematic position of being funded by the CNSC to provide review comments regarding groundwater and surface water quality impacts of the Pickering Nuclear Generating Station without having sufficient technical information available to me in order to properly complete a report to provide my comments. I apologize in advance to my clients, and to the CNSC.

A variety of critical information is not available to me, including the following:

- borehole logs and monitor installation details for OPG's network of groundwater monitoring wells and sampling points;
- the last 3 years' groundwater level and groundwater quality monitoring data for the full network of groundwater wells and sampling points;
- the 2014, 2015, 2016 and 2017 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).

For more details on information I am missing, please see **Appendix 1** of this report. The information request process to date and the problems encountered are described in more detail in **Appendix 1** of this report.

The net result of OPG's failure to provide all of the requested information has been to make impossible (for the second year running!) 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. As a result, key parts of my discussion of past and current water-related impacts of the PNGS on Lake Ontario are 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 extraordinary leak of heavily tritium-contaminated moderator water in the area of Reactor Unit 1 in 2018, and the rapid spread of contamination from the leak point;
- the adequacy of OPG's public reporting of PNGS groundwater and surface water impacts, including the main 2018 leak as well as additional significant leaks in 2017 and 2018;
- the adequacy of current groundwater and surface water monitoring programs.

In order to write this report, 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, Site History and Development

The PNGS site is situated in the Regional Municipality of Durham, on the north shore of Lake Ontario about 32 km east of downtown Toronto. The PNGS 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.

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 planned to remain in operation until 2024.

### b) Site Topography and Drainage

The 2018 Groundwater Report does not include a proper map showing the site topographical features and drainage network. This is a significant deficiency - normally such a map is included, as it will provide important information about surface water and likely shallow groundwater flow directions.

Based on what I saw on my site tour in 2018 and clues in several reports, it is clear to me 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. 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 2017 Environmental Risk Assessment Report (2017 ERA Report) 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 OPG staff did not provide proper mapping of these features (**see Appendix 1**).

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 <u>not</u> 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 leaky underground culverts and manholes. Once the contaminated groundwater is 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 no program of regular stormwater monitoring being done at the PNGS - this issue is discussed in more detail in **Section 4** of this report.

c) Site Geology

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.

d) Description of Site Hydrogeology and the 2018 Groundwater Report

There is almost no description of the site hydrogeology in the 2018 Groundwater Report - this is a major omission in a report claiming to report on the groundwater monitoring being done at a nuclear facility.

The 2018 Groundwater Report is a severely deficient document. This may be because the report itself and almost all of the technical work being reported on in the 2018 Groundwater Report were done "in-house" - raising the question of whether those involved in the report's production were given the latitude to produce a usable, informative report.

In the absence of a functional description of site hydrogeology in the 2018 Groundwater Report, I am providing my own description based on information gleaned from other documents pertaining to the PNGS.

An inadequate overview description of the site hydrogeology was provided in Section 2.3.3 of the 2017 ERA Report. The 2017 ERA Report's description of site hydrogeology is not helpful for anyone wanting to understand how and where groundwater is actually moving, and where groundwater contamination is most likely to be found and moving - but at that, it is still better than any other publicly available hydrogeology 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 deep 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 in this report.
- Past hydrogeologists associated with this site have classified the overburden groundwater flow system into three layers, which correspond to the stratigraphy at the site:
    - A **shallow flow system** is found in the near-surface construction fill and/or Upper Till. Where present the till is likely fractured. 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 and it will be the main pathway by which contaminants reach Lake Ontario.

- A lower permeability **intermediate flow system** is 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.

- **Overall the vast majority of the groundwater contamination at the PNGS is found in the shallow flow system** which is present in the upper till, the construction fill, and the bedding for the many subsurface conduits and lines at this site. The groundwater flow rates are also highest in the shallow flow system, and thus this is the unit in which most of the groundwater (and the contaminant load) will be moving. As a result, the rest of this report will be focussed on what is happening in the shallow flow system.

- 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 in some cases 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 may 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 sand/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 are considerably higher localized groundwater flow velocities in areas where the shallow overburden material is construction fill, and in the bedding for the conduits of all kinds which run across the site. The rapid spread of tritium contamination in groundwater in the Unit 1 area in 2018 confirms my hypothesis, and is discussed in more detail in the next section of this report.

## 3) Groundwater Contamination at the Pickering Nuclear Generating Station

a) Introduction

The flow of contaminated groundwater is a key pathway by which contamination from the PNGS can reach off-site ecological receptors (eg. Lake Ontario, and its aquatic ecosystem). Groundwater contamination at older industrial facilities is often heavy, and the PNGS is no exception. Contaminants in groundwater will include both radionuclides and potentially hazardous industrial chemicals. At the PNGS, the main contaminant of concern is tritium.

Most of the groundwater quality monitoring data and information provided in the 2018 Groundwater Report pertains to data on tritium levels in various wells. This appears to be because almost no sampling is being done for any parameter beside tritium. The 2018 Groundwater Report's tritium sampling results are reported in units of Bequerels per Litre (Bq/L). Ontario's Drinking Water Quality Standard (ODWQS) for tritium is 7,000 Bq/L.

There have been significant problems with transparency when it comes to the groundwater monitoring being done at the PNGS. OPG is refusing to release any groundwater monitoring reports (or groundwater data) prior to the 2018 Groundwater Report. This raises concerns about what the company may be seeking to keep from public view.

b) Historic Groundwater Tritium Contamination at the PNGS

In the course of searching for groundwater quality data for the PNGS in 2018 (when OPG staff were refusing to provide requested groundwater information about the site), I turned to internet searches to see what I could find about groundwater contamination at the PNGS.

In my internet searches for information on historic groundwater issues, 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. These public reports spoke with concern of peak groundwater tritium levels of up to 2+ million Bq/L.

I then combed various PNGS-related documents including the 2017 ERA Report and the 2017 PNGS License Application, and likewise found reference to peak groundwater tritium levels of up to 3+ million Bq/L. However figures buried in a consultant's 2007 Hydrogeology Report on the PNGS by Golder Associates Ltd. revealed that in fact peak tritium levels in groundwater at the PNGS were in excess of 30 million Bq/L throughout the years of 2001 - 2005.

It has become clear to me that major leaks and spills of heavily tritiated water which cause heavy contamination of the groundwater system are a regular occurrence at the Pickering Nuclear Generating Station.

These spills and leaks have apparently not only been due to honest operator error, given that page 89 of a 2007 Report on the PNGS by Golder Associates Ltd. stated 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"*.

**c) Extraordinary Incident of Groundwater Tritium Contamination in 2018**

Although it is downplayed in the 2018 Groundwater Report, it is clear that an extraordinary incident involving leakage of very significant quantities of heavily tritiated water into the groundwater flow system occurred in the vicinity of Reactor Unit 1 in 2018.

This incident is mildly referred to as "*an adverse condition*" and as "*an emerging groundwater matter*" in the 2018 Groundwater Report, but groundwater sampling results included in the report suggest that it was a major and quite possibly unprecedented incident for the PNGS.

The few details about the major tritium leakage incident provided in the 2018 Groundwater Report are found in Section 3.2.2.1 which indicates that there was a leaking valve inside the Unit 1 Moderator Purification Room, and a pathway which allowed leakage of tritium-contaminated moderator water into the underlying groundwater flow system.

No information is provided on how long the valve was leaking or how badly contaminated the leaking water actually was, and there is no estimate of how much heavily tritiated moderator water leaked into the groundwater system.

Certainly, the effects in groundwater system were marked by dramatic spikes in tritium levels and impacts spread rapidly to numerous groundwater monitors. The highest 2018 groundwater tritium levels were found in groundwater monitoring points U1-RBFD-1 and U1-RBFD-2 in the first quarter of 2018, when levels of 1.2 billion Bq/L and 1.1 billion Bq/L respectively were recorded.

Keeping in mind that the highest-ever historic tritium levels I had previously been able to find reference to were on the order of 30+ million Bq/L, and that publicly available reports spoke with concern of historic groundwater tritium levels on the order of 2 million Bq/L - these are alarmingly high tritium contamination levels.

OPG's refusal to provide pre-2018 data makes it difficult to interpret the data on the extraordinary 2018 leak, so I need to qualify the following discussion in that regard.

I am unable to provide a proper account of the lateral extent of the groundwater contamination resulting from the major leakage incident at the Unit 1 Moderator Purification Room, because the 2018 Groundwater Report does not contain a map identifying where the leak occurred relative to the locations of the sampled groundwater locations on the site and because I am missing pre-2018 data.

Groundwater wells and sampling points around Reactor Unit 1 at which tritium levels were very high in 2018 are shown in Table 1 below.

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**Table 1 - Peak 2018 Tritium Levels in Groundwater Wells and Sampling Points near Reactor Unit 1, Pickering Nuclear Generating Station**

| Well Designation | Peak 2018 Tritium Levels |
|---|---|
| U1-RBFD-1 | 1.2 billion Bq/L |
| U1-RBFD-2 | 1.1 billion Bq/L |
| U1-RBFD-3 | 367 million Bq/L |
| RBU2-GT-1 | 10 million Bq/L |
| RBU2-GT-4 | 13 million Bq/L |
| MW-262-25 | 55 million Bq/L |
| MW-270-20 | 17 million Bq/L |
| MW-271-20 | 222 million Bq/L |
| MW-273-20 | 9 million Bq/L |
| IFBA-GT-1A | 4 million Bq/L |
| IFBA-GT-2A | 6 million Bq/L |

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**Table 1** (above) lists a total of 11 wells at which tritium levels appear to have spiked very significantly in 2018. Other wells near Reactor Unit 1 also saw tritium level increases in 2018, but not as dramatically as the 11 wells featured in **Table 1**.

Based on review of **Table 1**, it is likely that the source location of the leak of contaminated water (from Unit 1 Moderator Purification Room) is situated in close proximity to groundwater monitoring locations U1-RBFD-1 and U1-RBFD-2.

Interestingly, the heavily tritiated water which leaked into the groundwater system from the Unit 1 Moderator Purification Room appears to have spread rapidly in the groundwater system - extending westward all the way past Reactor Unit 2, and into the Irradiated Fuel Bay (IFB) area on the far side of Reactor Unit 2. This is a distance of about 80 meters, and the contamination from the leak point at the Unit 1 Moderator Purification Room spread across those 80 meters in a matter of months.

The above observation is highly significant, because the rapid spread of contamination from the leak point confirms that shallow groundwater flow rates at the PNGS can exceed 100 meters per year - far above the 0.3 to 11 meters per year which had been indicated in documents provided to CNSC in 2018 at the time of OPG's 10-year license renewal application.

OPG staff should be directed to properly calculate shallow groundwater rates based on the spreading times of tritium contamination from recent spills, and to then correct the public record and the information which had been submitted to the CNSC. I could have done these recommended calculations myself, but OPG have withheld the information I would have needed in order to make such calculations.

In many cases, groundwater tritium levels near the leak point fell back into the range of 1 to 10 million Bq/L in subsequent quarters of 2018 - suggesting that there was a pulse of contamination which passed through the system. In the two wells closest to the leak point (U1-RBFD-1 and U1-RBFD-2) contaminant levels were still high at 62 million Bq/L and 87 million Bq/L respectively at the end of 2018, suggesting that it may take quite a bit longer for tritium levels in this area to return to prior levels.

Tritium contamination also spread to the northeast from the major leak point in the Unit 1 Moderator Purification Room, in a secondary contamination plume. Wells impact include MW231-30, MW232-30, MW234-30, MW235-30, MW237-30, MW238-30, MW249-25, and MW257-5. 2018 contamination levels in this separate plume ranged from 2 to 8 milllion Bq/L.

In total, tritium contamination spread in 3 distinct directions from the leak point (the Unit 1 Moderator Purification Room). The creation of several distinct plumes moving in several different directions (to the west, south, and northeast) confirms that a significant quantity of contaminated liquid was released from the Unit 1 leak point. You can only have flow in multiple directions in a groundwater flow system from a point of relatively higher groundwater levels - these higher groundwater levels would have been induced by the volume of liquid released during the leak. As stated previously, OPG staff have failed to respond to my information request concerning leakage volumes, duration, and strengths.

Overall, I find the handling of the 2018 leakage incident in the 2018 Groundwater Report to be unsatisfactory. Despite its seriousness and extraordinary nature, the incident and its consequences are downplayed. There is no real disclosure of the leakage incident in the report's conclusions on page 5, and (quite likely as a result) there is no mention of the incident in the 2018 ROR Report's section on the PNGS.

It is worth noting that there were also 2 other significant releases or occurrences of tritium-contaminated water in other parts of the PNGS property in 2017 and 2018, albeit with groundwater tritium levels which although still very high did not approach the peaks of the major leak near Reactor Unit 1.

These additional occurrences of tritium leaks or releases are discussed in the next sections of this report.

2017 Leak, Near Reactor Unit 5

A separate major plume of heavily tritiated groundwater developed from a leak from the Moderator Room at Reactor Unit 5 in 2017, with significant contamination still present (though mostly subsiding) in 2018.

Peak tritium levels in groundwater monitoring points around Reactor Unit 5 reached levels in excess of 100 million Bq/L in 2017 at monitoring points RBU5-GT-1, RBU5-GT-2, RBU5-GT-3, RBU5-GT-4, and U5-MK26, subsiding sharply in 2018 - although a level of 26 million Bq/L was still noted at RBU5-GT-1 in the first quarter of 2018. I do not know if the major 2017 leak was mentioned in the 2017 Groundwater Report, as OPG staff have refused to release that report.

2018 Leak, Near Reactor Unit 6

Yet another major plume of heavily tritiated groundwater developed in 2018, emanating from the Moderator Room at Reactor Unit 6. Peak tritium levels in groundwater monitoring points around Reactor Unit 6 reached levels of about 10-30 million Bq/L in 2018 at monitoring points RBU6-GT-2, RBU6-GT-3, and RBU6-GT-4 subsiding to between 1 and 7 million Bq/L by the end of 2018.

Though details are scant in the 2018 Groundwater Report, it seems clear that there were major leaks of tritiated water from the Moderator Rooms at Reactors 1, 5, and 6 in 2017 and 2018. I recommend that it would be well worth investigating and if needed carrying out preventative maintenance at the other active reactors' Moderator Rooms (ie. at Reactor Units 4, 7, and 8) in the very near future - it is not clear to me why this measure was not recommended in the 2018 Groundwater Report or the 2018 ROR Report.

It is quite possible that this recommendation was not provided in the 2018 ROR Report, because that report's authors may not have been aware of the extraordinary leaks which were happening at the PNGS in 2017 and 2018. As explained above, the issue is downplayed in the 2018 Groundwater Report.

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 failure to release useable current and historic monitoring data. There is no way to determine the magnitude of the leaks which led to the observed contaminant plume(s) or to determine 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. And from my knowledge of the site, I can additionally say that there is no treatment of that contaminated groundwater before it reaches the lake.

d) Pathways for Groundwater Contamination to Reach Lake Ontario

Interestingly, the 2017 ERA Report issued in support of the PNGS 10-year license extension application did not consider groundwater in its risk assessments. To the extent that there was one, the "rationale" for this astonishing oversight was 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.

The 2017 ERA Report does not attempt 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 conventional groundwater flow paths alone.

Moreover, the leakage volume of contaminated groundwater will be variable over time, depending on Lake Ontario water levels. Average Lake Ontario water levels range annually from 74.5 to 75 meters above sea level (masl), with highest average levels in the spring and summer and lowest levels in the late autumn and winter.

Extremes in lake levels range from 73.8 to 75.9 masl. When lake levels are higher, groundwater flows to the lake will be lower - and likewise the flows of contaminants being carried by the groundwater will be lower. But when lake levels are on the low side (eg. below 74.5 masl) then groundwater and contaminant flows will be higher. It is possible that groundwater in the vicinity of at least some of the reactor units will drain directly to the lake at times of low groundwater levels - this needs to be addressed in the groundwater monitoring program.

## 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 into 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 believe 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 OPG, 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.

b) Frequency of Sampling, and Availability of Results

I was told by OPG staff that there is no program of annual monitoring of the PNGS stormwater system for radiological or non-radiological contaminants. When I asked why, I was told "because we are not required to monitor the stormwater system". This speaks to a failure of the CNSC as regulator of this nuclear generating station.

When it comes to monitoring of the stormwater management system there is no regular, well thought out plan. 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, and by OPG staff):

- 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 (at one location)
- 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)
- no monitoring done in 2017
- no monitoring done in 2018

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. This lack of transparency concerns me greatly, as it raises the possibility of significant impacts being hidden from public view through the non-disclosure of monitoring results (as is the case with the groundwater monitoring program).

Following is a discussion of historic sampling results from the sporadic testing campaigns on the site stormwater management system which have been undertaken at the PNGS. I am unable to refer to 2017 or 2018 test results, because I was not provided with any such test results - which makes sense given that OPG staff confirmed that they did no testing.

I nonetheless feel it is important to provide a discussion of historic stormwater sampling results for the PNGS, because in my view the stormwater system is leaky and is allowing for contaminated groundwater to leak into the system and then be flushed into Lake Ontario untreated. The historic results attest to problem areas within the system.

If a regular and thorough monitoring campaign were undertaken, then problem areas could be investigated and proactively dealt with - possibly avoiding major leaks (such have occurred into the groundwater system at the PNGS in 2017 and 2018).

c) Stormwater Management System Monitoring Results

In looking for historic results, I was able 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.** Catchment 3 is the catchment which includes Reactor Units 3 and 4. At MH211 in Catchment 3, 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.** Catchment 5 is the catchment which includes Reactor Units 5, 6, and 7. Peak tritium levels of 35,300 Bq/L were noted in MH20 for October 28, 2015. Zinc levels of over 12 times the PWQO 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 straight 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 available stormwater system test results were acceptable.** In the discussion above I highlighted the problem areas - but the majority of the test results available to me were acceptable with only minor impairment evident. It remains to be seen if more systematic monitoring of the stormwater system and full access to historic test results would reveal more problematic contamination areas at the PNGS. In particular, a real opportunity was missed in 2017 and 2018, when spikes of tritium were moving through the groundwater system - storm sewer monitoring might have picked up these spikes in areas where leaks were present.

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.

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.

Quarterly water quality monitoring should be done on every line which is discharging to the forebay, the outfalls, or directly to Lake Ontario. 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/toxic stormwater to be discharged to Lake Ontario via the stormwater collection system.

## 5) Review of PNGS Surface Water Discharge Related Site Monitoring Programs

a) Introduction

There are a large variety of liquid discharges to surface water 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.).

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

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. Following is a list of the various surface 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. The following discussion of the programs and their results is taken from my 2018 Report on the PNGS.

I apologize in advance for any factual errors - where such errors crop up, it will be because of the 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 single document which I am aware of which lays out in a straight-forward, rational fashion the various 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 programs. But more detailed testing of Lake Ontario water quality in closer 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 for the parameters tested 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, Conservation, and Parks (MOECP).

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.

## 6) OPG's Lack of Transparency Regarding Some Aspects of Site Monitoring

a) Introduction

It was a shock to me in 2018, when we requested site monitoring data for the PNGS and were entirely rebuffed - with nothing being released by OPG in response to our information requests.

While there were grudging responses to information requests this time around (following direction from the CNSC), in many cases the responses were not helpful. My impression is that OPG staff are happy to carry out monitoring, and release the resulting monitoring results when they are favourable. Conversely, it seems that potential problem areas are being avoided in the site monitoring programs (ie. the stormwater system), and that when concerning results become available these are then downplayed if not suppressed entirely (as was the case for the major leaks of tritium-contaminated moderator water to the groundwater system in 2017 and 2018).

The lack of transparency is a matter of grave concern to my clients, and my colleague (Ms. Pippa Feinstein) will be addressing this issue in considerably more detail in her submission.

b) Groundwater Monitoring Program

At my request, OPG staff provided me with the *Pickering Nuclear Groundwater Sampling and Analysis Plan* for 2018. I appreciate being provided with the document. It is clear from the document that there is a well-established groundwater monitoring program at the PNGS. What is needed to properly assess that program is a site-wide large map showing all of the site's groundwater monitors, with those being sampled for a particular parameter (eg. tritium) being highlighted on the map.

However the bigger problem is the apparent suppression of adverse groundwater sampling results.

Based on the information available to me, I believe that the major leak from the Moderator Room at Unit 5 in 2017 was quite possibly the most serious leak into the groundwater flow system in the history of the PNGS up to that time. Last year when a 10-year extension of the site license was being considered by the CNSC, OPG staff flat out refused to release the 2017 monitoring results or the 2017 Groundwater Report.

This year OPG staff were directed by the CNSC (in Condition 408 of its Record of Decision) to release the requested information. The requested 2017 Groundwater Report was not however released, nor were requested groundwater monitoring data from 2017 or earlier years - in direct contravention of the direction given in Condition 408.

The only meaningful document released by OPG was the 2018 Groundwater Report - ironically, this report contained information confirming that the extraordinary leak of tritiated water from Reactor Unit 1's Moderator Purification Room was even worse that the prior leak at Unit 5 in 2017 (thus making it the new possibly worst leak into the groundwater system in the site's history).

I find it very hard to 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 absence of badly needed relevant information (such as maps illustrating the groundwater sampling program, and borehole logs and monitor installation details), 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 all 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 directly 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.

I should note that I recently found the 2018 Groundwater Report has been posted on the OPG website. This is a welcome step, though it does not address the need to post past groundwater monitoring information on the website.

Also on the OPG website is a new interactive GIS map of the PNGS which shows selected groundwater monitoring points - if you click on a given point, you can see monitoring data back to 2009 and you can even get a graph of the data. This sounds promising, however I carefully checked the GIS map and found that the map only contains a small subset of the site's groundwater monitoring points - and none of them were affected by the 2018 extraordinary leak of treated water from the Unit 1 area. For greater clarity, none of the monitoring points listed in **Table 1** of this report which showed 2018's elevated groundwater tritium levels are on the GIS map. Nor were any of the selected wells on the GIS map significantly affected by the major 2017 leak (which had been the biggest-ever leak as far as I know, until superseded by the extraordinary 2018 leak).

So OPG does not appear to be moving meaningfully in the direction of transparency when it comes to its handling of current or past groundwater monitoring results.

c) Stormwater Quality Monitoring Program

My understanding is that there is currently no annual stormwater quality monitoring program for the PNGS, even though past sporadic monitoring of the system has shown there are hot spots where contamination is getting into the system (and from there into Lake Ontario). These facts are not publicized by OPG, or by the CNSC.

In fact there is no mention of this issue in the 2018 ROR Report. In that regard, the ROR Report is similarly silent when it comes to monitoring of stormwater discharges from other nuclear power generating sites. My expectation is that there is no such monitoring being required by the CNSC, and thus that it is not being done. I strongly recommend that a change in course is required.

It is vital that the CNSC takes a more proactive, systematic approach to monitoring of the stormwater collection lines at the PNGS, and at the other nuclear generating stations and nuclear substance processing facilities which it oversees. A lot of water moves through such subsurface lines, and especially at older facilities they can become pathways for contaminants to escape from otherwise well-regulated facilities.

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. Moreover, if adverse monitoring results are acted on then this can help keep contaminants out of the Canada's lakes and rivers. It would be well worthwhile for OPG to take a more proactive, systematic, and transparent approach to monitoring of the stormwater collection lines at the PNGS. But likewise it would be well worthwhile for the CNSC to insist on it.

## 7) Improving ROR Reports and the Monitoring of Nuclear Generating Stations

Seen from the perspective of providing a complete and transparent overview of potential water-related impacts of a nuclear generating station, the 2018 ROR Report is an inadequate document.

There are at least four pathways by which a nuclear generating station could be having water-related impacts on the surrounding environment:

- spills, leaks, or discharges of tritium-contaminated moderator water
- contamination of groundwater
- leakage of contaminated groundwater into the facility's the storm sewer system
- contamination of waste water going to a waste water treatment facility.

Of these 4 potential pathways, only one is really covered for the nuclear facilities discussed in the 2018 ROR Report. In this report, I have addressed the first three pathways. Contamination of waste water going to a waste water treatment facility is a fourth possible pathway which also should not be overlooked.

I recommend that on a go-forward basis each ROR Report should list the 4 pathways for each nuclear facility, and provide an overview of the results of testing which hopefully confirms that there are no issues of concern.

## 8) Discussion

This report has identified a number of issues of concern regarding the PNGS. A change of mindset is needed among OPG staff, in order to properly address the identified issues.

To date, OPG staff have been unwilling to be transparent in making the results of the PNGS groundwater monitoring available to the public and to public interest groups. Moreover, the overall approach to site monitoring is reactive rather than proactive.

It is high time to take a new approach to the monitoring of this facility, which is Canada's oldest nuclear generating station. The oldest units at the PNGS have been in operation for 48 years, and as Canada's oldest station it is more vulnerable than newer facilities.

There is an urgent need to implement systematic, annual monitoring of water quality in the site's stormwater system - which is not being currently monitored. Past testing has shown that there are hot spots in the system with unacceptable water quality in the stormwater (which flows untreated into Lake Ontario). The groundwater monitoring program (and the reporting of test results) also needs an overhaul, and as regulator the CNSC has an important role to play in directing OPG to modernize.

## 9) Conclusions

1) I was funded to conduct a technical review of the 2018 ROR Report, and of groundwater monitoring reports and data which were to made available to my clients (Swim Drink Fish Canada / Lake Ontario Waterkeeper) as directed by the CNSC.

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 further information is provided in **Appendix 1** of this report.

2a) A shallow groundwater flow system is present in the near-surface overburden materials, which consist of the upper till, the construction fill, and the bedding for the many subsurface conduits and lines at this site.

2b) Overall the vast majority of the groundwater contamination at the PNGS is found in the shallow flow system. The groundwater flow rates are also highest in the shallow flow system, and thus this is the unit in which most of the groundwater (and the contaminant load) will be moving. All of the groundwater in the shallow flow system ultimately discharges into Lake Ontario.

2c) 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 in some cases have depressed groundwater levels in their vicinity to below the Lake Ontario water level. Groundwater flow will be toward these features from their surroundings.

3a) It is clear through information gleaned from a variety of sources that the groundwater at the PNGS is badly contaminated. Tritium is the main contaminant of concern, but there are also other potentially hazardous industrial chemicals contaminating parts of the on-site groundwater flow system.

3b) Publicly available reports speak with concern of peak groundwater tritium levels of up to 2+ million Bq/L at the PNGS, while various PNGS-related documents including the 2017 ERA Report and the 2017 PNGS License Application make reference to peak groundwater tritium levels of up to 3+ million Bq/L.
However figures buried in a consultant's report on the PNGS revealed that in fact peak tritium levels in groundwater at the PNGS were in excess of 30 million Bq/L throughout the years of 2001 - 2005.

4a) Historic levels of tritium contamination of the PNGS groundwater system were dwarfed by a major leak from the Unit 5 Moderator Room in 2017 and by an even greater, extraordinary leak from the Unit 1 Moderator Purification Room in 2018.

4b) The highest 2018 groundwater tritium levels were found in the first quarter of 2018, when levels of 1.2 billion Bq/L and 1.1 billion Bq/L respectively were recorded in groundwater monitoring points U1-RBFD-1 and U1-RBFD-2.

4c) Plumes spread in 3 directions from the leak point, confirming that a significant quantity of contaminated liquid was released from the Unit 1 leak point. OPG staff failed to respond to my information request concerning actual leakage volumes, duration, and strengths.

4d) The spread of contamination from the extraordinary 2018 leak was relatively rapid, confirming that shallow groundwater flow rates at the PNGS can exceed 100 meters per year - far above the 0.3 to 11 meters per year which had been indicated in documents provided to CNSC in 2018 at the time of OPG's 10-year license renewal application.

5) In total there were 3 major leaks of highly tritiated water from Moderator Rooms at Units 1, 5, and 6 in 2017 and 2018. The 2017 leak at Unit 5 may have been the worst-ever case of groundwater contamination at the PNGS, until it was superceded by the even greater leak at Unit 1 in 2018.

6) It is difficult to develop a full understanding of the extent or significance of the ongoing groundwater flow system contamination at the PNGS, given OPG's failure to release current and useable monitoring data.

In the absence of the information which is being withheld by OPG, there is no way to determine the magnitude of the leaks which led to the observed contaminant plume(s) or to accurately determine groundwater flow and contaminant transport rates in the groundwater flow system

7) At the PNGS all of the contaminated groundwater eventually ends up in Lake Ontario. There is no treatment of that contaminated groundwater before it reaches the lake.

8a) 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.

8b) 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.

8c) 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 stormwater system. From there it will be rapidly transported to the lake.

9) The available information on the stormwater collection system (at least in those lines which were sampled in 2015/2016 and reported on in the 2014 and 2017 ERA Reports) suggests that at the majority of sampled locations only minor and insignificant impairment of water quality was found.

10a) 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.

10b) There is currently no ongoing program of stormwater quality monitoring at the PNGS. My recommendations regarding stormwater quality monitoring are provided in **Section 4d**) and in **Recommendation 3** of this report.

11) Issues pertaining to the water-related PNGS site monitoring programs are discussed in **Section 5** of this report. The available information suggests that lake water quality is good around the PNGS, however additional monitoring measures to be added to these monitoring programs are recommended (as outlined in **Section 5**).

12) Although the 2018 Groundwater Report and a new interactive GIS map which shows selected PNGS groundwater monitoring points are now available on the OPG website, the extraordinary 2018 leak is downplayed in the 2018 Groundwater Report and none of the most heavily impacted groundwater monitoring points are included on the interactive GIS map. Further work on transparency is urgently needed.

## 10) Recommendations

**Recommendation 1)**

**Though details are scant in the 2018 Groundwater Report, it seems clear that there were major leaks of highly tritiated moderator water from the Moderator Rooms at Reactors 1, 5, and 6 in 2017 and 2018.**

**To the extent that these haven't happened yet, careful investigation and any necessary preventative maintenance at the other active reactors' Moderator Rooms should be carried out (ie. at Reactor Units 4, 7, and 8).**

**Recommendation 2)**

**The OPG staff should be directed to calculate shallow groundwater flow rates based on the spreading times of tritium contamination from recent 2017 and 2018 spills, and to then correct the public record and the information which was submitted to the CNSC in 2018 in the 10-year license extension application.**

**Recommendation 3)**

**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 should be metered.**

**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 4)**

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. Outfall water quality testing should also 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. Quarterly reports should provide a transparent explanation for how the data being presented in Table A.3 are obtained.**

**Recommendation 5)**

a) **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.**

b) **OPG should 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 6)**

**The 4 pathways by which a nuclear generating station could cause water-related impacts on the surrounding environment are outlined in Section 7 of this report. On a go-forward basis each ROR Report should list not just 1 but all 4 pathways for each nuclear facility, and provide an overview of the results of testing which confirms that there are no issues of concern.**

## 11) 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.

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

Signed on the 30th day of October, 2019


Wilf Ruland (P.Geo.)

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# Appendix 1

## Summary of Interactions with OPG and CNSC Staff regarding Requests for Provision of Information

Following is a summary of our interactions/requests with OPG staff, regarding the provision of requested water-related technical information.

**Information Request A**

This was sent by my colleague Ms. Pippa Feinstein. She requested the following:

*1) The last five years worth of Annual Groundwater Monitoring Reports; and*

*2) Raw monitoring data from all groundwater monitoring wells on and around the Pickering site (collected over the last three years at least), if the Annual Groundwater Monitoring Reports do not include raw data.*

On Item 1, only one of the last 5 Annual Groundwater Monitoring Reports was provided - the report for 2018.

On Item 2, the only data provided were the data in the 2018 Monitoring Report.

**Information Request B**

This information request was sent by myself on September 19, 2019. My request follows below in *italics*, and my assessment of each OPG response is provided in **bold type**.

*1) Was the 2018 Pickering Nuclear Groundwater Monitoring Program Results report submitted to the CNSC, and if so on what date?*
**A satisfactory response was provided.**

*2) Please provide a full copy of the 2018 Groundwater Sampling and Analysis Plan (SAP) referred to on pages 6 and 7 of the 2018 Pickering Nuclear Groundwater Monitoring Program Results report.*
**The requested plan was provided.**

*3) Please provide a legible map showing the locations and designations of all 146 sampling locations referred to in Section 2.2 of the 2018 Pickering Nuclear Groundwater Monitoring Program Results report.*
**The map provided was barely legible and really not very useful. A better map needs to be developed.**

*4) Please provide a legible map showing the locations and designations of all 80 wells referred to in Section 3.1 of the 2018 Pickering Nuclear Groundwater Monitoring Program Results report. Please also provide the 2018 water level data for each of the wells, and confirm which of the wells were used in preparing the groundwater contour map in Figure 2.*
**The requested water level data were not provided in a usable format.**

*5) Please provide a detailed description (including hydraulic conductivities) of each of hydrostratigraphic units listed in Section 3.1 of the 2018 Pickering Nuclear Groundwater Monitoring Program Results report. If possible, please provide cross-section(s) showing the units.*
**A description of the units and cross-sections were provided.**

*6) For each of the monitoring wells and ground tubes sampled in 2018, please indicate which hydrostratigraphic unit(s) the well or ground tube was screened/completed in.*
**This requested information was not provided.**

*7) Please confirm whether there was any sampling done of the storm sewer systems in the Unit 1 to 4 areas (and any other areas) where groundwater contamination dramatically worsened in 2018, and if sampling was done then please provide full results of that sampling.*
**No results were provided.**

*8) If there are any other groundwater sampling results for 2018 which have not been included in the 2018 Pickering Nuclear Groundwater Monitoring Program Results report then please provide them.*
**I was told there was no other testing done.**

*9) The linear graphical representations of tritium data in the 2018 Report all suffer from a major problem, in that there is a discontinuity between the 0 level on the y-axis and the next increment above the 0 level. This discontinuity makes it impossible to obtain an accurate visual overview of the sampling results on many of the graphs. Please explain why this linear method (with a major discontinuity) of data presentation is being used, instead of using other ways of presenting the data (for example using orders of magnitude)?*
**Clarification of the question was sought.**

*10) How does the leakage-related spike in groundwater contamination by tritium (in the Unit 1 to 4 area) in 2018 compare to other prior incidents of groundwater contamination at PNGS? Am I correct in considering this to be one of the worst groundwater contamination events in the station's history?*
**These questions were not answered.**

*11) It appears that the majority of sampling locations in the TAB foundation drains could not be sampled in 2018 - is this a recent development, or how long has there been an inability to sample these locations? What is being done to remedy the situation?*
**OPG did not indicate how long there had been a problem, but indicated that progress was being made in remedying the situation.**

*12) In my 2018 Report on the PNGS License Application, I identified several locations where the PNGS storm sewer system is significantly contaminated. Is it possible that there is a groundwater source for this contamination (i.e. leakage into the system at times of higher groundwater levels)? If not, then what are the most likely sources, and what efforts are underway to remediate them?*
**These questions were not answered.**

*13) The 2018 Pickering Nuclear Groundwater Monitoring Program Results report does not appear to have any recommendations, and to the extent that there are conclusions these appear to only be listed in the Executive Summary. Is this common practice?*
**The question regarding recommendations was not answered.**

## Follow-up Information Request C

This information request was sent by myself on October 7, 2019. My request follows below in *italics*, and my assessment of each OPG response is provided in **bold type**.

*1) Your Response #4 provides a table showing a list of wells and 2018 water levels. The units are "mbref" which I am assuming is short for "meters below reference" - please confirm that this is the case.*
**The requested confirmation was provided.**

*Assuming I have interpreted "mbref" correctly, the next question is what the reference elevation? If all of the wells are surveyed in to a common datum, then please provide the datum's elevation in meters above sea level (masl). If the reference elevation is unique to each well, then please provide the water levels in meters above sea level (masl), as the data in the table will not on their own be very useful.*
**The requested information was not provided.**

*Please note that I very much appreciate the drawing which you generated with the groundwater elevations in masl shown on the map. However comparison of the water levels and the contours on the figure raises questions about how the contours were generated, as there is often a discrepancy between the spot elevations and the nearest contours. Could you please confirm how the contours on the 2018 Q4 Shallow Groundwater Contours map were generated?*
**It was confirmed that the drawings are software-generated.**

*2) Your Response #6 requests further time to respond. It would be very helpful if the requested information could be provided by October 21, 2019.*
**The requested information was not provided.**

*3) Your Response #9 indicates that "more information is needed with respect to this inquiry". This is an understandable comment, as I expressed myself poorly.*

*If we consider Graph 1 on page 13 of the 2018 PNGS Groundwater Monitoring Results report, then when compared to prior years' results shown for location U1-RBFD-1 (in Graph 1) there is a very clear spike in tritium levels in early 2018. Consideration of the data table (Table A-1) in the report shows that indeed tritium levels for U1-RBFD-1 were very high at 1.19 billion Bq/L in Q1. Where Graph 1 is particularly unhelpful is when it comes to trying to put the Q1 spike into context. It can be seen from Graph 1 that the Q1 2018 spike in tritium levels dwarfs all prior sampling results back through 2009. Where Graph 1 is problematic for me, is that it is really hard to read 2009 through 2017 data from the graph, because the 2018 spike is taking up most of the "bandwidth" on the Y-axis. Normally this wouldn't matter much, because I could just go back and look at the data for previous years. It matters here, because OPG is refusing to either release the actual data from prior years or the prior years' monitoring reports.*

*I would again urge OPG to release the 2014-2017 groundwater monitoring reports. This should not be an onerous task, as I am assuming that they were provided to CNSC previously.*
**OPG staff indicated that there was "no value in providing" the requested information. The information was not provided.**

*4) With respect to your Response #10, you did not answer the question which was put to you. In my review of the 2018 PNGS Groundwater Monitoring Results report, I am planning to share with CNSC my determination that (based on the information available to me) the 2017 leak from the Unit 5 Moderator Room was likely the worst leak in PNGS history until that time in terms of measured groundwater tritium contamination levels (which reached about 400 million Bq/L at RBU5-GT-1). Then in 2018, the leak from the Unit 1 Moderator Purification Room exceeded the 2017 leak in terms of measured groundwater tritium contamination levels (which reached about 1.2 billion Bq/L at U1-RBFD-1) - making it the new worst leak in PNGS history.*

*If you have information which indicates I am incorrect in making the above statements then please let me know, and please provide the data confirming this to be the case.*
**There was no response to this information request.**

*5) Regarding the major leak of tritium-contaminated water from the Unit 1 Moderator Purification Room, please provide any available information on the following:*
*- the estimated length of time over which the leakage was occurring*
*- the estimated total volume of tritium-contaminted water which leaked into the groundwater system*
*- the estimated tritium levels in the leaking water*
*- any memo(s) or report(s) prepared in the course of the "very intensive and thorough investigation" (mentioned on page 12 of the 2018 PNGS Groundwater Monitoring Results report) of the elevated tritium levels found in the foundation drain at Reactor Unit 1,*
**The first and third points were addressed, the second and fourth were not.**

*6) The 2018 major leak occurred from the Unit 1 Moderator Purification Room, as outlined on page 12 of the 2018 PNGS Groundwater Monitoring Results report. There were also significant leaks of tritium contamination from the Moderator Room at Unit 5 (in 2017) and from the Moderator Room at Unit 6 (in 2018), as outlined on pages 16 and 17 of the 2018 Groundwater Report. Is there a difference between the "Moderator Purification Room" from which the 2018 leak occurred at Unit 1, and the "Moderator Room" from which the 2017 and 2018 leaks occurred at Unit 5 and Unit 6? If so, then please explain.*
**A helpful answer was provided.**

*Also, it appears that Moderator Room floor construction joints were implicated in the leaks from Unit 5 in 2017 and Unit 6 in 2018 - so I am interested in understanding why preventative inspections and/or maintenance on Moderator Room floor construction joints was not recommended for Units 4, 7 and Unit 8 in the 2018 PNGS Groundwater Monitoring Results report?*
**OPG staff indicated that work was performed on other units, as a result of the groundwater issues at Units 5 and 1. They further indicated that making the suggested recommendation was outside the scope of the program.**

*7) I note that OPG has only minimally responded to the information request submitted on my behalf by Ms. Pippa Feinstein on August 22nd, 2019. In her e-mail to yourself, Ms. Feinstein made the following request:*

*"At this time, we request the following information:*

*1) The last five years worth of Annual Groundwater Monitoring Reports; and*

*2) Raw monitoring data from all groundwater monitoring wells on and around the Pickering site (collected over the last three years at least), if the Annual Groundwater Monitoring Reports do not include raw data*."

*The requested information is needed for my CNSC-funded review, and I would very much appreciate OPG providing it*.
**OPG staff indicated that there was "no value in providing" the requested information. The information was not provided.**

# Appendix 2

# References

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


Canadian Nuclear Safety Commission. Sept. 6, 2019. Commission Member Document 19-M30. Regulatory Oversight Report for Canadian Nuclear Power Generating Sites: 2018

Canadian Nuclear Safety Commission. January 2008. Standards and Guidelines for Tritium in Drinking Water (INFO-0766).

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Domenico, P.A. and Schwartz, F.W. 1998. Physical and Chemical Hydrogeology.

ECOMETRIX INCORPORATED. January 7, 2014. Environmental Risk Assessment Report For Pickering Nuclear, P-Rep-07701-00001 R0.

Fairlie, Dr. Ian. Tritium Hazard Report: Pollution and Radiation Risk from Canadian Nuclear Facilities. Report prepared for Greenpeace.

Freeze, R.A. and Cherry, J.A. 1979. Groundwater.

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Lake Ontario Waterkeeper. April 25, 2013. Request To Intervene, Lake Ontario Waterkeeper, Hearing Regarding Opg's Requested Five Year Operating Licence For The Pickering Nuclear Generating Facility.

Ontario Clean Air Alliance. January 29, 2016. Pickering Nuclear: Unsafe At Any Speed.

Ontario Drinking Water Advisory Council. May 21, 2009/. Report and Advice on the Ontario Drinking Water Quality Standard for Tritium.

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Ontario Ministry of the Environment and Climate Change. July 1, 2011. Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act.

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Ontario Power Generation (OPG). 2019. Pickering Nuclear Groundwater Monitoring Data (GIS map), available on the OPG website.

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Ontario Power Generation (OPG). Q4, Q3, Q2, and Q1, 2018. Performance Reports for Pickering Nuclear.

Ontario Power Generation (OPG). May 26, 2017. 2016 Misa Annual Report - Pickering Nuclear (Misa Company Code 0001840206).

Ontario Power Generation (OPG). August 12, 2016. 2016 Pickering Nuclear Environmental Compliance Approval (Industrial Sewage - #4881-5Mhq9F) Annual Performance Report.

Ontario Power Generation (Opg). July 12, 2016. 2015 Results Of Environmental Monitoring Programs, N-Rep-03443-10015-R001.

Ontario Power Generation (OPG). April 16, 2013. 2012 Results Of Radiological Environmental Monitoring Programs, N-Rep-03481-10011.

Ontario Regulation 169/03: Ontario Drinking Water Quality Standards. Updated January 2017.

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 18, 2018. 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 B: Information Requests Made by LOW to OPG, and OPG responses to date

- August 22 Information request made to OPG:

*1) The last five years' worth of Annual Groundwater Monitoring Reports; and*
*2) Raw monitoring data from all groundwater monitoring wells on and around the Pickering site (collected over the last three years at least), if the Annual Groundwater Monitoring Reports do not include raw data.*

- August 26 received response with promise that OPG staff would respond to LOW requests.

- September 4, LOW receives invitation for site visit at PNGS. Agrees to attend but stresses the need to obtain requested information in advance and as soon as possible.

- September 13, LOW sends follow-up query about requested information.

- September 16, LOW sends follow-up query about requested information.

- September 17, OPG provides its 2018 Groundwater Monitoring Report to LOW.

- September 19, after reviewing the 2018 Groundwater Monitoring Report, LOW makes the following additional requests for information:

*1) Was the 2018 Pickering Nuclear Groundwater Monitoring Program Results report submitted to the CNSC, and if so on what date?*

*2) Please provide a full copy of the 2018 Groundwater Sampling and Analysis Plan (SAP) referred to on pages 6 and 7 of the 2018 Pickering Nuclear Groundwater Monitoring Program Results report.*

*3) Please provide a legible map showing the locations and designations of all 146 sampling locations referred to in Section 2.2 of the 2018 Pickering Nuclear Groundwater Monitoring Program Results report.*

*4) Please provide a legible map showing the locations and designations of all 80 wells referred to in Section 3.1 of the 2018 Pickering Nuclear Groundwater Monitoring Program Results report. Please also provide the 2018 water level data for each of the wells, and confirm which of the wells were used in preparing the groundwater contour map in Figure 2.*

*5) Please provide a detailed description (including hydraulic conductivities) of each of hydrostratigraphic units listed in Section 3.1 of the 2018 Pickering Nuclear Groundwater Monitoring Program Results report. If possible, please provide cross-section(s) showing the units.*

*6) For each of the monitoring wells and ground tubes sampled in 2018, please indicate which hydrostratigraphic unit(s) the well or ground tube was screened/completed in.*

*7) Please confirm whether there was any sampling done of the storm sewer systems in the Unit 1 to 4 areas (and any other areas) where groundwater contamination dramatically worsened in 2018, and if sampling was done then please provide full results of that sampling.*

*8) If there are any other groundwater sampling results for 2018 which have not been included in the 2018 Pickering Nuclear Groundwater Monitoring Program Results report then please provide them.*

*9) The linear graphical representations of tritium data in the 2018 Report all suffer from a major problem, in that there is a discontinuity between the 0 level on the y-axis and the next increment above the 0 level. This discontinuity makes it impossible to obtain an accurate visual overview of the sampling results on many of the graphs. Please explain why this linear method (with a major discontinuity) of data presentation is being used, instead of using other ways of presenting the data (for example using orders of magnitude)?*

*10) How does the leakage-related spike in groundwater contamination by tritium (in the Unit 1 to 4 area) in 2018 compare to other prior incidents of groundwater contamination at PNGS? Am I correct in considering this to be one of the worst groundwater contamination events in the station's history?*

*11) It appears that the majority of sampling locations in the TAB foundation drains could not be sampled in 2018 - is this a recent development, or how long has there been an inability to sample these locations? What is being done to remedy the situation?*

*12) In my 2018 Report on the PNGS License Application, I identified several locations where the PNGS storm sewer system is significantly contaminated. Is it possible that there is a groundwater source for this contamination (i.e. leakage into the system at times of higher groundwater levels)? If not, then what are the most likely sources, and what efforts are underway to remediate them?*

*13) The 2018 Pickering Nuclear Groundwater Monitoring Program Results report does not appear to have any recommendations, and to the extent that there are conclusions these appear to only be listed in the Executive Summary. Is this common practice?*

- September 25, LOW wrote to CNSC Secretariat to request assistance in obtaining requested information from OPG.

- October 4, OPG provided the following responses (in red) to LOW's questions:

*1) Was the 2018 Pickering Nuclear Groundwater Monitoring Program Results report submitted to the CNSC, and if so on what date?* ***OPG RESPONSE – Yes. It was submitted on April 26, 2019.***

*2) Please provide a full copy of the 2018 Groundwater Sampling and Analysis Plan (SAP) referred to on pages 6 and 7 of the 2018 Pickering Nuclear Groundwater Monitoring Program Results report.* ***OPG RESPONSE - Please see attached P-PLAN document.***

*3) Please provide a legible map showing the locations and designations of all 146 sampling locations referred to in Section 2.2 of the 2018 Pickering Nuclear Groundwater Monitoring Program Results report.* ***OPG RESPONSE - Figure 1 (pg 8) shows all the locations sampled. Figure 3 (pg 15), Figure 4 (pg 29), Figure 5 (pg 27) and Figure 6 (pg 34) zoom in on the various areas of the site and show the well identification names.***

*4) Please provide a legible map showing the locations and designations of all 80 wells referred to in Section 3.1 of the 2018 Pickering Nuclear Groundwater Monitoring Program Results report. Please also provide the 2018 water level data for each of the wells, and confirm which of the wells were used in preparing the groundwater contour map in Figure 2.* ***OPG RESPONSE – The well names and 2018 water levels (below reference elevation) are provided below. The locations can be found on the two attached monitoring well location drawings. The well names in the table below do not exactly coincide with the drawings, as they are shortened, but it should be fairly straightforward to figure out. I've also generate and attached a drawing that shows the elevations in addition to the contours. The * in the table below indicates the 44 wells that were used to generate the shallow groundwater contour map.***

| Well | Value | Unit |
|---|---|---|
| MW-024 * | 4.8 | mbref |
| MW-025 * | 10.11 | mbref |
| MW-027 | 9.85 | mbref |
| MW-028 | 10.85 | mbref |
| MW-033 | 7.72 | mbref |
| MW-037 * | 1.18 | mbref |
| MW-040 * | 4.23 | mbref |
| MW-046 | 5.6 | mbref |
| MW-047 | 8.24 | mbref |
| MW-049 * | 6.1 | mbref |
| MW-055 * | 3.1 | mbref |
| MW-056 * | 2.78 | mbref |
| MW-057 | 3.05 | mbref |
| MW-066 * | 1.87 | mbref |
| MW-075 | 3.19 | mbref |
| MW-076 * | 2.98 | mbref |
| MW-089 | 2.14 | mbref |
| MW-090 * | 2.4 | mbref |
| MW-091 | 3.64 | mbref |
| MW-093 * | 2.09 | mbref |
| MW-096 * | 2.8 | mbref |
| MW-102 | 1.53 | mbref |
| MW-105 | 2.42 | mbref |
| MW-111 | 2.45 | mbref |
| MW-117 * | 2.65 | mbref |
| MW-121 | 1.91 | mbref |
| MW-122 | 2.46 | mbref |
| MW-123 * | 1.58 | mbref |

| | | |
|---|---|---|
| *MW-124* | *2.61* | *mbref* |
| *MW-125* | *2.04* | *mbref* |
| *MW-145* | *2.35* | *mbref* |
| *MW-150* | *2.6* | *mbref* |
| *MW-161* | *4.08* | *mbref* |
| *MW-170 ** | *4.48* | *mbref* |
| *MW-171* | *2.2* | *mbref* |
| *MW-172 ** | *2.25* | *mbref* |
| *MW-186 ** | *2.92* | *mbref* |
| *MW-215 ** | *3.42* | *mbref* |
| *MW-221 ** | *2.75* | *mbref* |
| *MW-230 ** | *2.71* | *mbref* |
| *MW-235* | *2.83* | *mbref* |
| *MW-237 ** | *2.91* | *mbref* |
| *MW-239* | *2.89* | *mbref* |
| *MW-240 ** | *2.97* | *mbref* |
| *MW-241* | *3.24* | *mbref* |
| *MW-242 ** | *3.79* | *mbref* |
| *MW-243 ** | *4.93* | *mbref* |
| *MW-244* | *4.82* | *mbref* |
| *MW-246* | *2.96* | *mbref* |
| *MW-247* | *2.07* | *mbref* |
| *MW-260 ** | *2.65* | *mbref* |
| *MW-261 ** | *3.82* | *mbref* |
| *MW-264 ** | *1.59* | *mbref* |
| *MW-265 ** | *3.1* | *mbref* |
| *MW-266 ** | *2.99* | *mbref* |
| *MW-267 ** | *2.81* | *mbref* |
| *MW-269 ** | *3.03* | *mbref* |
| *MW-270 ** | *2.79* | *mbref* |
| *MW-273 ** | *3.03* | *mbref* |
| *MW-282* | *1.48* | *mbref* |
| *MW-285* | *1.48* | *mbref* |
| *MW-286 ** | *2.43* | *mbref* |
| *MW-288 ** | *2.4* | *mbref* |
| *MW-291* | *2.43* | *mbref* |
| *MW-293 ** | *2.37* | *mbref* |
| *MW-301* | *2.06* | *mbref* |

| | | |
|---|---|---|
| *MW-302* | *2.58* | *mbref* |
| *MW-303 ** | *3.23* | *mbref* |
| *MW-304 ** | *3.05* | *mbref* |
| *MW-313* | *2.99* | *mbref* |
| *MW-315 ** | *4.19* | *mbref* |
| *MW-317 ** | *2.99* | *mbref* |
| *MW-318* | *3.08* | *mbref* |
| *MW-320 ** | *2.8* | *mbref* |
| *MW-321 ** | *3.32* | *mbref* |
| *MW-322 ** | *1.72* | *mbref* |
| *MW-325 ** | *1.97* | *mbref* |
| *MW-345* | *2.4* | *mbref* |
| *MW-347* | *0.75* | *mbref* |
| *MW-348* | *1.15* | *mbref* |

*5) Please provide a detailed description (including hydraulic conductivities) of each of hydrostratigraphic units listed in Section 3.1 of the 2018 Pickering Nuclear Groundwater Monitoring Program Results report. If possible, please provide cross-section(s) showing the units.* ***OPG RESPONSE – The cross-sections are attached. Descriptions and hydraulic conductivities are provided below.***

- ***HU-1: Landfill – Landfill material consisting of excavated soils, construction debris, and miscellaneous solid wastes generated during construction and operation of the station. Due to the low hydraulic conductivity of the landfill materials, they were classified as an aquitard.***
- ***HU-2: Granular fill – Typically includes sand and gravel fill (i.e. Granular A or Granular B) that was used as bedding/backfill material for underground foundations/slabs, utility/service corridors, and for paved areas of the site. The granular fill materials (HU-2) adjacent to building foundations and service/ utility corridors are expected to be permeable and may act as conduits for the migration of groundwater, where they are present below the water table.***
- ***HU-3: Construction excavation fill (sandy to clayey silt) – The construction excavation fill material (HU-3) predominantly consists of sandy silt to clayey silt fill, containing pebbles, gravel, and shale fragments, which were derived from construction excavations and cut and fill operations.***
- ***HU-4: Organic clayey silt to silty clay – The fill material is locally underlain by a high organic silt/clay layer that has been generally described as black silt, peat, and organic clayey silt/silty clay. The presence of HU-4, representing the original ground surface, varies throughout the PNGS site, depending on the amount of re-grading that was undertaken prior to backfilling.***
- ***HU-4 is discontinuous and thin across the site. Because of its fine-grained texture, it may act as a partial confining layer or aquitard and may limit groundwater flow from the fill (HU-2 and HU-3) to the till (HU-5) where it is present.***
- ***HU-5: Brown sandy to clayey silt till – This HU generally consists of brown oxidized sandy silt to clayey silt till with some pebbles, gravel, cobbles, and shale fragments, containing local lenses and seams of fine sand. This HU is relatively thin***

***and discontinuous and, where present, likely represents the native shallow overburden material prior to re-grading/backfilling of the site. Throughout the PNGS, the presence of HU-5 varies depending on the amount of regrading that was undertaken in various areas of the site. Along the lakeshore and immediately offshore, HU-5 appears to be absent as deeper till units outcrop at surface in this area.***

- ***HU-6: Grey clayey silt to silty clay till – Underlying the brown till is a firm to stiff grey clayey silt to silty clay till with some pebbles, gravel, and shale fragments (HU-6). The till contains local interlayered lenses and seams of soft wet clay and sand with occasional gravel. The clayey silt/silty clay likely acts as an aquitard while the interlayered seams of sand and gravel will act as aquifers, although the seams appear to be localized and discontinuous and will have limited potential for groundwater flow.***
- ***HU-7: Grey sandy silt till – HU-7 comprises a dense to very dense complex of grey sandy silt till containing pebbles, gravel, and shale fragments. The till contains local interlayered lenses and seams of dense silts, sands, and gravel. The silt till likely acts as an aquitard while the interlayered seams of sand and gravel will act as aquifers; however, the seams appear to be localized and discontinuous and will have limited potential for groundwater flow.***
- ***HU-8: Shale bedrock – HU-8 is the underlying shale bedrock, generally described as dark-grey soft, weathered fissile shale with some clay along bedding planes. The shallow bedrock is noted to be weathered and fissile with horizontal fractures along bedding planes and infilling of the fractures with silty clay materials. The deeper bedrock, below 3 to 5 m from the bedrock surface, is noted to be more competent with fewer fractures, less weathering and no to slight infilling of fractures.***

| HUs | Description | Minimum (m/s) | Maximum (m/s) | Geometric Mean (m/s) |
|---|---|---|---|---|
| 1 | Landfill | 6.2x10-9 | 2.2x10-6 | 2.0x10-7 |
| 2 | Granular fill | 1.7x10-6 | 8.7X10-4 | 3.2X10-5 |
| 3 | Construction fill | 1.7X10-8 | 2.4X10-5 | 3.4X10-7 |
| 4 | Organic clayey silt to silty clay | No tests performed | | |
| 5 | Brown sandy to clayey silt till | 1.4X10-8 | 1.0X10-3 | 6.2X10-7 |
| 6 | Grey clayey silt to silty clay till | 1.5X10-9 | 2.9X10-4 | 2.2X10-7 |
| 7 | Grey sandy silt till | 4.6X10-9 | 2.5X10-4 | 4.6X10-7 |
| 8 | Shale bedrock | 3.5X10-8 | 1.3X10-7 | 7.0X10-8 |

*6) For each of the monitoring wells and ground tubes sampled in 2018, please indicate which hydrostratigraphic unit(s) the well or ground tube was screened/completed in.* ***OPG RESPONSE – We request more time for this particular request due to the time involved in order to extract this information.***

*7) Please confirm whether there was any sampling done of the storm sewer systems in the Unit 1 to 4 areas (and any other areas) where groundwater contamination dramatically*

*worsened in 2018, and if sampling was done then please provide full results of that sampling.* ***OPG RESPONSE - Monitoring storm sewer systems is not part of the groundwater monitoring program.***

*8) If there are any other groundwater sampling results for 2018 which have not been included in the 2018 Pickering Nuclear Groundwater Monitoring Program Results report then please provide them.* ***OPG RESPONSE - All results from 2018 are included in the report.***

*9) The linear graphical representations of tritium data in the 2018 Report all suffer from a major problem, in that there is a discontinuity between the 0 level on the y-axis and the next increment above the 0 level. This discontinuity makes it impossible to obtain an accurate visual overview of the sampling results on many of the graphs. Please explain why this linear method (with a major discontinuity) of data presentation is being used, instead of using other ways of presenting the data (for example using orders of magnitude)?* ***OPG RESPONSE - More clarification is needed with respect to this inquiry.***

*10) How does the leakage-related spike in groundwater contamination by tritium (in the Unit 1 to 4 area) in 2018 compare to other prior incidents of groundwater contamination at PNGS? Am I correct in considering this to be one of the worst groundwater contamination events in the station's history?* ***OPG RESPONSE - The concentration of tritium in groundwater noted in the Unit 1 area during 2018 were significantly higher than would be expected, which prompted the investigation and corrective action.***

*11) It appears that the majority of sampling locations in the TAB foundation drains could not be sampled in 2018 - is this a recent development, or how long has there been an inability to sample these locations? What is being done to remedy the situation?* ***OPG RESPONSE – Progress has been made with respect to modifying the IAD sump lids in order to simplify the collection of these samples.***

*12) In my 2018 Report on the PNGS License Application, I identified several locations where the PNGS storm sewer system is significantly contaminated. Is it possible that there is a groundwater source for this contamination (i.e. leakage into the system at times of higher groundwater levels)? If not, then what are the most likely sources, and what efforts are underway to remediate them?* ***OPG RESPONSE - Monitoring storm sewer systems is not part of the groundwater monitoring program.***

*13) The 2018 Pickering Nuclear Groundwater Monitoring Program Results report does not appear to have any recommendations, and to the extent that there are conclusions these appear to only be listed in the Executive Summary. Is this common practice?* ***OPG RESPONSE - The conclusions in the Executive Summary are also found in the many body of the report (pg 9, 11, and 28).***

- On October 7, LOW made the following follow-up request:

*1) Your Response #4 provides a table showing a list of wells and 2018 water levels. The units are "mbref" which I am assuming is short for "meters below reference" - please confirm that this is the case.*

*Assuming I have interpreted "mbref" correctly, the next question is what the reference elevation? If all of the wells are surveyed in to a common datum, then please provide the datum's elevation in meters above sea level (masl). If the reference elevation is unique to each well, then please provide the water levels in meters above sea level (masl), as the data in the table will not on their own be very useful.*

*Please note that I very much appreciate the drawing which you generated with the groundwater elevations in masl shown on the map. However comparison of the water levels and the contours on the figure raises questions about how the contours were generated, as there is often a*

*discrepancy between the spot elevations and the nearest contours. Could you please confirm how the contours on the 2018 Q4 Shallow Groundwater Contours map were generated?*

*2) Your Response #6 requests further time to respond. It would be very helpful if the requested information could be provided by October 21, 2019.*

*3) Your Response #9 indicates that "more information is needed with respect to this inquiry". This is an understandable comment, as I expressed myself poorly.*
*If we consider Graph 1 on page 13 of the 2018 PNGS Groundwater Monitoring Results report, then when compared to prior years' results shown for location U1-RBFD-1 (in Graph 1) there is a very clear spike in tritium levels in early 2018. Consideration of the data table (Table A-1) in the report shows that indeed tritium levels for U1-RBFD-1 were very high at 1.19 billion Bq/L in Q1. Where Graph 1 is particularly unhelpful is when it comes to trying to put the Q1 spike into context. It can be seen from Graph 1 that the Q1 2018 spike in tritium levels dwarfs all prior sampling results back through 2009. Where Graph 1 is problematic for me, is that it is really hard to read 2009 through 2017 data from the graph, because the 2018 spike is taking up most of the "bandwidth" on the Y-axis. Normally this wouldn't matter much, because I could just go back and look at the data for previous years. It matters here, because OPG is refusing to either release the actual data from prior years or the prior years' monitoring reports.*
*I would again urge OPG to release the 2014-2017 groundwater monitoring reports. This should not be an onerous task, as I am assuming that they were provided to CNSC previously.*

*4) With respect to your Response #10, you did not answer the question which was put to you. In my review of the 2018 PNGS Groundwater Monitoring Results report, I am planning to share with CNSC my determination that (based on the information available to me) the 2017 leak from the Unit 5 Moderator Room was likely the worst leak in PNGS history until that time in terms of measured groundwater tritium contamination levels (which reached about 400 million Bq/L at RBU5-GT-1). Then in 2018, the leak from the Unit 1 Moderator Purification Room exceeded the 2017 leak in terms of measured groundwater tritium contamination levels (which reached about 1.2 billion Bq/L at U1-RBFD-1) - making it the new worst leak in PNGS history. If you have information which indicates I am incorrect in making the above statements then please let me know, and please provide the data confirming this to be the case.*

*5) Regarding the major leak of tritium-contaminated water from the Unit 1 Moderator Purification Room, please provide any available information on the following:*
*- the estimated length of time over which the leakage was occurring*
*- the estimated total volume of tritium-contaminted water which leaked into the groundwater system*
*- the estimated tritium levels in the leaking water*
*- any memo(s) or report(s) prepared in the course of the "very intensive and thorough investigation" (mentioned on page 12 of the 2018 PNGS Groundwater Monitoring Results report) of the elevated tritium levels found in the foundation drain at Reactor Unit 1,*

*6) The 2018 major leak occurred from the Unit 1 Moderator Purification Room, as outlined on page 12 of the 2018 PNGS Groundwater Monitoring Results report. There were also significant leaks of tritium contamination from the Moderator Room at Unit 5 (in 2017) and from the Moderator Room at Unit 6 (in 2018), as outlined on pages 16 and 17 of the 2018 Groundwater Report. Is there a difference between the "Moderator Purification Room" from which the 2018 leak occurred at Unit 1, and the "Moderator Room" from which the 2017 and 2018 leaks occurred at Unit 5 and Unit 6? If so, then please explain.*

*Also, it appears that Moderator Room floor construction joints were implicated in the leaks from Unit 5 in 2017 and Unit 6 in 2018 - so I am interested in understanding why preventative inspections and/or maintenance on Moderator Room floor construction joints was not recommended for Units 4, 7 and Unit 8 in the 2018 PNGS Groundwater Monitoring Results report?*

*7) I note that OPG has only minimally responded to the information request submitted on my behalf by Ms. Pippa Feinstein on August 22nd, 2019. In her e-mail to yourself, Ms. Feinstein made the following request:*

"At this time, we request the following information:

1) The last five years worth of Annual Groundwater Monitoring Reports; and
2) Raw monitoring data from all groundwater monitoring wells on and around the Pickering site (collected over the last three years at least), if the Annual Groundwater Monitoring Reports do not include raw data."

*The requested information is needed for my CNSC-funded review, and I would very much appreciate OPG providing it.*

- LOW followed up with OPG on October 16, and again on October 22nd
- OPG replied on October 22 indicating they required further time to put together responses
- On October 23, OPG provided the following responses (in red) to LOW's follow-up questions and information requests:

1. Your Response #4 provides a table showing a list of wells and 2018 water levels. The units are "mbref" which I am assuming is short for "meters below reference" - please confirm that this is the case.

**Confirmed.**

Assuming I have interpreted "mbref" correctly, the next question is what the reference elevation? If all of the wells are surveyed in to a common datum, then please provide the datum's elevation in meters above sea level (masl). If the reference elevation is unique to each well, then please provide the water levels in meters above sea level (masl), as the data in the table will not on their own be very useful.

**Each monitoring well on site has its own reference elevation (top of pipe elevation). The software that is utilized to assist in preparation of our annual report is customized to include these unique data points and performs the conversion in the background, prior to generation of the contours. As such, we do not have the water levels in masl readily available.**

Please note that I very much appreciate the drawing which you generated with the groundwater elevations in masl shown on the map. However comparison of the water levels and the contours on the figure raises questions about how the contours were generated, as there is often a discrepancy between the spot elevations and the nearest contours. Could you please confirm how the contours on the 2018 Q4 Shallow Groundwater Contours map were generated?

**A customized software program is used for the generation of the contours.**

2. Your Response #6 requests further time to respond. It would be very helpful if the requested information could be provided by October 21, 2019.

**This information is included in our customized software but not readily available to provide.**

3) Your Response #9 indicates that "more information is needed with respect to this inquiry". This is an understandable comment, as I expressed myself poorly.

If we consider Graph 1 on page 13 of the 2018 PNGS Groundwater Monitoring Results report, then when compared to prior years' results shown for location U1-RBFD-1 (in Graph 1) there is a very clear spike in tritium levels in early 2018. Consideration of the data table (Table A-1) in the report shows that indeed tritium levels for U1-RBFD-1 were very high at 1.19 billion Bq/L in Q1. Where Graph 1 is particularly unhelpful is when it comes to trying to put the Q1 spike into context. It can be seen from Graph 1 that the Q1 2018 spike in tritium levels dwarfs all prior sampling results back through 2009. Where Graph 1 is problematic for me, is that it is really hard to read 2009 through 2017 data from the graph, because the 2018 spike is taking up most of the "bandwidth" on the Y-axis. Normally this wouldn't matter much, because I could just go back and look at the data for previous years. It matters here, because OPG is refusing to either release the actual data from prior years or the prior years' monitoring reports.

I would again urge OPG to release the 2014-2017 groundwater monitoring reports. This should not be an onerous task, as I am assuming that they were provided to CNSC previously.

OPG is of the belief that there is no value in providing you with the 2014 -2017 groundwater monitoring reports. As was communicated to you, the format of the groundwater monitoring report for 2018 was revised earlier this year to improve the layout, readability and access to the relevant information associated with each well monitored throughout the year. In addition, OPG has also posted on our website the Pickering Groundwater Monitoring GIS Map which shows the wells that are most frequently monitored along with the data for the last 10 years and trend graphs.

3. With respect to your Response #10, you did not answer the question which was put to you. In my review of the 2018 PNGS Groundwater Monitoring Results report, I am planning to share with CNSC my determination that (based on the information available to me) the 2017 leak from the Unit 5 Moderator Room was likely the worst leak in PNGS history until that time in terms of measured groundwater tritium contamination levels (which reached about 400 million Bq/L at RBU5-GT-1). Then in 2018, the leak from the Unit 1 Moderator Purification Room exceeded the 2017 leak in terms of measured groundwater tritium contamination levels (which reached about 1.2 billion Bq/L at U1-RBFD-1) - making it the new worst leak in PNGS history.

If you have information which indicates I am incorrect in making the above statements then please let me know, and please provide the data confirming this to be the case.

5) Regarding the major leak of tritium-contaminated water from the Unit 1 Moderator Purification Room, please provide any available information on the following:
- the estimated length of time over which the leakage was occurring
- the estimated total volume of tritium-contaminated water which leaked into the groundwater system
- the estimated tritium levels in the leaking water
- any memo(s) or report(s) prepared in the course of the “very intensive and thorough investigation” (mentioned on page 12 of the 2018 PNGS Groundwater Monitoring Results report) of the elevated tritium levels found in the foundation drain at Reactor Unit 1,

**The increase in tritium concentrations in the reactor building foundation drainage was first identified in Jan 2017. Corrective actions were completed by June 2018. The estimated concentration of tritium in moderator water is approximately 17 Ci/kg.**

6) The 2018 major leak occurred from the Unit 1 Moderator Purification Room, as outlined on page 12 of the 2018 PNGS Groundwater Monitoring Results report. There were also significant leaks of tritium contamination from the Moderator Room at Unit 5 (in 2017) and from the Moderator Room at Unit 6 (in 2018), as outlined on pages 16 and 17 of the 2018 Groundwater Report. Is there a difference between the “Moderator Purification Room” from which the 2018 leak occurred at Unit 1, and the “Moderator Room” from which the 2017 and 2018 leaks occurred at Unit 5 and Unit 6? If so, then please explain.

**The moderator purification room is inside the moderator room.**

Also, it appears that Moderator Room floor construction joints were implicated in the leaks from Unit 5 in 2017 and Unit 6 in 2018 - so I am interested in understanding why preventative inspections and/or maintenance on Moderator Room floor construction joints was not recommended for Units 4, 7 and Unit 8 in the 2018 PNGS Groundwater Monitoring Results report?

**There was extent of condition inspections/work performed on other units, as a result of the groundwater issues at Unit 5 and Unit 1. This recommendation was not made in the groundwater report as it’s outside the scope of the program.**

7) I note that OPG has only minimally responded to the information request submitted on my behalf by Ms. Pippa Feinstein on August 22nd, 2019. In her e-mail to yourself, Ms. Feinstein made the following request:

*"At this time, we request the following information:*

*1) The last five years worth of Annual Groundwater Monitoring Reports; and*

*2) Raw monitoring data from all groundwater monitoring wells on and around the Pickering site (collected over the last three years at least), if the Annual Groundwater Monitoring Reports do not include raw data."*

The requested information is needed for my CNSC-funded review, and I would very much appreciate OPG providing it.

OPG is of the belief that there is no value in providing you with the 2014 -2017 groundwater monitoring reports. As was communicated to you, the format of the groundwater monitoring report for 2018 was revised earlier this year to improve the layout, readability and access to the relevant information associated with each well monitored throughout the year. In addition, OPG has also posted on our website the Pickering Groundwater Monitoring GIS Map which shows the wells that are most frequently monitored along with the data for the last 10 years and trend graphs.

Appendix C

**Pippa Feinstein BA (Hons), JD**
166 Howland Avenue
Toronto, ON M5R 3B6
Cell: 647 923 4927
Email: pippa.d.feinstein@gmail.com

## Education

- **LLM** (2019), Osgoode Hall Law School, Toronto ON
  - Faculty of Graduate Studies Entrance Scholarship (2018-9)
  - Hon. Willard Z. Estey Teaching Fellowship (2018-9)
- **Certificate in Alternative Dispute Resolution** (2015), York University, Toronto, ON.
- **JD** (2013), University of Alberta, Edmonton, AB.
  - Suzanne Mah Award for Community Leadership and Commitment to Human Rights (2013)
- **BA (Honours)** (2009), McGill University, Montreal, QC.

## Work Experience

- **Lawyer and legal educator in sole practice** (May 2014 - Present) Toronto, ON.
  - Provide legal representation to grassroots community groups, and more established charities and not-for-profit organizations. Areas of practice include not-for-profit law, access to information, environmental and energy law, and alternative dispute resolution.
- **External Research Expert** (May 2017 – June 2018), Toronto, ON.
  - The National Inquiry into Murdered and Missing Indigenous Women and Girls, Winnipeg, MB.
- **Community Mediator, Bylaw and Private Complaints** (August 2015 – present)
  - Conflict Resolution Service, Dixie Bloor Neighbourhood Centre, Mississauga, ON.
- **Community Mediator, Criminal Court Diversion** (January 2016 – present)
  - Conflict Resolution Service, Warden Woods Community Centre, Scarborough, ON.
- **Law Foundation of Ontario Public Interest Articling Fellow** (2013-2014)
  - Lake Ontario Waterkeeper, Toronto, ON.
  - Selected as one of seven law students (the only student in environmental law) to be funded by the Law Foundation of Ontario to article with a non-profit organization.

## Selected Publications

- Sarah Hamill & Pippa Feinstein, **"The Silencing of Queer Voices in the Litigation over Trinity Western University's Proposed Law School"** (2018) 34:2 Windsor Y B Access Just 156.
- Pippa Feinstein, **"The Canadian Nuclear Safety Commission: Case Study"** (January 2018)
  - Written for Voices-Voix Canada, available at voices-voix.ca.
- **"An Ontario model public sewage alert"**, (January 2018) Toronto, ON.
  - Written for the Canadian Freshwater Alliance and an ad-hoc group of Canadian and US environmental non-profit organizations concerned about the lack of real-time public notification of sewage releases to waterbodies in the Great Lakes watersheds.
- Pippa Feinstein, **"National Energy Board vs. Canadian Nuclear Safety Commission: Comparing ethical standards behind closed doors"** (September 26, 2016)
  - Drafted for Lake Ontario Waterkeeper and picked up in the Globe and Mail and Toronto Star, available at waterkeeper.ca.
- Pippa Feinstein, **"Loyalty Oaths and the Public Service: Case Study"**
  - Written for Voices-Voix Canada, available at voices-voix.ca. These case studies document ways in which the federal government curbs political dissent in Canada.
- Pippa Feinstein, **"The National Energy Board: Case Study"**

- Written for Voices-Voix Canada, available at voices-voix.ca.
- Pippa Feinstein, **"Federal Judicial Appointments: Case Study"**
  - Co-authored with Megan Pearce for Voices-Voix Canada, available at voices-voix.ca.
- Pippa Feinstein, **"An LSC Interactive Frequently Asked Questions (FAQ) Document for the National Inquiry into Violence against Indigenous Women"**
  - Written for the Legal Strategy Coalition on Violence Against Indigenous Women, available at leaf.ca/LSC.
- Pippa Feinstein, **"A Guide to Canadian Border Security Agency (CBSA) Enforcement in Edmonton"** (August, 2015)
  - Written with input from community organizations and CBSA employees as an accessible resource for those in Edmonton without immigration status.
- Pippa Feinstein & Megan Pearce, **"Dismantling Democracy: Stifling debate and dissent in Canada"** (May 2015)
  - Report co-written for Voices-Voix Canada, available at voices-voix.ca.
- Pippa Feinstein & Megan Pearce, **"Review of Reports and Recommendations on Violence Against Indigenous Women in Canada"** (February 25, 2015)
  - Report written for the Legal Strategy Coalition on Violence Against Indigenous Women, available at leaf.ca/LSC.
- Pippa Feinstein & Megan Pearce, **"What does it take to protect Indigenous women from violence?"** (December 11, 2014)
  - Op-ed co-written for rabble.ca.

**Selected Presentations and Workshops**

- **"Queer international legal theory and "queer visibility": challenging mainstream international law and predominant global legal orders"** (forthcoming, March 29, 2019) Toronto, ON.
  - 12th Annual Toronto Group Conference for the Study of International, Transnational, and Comparative Law, "Resistance to International Law and the Global Legal Order".
- **"Understanding and using Canadian access to information law"** (February 13, 2019) Toronto, ON.
  - Tools for Change's capacity-building workshop series. These workshops are provided to increase the skill sets of engaged members of the public, grassroots organizations, students, and more established NGOS advocating for social, environmental, and economic change.
- **"Adding formal legal processes to the advocate's toolkit"** (November 15, 2018) Toronto, ON.
  - Tools for Change's capacity-building workshop series.
- **"Submissions on the current state and future of national energy data"**, (May 29, 2018) Ottawa, ON.
  - Invited to address the House of Commons' Standing Committee on Natural Resources, based on the submissions I prepared for the National Energy Board Modernization Expert Panel.
- **"Updates concerning sewage bypass public alerts in Ontario"**, (November 13, 2017) Toronto, ON.
  - The People's Great Lakes Summit, organized and hosted by the Canadian Environmental Law Association.
- **"Understanding and addressing conflict in groups"** (March 21, 2017) Toronto, ON.
  - Tools for Change's capacity-building workshop series.
- **"An introduction to legal structures, internal infrastructure, and strategic planning for art collectives"** (March 8, 2017) Toronto, ON.
  - Scarborough Arts' pilot program providing capacity-building residencies for art collectives.
- **"The contribution of socio-cultural difference to conflict"** (October 14, 2016) Toronto, ON.
  - Alternative Dispute Resolution Institute of Canada Annual Conference.
- **"Backgrounder for the Assembly of First Nations Pre-Inquiry Forum"** (February 4, 2016) Enoch Cree Nation, AB.

    - Missing and Murdered Indigenous Women & Girls – AFN Pre-Inquiry Forum.
- **"Legal Strategies to address violence against Indigenous women and girls"** (May 9, 2015) Saskatoon, SK.
    - Sallows-Fry Conference, "A Canadian Crisis: The Criminalization & Imprisonment of Indigenous Women & Those with Disabling Mental Health Issues".
- **"The Secret Power of Facts: how collecting and sharing information empowers people to protect the environment" (**February 22, 2014) Ottawa, ON.
    - Canadian Association of Environmental Law Students' Societies (CAELS) Annual Conference.

**Selected list of cases**

- **Pickering Nuclear Generating Station Licence Renewal,** June 2018, Canadian Nuclear Safety Commission.
- **Deloro Mine Site Remediation Licence Renewal,** October 2017, Canadian Nuclear Safety Commission.
- **National Energy Board Modernization Public Consultation**, 2017, Natural Resources Canada.
- **TransCanada Energy East and Eastern Mainline Project Applications,** 2016 - 2017, National Energy Board.
- **Pickering Waste Management Facility Licence Renewal,** April 2017, Canadian Nuclear Safety Commission.
- **Port Hope Area Initiative Commission Update Report,** November 2016, Canadian Nuclear Safety Commission.
- **Cameco Port Hope Conversion Facility Licence Renewal,** November 2016, Canadian Nuclear Safety Commission.
- **Darlington Nuclear Generating Station Licence Renewal,** November 2015, Canadian Nuclear Safety Commission.
- **SRB Technologies Licence Renewal,** May 2015, Canadian Nuclear Safety Commission.
- **Ontario Power Generation Rate Increase Application,** June 2014, Ontario Energy Board.
- **Toronto Island Airport Expansion Application,** December 2013, Toronto City Council.
- **Enbridge Line 9B Reversal Application**, October 2013, National Energy Board.

**Community Engagement Experience**

- **Member,** Voices-Voix Editorial Collective (2015 – present)
    - I identify issues for, and draft, new case studies for the Voices Documentation Project. The project is geared towards educating members of the public about threats to Canadian democracy.
- **Chair, Social Action Committee,** First Narayever Congregation (2016 – 2018)
- **Board Secretary and Director,** Scarborough Arts (2014 – 2016)
- **Winner,** Second Annual West Coast Environmental Law Twitter Moot (2013)
    - This was an initiative that sought to increase public engagement with and understanding of issues in environmental law. I represented the Centre for Indigenous Environmental Resources (CIER).
- **Legal Clinic Student** (2012-2013), University of Alberta Faculty of Law 'Low Income Individuals and the Law' Clinical Placement and Seminar, Edmonton, AB.
- **Delegate** (2011)**, VP External** (2012)**,** University of Alberta Oil Sands Student Delegation, Edmonton, AB.
- **Co-leader/Coordinator** (2010 – 2012), 'Edmonton REDdress Project', Edmonton, AB.
- **Researcher and Project Leader** (2010 – 2013), Pro Bono Students Canada, Edmonton, AB.
- **Delegate,** (2009), Delegation and politician-shadowing program, Equal Voice, Ottawa, ON.

Called to the Ontario Bar June 2014. Member in good standing of the Law Society of Ontario.

Appendix D

# Curriculum Vitae of Wilf Ruland

# (Professional Geoscientist)

**Address:** Wilf Ruland (P. Geo.)
766 Sulphur Springs Road
Dundas, Ontario
L9H 5E3
Tel: (905) 648-1296 E-mail: deerspring1@gmail.com

## Education:

1988 Master of Sciences in Earth Sciences,
University of Waterloo.
Supervisor: Dr. John Cherry

Master's project focussed on the hydrogeological properties of fractured clay deposits in Lambton County. 15 courses provided a broad background in hydrogeology.

1982 Honours Bachelor of Science in Geography and Geology,
McMaster University.

30 courses provided a broad background in natural science, geography and geology.

## Experience:

Since 1988 Environmental Consultant, as head of own consulting firm (Citizens' Environmental Consulting).

Active as advisor and consultant on issues related to groundwater or surface water contamination or depletion for private citizens, citizens' groups, environmental groups, First Nations, companies and public agencies from across Ontario.

Specialization in addressing landfill-related groundwater and surface water contamination problems through review of hydrogeological impact studies, field investigations, and participation in public meetings and hearings.

Ongoing contracts include investigations of water contamination at landfills near St. Catharines, Brockville, Kingston, Waterloo, and Windsor.

Other significant areas of work include review of pit and quarry proposals and applications for Permits to Take Water, investigations of well interference resulting from quarries, and groundwater contamination emanating from major industrial properties and gas stations.

**Experience: continued**

1988-1993 Research Associate, Waterloo Centre for Groundwater Research,
University of Waterloo

Work included research into the hydrogeology of fractured clays and into the impacts of landfills on groundwater.

1983-1985 Hydrogeologist, Ingenieur-Geologisches Institut, Westheim, Germany.

Work included hydrogeological field work, supervision and evaluation of drilling programs, supervision and evaluation of pumping tests, research and preparation of hydrogeologic reports, and supervision of environmental monitoring for a major railway construction project.

**Publications, Papers and Research Reports:**

Worthington, S.R.H., Smart, C.C., and Ruland, W.W. 2012. Effective Porosity of a Carbonate Aquifer with Bacterial Contamination: Walkerton, Ontario, Canada. Published in the Journal of Hydrology, Vol. 464-465 (2012), p. 517-527.

Ruland, W.W. 2005. Presentation on Source Water Considerations and the Walkerton Setting. Presented at the Canadian Water Network's Walkerton Water and Public Health Training Workshop, May 28 - June 2, 2005.

Worthington, S.R.H., Smart, C.C., and Ruland, W.W. 2002.
Assessment of Groundwater Velocities to the Municipal Wells at Walkerton. Paper presented at the 3rd Joint IAH-CNC/CGS Conference, October 20 - 23, 2002 in Niagara Falls, Ontario.

Worthington, S.R.H., Smart, C.C., and Ruland, W. 2001.
Karst Hydrogeological Investigations at Walkerton. Report prepared for and submitted as evidence at the Walkerton Inquiry.

Ruland, W.W., Schellenberg, S.S., and Farquhar, G. 1993.
The Fate of Landfill Leachate in Waste Water Treatment Plants and in Groundwater at Attenuation Landfills. Report prepared for the Ontario Ministry of Environment and Energy.

Ruland, W.W., Cherry, J.A., and Feenstra, S. 1991.
The Depth of Fractures and Active Ground Water Flow in a Clayey Till Plain in Southwestern Ontario. Published in the Journal of Ground Water, Vol. 29, No. 3, p. 405-417.

D'Astous, A.Y., Ruland, W.W., Bruce, R.J., Cherry, J.A., and Gillham, R.W. 1989. Fracture Effects in the Shallow Groundwater Zone in Weathered Sarnia Area Clay. Published in the Canadian Geotechnical Journal, Vol. 26, No. 1, p. 43-56.

Fracture Depths and Active Groundwater Flow in a Clayey Till in Lambton County, Ontario. 1988. Unpublished M.Sc.Project, University of Waterloo.

Cherry, J.A., MacQuarrie, K.T.B., and Ruland, W.W. 1987.
Hydrogeologic Aspects of Landfill Impacts on Groundwater and Some Regulatory Implications. Paper presented at the PCAO/MOE Seminar on Landfill Regulations May 13, 1987.

**Wilf Ruland (P. Geo.) - Partial List of Consulting Experience:**

**1) Investigations/Reviews of Landfill-Related Water Contamination:**

Niagara Road 12 Landfill, near Grimsby, Ontario.
- Peer Review for the Niagara Road 12 Litizen Liaison Committee (2008-2010).

Humberstone Landfill in Welland, Ontario.
- Peer Review for the Humberstone Public Liaison Committee (since 2007).

City of Owen Sound's Derby Landfill site, near Owen Sound, Ontario.
- investigation and review for the Ledingham family (2004-2006)

Town of Northeastern Manitoulin and the Islands Landfill, near Little Current, Ontario;
- investigation and review for Mr. Raeburn Smith and Mrs. Virginia Smith (since 2004).

Rennie and Brampton Street Landfill Sites, Hamilton, Ontario;
- Peer Review for the Rennie/Brampton Citizens' Liaison Committee (2001-2005).

Town of Thessalon Landfill Site, near Thessalon, Ontario;
- investigation for Mr. Mark Petingalo and Mrs. Wendy Petingalo (in 2000).

City of Brockville Landfill Site, Brockville, Ontario;
- review for Brockville Public Liaison and Monitoring Group (since 1997).

Fletcher Tile Landfill Site, near Chatham, Ontario;
- investigation for Citizens Opposed to Landfill Development (1996-1997).

Bracebridge Landfill Site, Bracebridge, Ontario;
- investigation for Dr. David Kent (1995-1996).

Waterloo Sanitary Landfill Site, Waterloo, Ontario;
- review for Waterloo Waste and Water Watchers (since 1995).

Innisfil Landfill Site, Innisville, Ontario; investigation for Mrs. Helen Hodgson (1995 - 1999).

Tom Howe Landfill Site, near Hagersville, Ontario;
- review for the Mississaugas of the New Credit First Nation (since 1994).

Wolfe Island Waste Disposal Site, Wolfe Island, Ontario;
- investigation for Ms. Theresa James (since 1994).

Bensfort Road Landfill, near Peterborough, Ontario;
- investigation for Mr. Gary McCarrell and Mrs. Lori McCarrell (1991-1993).

Orillia Landfill Site, in Orillia, Ontario; investigation for Citizens Acting Now (1991).

Storrington Landfill near Kingston, Ontario;
- investigation for Storrington Committee Against Trash (1990-1997).

Glenridge Quarry Landfill in St. Catharines, Ontario;
- review for Glenridge Landfill Citizens' Committee (since 1989).

Warwick Landfill near Watford, Ontario;
- investigation for Watford Warwick Landfill Committee (1989-1996).

Brow Quarry Landfill near Dundas, Ontario;
- investigation for Greensville Against Serious Pollution (1988-1989).
-
Essex County Landfill No. 3 in Maidstone Township, Ontario;
- reviews for Maidstone Against Dumping and Maidstone Township (1988-2008).

Town of Cobourg Landfill, in Haldimand Township, Ontario;
- investigation for Mr. Joe Sherman (1988-1991).

**2) Reviews of Proposals to Site New or Expand Existing Landfills**

Peer Review of (amended) Terms of Reference for the Walker Environmental Group Southwestern Landfill proposed, to be situated near Ingersoll, Ontario;
- review for the OPAL Alliance (2013/2014).

Review of the proposed Capital Region Resources Recovery Center and Landfill;
- review for the Citizens' Environmental Stewardship Association - East of Ottawa (2013).

Proposal to massively expand the Richmond Landfill near Napanee, Ontario;
- review for the Concerned Citizens Committee of Tyendinaga Twp. (2004 - 2006).

Proposal to expand and significantly alter the Edwards Landfill
(including excavation of hazardous wastes, and relocation of other wastes) near Cayuga, Ontario;
- review for Haldimand Against Landfill Transfers (2004 - 2006)

Proposal to massively expand the Warwick Landfill near Watford, Ontario;
- Peer Review for the Township of Warwick (1998-2008).

Proposal to site a landfill near Cochrane, Ontario;
- review for the Fournier Action Committee (1997 -1999).

Proposal to site a landfill in the abandoned Adams Mine Site near Kirkland Lake;
- review for the Coalition of Temiskaming Concerned Citizens (in 1995).

Proposal to site a landfill in the Taro East Quarry near the Niagara Escarpment
in Stoney Creek, Ontario;
- review for Stoney Creek Residents Against Pollution (in 1995).

Proposal to develop a perimeter-berm landfill around the Lake Ontario Steel Company Limited property in Whitby, Ontario; Peer Review for the Lasco Berm Liason Committee (1991-1995).

Proposal to build a landfill in a Class 2 Wetland near Cayuga, Ontario;
- review for Haldimand-Norfolk Organization for a Pure Environment (1989-1990).

Proposal to site a landfill in the Acton Quarry near Milton, Ontario;
- review for Protect Our Water and Environmental Resources (in 1989).

**3) Review of Landfill Closure and End Use Plans**

Closure Plan for the Wolfe Island Landfill Site (since 2012); review done for Ms. Theresa James.

Closure Plan for the Tom Howe Landfill Site; review done for the Mississaugas of the New Credit First Nation (2005, and 2009/2010).

Closure Plan for the Richmond Landfill near Napanee, Ontario;
for the Concerned Citizens Committee of Tyendinaga Twp. (2007).

End Use Plan for the Glenridge Quarry Naturalization Site (formerly the Glenridge Laandfill), for the Glenridge Landfill Liaison Committee (2002).

Closure and post-Closure Care Plan for the Brockville Landfill Site, for the Brockville Public Liaison and Monitoring Group (2000-2001).

Closure and End Use Plan for Essex County Landfill No. 3, for Maidstone Against Dumping (1996).

Closure Plan for the Cobourg Landfill. For Mr. Joe Sherman (1990s).

Closure Plan for the Brow Quarry Landfill. For Greensville Against Serious Pollution (1990s).

**4) Other Landfill-Related Projects**

Peer Review of proposal to expand the Clean Harbors Hazardous Waste Landfill Facility near Sarnia, Ontario (since 2010); for the Township of St. Clair.

Investigation and review of groundwater and surface water contamination being caused by a cement kiln dust landfill near Bath, Ontario. Negotiated an agreement with Lafarge Cement to remediate the existing landfill and use an industry-standard design on a go-forward basis. For Lake Ontario Waterkeeper (2007-2010).

Member of the Expert Panel (appointed by the Minister of the Environment) to look into potential health and environmental impacts from the Taro East Landfill in Stoney Creek, Ontario (in 2000). The final report of the Expert Panel was released in October 2000, and the Addendum Report was released in December 2000.

Technical advisor to private citizens who successfully prosecuted the City of Hamilton (which pleaded guilty) for contamination by PCB-laden leachate of Redhill Creek (in 2000).
The resulting $450,000 fine was a record for fines paid under such prosecutions.

**5) Reviews of Waste Management Master Plan (WMMP) Studies**

Region of Region of Waterloo Management Master Plan (WMMP);
- review for the Waterloo Landfill Liaison Committee (2013).

Region of Haldimand-Norfolk Waste Management Master Plan (WMMP);
- review for the Mississaugas of the New Credit First Nation (1995-1996).

South Simcoe County Waste Management Master Plan;
- review for the South Simcoe Waste Action Network (1994-1995).

Leeds and Grenville Waste Management Master Plan;
- review for Sabourins Crossing Residents Against Megadumps (in 1994).

Pembroke and Area Waste Management Master Plan;
- review for the Snake River/Micksburg Anti-Dump Association (1991-1992).

Northumberland County Waste Management Master Plan;
- review for Mr. and Mrs. J. Sherman (1989-1991).

Wellington County Waste Management Master Plan;
- review for the Concerned Alma Citizens (1988-1991).

**6) Nuclear-Related Peer Review Work**

Review of the Draft Environmental Impact Statement for the proposed Darlington 'B' New Nuclear Power Plant Project;
- review for Lake Ontario Waterkeeper (2010-2012).

Review of the proposed remediation of the Cameco Nuclear Waste Processing Facility in Port Hope, Ontario;
- review for Lake Ontario Waterkeeper (starting in 2010).

Review of the Draft Guidelines for the Environmental Impact Statement for the proposed Darlington 'B' New Nuclear Power Plant Project;
- review for Lake Ontario Waterkeeper (2008).

**7) Other Investigations/Reviews of Groundwater Contamination**

Review of clean-up of an area of contamination at a former Ontario Hydro Transformer Station;
- review conducted for Ms. Kathy MacLeod (2014).

Contamination by petroleum hydrocarbons of a greenhouse property from an adjacent Hydro One maintenance center in Kenora, Ontario;
- investigation for the Schmidt Family (2008)

Impacts of residual contamination on a former industrial property, which is now the site of St. Mary's High School;
- investigation for Environment Hamilton (2002 - 2004).

Contamination by petroleum hydrocarbons and volatile organic chemicals (VOCs) from a former service center near High Park, Toronto;
- investigation for Mr. Gerard Kennedy, MPP (in 2002).

Contamination of municipal water supply wells by E-coli bacteria in Walkerton, Ontario;
- investigation for Concerned Walkerton Citizens (2000 - 2002).

Contamination by petroleum hydrocarbons and volatile organic chemicals (VOCs) from an Imperial Oil fuel and liquid transfer facility in Kapuskasing, Ontario;
- investigation for the Schlechter family (in 2000).

Contamination by petroleum hydrocarbons from a Gulf Canada gas station in Port Loring, Ontario;
- investigation done for People Against Contaminated Water (PACW); (1999 - 2001).

Contamination by petroleum hydrocarbons from a gas station in Bamberg, Ontario;
- investigation for the Bush and Fink families (1997 - 1998).

Groundwater contamination in Cambridge, Ontario caused by Ciba-Geigy Canada Ltd;
- investigation conducted for Thomas Construction Company Ltd. (1993 - 1997).

Groundwater contamination from the Bristol Aerospace Plant near Lockport, Manitoba;
- investigation for Mrs. Elizabeth Andresen and Miss Ursula von Krogh (in 1993).

Extensive/review of water contamination in Elmira, Ontario caused by Uniroyal Chemical Ltd (subsequently renamed Crompton Corp. and now Chemtura Canada Co;
- investigation for various clients, most recently the Region of Waterloo (since 1989).

**8) Permits to Take Water and Drinking Water Systems**

Review of an application for a Permit to Take Water to allow draining of a 25 hectare lake on the Carmeuse Canada Lime Inc. property situated near Ingersoll, Ontario.
for the OPAL Alliance (2014).

Preparation of applications to the Ministry of the Environment to upgrade the drinking water systems for Camp NeeKauNis near Waubaushene, Ontario (since 2012).

Review of an application for a Permit to Take Water for a Water Bottling Operation
(to be operated by CJC Bottling Limited), with water to be taken from a well which feeds the headwaters of Colborne Creek; for the Concerned Citizens of Northumberland (2001 - 2004).

Review of an application for a Permit to Take Water for a municipal water supply project (for the Village of Woodville), with water to be taken from pumping wells near 5 families' homes;
- for the Mariposa Aquifer Protection Association (2000 - 2004).

Review of an application for a Permit to Take Water for a Water Bottling Operation
(to be operated by Artemesia Springs Limited), with water to be taken from a springwell which feeds a headwater stream of the Rocky Saugeen River;
- for the Water Protection Coalition of South Grey (1999 - 2001).

Review of an application for a Permit to Take Water for a Water Bottling Operation
(to be operated by Aquafarms 93 Limited), with water to be taken from a spring and 3 pumping wells situated near the headwaters of the Beaver River;
- for Ms. Samantha Wickens and other local residents (in 1999).

Preparation of an application for a Permit to Take Water for a fish farming operation
(to be operated by Van Aqua Inc.), with water to be taken from a pumping well near the Town of Burford in Brant County; for Mr. Peter Van Kruistum (in 1988).

**9) Reviews/Investigations Related to Impacts of Major Water-Takings**

Impacts of ongoing pumping of municipal supply wells K50/K51 in Wilmot Township;
- review for Wilmot Center Monitoring Program Public Liaison Committee (2003-2013).

Impacts of ongoing dewatering of the Canadian Gypsum Company mine near Hagersville Ontario;
- review for residents of 3rd Line, Six Nations Indian Reserve (1999-2003).

**10) Reviews/Investigations related to Impacts from Pits, Quarries, and Mines**

Review of Environmental Impact Statement (EIS) for the proposed Marathon PGM-Cu Mine Project which has been put forward by Stillwater Canada Inc. (SCI).
- review for Northwatch (ongoing 2013-2014).

Investigation of potential impacts from the Miller Braeside Quarry near Braeside, Ontario;
- review for Friends Addressing Concerns Together in McNab/Braeside (since 2008).

Investigation of potential impacts from the unlicensed Nichol Quarry near Hagersville, Ontario;
- review for the Mississaugas of the New Credit First Nation (2007-2011).

Impacts of the proposed expansion of the Nelson Aggregates Quarry near Mount Nemo, Ontario;
- review for Protecting Escaparment Rural Land (2005-2007).

Cumulative impacts of the proposed Halminen Quarry and Lafarge Quarry near Buckhorn, Ontario;
- review for Friends of Life in the Kawarthas (2004 - 2006).

Impacts of the proposed expansion of the Graham Brothers Aggregates Limited gravel pit near Caledon, Ontario;
- review for Dr. David Sylvester (2000 - 2001).

Impacts of the proposed Nichol Gravel Limited quarry near Hagersville, Ontario;
Quarry operated in violation of MNR and MOE regulations for many years;
- review for the Mississaugas of the New Credit First Nation (1999 - 2011).

Impacts of well interference from the Canadian Gypsum Company mine near Hagersville;
- investigation for several families on the Six Nations Reserve (1999 - 2003).

Impacts of well interference from the Dunnville Rock Products Quarry near Dunnville;
- investigation for Mr. Ken Ricker and Mrs. Ethel Ricker (1997 - 2000).

Impacts of water takings asssociated with the Acton Quarry near Acton, Ontario;
- review for Protect Our Water and Environmental Resources (1997-2007).

Impacts of a quarry proposed adjacent to Mitchell Lake, near Victoria Road, Ontario;
- review for the Northern Victoria Ratepayers Association (1997 - 1999).

Impacts of a quarry, proposed to be located on the Bruce Peninsula;
- review for Mr. Ziggy Kleinau (1996).

Impacts of a proposed gravel pit, to be sited near Grippen Lake, Ontario;
- review for Township Residents Against Pit Pollution (1995 - 1998).

Impacts of a gravel pit to be built in an Earth Science Area of Natural Interest (ANSI);
- review for Ms. Jeanette Mazur (1995 - 1996).

Impacts of the proposed Seeley and Arnill Quarry near Orillia, Ontario;
- review for Mr. David Lowry (1993 - 1997)

Impacts of a proposed expansion of the Walker Brothers Quarry, near St. Catharines;
- review for Mrs. Ronnie DeMeel (1992).

Impacts of six (6) proposed gravel pit operations in Oro Twp., Ontario;
- review for Dr. E.J. Beaton and Dr. A.C. Beaton (1990 - 1992).

**11) Participation in Public Hearings**

A hearing into the appeal of deficient monitoring, contingency, and closure plans for the badly leaking Richmond Landfill near Napanee, Ontario.
• before the Environmental Review Tribunal; Decision dated December 24, 2016.

A hearing into the proposed massive expansion of a quarry and proposed development of an asphalt plant on the Braeside Ridge, in the middle of a potential Provincially Significant Wetland complex and uphill of numerous residential wells.
• before the OMB; Decision dated October 27, 2015.

A hearing into the proposed Deep Geologic Repository, designed to accept low- and intermediate-level nuclear waste, and to be situated at the Bruce Nuclear Plant;
• before the Canadian Nuclear Safety Commission;
• Decision dated May 6, 2015.

An application to site a quarry in a Provincially Significant Wetland Complex near Duntroon, Ont;
• before the Ontario Municipal Board;
• Decision dated August 24, 2012.

A hearing into the proposed Darlington 'B' New Nuclear Power Plant Project;
• before the Canadian Nuclear Safety Commission;
• Decision dated August 17, 2012.

An application to develop a quarry in the Niagara Escarpment Plan area near Duntroon, Ontario;
• before the Joint Board;
• Decision dated June 18, 2012.

An application to develop a gravel pit in the Municipality of Grey Highlands, Ontario;
• before the Ontario Municipal Board; Decision dated April 30, 2008.

An application to massively expand the Dufferin Aggregates Milton Quarry;
• before the Joint Board;
• Decision dated June 8, 2005.

An application for conversion of 81 cottages into permanent homes adjacent to a World Biosphere Reserve, Class 1 Wetland and Wilderness Area in Turkey Point;
• before the Ontario Municipal Board;
• Decision dated August 13, 2002.

An application to develop a quarry near Mitchell Lake and Victoria Road, Ontario;
• before the Ontario Municipal Board;
• Decision dated January 22, 1999.

An application to develop a gravel pit adjacent to a Class 1 Wetland along the shore of Lake Katchewanooka near Lakefield, Ontario;
• before the Ontario Municipal Board;
• Decision dated June 4, 1998.

An application to develop a quarry near Kinmount, Ontario;
• before the Ontario Municipal Board;
• Decision dated August 18, 1995.

An act (Bill 62) to amend the Environmental Protection Act to phase out landfilling in the Niagara Escarpment Plan Area;
• before the Standing Committee on the Administration of Justice;
• Bill 62 received Royal Assent June 23, 1994.

An application to expand the Eastview Road Landfill Site near Guelph, Ontario;
• before the Environmental Assessment Board;
• Decision EP 92-02 dated September 22, 1993.

An application to develop six (6) gravel pits on the Oro Moraine in Oro Twp.;
• before the Ontario Municipal Board;
• Decision dated July 23, 1993.

An application to expand the Storrington Landfill Site;
• before the Environmental Assessment Board;
• Decision EP 91-01 dated March 31, 1993.

An amendment (No. 52/89) to the Niagara Escarpment Plan to delete waste disposal sites as a permitted land use in lands protected by the Plan;
• before a Niagara Escarpment Commission Hearing Officer;
• Decision dated Oct. 22, 1991.

An appeal against a zoning bylaw and a proposed plan of subdivision (which allowed construction of a golf course on a Class 1 Wetland);
• before the Ontario Municipal Board;
• Decision dated August 29, 1990.

An application to expand the Seeley and Arnill Aggregates Ltd. gravel pit in Oro Twp.;
• before the Ontario Municipal Board;
• Decision dated May 29, 1990.

An application to expand Essex County Landfill No. 3;
• before the Environmental Assessment Board;
• Decision EP 89-02 dated December 12, 1989.

An application to expand the Town of Cobourg landfill;
• before the Environmental Assessment Board;
• Decision EP 89-01 dated October 16, 1989.