Board Staff Interrogatory #047

Ref: Exh D2-2-1 & Exh N1-1-1 Updated D2-2-1 Attachment 5 & Feb 6, 2014 Cover Letter from OPG.

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project appropriate?

Interrogatory

OPG notes at page 13 of Exh D2-2-1, that “In November 2013, Management will update the overall Business Case for the DRP and present it to OPG’s Board of Directors for approval. Management will also request a release of funds to complete the Definition Phase, projected in the amount of $857M in 2014 and $650M in 2015.” On December 6, 2013 OPG filed its 2014-2016 Corporate Business Plan, dated November 14, 2013, which it had presented to its Board of Directors. On February 6, 2014 OPG filed an updated Business Case Summary for the DRP, including a cover letter which stated that the Updated Business Case Summary was approved by OPG’s Board of Directors in November 2013.

a) Did the Board of Directors approve without qualification the Corporate Business Plan dated November 14, 2013?

b) Are the elements (e.g. costs, schedule) in the DRP Updated Business Case, exactly the same as those presented in the 2014-2016 Corporate Business Plan regarding the DRP? If not, please list and explain the differences.

c) Please list the material differences between the Updated Business Case Summary filed on Feb 6, 2014 and the Recommendation For Submission to the Board of Directors (dated November 15, 2012) it replaced.

d) Are there any differences between the Updated Business Case Summary approved by the Board of Directors in November 2013 and the one filed with the Board on February 6, 2014?

i. If the two versions are the same, please identify and explain the cause for the delay in filing the Updated Business Case Summary with the OEB. In your response please address OPG’s stated commitment that it would be filing its DRP Updated Business Case in late 2013.

ii. If the Updated Business Case Summary approved by the OPG’s Board of Directors is not the same as the one filed on February 6, 2014, please identify and explain the differences.

Response

a) Yes.
b) The elements in the DRP Updated Business are aligned with those in the 2014 -2 016
Corporate Business Plan regarding the DRP. For differences, see part c) below.

c) The updated Business Case Summary (Ex. D2-2-1, Attachment 5) filed on Feb. 6, 2014
incorporated the following changes from the Economic Update approved on November 15, 2012.
   I. An update on project progress including revised annual cash flows for 2014 and
      2015 within the Definition phase.
   III. A revised schedule, for planning purposes, which includes a decision to un-lap the
        first refurbishment unit from the subsequent units resulting in a 108 month
        refurbishment execution phase schedule.

d) The updated Business Case Summary submitted on Feb. 6, 2014, is the same as the basis
for OPG approval on November 14, 2013. OPG intended to file the updated Business Case
Summary in time for OEB Staff and Intervenors to review it prior to submission of
interrogatories, which is what happened.
**Board Staff Interrogatory #048**

**Ref:** Exh D2-2-1 page 22-23

**Issue Number:** 4.9

**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Project appropriate?

**Interrogatory**

OPG states that “Some projects [DRP related] arising from pre-requisite work done in the Definition Phase….. will be placed in service and included in rate base as soon as they are used or useful to OPG, and as such will be depreciated over their useful lives. These projects are expected to remain useful to OPG’s current or future nuclear operations independent of whether the DRP is completed.”

a) Please confirm that the DRP related in-service additions to rate base are $5.0M in 2012, $104.2M in 2013, $18.7M in 2014 and $209.4M in 2015.

b) Please populate the table below. Please confirm that the projects listed in the table below are those identified by OPG as projects, including three safety improvements projects/DRP EA, which will be completed and placed in service in the test period. If this is an inaccurate summary please amend the table accordingly.

c) Please provide the rationale for treating these projects as part of the DRP initiative even though the evidence states that the projects are expected to remain useful to OPG independent of whether the DRP is completed. In your response please respond to the question: “Would these projects proceed had there not been a DRP?”

d) Assume that the Water and Sewer Project went ahead regardless of the DRP, and that costs were incurred in 2012 and 2013 and portions of the Water and Sewer Project were put

<table>
<thead>
<tr>
<th>DRP projects wholly or partially in service in the test period ($millions)</th>
<th>In service year</th>
<th>Projected Total Capital Expenditure</th>
<th>Amount in 2014 Rate Base</th>
<th>Amount in 2015 Rate Base</th>
<th>Depreciation in 2014 Rev Req</th>
<th>Depreciation in 2015 Rev Req</th>
<th>Amount recorded in Capacity Refurb Variance Acct (Dec. 2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darlington Energy Complex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water and Sewer Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy Water Storage &amp; Drum Handling Facility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Darlington Operations Support Building Refurb.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auxiliary Heating System</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Power Distribution System</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>powerhouse Steam Venting System</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third Emergency Power Generator Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Container Venting System Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Note: Account records variances between actual capital and non capital and firm capital commitment incurred for the DRP and the corresponding forecasts reflected in the revenue requirement approved by the OEB

Witness Panel: Finance, D&V Accounts, Nuclear Liabilities
into service in 2012 and 2013. Would OPG have proposed recovery in the 2014 and 2015 payment amounts for the related capital carrying costs on 2012 and 2013 rate base and for the associated depreciation expense? If so, please provide the regulatory accounting principle underpinning this treatment.

Response

a) Confirmed. The DRP-related in-service additions reflected in rate base are: $5.0M in 2012 (actual), $104.2M in 2013 (budget), $18.7M in 2014 and $209.4M in 2015 (plan), as found at Ex. D2-2-1, Table 6, line 14.

b) Chart 1 below provides information requested in respect of the DRP-related projects expected to be in-service during the test period per OPG’s pre-filed evidence. OPG has added a column to identify the years where there has been a partial in-service amount for greater clarity. Amounts recorded in the Capacity Refurbishment Variance Account as at December 31, 2013 provided in the last column reflect 2013 actual amounts.

### Chart 1

<table>
<thead>
<tr>
<th>DRP projects wholly or partially in service in the test period ($millions)</th>
<th>Final In service year</th>
<th>Partial in-service years</th>
<th>Projected Total Capital Expenditure</th>
<th>Amount in 2014 Rate Base</th>
<th>Amount in 2015 Rate Base</th>
<th>Dep’n in 2014 Rev Req¹</th>
<th>Dep’n in 2015 Rev Req¹</th>
<th>Amount recorded in Capacity Refurb Variance Acct (Dec. 2013)²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darlington Energy Complex</td>
<td>2013</td>
<td></td>
<td>105.4</td>
<td>92.0</td>
<td>89.6</td>
<td>2.4</td>
<td>2.4</td>
<td>6.8</td>
</tr>
<tr>
<td>Water and Sewer Project</td>
<td>2014</td>
<td>2012, 2013</td>
<td>36.0</td>
<td>20.8</td>
<td>26.4</td>
<td>0.4</td>
<td>0.6</td>
<td>1.5</td>
</tr>
<tr>
<td>Heavy Water Storage &amp; Drum Handling Facility</td>
<td>2015</td>
<td></td>
<td>108.1</td>
<td>-</td>
<td>20.3</td>
<td>-</td>
<td>1.1</td>
<td>-</td>
</tr>
<tr>
<td>Darlington Operations Support Building Refurb</td>
<td>2015</td>
<td></td>
<td>46.8</td>
<td>-</td>
<td>14.6</td>
<td>-</td>
<td>0.4</td>
<td>-</td>
</tr>
<tr>
<td>Auxiliary Heating System</td>
<td>2015</td>
<td></td>
<td>45.6</td>
<td>-</td>
<td>17.9</td>
<td>-</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>Electrical Power Distribution System</td>
<td>2015</td>
<td>2014</td>
<td>17.8</td>
<td>2.2</td>
<td>7.3</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Powerhouse Steam Venting System</td>
<td>2015</td>
<td></td>
<td>10.2</td>
<td>-</td>
<td>5.0</td>
<td>-</td>
<td>0.1</td>
<td>-</td>
</tr>
<tr>
<td>Third Emergency Power Generator Project</td>
<td>2015</td>
<td></td>
<td>32.5</td>
<td>-</td>
<td>16.0</td>
<td>-</td>
<td>0.4</td>
<td>-</td>
</tr>
<tr>
<td>Container Venting System Project</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other Miscellaneous Projects</td>
<td>2014, 2015</td>
<td></td>
<td>13.2</td>
<td>1.0</td>
<td>7.5</td>
<td>0.0</td>
<td>0.2</td>
<td>-</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td>415.4</td>
<td>116.0</td>
<td>204.6</td>
<td>3.0</td>
<td>6.1</td>
<td>8.4</td>
</tr>
</tbody>
</table>

¹ Note: Account records variances between actual capital and non capital and firm capital commitment incurred for the DRP and the corresponding forecasts reflected in the revenue requirement approved by the OEB

² Total depreciation as shown in Ex. F4-1-1, Table 2, Note 1.

² Includes income tax impacts related to cost of capital and depreciation account additions. Does not reflect CCA variances, as CCA is claimed for all eligible DRP expenditures pursuant to an election under the *Income Tax Act (Canada)* noted in Ex. D2-2-1, p. 29, note 2. Interest on the outstanding account balance is also excluded.

c) These projects are deemed to be critical to the success of DRP and are largely integrated with the overall DRP schedule. For each project, OPG considered the economics of the solution based on achievement of the DRP and 25 - 30 years of additional life. As noted in
Ex. D2-2-1, section 7.2, these projects are expected to remain useful to OPG’s current or future nuclear operations independent of whether the DRP is completed. ..

d) As the station life will be extended by a further 25 - 30 years under the DRP, the investment in the Water and Sewer Project is deemed necessary to deal with current adverse conditions, to meet current codes and regulations, and to mitigate environmental concerns. As such, the Water and Sewer Project is considered part of the pre-requisite work in the Definition Phase of the DRP.

Expenditures on the DRP are subject to the Capacity Refurbishment Variance Account ("CRVA") authorized by the OEB pursuant to O. Reg. 53/05. As no cost of capital or depreciation amounts were included in the EB-2010-0008 payment amounts in respect of the Water and Sewer Project, OPG recorded such 2012 and 2013 amounts into the CRVA for recovery.

Absent a variance or deferral account, costs that are not reflected in rates would not be eligible for recovery. However, as noted above, the CRVA is established pursuant to O. Reg 53/05, the Water and Sewer Project is integral to the DRP, the project scope and timing was a necessary prerequisite to facilitate the DRP, and the CRVA provides for the recovery of capital costs incurred for refurbishment investments.

If there was no refurbishment project, the CRVA would not likely apply; therefore costs not reflected in rates would not be eligible for recovery.
Board Staff Interrogatory #049

Ref: Exh D2-2-1, Attachment 5 and Updated Attachment 5

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project appropriate?

Interrogatory

OPG states that the DRP is a program to enable the replacement of life-limiting critical components, the completion of upgrades to meet current regulatory requirements and the rehabilitation of components. This will extend the life of Darlington by 30 years, from 2020 to 2050.

a) Is the following description of the timing of the Initiation, Definition and Execution phases accurate? The Initiation phase was completed in December 2009 with the Board of Director’s approval to proceed with the project. The preliminary planning sub-phase of the Definition phase was competed in November 2011 with Board of Directors approval to proceed. The detailed planning sub-phase of the Definition phase commenced in January 2012 and is expected to conclude in 2015. The Execution Phase commences 2016 and concludes 2024.

b) Board staff has reproduced and added a few lines to a portion of Table 3 (DRP Overall Project Estimate) found at Exhibit D2-2-1 Attachment 5 (titled “Recommendation for Submission to the Board of Directors and includes “Appendix 1- Update on the Darlington Refurbishment Project Economics” dated November 15, 2012).
Please complete the table and reflect the following: The dollar amounts should be consistent with the total cost forecast/estimate found in the Updated Business Case Summary dated November 14, 2013 and filed with the Board on February 6, 2014. Breakout the dollar amount in line 5 into its component parts, lines 1-4. At Exh D2-2-1 page 21 “Balance of Plant” is described as remaining work to be performed by OPG that is not included in the Contracts for Major Work Package and is broken into 6 work groups: Reactor, Conventional Systems, Common Systems, Pre-refurbishment, Safety & Controls and Special. If possible/practical, please add the necessary rows to capture this cost information for these work groups.

c) Are the costs associated with the following projects [Darlington Energy Complex, Water and Sewer Project, Heavy Water Storage and Drum Handling Facility, Darlington Operations Support Building Refurbishment, Auxiliary Heating System and Electrical Power Distribution System, Powerhouse Steam Venting System, Emergency Power Generator and Containing Venting System] included in the table above?

Witness Panel: Darlington Refurbishment
i. If yes please identify the line in which they are captured.
ii. If not, please amend the table, as appropriate, to incorporate these costs.

d) How much of the total (row 31) has already been recovered through historical and proposed for 2014-15 prescribed payment amounts, including any disposition of deferral/variance accounts?

Response

a) The following summarizes the key phases and current planning dates:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiation Phase</td>
<td>2007</td>
<td>December 31, 2009</td>
</tr>
<tr>
<td>Definition Phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Preliminary Planning</td>
<td>January 1, 2010</td>
<td>December 31, 2011</td>
</tr>
<tr>
<td>- Detailed Planning</td>
<td>January 1, 2012</td>
<td>December 31, 2015</td>
</tr>
<tr>
<td>Execution Phase</td>
<td>January 1, 2016</td>
<td>September, 2025</td>
</tr>
<tr>
<td>Close-Out Phase</td>
<td>October 1, 2025</td>
<td>October 31, 2026</td>
</tr>
</tbody>
</table>

b) The completed table is attached below. It is not possible to breakout the “Balance of Plant” project estimate by work groups as requested. The remaining work is estimated at the project level.
<table>
<thead>
<tr>
<th>In</th>
<th>Darlington Refurbishment Project-Components (in millions$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Retube and Feeder Replacement</td>
</tr>
<tr>
<td>2</td>
<td>Fuel Handling</td>
</tr>
<tr>
<td>3</td>
<td>Defueling</td>
</tr>
<tr>
<td>4</td>
<td>Steam Generators</td>
</tr>
<tr>
<td>5</td>
<td>Turbine Generators</td>
</tr>
<tr>
<td>6</td>
<td><strong>Subtotal Major Contracts</strong></td>
</tr>
<tr>
<td>7</td>
<td>Reactor System</td>
</tr>
<tr>
<td>8</td>
<td>Conventional System</td>
</tr>
<tr>
<td>9</td>
<td>Common System</td>
</tr>
<tr>
<td>10</td>
<td>Pre-Refurbishment</td>
</tr>
<tr>
<td>11</td>
<td>Safety &amp; Controls</td>
</tr>
<tr>
<td>12</td>
<td>Special Programs</td>
</tr>
<tr>
<td>13</td>
<td><strong>Subtotal Balance of Plant</strong></td>
</tr>
<tr>
<td>14</td>
<td>Islanding</td>
</tr>
<tr>
<td>15</td>
<td>System Shutdown</td>
</tr>
<tr>
<td>16</td>
<td>Operations/Maintenance Support</td>
</tr>
<tr>
<td>17</td>
<td>Waste Management</td>
</tr>
<tr>
<td>18</td>
<td>New Fuel</td>
</tr>
<tr>
<td>19</td>
<td>Infrastructure Projects</td>
</tr>
<tr>
<td>20</td>
<td><strong>Total Direct Work</strong></td>
</tr>
<tr>
<td>21</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Program Support and Oversight</td>
</tr>
<tr>
<td>23</td>
<td>Regulatory</td>
</tr>
<tr>
<td>24</td>
<td><strong>Total Support</strong></td>
</tr>
<tr>
<td>25</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Contingency</td>
</tr>
<tr>
<td>27</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Interest</td>
</tr>
<tr>
<td>29</td>
<td>Escalation</td>
</tr>
<tr>
<td>30</td>
<td><strong>Total Interest &amp; Escalation</strong></td>
</tr>
<tr>
<td>31</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>(Provision) Retube Waste Containers</td>
</tr>
<tr>
<td>33</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Infrastructure Projects - Station-CS</td>
</tr>
<tr>
<td>35</td>
<td>Contingency</td>
</tr>
<tr>
<td>36</td>
<td>Interest</td>
</tr>
<tr>
<td>37</td>
<td>Escalation</td>
</tr>
<tr>
<td>38</td>
<td><strong>Subtotal F &amp; IP CS Projects</strong></td>
</tr>
<tr>
<td>39</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td><strong>GRAND TOTAL</strong></td>
</tr>
</tbody>
</table>

Notes:
- BOP Safety & Controls includes Specialized Projects
- O&M Support (OM&A) includes Ops & Mtce swing staff estimate and additional cyclical $$ contract value
- Regulatory costs incurred prior to Rel 4 are included in Program Support and Oversight.
b) Yes, all listed projects are included in the above table and captured in the lines noted below:

- Line 19: Includes direct work related to Darlington Energy Complex, Water and Sewer project, Heavy Water Storage and Drum Handling Facility, and Electrical Power Distribution system

- Line 10: Includes direct work related to Powerhouse Steam Venting System, Emergency Power Generator, and Containment Filtered Venting System

- Line 34: Includes direct work related to Darlington Operations support Building Refurbishment, and Auxiliary Heating System

- Line 26 - 29: Includes indirect costs such as contingency, interest and escalation for Darlington Energy Complex, Water and Sewer project, Heavy Water Storage and Drum Handling Facility, Electrical Power Distribution system, Powerhouse Steam Venting System, Emergency Power Generator, and Containment Filtered Venting System

- Line 35 - 37: Includes indirect costs such as contingency, interest and escalation for Darlington Operations support Building Refurbishment, and Auxiliary Heating System.

c) The recovery of total Darlington Refurbishment costs provided in part (c) occurs through the recovery of non-capital costs (OM&A), and depreciation expense for invested capital. Of the total costs in part (c), OPG expects to recover $64.1M through payment amounts, including rate riders, by the end of 2015. This consists of $16.9M recovered by the end of 2013, a debit amount of $0.3M in the Capacity Refurbishment Variance Account as at December 31, 2013, and forecast expenses of $46.9M included in the proposed test period revenue requirement. The $46.9M forecast expenses comprise OM&A expenses of $37.9M (Ex. F2-1-1, Table 1, line 5) and depreciation expense of $9.0M (Ex. F4-1-1, Table 2, note 1).
Ref: Exh D2-T2-S1

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project appropriate?

Interrogatory

OPG indicates that it developed an overall Commercial Strategy and separate Contracting Strategies for all major project work packages.

Using the information from the completed IR above [4.9-Staff-49] please complete the table below. The table assumes that the major work projects are not yet in execution phase, but are in one of the two sub-phases of the Definition Phase (either preliminary planning or detailed planning). In the projected cost column, please show the latest projected costs for the work project. In the percentage column, please indicate the “accuracy” range for the project cost associated with the sub-phase for the work project. In the appropriate sub-phase column briefly state the pricing/$ risk mitigating arrangement e.g. Fixed/Firm Price or Guaranteed Maximum or Target Price or Cost Reimbursable.

If any of the Facility & Infrastructure projects are still in the Definition Phase please add them to the table.

<table>
<thead>
<tr>
<th>DRP Work Packages/ Other Components and Overall Commercial Stratgy (Multi Prime Contractor) and Contracting Strategies</th>
<th>Estimated costs and current phase and % estimation accuracy and approach to cost vs estimate risk management</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Latest Projected (Cost $M)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Contracts for Major Work Projects</td>
<td></td>
</tr>
<tr>
<td>Retube and Feeder Replacement</td>
<td></td>
</tr>
<tr>
<td>Fuel Handling</td>
<td></td>
</tr>
<tr>
<td>Steam Generators</td>
<td></td>
</tr>
<tr>
<td>Turbine Generators</td>
<td></td>
</tr>
<tr>
<td>Subtotal major contracts</td>
<td></td>
</tr>
<tr>
<td>Balance of Plant</td>
<td></td>
</tr>
<tr>
<td>Reactor Systems</td>
<td></td>
</tr>
<tr>
<td>Conventional Systems</td>
<td></td>
</tr>
<tr>
<td>Common Systems</td>
<td></td>
</tr>
<tr>
<td>Pre-refurbishment</td>
<td></td>
</tr>
<tr>
<td>Safety &amp; Controls</td>
<td></td>
</tr>
<tr>
<td>Special Groups</td>
<td></td>
</tr>
</tbody>
</table>

Source: Exh D2-2-1 Attachment 6
The Darlington Refurbishment Program (“DRP”) is currently in the Definition Phase (2010 to 2015) with planned execution phase to commence in 2016. The major DRP related projects, i.e., Re-tube and Feeder Replacement, Fuel Handling, Defueling, Turbine Generators, and Steam Generators, are also in the Definition Phase. They will transition to the Execution Phase of the project with the DRP.

However, there are some projects, such as Facility and Infrastructure, Safety Improvement Opportunities, and some Balance of Plant Projects which will move through the Initiation, Definition, Execution, and Close-out phase of the projects during the period of the DRP Definition Phase at the Program level before 2015. As an example, The Darlington Energy Complex (“DEC”), was initiated, defined, constructed, and the project closed out in the 2010 to 2013 period, within the DRP Definition Phase.

The table below presents a listing of the major contracts which were released during Detailed Planning within the Definition Phase of the DRP.

In addition, the table lists two facility and infrastructure projects currently in the Definition Phase; the amounts shown are for the entire project life-cycle as these projects will be fully executed in the Definition Phase of the DRP.

<table>
<thead>
<tr>
<th>Line # (Board Staff Interrogatory #49)</th>
<th>Latest Projected Cost ($M)</th>
<th>Estimate Range</th>
<th>Project Phase</th>
<th>Commercial Strategy to Minimize Cost and Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retube and Feeder Replacement</td>
<td>1</td>
<td>592</td>
<td>AACE 3</td>
<td>• Definition Phase Planning (Combination of Fixed Price and Target Price with incentives/disincentives for achieving Definition Phase Target Price) • Owner Specified Materials (Cost Plus) to minimize cost and schedule risks. • R&amp;FR Tooling (Fixed Price) • R&amp;FR Mock-up (Fixed Price)</td>
</tr>
<tr>
<td>Fuel Handling</td>
<td>2</td>
<td></td>
<td>AACE 4</td>
<td>• Contract is expected to be Fixed Price</td>
</tr>
</tbody>
</table>

Witness Panel: Darlington Refurbishment
<table>
<thead>
<tr>
<th>Line # (Board Staff Interrogatory #49)</th>
<th>Latest Projected Cost ($M)</th>
<th>Estimate Range</th>
<th>Project Phase</th>
<th>Commercial Strategy to Minimize Cost and Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defueling</td>
<td>3</td>
<td>14</td>
<td>AACE 2</td>
<td>• Engineering Services and Equipment Supply (Fixed Price)</td>
</tr>
<tr>
<td>Steam Generators</td>
<td>4</td>
<td>7</td>
<td>AACE 2</td>
<td>• Definition Phase Engineering and Tooling (Fixed Price)</td>
</tr>
</tbody>
</table>
| Turbine Generators                     | 5                           | 78             | AACE 3        | Eng Services & Equipment Supply:  
- Equipment Supply (Fixed Price)  
- Definition Phase Planning - Combination of Fixed Price and Target Price with incentives/disincentives for achieving Definition Phase Target Price)  
EPC Engineering and Installation:  
- Definition Phase Planning (Combination of Fixed Price and Target Price with incentives/disincentives for achieving Definition Phase Target Price) |

Subtotal major contracts: 707

**Balance of Plant**

| Reactor System | 7 | AACE 4 or 5 | Initiation | Target price established and a performance fee model whereby a percentage of the Contractors overheads and profit are withheld and paid out subject to performance. |
| Conventional System | 8 | AACE 4 or 5 | Initiation |

Witness Panel: Darlington Refurbishment
<table>
<thead>
<tr>
<th>Line # (Board Staff Interrogatory #49)</th>
<th>Latest Projected Cost ($M)</th>
<th>Estimate Range</th>
<th>Project Phase</th>
<th>Commercial Strategy to Minimize Cost and Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common System</td>
<td>9</td>
<td>AACE 4 or 5</td>
<td>Initiation</td>
<td></td>
</tr>
<tr>
<td>Pre-Refurbishment</td>
<td>10</td>
<td>AACE 4 or 5</td>
<td>Initiation</td>
<td></td>
</tr>
<tr>
<td>Safety &amp; Controls</td>
<td>11</td>
<td>AACE 4 or 5</td>
<td>Initiation</td>
<td></td>
</tr>
<tr>
<td>Special Programs</td>
<td>12</td>
<td>AACE 4 or 5</td>
<td>Initiation</td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal Balance of Plant</strong></td>
<td><strong>150</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Facility & Infrastructure Projects still in Definition Phase**

- **Darlington OSB Refurbishment**: Included in Line 34, 36, AACE 3, Definition. Target price established and a performance fee model whereby a percentage of the Contractors overheads and profit are withheld and paid out subject to performance.
- **Retube Feeder Replacement Island Support Annex**: Included in Line 19, 23, AACE 3, Definition. Target price established and a performance fee model whereby a percentage of the Contractors overheads and profit are withheld and paid out subject to performance.

**Notes:**
1. The above includes the project estimate for direct work only during the DRP Definition Phase.
2. Balance of Plant: Pre-Refurbishment work will be 100% complete during the DRP Definition Phase. Safety & Controls, including specialized projects, BOP Engineering and ISR Fire Protection work, will be ~50% complete. Definition phase work for other work groups is estimated at ~12.5% of the total projected cost.
3. AACE3 Range -10% to -20% on the low side and +10% to +30% on the high side
4. AACE4 Range -15% to -30% on the low side and +20% to +50% on the high side
5. AACE5 Range -20% to -50% on the low side and +30% to +100% on the high side
GEC Interrogatory #001

Ref: Ex. D2-2-1, p. 17 & D2-2-1 Atts. 5 & 6-1: (Darlington Contracting Strategy)

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project appropriate?

Interrogatory

Please update D-2-2-1 Att. 5, Table 1 to include alternative 4 (Abandon the DRP) using a representative range of current gas price forecasts and with and without GHG emission impacts. Also, please provide LUECs corresponding to each entry in the table.

Response

Please see Ex. D-2-1-1, Attachment 5, page 46, for a discussion of the alternative of not proceeding with the DRP and the impact of carbon prices on LUEC. The CCGT alternative is based on OPG’s forecast of long term natural gas prices. It would not be meaningful to compare a CCGT alternative at March 2014 prices to the Darlington station post refurbishment.
Ref:

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project) appropriate?

Interrogatory

Please provide a detailed list of major contracts for the Darlington refurbishment indicating the value of each contract, when they have been signed or are expected to be signed (or the extent of expenditure contractually committed) and categorizing them according to risk management strategy. Specifically, for each contract please indicate whether, and to what extent, and under what circumstances, OPG assumes any of the risk of cost overruns or costs of delay. Please provide an estimate of the value of minor contracts in each risk category.

Response

The table below provides a list of all contracts issued to date.

As noted, contracts are structured in a manner that allocates risk to the entity that is best able to manage that risk. For example, The Re-tube and Feeder Replacement tooling contract is fixed price as the vendor holds all of the risk associated with that work scope; no cost overruns would be passed along to OPG for the requested scope of work. The Re-tube and Feeder Replacement definition phase planning is target price as the vendor is required to work closely with OPG to meet OPG’s requirements in ultimately preparing a Release Quality Estimate for the project. The risks are shared between OPG and the vendor, however, the vendor remains incented to lower the overall cost of the work scope through the fixed fee. In all cases, OPG’s contracting approach required a provision for risk minimization including off ramps.

<table>
<thead>
<tr>
<th>Refurbishment Major Contracts</th>
<th>Major Contract Type</th>
<th>Contract Value $ Millions</th>
<th>Date signed/ expected to be signed</th>
<th>Scope of Work and Contract Strategy</th>
</tr>
</thead>
</table>
| Retube and Feeder Replacement | EPC                 | 702                       | 1-Mar-12                          | • Definition Phase Planning (Combination of Fixed Price and Target Price with incentives/disincentives for achieving Definition Phase Target Price)  
                                  |                     |                           |                                   | • Owner Specified Materials (Cost Plus)  
                                  |                     |                           |                                   | • R&FR Tooling (Fixed Price)  
                                  |                     |                           |                                   | • R&FR Mock-up (Fixed Price)  
                                  |                     |                           |                                   | Note: Contract Commitment is for Definition Phase only. The Target Price for the Execution Phase will be determined within the Definition Phase. |

Witness Panel: Darlington Refurbishment
<table>
<thead>
<tr>
<th>Refurbishment Major Contracts</th>
<th>Major Contract Type</th>
<th>Contract Value $ Millions</th>
<th>Date signed/expected to be signed</th>
<th>Scope of Work and Contract Strategy</th>
</tr>
</thead>
</table>
| Fuel Handling                 | EPC                 | TBD                      | Q3 2014                           | • Contract is expected to be Fixed Price for Definition Phase Planning  
• Execution Phase (Target Price with incentives/disincentives for achieving Target Price and Schedule) |
| Defueling                     | Eng Services & Equipment Supply | 18                      | 17-May-13                        | • Engineering Services and Equipment Supply (Fixed Price) |
| Steam Generator               | EPC                 | 79                       | 30-Dec-13                         | • Definition Phase Engineering and Tooling (Fixed Price)  
• Execution Phase (Target Price with incentives/disincentives for achieving Target Price and Schedule) |
| Turbine Generator             | Eng Services & Equipment Supply | 372                     | 27-Mar-13                         | • Equipment Supply (Fixed Price)  
• Definition Phase Planning (Combination of Fixed Fee and Target Price with incentives/disincentives for achieving Definition Phase Target Price)  
• Execution Phase (Target Price - with incentives/disincentives for achieving Target Price and Schedule) |
| Turbine Generator             | EPC - Eng and installations | 30                      | 6-Feb-14                          | • Definition Phase Planning (Combination of Fixed Price Target Price with incentives/disincentives for achieving Definition Phase Target Price)  
Note: Contract Commitment is for Definition Phase only. The Target Price for the Execution Phase will be determined within the Definition Phase. The Execution Phase Fee will be set based on the Execution Phase Target Price. |
| Balance of Plant              | EPC                 | TBD                      | 2014                              | • Mainly Target Price with some Fixed Price work scope. |

Witness Panel: Darlington Refurbishment
A summary of minor contracts is provided below:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AMEC NSS</td>
<td>45</td>
<td>• Owners Support Services for Engineering and Project Management (Time and Material with some Fixed Price)</td>
</tr>
<tr>
<td>Worley Parsons Canada Limited</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Black and McDonald Ltd.</td>
<td>7</td>
<td>• Project planning and execution for SIO projects (Target Price)</td>
</tr>
<tr>
<td>ES Fox Limited</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Faithful and Gould Inc.</td>
<td>9</td>
<td>• Project Controls and Estimating Support Services (Time and Material)</td>
</tr>
</tbody>
</table>
GEC Interrogatory #003

Ref:

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project) appropriate?

Interrogatory

The LTEP document speaks of entrenching appropriate and realistic off-ramps and scoping for the nuclear projects. For each major contract listed in answer to IR 2 above, please provide details of the manner and extent to which these features have been incorporated.

Response

The refurbishment project has a robust scope control process. Scope is identified through detailed reviews at the component level. The scope then goes through a number of challenge meetings to ensure value for money and that only the required work will be executed. Once through the process it must be approved by the Program Scope Review Board (“PSRB”). Any changes to scope from that point forward must be approved by the PSRB. This process applies for all projects within the Refurbishment Project.

For all contracts listed in GEC Interrogatory 002, off-ramps have been incorporated into the contracts which include Termination for Convenience and Suspension of Work/Services. OPG is not liable to the Contractor for consequential or indirect loss or damages, loss of profit, economic loss, interest or any other damages or loss suffered or incurred by the Contractor. OPG’s obligation is to pay for work completed and Contractor’s reasonable direct costs (e.g. cost of demobilization).
GEC Interrogatory #004

Ref:

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project) appropriate?

Interrogatory

What major contracts are being delayed or could be delayed as a result of the recent LTEP policy calling for risk minimization including off ramps?

Response

No major contracts will be delayed as a result of the recent LTEP policy calling for risk minimization, including off ramps. Prior to the LTEP, OPG’s contracting approach required a provision for risk minimization, including off ramps.
LOW Interrogatory #001

Ref: Ex. D2-02-01 Darlington Refurbishment

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project) appropriate?

Interrogatory

Please provide a detailed budget of expenses related to the environmental studies and monitoring of the Darlington Nuclear Generating Station (DNGS) required by the Darlington Refurbishment Environmental Assessment (EA) and EA Follow-up Program. We request a budget for the test period, as well as one for the continued operation of the DNGS.

Response

The 2014-2015 budget amounts related to the environmental studies and monitoring required by the Darlington Refurbishment Environmental Assessment ("EA") and EA Follow-up Program for the test period is shown below for activities which are incremental to the normal operations of the plant. The purpose of the follow-up program is to determine if the environmental effects are as predicted in the EA, to confirm whether the proposed mitigation measures are effective, and determine if new mitigation strategies are required. Any additional mitigation/monitoring requirements will be determined based on whether any exceedance of the effects thresholds agreed to by the appropriate regulatory agencies or prescribed through the Fisheries Act authorization. Any additional funding will be identified as part of the continued operation of the DNGS.

<table>
<thead>
<tr>
<th>Environmental Follow-up Program</th>
<th>Estimated Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2014</td>
</tr>
<tr>
<td>Effluent Characterization</td>
<td>$60 K</td>
</tr>
<tr>
<td>Fisheries Authorization</td>
<td>$100 K</td>
</tr>
<tr>
<td>Entrainment Study</td>
<td>$150 K</td>
</tr>
<tr>
<td>Benthic Invertebrate Community Study</td>
<td>$100 K</td>
</tr>
<tr>
<td>Thermal Monitoring</td>
<td>$60 K</td>
</tr>
</tbody>
</table>
LOW Interrogatory #002

Ref: Ex. D2-02-01 Darlington Refurbishment

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project) appropriate?

Interrogatory

Please provide a detailed budget of expenses related to environmental mitigation plans and technologies for the DNGS. We request a budget for the test period, as well as one for the continued operation of the DNGS.

Response

Please see the response to L-04.9-12 LOW-001.
LOW Interrogatory #003

Ref: Ex. D2-02-01, Attachment 4-12, Program Environmental Management Plan (Program EMP)

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project appropriate?

Interrogatory

How will this Program EMP integrate continuing environmental studies and monitoring required by the EA and EA Follow-up Program?

Response


The Darlington Refurbishment Program Management Plans set out the activities that OPG will undertake to manage the refurbishment activities. As set out on pages 7 and 8 of the attachment, OPG will establish environmental metrics for the refurbishment project that will be used to monitor performance. These monitoring activities, in combination with field inspection, will be used to confirm that OPG’s contractors performing the refurbishment are effectively managing their responsibilities.

The environmental studies and monitoring program for the Darlington Nuclear Generating Station will continue throughout the Darlington Refurbishment project. All effluents, emissions, and wastes that are currently safely managed will continue to be monitored during the refurbishment activities. The requirements for emissions, effluents and waste that have been established in the licence issued by the CNSC and in the Ontario Ministry of the Environment Environmental Compliance Approvals for Darlington Nuclear Generating Station will apply throughout the refurbishment activities.

The EA Follow-up program is a separate program that will be performed in accordance with the requirements established by the CNSC. The elements of the EA Follow-up program that pertain to ongoing performance monitoring will be integrated, as applicable. Elements of the EA follow-up program that are distinct from ongoing monitoring activities will not be integrated.
Darlington Refurbishment -
Environmental Program Management Plan

NK38-NR-PLAN-09701-10001-0004-R000
2014-01-31

Order Number: N/A
Other Reference Number:

Prepared by: Elio Fracalanza
Sr. Advisor
Chemistry & Environment
Nuclear Refurbishment

Reviewed by: Roger Daly
Manager
Chemistry and Environment
Nuclear Refurbishment

Approved by: Ron Chatterton
Director
Operations and Maintenance
Nuclear Refurbishment
Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>PURPOSE</td>
<td>5</td>
</tr>
<tr>
<td>2.0</td>
<td>PROGRAM REQUIREMENTS</td>
<td>6</td>
</tr>
<tr>
<td>2.1</td>
<td>Objectives and Goals</td>
<td>6</td>
</tr>
<tr>
<td>2.1.1</td>
<td>Objectives</td>
<td>6</td>
</tr>
<tr>
<td>2.1.2</td>
<td>Goals</td>
<td>6</td>
</tr>
<tr>
<td>2.2</td>
<td>Environmental Management System (EMS) Framework</td>
<td>7</td>
</tr>
<tr>
<td>2.3</td>
<td>Contracting Requirements for Environmental Management</td>
<td>7</td>
</tr>
<tr>
<td>2.4</td>
<td>Environmental Performance Metrics and Targets</td>
<td>7</td>
</tr>
<tr>
<td>2.5</td>
<td>Environmental Oversight and Monitoring</td>
<td>8</td>
</tr>
<tr>
<td>3.0</td>
<td>ROLES &amp; ACCOUNTABILITIES</td>
<td>9</td>
</tr>
<tr>
<td>3.1</td>
<td>All OPG and Contractor employees</td>
<td>9</td>
</tr>
<tr>
<td>3.2</td>
<td>OPG Nuclear Refurbishment is accountable for</td>
<td>9</td>
</tr>
<tr>
<td>3.3</td>
<td>All OPG and Contractor line management are accountable for</td>
<td>9</td>
</tr>
<tr>
<td>3.4</td>
<td>Contractor Requirements for Environmental Management</td>
<td>9</td>
</tr>
<tr>
<td>4.0</td>
<td>DEFINITIONS &amp; ACRONYMS</td>
<td>11</td>
</tr>
<tr>
<td>4.1</td>
<td>Definitions</td>
<td>11</td>
</tr>
<tr>
<td>4.2</td>
<td>Acronyms</td>
<td>11</td>
</tr>
<tr>
<td>5.0</td>
<td>REFERENCES</td>
<td>11</td>
</tr>
<tr>
<td>Appendix A</td>
<td>EMS</td>
<td>13</td>
</tr>
<tr>
<td>Appendix B</td>
<td>Framework of Documents</td>
<td>14</td>
</tr>
</tbody>
</table>
## Revision Summary

<table>
<thead>
<tr>
<th>Revision Number</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>R000</td>
<td>2014-01-31</td>
<td>This document supersedes NK38-PLAN-09701-10067 Sheet 0012. The changes between NK38-PLAN-09701-10067 Sheet 0012 and this document are as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The document number has been changed to meet the requirements of NK38-NR-MAN-09701-10001,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The security classification has been removed so that the document can be submitted to the CNSC, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- References have been updated.</td>
</tr>
</tbody>
</table>
Darlington Refurbishment - Environmental Program Management Plan

Reviewers Listing

This guide has been reviewed and concurred by:

Name: Paul Davies
Title: Section Manager O&M Procedures
Site: Nuclear Refurbishment

Name: Brett Washbrook
Title: OSS Representative, Management System Oversight
Site: Nuclear Refurbishment
1.0 PURPOSE

The Nuclear Refurbishment (NR) Environmental Management Plan (EMP) describes how NR and Contractors will manage environmental issues for the NR Program.

It establishes a framework for Environmental Management System (EMS) for NR Projects, Departments and Vendors/Contractors in accordance to defined goals, objectives and expectations for the NR Program.

The *Environmental Mission* is to effectively manage all Environmental Aspects during the NR project, in accordance with the EMS.
2.0 PROGRAM REQUIREMENTS

This plan will provide NR and other business unit support staff with clear understanding of the environmental management requirements for the entire NR Program including:

- Environmental Objectives and Goals
- Environmental Management System Framework
- Roles and Responsibilities
- Contractor Environmental Management System Requirements
- Contractor Program monitoring and oversight,
- Contractor Environmental Performance Metrics and Targets

The changes that will occur as a result of the NR project have the potential to cause Environmental Impacts.

2.1 Objectives and Goals

2.1.1 Objectives:

- Maintain EMS Certification during the project
- Event-free operations during the project.
- Minimize impacts on the operating units.
- Minimize delays in return to service.

2.1.2 Goals:

- Operate As Low As Reasonably Achievable (ALARA) for radiation exposure of the Public and the Environment (PE-ALARA)
- Zero Reportable Spills and Environmental Infractions
- Maximize landfill diversion of conventional waste in alignment with regional objectives.
- Maintain top quartile performance for the generation of Low and Intermediate Level Radioactive Waste (LILRW) during Refurbishment and sustain top decile performance following the project.
2.2 Environmental Management System (EMS) Framework

The NR Project will meet the requirements of the ISO-14001 Standard for Environmental Management. In addition to the standard, CNSC Regulatory Standard (S-296) will apply.

The refurbishment project will follow a Centre-Led single EMS which will embody the principles shown on the graphic in Appendix A and the framework included in Appendix B.

2.3 Contracting Requirements for Environmental Management

With respect to the Project, there are certain elements that must be considered: the standard requires that any person performing work or services on a site, which has the potential to cause a significant environmental impact, should be aware of the requirements and importance of the EMS and are competent to perform the job assigned. Also, for Contractors performing an operation or activity that has the potential where environmental impacts are significant, these controls should take the form of documented procedures. Regardless of who performs the work (i.e. sub-Contractors) the Contractor is accountable for ensuring compliance.

Whether or not OPG is the Constructor of a project or the project is an Owner only project, OPG can be found liable for environmental regulatory infractions. The Project Manager is responsible for ensuring environmental requirement specifications are prepared, approved and followed. This must be done with full knowledge of the degree of environmental risk inherent to the construction or maintenance activities involved in the project (including environmental impact risks, stakeholder risks and legal risks).

The Project Manager’s assessment of the Environmental Aspects and potential Environmental Impacts will be unique to their project. This assessment will be integrated into the Contractor’s Environmental Management Program (CEMP). The assessment provides assurance to the workplace parties that the environmental risks unique to the project have been identified and that adequate controls to eliminate or mitigate the risks are in place before work commences.

This plan provides the Project Manager with an understanding of the environmental risks of the project and in conjunction with the N-GUID-09701-10013: Nuclear Refurbishment – Environmental Requirements Guideline which provides expectations and specific requirements for the CEMP.

2.4 Environmental Performance Metrics and Targets

A single, consistent set of Environmental Metrics (measures and targets) for Nuclear Refurbishment and Contractors at the Program and Project levels are under review and will be approved for use as per NK38-REP-09701-10145: Proposal for Refurbishment Chemistry & Environment Metrics.

NR Senior Line Management, NR Project Teams and Contractors will use the metrics to identify unsatisfactory performance against prescribed targets and identify methods to eliminate causes for unsatisfactory safety performance.
Program and Project Environment metrics will be tracked on a prescribed frequency and reported graphically, or otherwise, through the NR Program Monthly Status Report and Project Manager Status Reports.

2.5 Environmental Oversight and Monitoring

Environmental oversight and monitoring requirements for Nuclear Projects will be established under direction of N-STD-AS-0030, Project Oversight Standard. Environmental oversight criteria are identified in N-GUID-09701-10013, Nuclear Refurbishment – Environmental Requirements Guideline. Environmental oversight criteria will be included in Project Oversight Plans (POPs).

A Darlington Environmental Review Team (DERT) has been established and will be a key environmental compliance oversight mechanism for the Program Roles & Accountabilities.
3.0 **ROLES & ACCOUNTABILITIES**

For the Nuclear Refurbishment Program, safety is a shared responsibility.

3.1 **All OPG and Contractor employees:**

- Have accountability for safety. This includes making conservative decisions regarding refurbishment operation and construction activities as they relate to the health and safety of our employees and the environment.

- Are accountable for performing work safely and for identifying, communicating and, where appropriate, correcting workplace hazards in order to protect themselves, their co-workers, other contractors or the environment from harm.

3.2 **OPG Nuclear Refurbishment is accountable for:**

   The role and responsibility of the *Owner/Constructor*.

3.3 **All OPG and Contractor line management are accountable for:**

- The safety of their employees at OPG workplaces and ensuring their activities do not harm any employees or the environment.

- Ensuring the work environment is designed to protect workers and the environment.

- Ensuring that work is planned and performed to protect workers and the environment.

- Providing employees with the information, training, tools, procedures and support required to do their job safely and without harming other workers or the environment.

3.4 **Contractor Requirements for Environmental Management**

Contractors are required by OPG to identify hazards, evaluate risks and develop appropriate plans to mitigate risks. OPG expects Contractors to manage their operations to protect the environment the welfare of site staff and the environment. Their process, procedures shall be subject to competent scrutiny through the supply chain. Environmental programs and/or operations that do not meet these expectations, and in particular where there are opportunities that have not been utilized to improve the use of good environmental practice and/or eliminate/reduce significant risks, shall not be deemed acceptable (subject to assessments of reasonable practicability).

Where design is part of the works, the contractor shall comply with this list of requirements:
The Principal Contractor shall ensure that: all environmental requirements are fully incorporated into the Engineering, Procurement and Construction (EPC) process;

There is clear allocation of responsibility and authority for environmental management matters;

There is an effective interface with regulators, including obtaining relevant licences, consents and permits;

These requirements are clearly communicated through their supply chain, and reflected in the Contractor Environmental Management Program (CEMP);

Ensure that sub-Contractors are competent and resourced to work to the required standards;

Ensure compliance with site as well as their own requirements by their personnel, sub-Contractors personnel and visitors;

There is cooperation with the Project Manager and Environment Advisor;

There is cooperation and participation in environmental programs for Contractors;

There are mechanisms in place to ensure cooperation and exchange of information on neighbouring/shared risks and logistics;

Ensure that relevant information on work in the area designated as under their control is provided to OPG to facilitate coordination, so that the activity of any party does not result in undue risk;

Members of the team have access to appropriate, competent environmental management advice and support;

Monitoring and reporting including: completion of the monthly Environment Scorecard and reporting of incidents and accidents is undertaken.
4.0 DEFINITIONS & ACRONYMS

Below is a list of definitions and acronyms

4.1 Definitions

- **Environment Aspect**: Element of an organization’s activities, products or services that can interact with the environment

- **Environmental Impact**: A change in the environment that could have a negative effect on the ecosystem.

- **EMS**: Management of an organization’s environmental programs in a comprehensive, systematic, planned and documented manner. It includes the organization structure, planning and resources for developing, implementing and maintaining policy for environmental protection.

- **Environment Policy**: refers to the commitment of an organization to the laws, regulations and other policy mechanisms concerning environmental issues and sustainability

4.2 Acronyms

- **ALARA** – As low As Reasonable Achievable

- **CEMP** - Contractor Environmental Management Program

- **DERT** - Darlington Environmental Review Team

- **EMP** – Environment Management Plan

- **EMS** - Environment Management System

- **EPC** - Engineering, Procurement and Construction

- **LILRW** - Low and Intermediate Level Radioactive Waste

- **POP** - Project Oversight Plans

5.0 REFERENCES

[R-1] OPG Environmental Management System (Under development)

[R-2] Nuclear Refurbishment – Environmental Requirements Guideline (N-GUID-09701-10013)

[R-3] Nuclear Refurbishment - Project Environmental Management Plan (NK38-PLAN-09701-10149)
DARLINGTON REFURBISHMENT - ENVIRONMENTAL PROGRAM MANAGEMENT PLAN

[R-4] Proposal for Refurbishment Chemistry & Environment Metrics (NK38-REP-09701-10145)

[R-5] Project Oversight Standard (N-STD-AS-0030)

[R-6] Information Management (N-PROG-AS-0006)

[R-7] Contractor and General Employee Training (NK38-PLAN-09701-10007)
Appendix A: EMS
Appendix B: Framework of Documents
LOW Interrogatory #004

Ref: Ex. D2-02-01, Attachment 4-12, Program Environmental Management Plan (Program EMP)

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project) appropriate?

Interrogatory

Please provide copies of the following documents:

(a) The Environmental Vision, referenced in the Program EMP

(b) The Ontario Power Generation (OPG) Environmental Management System (EMS)

(c) The Project Oversight Standard (N-STD-AS-0030)

(d) The Nuclear Refurbishment - Environmental Requirements Guideline (NGUID-09701-10013)

(e) The Nuclear Refurbishment - Project Environmental Management Plan (NK38-PLAN-09701-10149)

(f) The Proposal for Refurbishment Chemistry & Environment Metrics (NK 38-REP-09701-10145)

(g) The Risk Project Management Standard (N-PROC-LE-0028)

Response

a) Ex. D2-02-01, Attachment 4-12, “Program Environmental Management Plan”, has been replaced by NK38-NR-PLAN-09701-10001, “Darlington Refurbishment – Environmental Program Management Plan”. A copy of the new document was attached to the response to Ex. L-4.9-12 LOW-003.

The Environmental Vision mentioned in Ex. D2-02-01 has been replaced by the Environmental Mission, as provided on page 5 of the new document:

“The Environmental Mission is to effectively manage all Environmental Aspects during the NR project, in accordance with the EMS”.

There is no separate Environmental Vision document.

b) OPG-PROG-0005, “Environmental Management System”, is attached (Attachment 1).

Witness Panel: Darlington Refurbishment
c) N-STD-AS-0030, “Project Oversight Standard”, is attached (Attachment 2).

d) N-GUID-09701-10013, “Nuclear Projects – Environmental Requirements Guideline” is attached (Attachment 3).

e) This document has not been issued.


g) N-PROC-LE-0028 has been superseded by N-MAN-00120-10001, “Nuclear Project Risk Management Process” which is attached (Attachment 5).
Program

<table>
<thead>
<tr>
<th>TITLE</th>
<th>ENVIRONMENTAL MANAGEMENT SYSTEM</th>
</tr>
</thead>
</table>

**PURPOSE**
Ontario Power Generation (OPG) has developed an Environmental Management System (EMS) to implement the requirements of OPG’s Environmental Policy.

**EXCEPTIONS**
None

**AUTHORIZATION**

<table>
<thead>
<tr>
<th>SINGLE POINT OF CONTACT:</th>
<th>R. Lyng</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Director, Environmental Governance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GOVERNING DOCUMENT OWNER:</th>
<th>B. Reuber</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vice-President, Environment</td>
</tr>
</tbody>
</table>

**DOCUMENT RELATIONSHIP**

| Receives Authority from: | OPG-POL-0021, Environmental Policy |

**DATES**

<table>
<thead>
<tr>
<th>Document Author Approval Date:</th>
<th>November 14, 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review By:</td>
<td>February 15, 2016</td>
</tr>
<tr>
<td>Compliance Date:</td>
<td>November 30, 2013</td>
</tr>
</tbody>
</table>
## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 DIRECTION</td>
<td>4</td>
</tr>
<tr>
<td>1.1 Ontario Power Generation Business Model and the ISO 14001 Standard</td>
<td>4</td>
</tr>
<tr>
<td>1.2 Environmental Management System</td>
<td>4</td>
</tr>
<tr>
<td>1.2.1 General Requirements</td>
<td>4</td>
</tr>
<tr>
<td>1.2.2 Environmental Policy</td>
<td>5</td>
</tr>
<tr>
<td>1.3 Plan</td>
<td>5</td>
</tr>
<tr>
<td>1.3.1 Environmental Aspects</td>
<td>5</td>
</tr>
<tr>
<td>1.3.2 Legal and Other Requirements</td>
<td>5</td>
</tr>
<tr>
<td>1.3.3 Objectives, Targets and Programs</td>
<td>6</td>
</tr>
<tr>
<td>1.4 Do</td>
<td>6</td>
</tr>
<tr>
<td>1.4.1 Resources, Roles, Responsibilities and Authority</td>
<td>6</td>
</tr>
<tr>
<td>1.4.2 Competence, Training and Awareness</td>
<td>6</td>
</tr>
<tr>
<td>1.4.3 Communication</td>
<td>7</td>
</tr>
<tr>
<td>1.4.4 Documentation</td>
<td>9</td>
</tr>
<tr>
<td>1.4.5 Control of Documents</td>
<td>9</td>
</tr>
<tr>
<td>1.4.6 Operational Control</td>
<td>10</td>
</tr>
<tr>
<td>1.4.7 Emergency Preparedness and Response</td>
<td>11</td>
</tr>
<tr>
<td>1.5 Check</td>
<td>11</td>
</tr>
<tr>
<td>1.5.1 Monitoring and Measurement</td>
<td>11</td>
</tr>
<tr>
<td>1.5.2 Evaluation of Compliance</td>
<td>12</td>
</tr>
<tr>
<td>1.5.3 Nonconformity, Corrective Action and Preventive Action</td>
<td>12</td>
</tr>
<tr>
<td>1.5.4 Control of Records</td>
<td>12</td>
</tr>
<tr>
<td>1.5.5 Internal Audit</td>
<td>13</td>
</tr>
<tr>
<td>1.6 Act</td>
<td>13</td>
</tr>
<tr>
<td>1.6.1 Management Review</td>
<td>13</td>
</tr>
<tr>
<td>2.0 ROLES AND ACCOUNTABILITIES</td>
<td>13</td>
</tr>
<tr>
<td>3.0 DEFINITIONS AND ACRONYMS</td>
<td>13</td>
</tr>
<tr>
<td>3.1 Definitions</td>
<td>13</td>
</tr>
<tr>
<td>3.2 Abbreviations and Acronyms</td>
<td>13</td>
</tr>
<tr>
<td>4.0 BASES AND REFERENCES</td>
<td>14</td>
</tr>
<tr>
<td>4.1 Bases</td>
<td>14</td>
</tr>
<tr>
<td>4.2 References</td>
<td>14</td>
</tr>
<tr>
<td>4.2.1 Performance References</td>
<td>14</td>
</tr>
<tr>
<td>4.2.2 Developmental References</td>
<td>14</td>
</tr>
</tbody>
</table>

---

OPG-TMP-0001-R004 (Microsoft© 2007)
ENVIRONMENTAL MANAGEMENT SYSTEM

5.0 REVISION SUMMARY

APPENDICES

Appendix A: Roles Specific to the Environmental Management System
Appendix B: Linking Management System Manuals
1.0 DIRECTION

Ontario Power Generation (OPG) has developed an Environmental Management System (EMS) to implement the requirements of OPG-POL-0021, Environmental Policy. The EMS and the employees that implement it are directed by the OPG Business Model and bounded by the Model’s Integrated Control Framework, including the Code of Business Conduct. The EMS builds on the OPG Business Model by providing specific direction on how the Environment Policy is implemented.

1.1 Ontario Power Generation Business Model and the ISO 14001 Standard

The OPG Business Model is based on a Plan-Do-Check-Act model. The EMS aligns with and responds to the OPG business model. The EMS also integrates with the management systems in-place at the Hydro-Thermal plants and plant groups and within Nuclear.

OPG’s Environmental Policy specifies that the EMS is to be registered under the International Standards Organization (ISO) 14001 Standard. The following table clarifies where the Standard’s requirements are implemented within the OPG Business Model.

<table>
<thead>
<tr>
<th>Plan</th>
<th>1.3.1, Environmental Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.3.2, Legal and Other Requirements</td>
</tr>
<tr>
<td></td>
<td>1.3.3, Objectives, Targets and Programs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Do</th>
<th>1.4.1, Resources, Roles, Responsibilities and Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.4.2, Competence, Training and Awareness</td>
</tr>
<tr>
<td></td>
<td>1.4.3, Communication</td>
</tr>
<tr>
<td></td>
<td>1.4.4, Documentation</td>
</tr>
<tr>
<td></td>
<td>1.4.5, Control of Documents</td>
</tr>
<tr>
<td></td>
<td>1.4.6, Operational Control</td>
</tr>
<tr>
<td></td>
<td>1.4.7, Emergency Preparedness and Response</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Check</th>
<th>1.5.1, Monitoring and Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.5.2, Evaluation of Compliance</td>
</tr>
<tr>
<td></td>
<td>1.5.3, Nonconformity, Corrective Action and Preventive Action</td>
</tr>
<tr>
<td></td>
<td>1.5.4, Control of Records</td>
</tr>
<tr>
<td></td>
<td>1.5.5, Internal Audit</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Act</th>
<th>1.6.1, Management Review</th>
</tr>
</thead>
</table>

1.2 Environmental Management System

1.2.1 General Requirements

OPG’s Environmental Policy includes a commitment to register the EMS under the ISO 14001 Standard. Accordingly, OPG is committed to establish, implement, maintain, and continually improve this EMS in accordance with the Standard and use the EMS as a means of describing how the Standard’s requirements are fulfilled.

The scope of the EMS includes activities associated with the construction, operation, emissions, effluent and waste management, decommissioning and demolition of electricity generating stations and associated buildings and structures solely owned by OPG and operated by OPG or sites operated by OPG on behalf of OPG’s partner owners. Excluded from scope are sites or portions of sites leased to others. Activities associated with the supply
chain that are managed by our suppliers are not within the scope of the EMS; however, OPG may establish environmental criteria for selected goods or services to meet OPG’s needs or priorities. Also excluded from the scope are activities associated with employee or contractor travel.

1.2.2 Environmental Policy

The Environmental Policy (OPG-POL-0021) provides OPG with direction related to environmental performance and environmental management. This policy is approved by the OPG Board of Directors. The Environmental Policy is reviewed by the President annually during the EMS Management Review. The Policy is also reviewed annually by the Risk Oversight Committee (ROC) of the Board. Any revisions are submitted via ROC to the Board for approval. The Corporate Secretary is responsible for ensuring that the annual Policy review by Management is scheduled at one of the ROC meetings.

The Environmental Policy is communicated to all persons including OPG employees and contractors performing work for or on behalf of the organization. Employees’ on-going knowledge of the policy is expected to be commensurate with their work and, at a minimum, employees are expected to understand the potential environmental impact of the work they perform within the scope of the EMS.

The Environmental Policy is available to the public at www.opg.com.

1.3 Plan

OPG’s business planning process is central to the planning conducted under the EMS. It is through business planning that OPG activities are approved, resources allocated and a corporate scorecard is established. Through business planning, OPG shall identify changes in planned activities that may result in new or revised environmental aspects; account for changes in legal and other requirements; and approve corporate objectives, targets and programs.

1.3.1 Environmental Aspects

Environmental aspects are the activities that can interact with the environment. OPG-PROC-0036, Environmental Aspects Identification and Significance Rating describes how OPG identifies environmental aspects within the scope of the EMS and determines those that are significant. The operations associated with the significant environmental aspects are under operational control and are typically managed locally at the relevant sites. There may also be corporate objectives, targets and programs established to improve performance associated with significant environmental aspects. Aspects that are not determined to be significant at the corporate level shall be under operational control and managed locally.

1.3.2 Legal and Other Requirements

Legal requirements include requirements from all levels of government: Federal and Provincial statutory requirements and municipal bylaws. Other requirements are non-legal requirements to which OPG subscribes. Other requirements may be negotiated or voluntary arrangements such as shareholder directives, agreements with stakeholders, memoranda of understanding,
non-regulatory guidelines, voluntary codes of practice, or requirements of industry associations.

The process for identifying and evaluating the applicability of legal requirements and other requirements is documented in OPG-PROC-0049, Identification of Environmental Legal and Other Requirements.

A current list of other requirements to which OPG subscribes at the corporate level is accessible on the OPG Environment sharepoint site.

1.3.3 Objectives, Targets and Programs

Corporate level environmental objectives and targets shall be established and approved through the OPG business planning process and subsequent establishment of the corporate scorecard by Environment. Business unit leaders or local management may establish additional objectives, targets and programs to facilitate management of aspects under local operational control. Environment routinely monitors performance against objectives and targets (the scorecard), and reports performance to the Enterprise Leadership Team (ELT) and the ROC of the Board on a quarterly basis. Corporate Secretary is responsible for ensuring that the environmental reports are provided quarterly to the ROC. Environment is responsible for preparing the quarterly reports to the ELT and ROC. Environment is accountable for establishing, implementing and the overall management of programs. Individual program elements may be executed by groups across OPG and managed locally. Environmental Programs are summarized in the EMS Program Summary documents which are prepared annually (ENV-0010, SCI 07002.1 T7).

1.4 Do

1.4.1 Resources, Roles, Responsibilities and Authority

Resources required for environmental management shall be identified and allocated in the business planning process. Roles, responsibilities and authority are defined in Job Documents maintained by People and Culture, and the Organizational Authority Register (OAR) and the documentation supporting the EMS (e.g., procedures). Specific roles related to the EMS are outlined in Appendix A, Roles Specific to the Environmental Management System.

The Head of Generating Unit/Function (HGU/F) are accountable to ensure adequate resources are allocated to enable effective implementation of the requirements of the EMS as applicable within their respective organizations.

1.4.2 Competence, Training and Awareness

Line-Management shall ensure employees and contractors performing work on their behalf are competent based on education, training, or experience. Line-Management shall also ensure employees working on their behalf are, to an extent appropriate with their accountabilities, aware of the following:
(a) The importance of conformity with the environmental policy, procedures and the requirements of the EMS;

(b) The aspects and actual or potential environmental impacts associated with their work and the benefit of improved personal performance;

(c) Their roles and responsibilities in meeting the requirements of the EMS; and

(d) The potential consequences of departure from specified procedures.

This awareness is generally accrued through knowledge of individual accountabilities and application of the Code of Business Conduct. Specific knowledge for individual tasks is gained through training, experience, reference to procedures, and the job planning process.

Line Management shall ensure contractors working on their behalf have similar levels of awareness to an extent appropriate to the work being performed, through application of Contractor Management Processes in the individual lines of business as follows:


Hydro Thermal Operations and Business and Administrative Services may switch to using the N-GUID-00120-10008, Contractor Management Process.

Environment shall identify competence, training and awareness needs associated with environmental aspects and the EMS, including environmental training requirements specified by legal requirements. Environment shall ensure operational control procedures and practises associated with environmental aspects appropriately identify these requirements.

People and Culture shall deliver the identified training and maintain training and personnel records. Some environmental training may be defined and delivered locally by sites in accordance with site specific operational control needs.

1.4.3 Communication

Internal and external communications is a shared responsibility governed by the OPG Business Model and detailed in the table below. The scope of communications includes issues such as:

(a) Changes to procedures, policies, templates etc.;

(b) Corporate Significant Environmental Aspects;

(c) Notice of upcoming reviews, events, audits, meetings;

(d) EMS planning;
(e) Receipt of and response to complaints or comments;

(f) Government communication, including requests for information, reporting, applications, permits;

(g) Legislative information or notices of impending legislative changes; and

(h) Other reports (i.e., spill reports, etc.).

Formal internal communication related to OPG’s environmental aspects and the EMS is governed by the procedures prepared by Corporate Secretary associated with Board of Directors meetings and ELT meetings and the associated key results performance reporting and quarterly reporting.

Business and Functional Leaders establish communication practices using tools such as meetings, email, and verbal instructions appropriate to their needs. Similarly, communication between businesses and functions occurs as required including, for example, participation and presentation at meetings of the Nuclear Executive Committee (NEC) and Hydro-Thermal Operations Management Team (HTOMT).

Significant environmental events are communicated in accordance with OPG-PROC-0041, Environmental Event Identification, Classification, and Reporting.

Environment has accountability for external communication of content related to the EMS. The lead groups accountable for receiving, documenting and responding to relevant communication are summarized in the following table.

<table>
<thead>
<tr>
<th>Table 1: External Communications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agency</strong></td>
</tr>
<tr>
<td><strong>Federal</strong></td>
</tr>
<tr>
<td>Canadian Nuclear Safety Commission (CNSC)</td>
</tr>
<tr>
<td>Environment Canada, Department of Oceans and Fisheries, Canadian Environmental Assessment Agency, Natural Resources Canada (environmental matters)</td>
</tr>
<tr>
<td>Transport Canada</td>
</tr>
<tr>
<td>Other Federal Departments and Agencies</td>
</tr>
<tr>
<td><strong>Provincial</strong></td>
</tr>
<tr>
<td>Environment, Natural Resources, Tourism and Culture (Heritage Assets)</td>
</tr>
<tr>
<td>Energy as Shareholder (Minister and Deputy Minister)</td>
</tr>
<tr>
<td>Energy (below Deputy Minister) and other Provincial Ministries or Agencies</td>
</tr>
<tr>
<td>First Nations</td>
</tr>
<tr>
<td>Local Government</td>
</tr>
<tr>
<td>Public communication</td>
</tr>
</tbody>
</table>
OPG does not actively communicate information pertaining to its significant environmental aspects externally. However, general information pertaining to the significant environmental aspects may be included in public documents such as Environmental Assessment reports and the annual Corporate and Environment reports, newsletters, community meetings and on www.opg.com.

The tools used for communication can vary depending on the situation and can change in light of continual improvement initiatives. Examples include:

(a) Verbal in-person, telephone, e-mail, voice-mail and conference call exchanges;
(b) ELT, Key Results Meetings, or other formal meetings;
(c) Seminars, workshops, training sessions;
(d) Annual Sustainable Development Report;
(e) EMS documentation;
(f) PowerNews or other employee communication publications;
(g) OPG Intranet; and
(h) www.opg.com.

Where responses are related to environmental performance and the EMS, they shall be guided by the content specified by Environment. Signatories of correspondence reflect individual circumstances.

1.4.4 Documentation

Documentation of this EMS is the responsibility of Environment. Accountability for supporting documentation aligns with the roles specified in Appendix A. Local management system documentation is summarized in Appendix B, Linking Management System Manuals.

The EMS documentation (and direction where documented) is comprised of the following:

(a) Description of the scope of the EMS (refer to Section 1.2.1 of this Program).
(b) The OPG Environmental Policy (refer to Section 1.2.2 of this Program).
(c) Documents, including records, determined by Environment to be necessary to ensure the effective planning, operation and control of processes that relate to its SEAs and hazards (refer to Section 1.3.1 Environmental Aspects).
(d) Objectives, targets and programs (refer to Section 1.3.3 of this Program).
(e) Description of the main elements of the EMS and their interaction, and reference to related documents (refer to this Program).
(f) Documents, including records, required by ISO 14001 (refer to this Program).

1.4.5 Control of Documents

The EMS and the supporting governing documents are maintained in accordance with OPG-PROC-0001, Process Administrative Governing Documents. OPG-STD-0001,
Requirements for Administrative Governing Documents describes the criteria for selecting the type of governing document to use for a particular purpose and minimum requirements for structure, minimum content, and format that shall be applied.

The documentation listed in Table 2 is governance support documentation that forms part of the EMS. This working documentation is controlled through limited access and authorization to the SharePoint and intranet sites where it is saved. The EMS governance support documentation is saved as a record in accordance with the relevant OPG EMS procedures of this manual.

<table>
<thead>
<tr>
<th>Document</th>
<th>Approving Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Plan Instructions</td>
<td>VP - Business Planning and Reporting or delegate</td>
</tr>
<tr>
<td>Environmental Aspects Database</td>
<td>VP – Environment or delegate</td>
</tr>
<tr>
<td>Registry of Environmental Legislation Federal and Provincial</td>
<td>VP – Environment or delegate</td>
</tr>
<tr>
<td>List of other Requirements to which OPG subscribes</td>
<td>VP – Environment or delegate</td>
</tr>
<tr>
<td>EMS Program Summary Documents</td>
<td>VP – Environment or delegate</td>
</tr>
<tr>
<td>Corrective Preventive Action Database (CPAD)</td>
<td>VP – Environment or delegate</td>
</tr>
</tbody>
</table>

EMS documentation also includes informal local procedures used exclusively by Environment as guidance or reference material. This documentation is maintained and controlled as required by Environment and not subject to the OPG-PROC-0001 and OPG-STD-0001.

1.4.6 Operational Control

Commercial Operations and Environment (COE), Nuclear Operations, Nuclear Projects, Hydro-Thermal Operations, and/or Business and Admin Services identify and plan those operations that are associated with their identified significant environmental aspects consistent with the Environmental Policy, and objectives and targets in order to ensure that they are implemented under specified conditions. Operating control measures may also be developed for aspects where the need is identified. Local management system documentation is available on the OPG intranet, providing access to local operational control. Operational control measures include procedures, business instructions, work orders, operations or maintenance call-ups, inspection forms, checklists, etc. and are developed locally. Local operational control measures are not expected to conform to consistent formats.

Where appropriate, operational control may also be exercised through corporate procedures.

Line Management shall ensure contractors working on their behalf exercise operational controls, through application of local Contractor Management Processes in the individual lines of business as follows:


Hydro Thermal Operations and Business and Administrative Services may switch to using the N-GUID-00120-10008, Contractor Management Process.

1.4.7 Emergency Preparedness and Response

OPG has developed OPG-POL-0032, Safe Operations Policy and OPG-PLAN-09011.0011-0001, Emergency Preparedness and Response Plan to ensure timely and effective emergency response. Nuclear Operations provides corporate leadership of OPG’s emergency preparedness and response, including procedural direction and coordinating emergency preparedness and planning with Regional, Provincial and National agencies and responders. COE, Nuclear, Nuclear Projects, Hydro-Thermal Operations, and Business and Admin Services shall establish and maintain local emergency response procedures appropriate with their accountabilities.

These plans and procedures identify potential emergency situations and/or accidents that can have an impact on the environment and describes the appropriate response, and are regularly tested and evaluated to ensure their adequacy and its ongoing effectiveness. The procedures will be revised as necessary to capture lessons-learned and to address any identified gaps or opportunities for improvement.

Potential or actual emergencies or accidents of a significant environmental nature are reported through OPG-PROC-0041, Environmental Event Identification, Classification, and Reporting or through community notifications of “newsworthy” events (e.g., 911 called, visible impact like smoke, or oil sheen).

1.5 Check

1.5.1 Monitoring and Measurement

Environment monitors and measures performance against objectives and targets established in business planning through regular monthly, quarterly, and annual reporting requirements.

Related reporting requirements where Environment monitors OPG’s environmental performance includes the following:

- Environmental event reporting in accordance with OPG-PROC-0041 – Environmental Event Identification, Classification and Reporting
- Environment Report to Monthly Key Results meetings
- Quarterly Environmental Performance Reporting to ELT and the Risk Oversight Committee of the OPG Board of Directors
Environment also monitors OPG’s environmental activities through attendance at the Nuclear Executive Committee (NEC), the Hydro-Thermal Operations Management Team (HTOMT) meeting, individual plant/plant group quarterly review meetings and where appropriate, project team meetings.

Nuclear Operations, Nuclear Projects, Hydro-Thermal Operations, COE, and Business and Admin Services shall establish local procedures to monitor and measure, on a regular basis, the key characteristics of its operations that can have a significant environmental impact.

Where appropriate, procedures include that monitoring and measurement equipment is calibrated or verified to be functioning properly and that records are retained.

**1.5.2 Evaluation of Compliance**

The reporting of all legal environmental infractions is a requirement for each part of OPG. Evaluation of compliance to legal and other requirements is done by following:

(a) Assessing the legal environmental infractions identified and reported internally through performance monitoring or management self-assessments.

(b) Assessing the results of inspections by regulators.

(c) Conducting compliance audits as described in OPG-PROC-0044, Environmental Internal Audit and Compliance Audit.

The VP, Environment may also commission additional compliance audits in consultation with Risk Services.

**1.5.3 Nonconformity, Corrective Action and Preventive Action**

The responsibilities and authorities for dealing with actual and potential nonconformities and for taking corrective action and preventive action are described in OPG-PROC-0042, Environmental Nonconformity, Corrective and Preventive Action. Any actions that are taken, along with the extent of verification and effectiveness review of the action, shall be risk-ranked to ensure they are appropriate to the magnitude of the problems and the potential environmental and business risk presented by the nonconformity.

**1.5.4 Control of Records**

The records required to support the EMS are maintained in accordance with OPG-PROC-0001, Records and Document Control which establishes a set of standards and procedures for the management of records and documents. The specific requirements for the control of records are outlined in the OPG-PROC-0019, Records and Document Management Environment maintains critical records necessary to demonstrate conformity to the requirements of its EMS through records control. These records include: approved objectives, targets, and programs arising from the business planning; quarterly Environment Reports, internal and compliance audit reports, registration/surveillance audit reports, and Management Review input and decision output. Additional documents may be maintained by Environment
and locally to lines of business if these are not required to be controlled by OPG-PROG-0001 and OPG-PROC-0019.

1.5.5 Internal Audit

Internal audits shall be conducted as described in OPG-PROC-0044, Environmental Internal Audit and Compliance Audit.

1.6 Act

1.6.1 Management Review

OPG senior management comprised of the President and Chief Executive Officer (CEO) and designated members of the ELT participate in the annual review of the EMS to ensure its ongoing suitability, adequacy and effectiveness. Environment shall prepare a Management Review (Input) report, including recommendations, based on requirements of the ISO 14001 standard and the judgement of the VP, Environment. The VP, Environment shall review the Input report in a meeting with the President and CEO and designated members of the ELT. The outputs of the management review include any decisions and actions related to possible changes to the EMS, consistent with the commitment to continual improvement. These outputs are expected to be inputs to the business planning process. The VP, Environment shall ensure these outputs are reflected in revisions to the EMS and communicated to those accountable for the action required.

2.0 ROLES AND ACCOUNTABILITIES

Roles and accountabilities are outlined in Section 1.4.1, Resources, Roles, Responsibilities and Authority.

3.0 DEFINITIONS AND ACRONYMS

3.1 Definitions

None

3.2 Abbreviations and Acronyms

CEO - Chief Executive Officer
CNSC - Canadian Nuclear Safety Commission
COE - Commercial Operations and Environment
ELT - Enterprise Leadership Team
EMS - Environmental Management System
HGU/F - Head of Generating Unit/Function
HTOMT - Hydro-Thermal Operations Management Team
ISO - International Standards Organization
NEC - Nuclear Executive Committee
OAR - Organizational Authority Register
OPG - Ontario Power Generation
ROC - Risk Oversight Committee
4.0 BASES AND REFERENCES

4.1 Bases

- OPG-POL-0021, Environmental Policy.

4.2 References

4.2.1 Performance References

- OPG-PROC-0019, Records and Document Management.
- OPG-PROC-0036, Environmental Aspects Identification and Significance Rating.
- OPG-PROC-0041, Environmental Event Identification, Classification, and Reporting.
- OPG-PROC-0042, Environmental Nonconformity, Corrective and Preventive Action.
- OPG-PROC-0044, Environmental Internal Audit and Compliance Audit.
- OPG-PROC-0049, Identification of Environmental Legal and Other Requirements.
- OPG-PROC-0001, Information Management.
- OPG-STD-0001, Requirements for Administrative Governing Documents.

4.2.2 Developmental References

None

5.0 REVISION SUMMARY

This is a low impact non-intent revision.

- Revisions are response to the findings from the PriceWaterhouse Coopers’ (PwC) Phase I Documentation Readiness Review.
Appendix A: Roles Specific to the Environmental Management System

<table>
<thead>
<tr>
<th>Requirement</th>
<th>President and CEO</th>
<th>Commercial Ops and Environment</th>
<th>Nuclear Operations</th>
<th>Hydro Thermal Operations</th>
<th>Nuclear Projects</th>
<th>Business and Admin Services</th>
<th>People and Culture</th>
<th>Finance</th>
<th>Corporate Secretary</th>
<th>Corporate Business Dev.</th>
<th>Corp. Relations and Communications</th>
<th>Law</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communicate Environmental Policy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3.1, Environmental Aspects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify, maintain and rank environmental aspects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify changes in operations or activities that may alter environmental aspects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3.2, Legal and Other Requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identify changes in legal and other requirements: Federal and Provincial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintain Legal Requirements registry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3.3, Objectives, Targets and Programs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recommend Objectives, Targets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approve Programs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4.1, Resources, Roles, Responsibilities and Authority</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appoint management representative for EMS</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management representative for EMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Document roles, responsibilities and authorities (EMS/job docs/OAR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4.2, Competence, Training and Awareness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ensure competence (line-organization)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Define environment training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deliver training, maintain training and personnel records</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4.3, Communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Define procedures for Board, ELT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication with environmental regulators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## ENVIRONMENTAL MANAGEMENT SYSTEM

<table>
<thead>
<tr>
<th>Title</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>President and CEO</td>
<td>Commercial Ops and Environment</td>
</tr>
<tr>
<td>Nuclear Operations</td>
<td>Hydro Thermal Operations</td>
</tr>
<tr>
<td>Nuclear Projects</td>
<td>Business and Admin Services</td>
</tr>
<tr>
<td>People and Culture</td>
<td>Finance</td>
</tr>
<tr>
<td>Corporate Secretary</td>
<td>Corporate Business Dev.</td>
</tr>
<tr>
<td>Corp. Relations and Communications</td>
<td>Law</td>
</tr>
</tbody>
</table>

### 1.4.4, Documentation
- Maintain EMS Documentation

### 1.4.5, Control of Documents
- Implement controlled document procedures

### 1.4.6, Operational Control
- Identifying and support changes in Operation Control to address changes in legal requirements
- Implement Operation Control

### 1.4.7, Emergency Preparedness and Response
- Emergency Preparedness and response procedures

### 1.5.1, Monitoring and Measurement
- Establish procedures for Monitoring & Measurement

### 1.5.2, Evaluation of Compliance
- Evaluation of Compliance

### 1.5.3, Nonconformity, Corrective Action and Preventive Action
- Maintain and implement nonconformity, corrective and preventive action procedure

### 1.5.4, Control of Records
- Control of Corporate Records

### 1.5.5, Internal Audit
- Establish and implement internal audit procedure

### 1.6.1, Management Review
- Prepare Management review Input
- Decide Management Review Output
Appendix B: Linking Management System Manuals

(a) Nuclear:

- N-PROG-OP-0006, Environmental Management

(b) Hydro Thermal Operations:

- Central Hydro Plant Group – Environment
- Niagara Plant Group – Environment
- Northeast Plant Group
- Northwest Plant Group – Environment
- Ottawa Saint Lawrence Plant Group
- Lambton – Environmental Framework
- Lennox
- Nanticoke – Nanticoke GS Managed System Manual
- Business and Administrative Services, Real Estate
TITLE
PROJECT OVERSIGHT STANDARD

AUTHORIZATION

SINGLE POINT OF CONTACT: D. Popovic
Director, Projects and Modifications

AUTHORIZATION AUTHORITY: M. Peckham
Vice President, Projects and Modifications

COMPLIANCE DATE: Immediate

PURPOSE
This standard provides direction for the Project Oversight requirements and key elements for projects executed in Ontario Power Generation – Nuclear (OPG-N). Project oversight is an important aspect of project management used to ensure project deliverables and objectives are achieved.

This standard receives its authority from N-PROG-AS-0007, Project Management.

EXCEPTIONS
None.
1.0 DIRECTION

This standard provides the Project Oversight principles and requirements to be applied to projects initiated and/or executed within OPG-N. Oversight is the independent assessment necessary to ensure project objectives are achieved. It is distinct from the in-line and normal quality assurance and control process. Oversight is applicable but not limited to:

- Safety
- Quality
- Cost and schedule performance
- Solution effectiveness
- Value for money
- Regulatory and environmental compliance
- Human performance
- Project planning
- Engineering
- Procurement, suppliers and contractors
- Installation and construction activities

Oversight is based on a proactive and graded, risk based approach. The means by which the different executing organizations implement this standard may vary based on business requirements.

1.1 Key Oversight Elements

(a) Oversight shall be performed throughout the project lifecycle.

(b) The amount and frequency of oversight shall be applied strategically using a graded approach based on project complexity, risks, and performance. The level of oversight shall be modified to reflect the current project performance and changes in the risk profile. Examples where increased levels of oversight may be required include:

- Project areas that include new processes or technology
- Activities of high consequence to safety, quality, cost or schedule
- Critical evolutions or changes
- Where suppliers are new or have performed less than expected on previous projects
- Fabrication by sub-contractors
- Where nuclear safety or operation may be impacted
- Project areas with evidence of negative trends, e.g. cost, schedule, safety or quality performance.
(c) Oversight shall be applied proactively in a manner that allows for early detection of potential issues and effective implementation of corrective actions. Methods of proactive oversight may include:

- Communicating and establishing expectations and targets
- Conducting regular status meetings
- Look ahead planning and strategizing
- Conducting challenge and preparedness meetings
- Performing direct observation, surveillance and assessments
- Using trend analysis and performance metrics
- Tracking and resolving issue
- Prompt escalation of issues

(d) Oversight shall be applied in a manner that respects contract terms and conditions. It does not direct the work of suppliers who are performing under their own approved management system. Oversight results shall be communicated to stakeholders through the Project Manager or designated authority.

(e) Oversight shall be applied to the portfolio or program of projects as well as to individual projects. The portfolio or program oversight shall be conducted in a manner that ensures:

- communication, coordination and integration between projects in order to establish and understand the interrelationships
- overall portfolio safety, quality, cost and schedule performance
- a higher degree of oversight for large projects and programs that include multiple projects.

(f) The oversight strategy, roles and responsibilities shall be documented in a project oversight plan. The oversight plan shall be reviewed and updated when required to meet the project objectives in alignment with project and supplier performance.

(g) The Project Manager should develop the oversight plan with stakeholder input and shall:

1. Direct and execute the overall project oversight.
2. Obtain the necessary resources to execute the oversight.

(h) Oversight results that include corrective actions shall be documented and communicated to the appropriate project stakeholders.

(i) Lessons learned are used for continuous improvement.

2.0 ROLES AND ACCOUNTABILITIES

None.
3.0 DEFINITIONS AND ACRONYMS

3.1 Definitions

None.

3.2 Abbreviations and Acronyms

OPG-N Ontario Power Generation - Nuclear

4.0 RECORDS AND REFERENCES

4.1 Records

None.

4.2 References

4.2.1 Performance References

N-PROG-AS-0007, Project Management

4.2.2 Developmental References

N-INS-00120-10023, Contractor Management Process
N-STD-AS-0028, Project Management Standard
N-STD-AS-0029, Contract Management Standard
N-STD-AS-0031, Field Engineering Standard

5.0 REVISION SUMMARY

This is a new document.
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision Summary</td>
<td>4</td>
</tr>
<tr>
<td>1.0 Notice</td>
<td>5</td>
</tr>
<tr>
<td>2.0 Acknowledgements</td>
<td>6</td>
</tr>
<tr>
<td>3.0 Introduction</td>
<td>7</td>
</tr>
<tr>
<td>4.0 Project Environmental Management</td>
<td>8</td>
</tr>
<tr>
<td>4.1 Role of this Guideline in Projects</td>
<td>8</td>
</tr>
<tr>
<td>4.2 Project Environmental Planning and Management</td>
<td>8</td>
</tr>
<tr>
<td>4.3 Principle Contractor's Role and Responsibilities</td>
<td>9</td>
</tr>
<tr>
<td>5.0 Preparing RFP Environmental Requirements</td>
<td>9</td>
</tr>
<tr>
<td>6.0 Environmental Requirements</td>
<td>12</td>
</tr>
<tr>
<td>6.1 Contractor Environmental Management Program (CEMP)</td>
<td>12</td>
</tr>
<tr>
<td>6.1.1 Environmental Program Elements</td>
<td>12</td>
</tr>
<tr>
<td>6.2 Environmental Protection Plans (EPPs)</td>
<td>14</td>
</tr>
<tr>
<td>6.2.1 Environmental Inspection and Monitoring Plan</td>
<td>15</td>
</tr>
<tr>
<td>6.2.2 Spill Prevention and Contingency Plan (SPCP)</td>
<td>16</td>
</tr>
<tr>
<td>6.2.3 Environmental Awareness Training Plan</td>
<td>18</td>
</tr>
<tr>
<td>6.2.4 Hazardous Materials Management Plan</td>
<td>19</td>
</tr>
<tr>
<td>6.2.5 Waste Management Plan</td>
<td>21</td>
</tr>
<tr>
<td>7.0 Abbreviations and Acronyms</td>
<td>24</td>
</tr>
<tr>
<td>8.0 References</td>
<td>25</td>
</tr>
<tr>
<td>8.1 OPG Governing Documents</td>
<td>25</td>
</tr>
<tr>
<td>8.2 Other References</td>
<td>25</td>
</tr>
</tbody>
</table>
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

Appendix A: PROJECT-SPECIFIC ENVIRONMENTAL REQUIREMENTS ........................................27
Appendix B: GOOD ENVIRONMENTAL PRACTICES (GEPs) FOR CONSTRUCTION
PROJECTS ...................................................................................................................................43
Appendix C: NR ENVIRONMENTAL COMPLIANCE PERFORMANCE METRICS ..........102
Appendix D: DN REGULATORY ENVIRONMENTAL REPORTING........................................104
# Revision Summary

<table>
<thead>
<tr>
<th>Revision Number</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
</table>
| R001            | 2013-06-06| - To be consistent with the Supply Chain ES MSA process, added wording indicating that this guide is a reference to Nuclear Project Request for Proposals (RFPs). A CEMP is required for projects, for which the Contractor to perform all Work to meet the requirements in accordance with this Guideline.  
  - Section 3.0 Added Nuclear Refurbishment Environment Process Documents.  
  - Section 4.2 Added wording to describe the Environmental Metrics (Appendix C).  
  - Section 6.0 Added wording to allow flexibility for small projects that have potential environmental impacts.  
  - Section 6.1.1 Added wording to describe the routine regulatory environmental reports and correspondence submitted to regulators (Appendix D).  
  - Section 6.2 Added wording to allow flexibility for small that have potential environmental impacts.  
  - Section 6.2.2. Added background on why the SPCP Regulations applies to the DN site.  
  - Section 6.2.2. Clarified the requirements of the Project-specific SPCP.  
  - Section 6.2.2. Added wording to allow flexibility for small projects - depending on the size and environmental risk of a Project, the Contractor may be required to conduct a spills drill and document the results for OPG records.  
  - Section 6.2.4 Added regular reporting to OPG oversight staff  
  - Section 6.2.5 Provided further details on conventional and radiological waste  
  - Section 7.0 added Abbreviations and Acronyms  
  - Section 8.0 added References  
  - Appendix A:  
    - Added information on the Biological Management Plan (maintaining connectivity for wildlife on the east-west corridor – from the Environmental Assessment).  
    - Added information on the Dust Management Plan.  
    - Deleted Specific Activities that were duplicated in Section 6 or Appendix B.  
    - Section A.2.0 References added.  
  - Appendix B:  
    - Added references for radiological GEPs.  
    - Added specific GEPs from the Refurbishment and Continued Operation EA to maintain access for wildlife travel on the east-west wildlife corridor of the DN site through protection and enhancement of the existing natural areas along the designated corridor; and enhance wildlife crossings along the east-west corridor of the DN site, where feasible and to the extent practicable.  
    - Deleted Specific Activities that were duplicated in Section 6 or Appendix A.  
    - Deleted references to obsolete documents.  
    - Section B.5.0 References added.  
  - Appendix C NR Environmental Compliance Performance Metrics added.  
  - Appendix D DN Regulatory Environmental Reporting added. |
1.0 NOTICE

This Guide is owned by Ontario Power Generation Inc. No part of this manual may be reproduced in any form by any photographic, electronic, mechanical or other means, or used in any information storage or retrieval system without prior written permission of Ontario Power Generation Inc. – Nuclear.
2.0 ACKNOWLEDGEMENTS

Nuclear Refurbishment acknowledges the valuable contributions of present and previous staff from Ontario Power Generation Inc. – Hydroelectric in having provided the framework and much of the contents of this guide. In particular, we would like to thank Mr. J. Rowsell for his contribution in the development of the "Environmental Construction Guidelines Manual “(2003).
3.0 INTRODUCTION

Ontario Power Generation (OPG) will be undertaking a number of large projects including the refurbishment of Darlington units 1-4 over a multi-year period and will the designated Owner/Constructor for the majority of work within the scope of refurbishment project.

Due to the unique requirements associated with the large scope and duration of these projects and the multi-employer configurations, it is recognized that a unique approach to the management of operations and construction safety integrity is required so that the projects are completed in a safe, high quality, and economic manner.

In addition, it is also recognized that smaller projects may benefit from the use of this guide because it contains information, which if judiciously used on construction projects, will lead to reduced environmental impacts and efficient environmental management.

This document is a reference to Nuclear Project Request for Proposals (RFPs) to inform Contractors of OPG's Environmental Requirements. This document contains 3 Sections:

- Section 4.0 - Project Environmental Management;
- Section 5.0 – Preparing RFP Environmental Requirements; and
- Section 6.0 - Environmental Requirements.

Figure 1 provides a brief overview of the hierarchy of process documents that have been developed for Environmental Management related to the Project.

Figure 1: Nuclear Refurbishment Environment Process Documents
4.0 PROJECT ENVIRONMENTAL MANAGEMENT

4.1 Role of this Guideline in Projects

This document has several roles to play in the project. The primary purpose of the Guideline is to assist OPG staff and Contractors in managing Environmental Aspects of the project through the implementation of the Contractor Environment Management Program (CEMP).

OPG is registered to the ISO 14001 Standard for Environmental Management. The standard requires that any person performing work or services on a site, where such work or service has the potential to cause a significant environmental impact, should be aware of the requirements and importance of the Environment Management System (EMS) and be competent to perform the job assigned. OPG expects the Contractor who performs an operation or activity that has the potential for significant environmental impacts, to implement measures and controls to minimize the environmental risk (i.e. documented procedure controls). Regardless of who performs the work (i.e. sub-Contractors) the Contractor is accountable for compliance with environmental requirements in accordance with Section 2.3.6 Operational Control of the ISO 14001 Environmental Management System Standard (ISO 2004).

4.2 Project Environmental Planning and Management

Preliminary environmental requirements for a project are identified by OPG at the initiation of the project, through the development of the Project Charter (N-TMP-10117). Depending on the potential environmental risks, the Environmental Advisor will determine if an Environmental Impact Worksheet (N-FORM-10422) is required for the Project. If required, the Environmental Impact Worksheet will specify the environmental considerations for the project (i.e. Planning, Design, Construction, Operation, Maintenance and Decommissioning) and specify the requirements of the CEMP and the applicable Environmental Protection Plans (EPPs) so that these environmental requirements can be captured in the Scope of Work (SOW) for the RFP.

The OPG Project Manager is responsible for ensuring environmental requirement specifications are prepared, approved and followed. This must be done with full knowledge of the degree of environmental risk inherent to the construction or maintenance activities involved in the project (including environmental impact risks, stakeholder risks and legal risks). The Project Manager or his/her delegate must communicate this risk to the team of planners and workers. The OPG Environmental Advisor provides the Project Manager with environmental management support throughout the project.
4.3 Principle Contractor’s Role and Responsibilities

OPG expects that during the planning, preparation and execution phases, project Environmental Aspects and Environmental Impacts are to be identified by the Contractor. The corresponding impact mitigation measures should then be incorporated into the design and put in place during construction. This process depends heavily on a team approach which includes Design Engineers, Project Managers and Environmental Advisors. Good Environmental Practices (GEPs) are among the most important of impact mitigation measures available for use in reducing environmental impacts. As such, it is OPG’s expectation that the Contractor utilize these GEPs, where applicable. Mitigated effects are then re-evaluated by the Contractor to determine the potential residual risk (i.e., the effect that remains after mitigation measures are considered) to ensure that the impacts are reduced to manageable levels.

Next, these activities are reviewed for the potential environmental interactions (i.e. their Environmental Aspects) which could result in Environmental Impacts, and to which GEPs (including mitigation and remedial measures or operational controls) are proposed to be applied. It is OPG’s expectation that the Contractor tailor the GEPs to the specific features of a project and document the GEPs to be utilized. Follow-up mechanisms would then need to be put in place by the Contractor to ensure that project staff are aware of the need to comply with the risk-related environmental requirements. During the project execution, the Contractor will then be monitored and/or measured against these specific deliverables and commitments to ensure compliance.

For larger-scale refurbishment Projects, Contractors will be measured against a monthly Environment Scorecard (i.e. spills and regulatory infractions), as provided in Appendix C. For smaller projects, the Contractor may also be measured against this Environment Scorecard, where specified by OPG. The Environmental Scorecard will also provide valuable data to Project Managers to assist with oversight and proof of Contractor capability for managing environmental requirements.

5.0 PREPARING RFP ENVIRONMENTAL REQUIREMENTS

As discussed in Section 4, the need to convey environmental requirements to Contractors and others involved in projects is provided as part of the RFP process for prospective Contractors (Vendors). This Guideline will provide Vendors with additional information regarding Nuclear Projects Environmental Requirements and GEPs (Appendix B) to assist with the development their CEMP for the Project Bid submission.

The following steps are taken to prepare RFP Environmental Requirements:
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

Step 1: RFP Issued to Vendors with N-GUID-09701-10013 (Nuclear Projects – Environmental Requirements Guideline) as a reference.

The RFP contains the SOW for the project, and includes a requirement for the Vendor to prepare a CEMP as part of the Project Bid.

Step 2: Vendor’s Environmental Submission in

It is OPG’s expectation that the CEMP address how the activities, products and services will be managed during the project to meet the environmental requirements in accordance with this guide. This also includes identifying project Environmental Aspects, Environmental Impacts and mitigative measures that will be put in place through specific EPPs to address environmental risks.

Step 3: Project Manager Environmental Submission Review

The Project Manager and Environmental Advisor review the CEMP (and associated EPPs) submitted by the Vendor as part of the Project Bid. The quality of the CEMP and EPPs will be compared to this guide and will be used to rank Vendors during OPG’s environmental review of the Bid Evaluation. Recommendations to close the potential gaps may be communicated to the Vendor during the Bid Evaluation phase.

Step 4: Post award input into the CEMP

Following award of the contract, the Project Manager and Environmental Advisor review Significant Environmental Aspects, mitigative measures and determine Contractor Environmental Controls and Commitments for the project. This information is communicated to Contractor for final submission of the CEMP.

Step 5: Contractor Final Submission of the CEMP

The final submission of the CEMP is submitted to the Project Manager and includes controls and Environmental Commitments (i.e. regulatory requirements). The CEMP is signed off (Accepted) by the Project Manager.

Step 6: Tracking Compliance with Environmental Controls and Commitments

Environmental commitments in the CEMP are to be managed by the Contractor through a managed tracking system and reviewed with OPG on a monthly basis (as a minimum). Commitments that require OPG input, acceptance or approval (i.e. Environmental Compliance Approvals) will also be entered into the OPG Action Tracking system. These actions are tracked for compliance by the Project Manager and are reviewed monthly by the Darlington Environmental Review Team (DERT).
6.0 ENVIRONMENTAL REQUIREMENTS

The following section is included to provide direction for the Vendor, Project Manager and Contractor in the development or enhancement of their Environmental Management Program. The Vendor's CEMP submission will be compared to items depicted by the “checked box” (✓), during the environmental review for the Bid Evaluation for large-scale refurbishment projects, but may also be applied to smaller projects that have potential environmental impacts. These items will also form the basis of OPG’s Environmental Oversight and Surveillance program, where applicable.

6.1 Contractor Environmental Management Program (CEMP)

6.1.1 Environmental Program Elements

Environmental Policy

✓ The Contractor has an Environmental Management Policy.

Environmental Aspects

✓ The Contractor has a process for identifying environmental aspects.

✓ The Contractor has a process for identifying environmental impacts.

✓ The Contractor has a process for determining Significant Aspects and their associated impacts.

Legal and Other Requirements

✓ The Contractor has a procedure to identify and maintain an up-to-date register of all legal and other requirements. A list of current routine regulatory environmental reports and correspondence submitted to regulators by OPG on a routine basis is provided in Appendix D. The Contractor is responsible for ensuring that Project data for activities that generate effluent/emissions which require routine regulatory reporting for the site are made available to the Project Manager.

Environmental Objectives, Targets and Program

✓ The Contractor sets goals and objectives based on the environmental policy and the environmental objectives of the project.

✓ The Contractor develops programs and plans to achieve the project's environmental objectives and targets.
The Contractor develops measurable performance indicators based on the organization’s activities, products and services; consistent with objectives of the project.

Resources, Roles and Responsibility and Authority

- The Contractor assigns a representative or function with sufficient authority, awareness, competence and resources to:
  1. Ensure the establishment, implementation and maintenance of the environmental management system at all applicable levels of the organization; and
  2. Report to top management on the environmental management system performance and its opportunities for improvement.

Competence, Training and Awareness

- The Contractor identifies the knowledge, understanding, skills or abilities that make an individual competent to perform their work.
- The Contractor ensures that persons performing work have the required competence.

Communication

- The Contractor has a process to encourage feedback from and involvement of all levels of the organization and receive and respond to employees’ suggestions and concerns.
- The Contractor has established implemented and maintained procedures for receiving, documenting and responding to relevant communication from external parties.

Document Control

- The Contractor has a process to collect, maintain and control documentation in a way that reflects the culture and needs of the organization, building onto and improving the existing information system.

Operational Control

- The Contractor identified the need for, documented and communicated the operational controls as appropriate.
Emergency Preparedness & Response

☑ The Contractor has procedures that take into account the potential consequences of abnormal operating conditions, potential emergency situations and events.

Monitoring and Measurement

☑ The Contractor has appropriate measurement processes for assuring validity of results, such as adequate calibration or verification of monitoring and measurement equipment, use of qualified personnel, and use of suitable quality control methods.

Non-conformities, Corrective and Preventive Action

☑ The Contractor has a process for identifying nonconformities, ensuring the corrective and preventive actions have been implemented and that there is systematic follow-up to ensure effectiveness.

Control of Records

☑ The Contractor has a process for controlling records to provide evidence of the ongoing operations and implementation of the environmental management system.

Internal Audit

☑ The Contractor conducts an objective and impartial environmental management system audit, aided by technical experts, where appropriate, selected from within the organization or from external sources.

Management Reviews

☑ The Contractors’ Top Management annually conducts a review of its environmental management system to evaluate the system’s continuing suitability, adequacy and effectiveness.

6.2 Environmental Protection Plans (EPPs)

EPPs contain specific approaches and mitigation measured to address environmental risks. As described in detail below, it is OPG’s expectation that the following 5 EPPs (Environmental Inspection and Monitoring Plan; Spills Prevention and Contingency Plan; Environmental Training Plan; Hazardous Materials Management Plans; and Waste Management Plan) be included in the CEMP particularly for large-scale refurbishment projects but may also be necessary for smaller-scale projects to meet regulatory requirements (i.e. Spills Prevention and Contingency Plan, Waste Management Plan).
Additional project-specific EPPs may also need to be identified/developed by the Vendor or Contractor in the CEMP; based on the potential environmental impacts (see Appendix A for examples). Applicable project-specific EPPs are typically identified on a case-by-case basis during the design planning phase, identified through the review and preparation of the Environmental Impact Worksheet (N-FORM-10422, Environmental Impact Worksheet).

6.2.1 Environmental Inspection and Monitoring Plan

Environmental monitoring is the process of observing, quantifying and documenting environmental effects (expected or unanticipated) or checking compliance to regulatory or other environmental requirements. The level of detail required is variable, but it is OPG’s expectation that comprehensive Environmental Inspection and Monitoring Plans be developed for larger, complex projects or those with significant environmental impacts.

The main types of monitoring are environmental construction monitoring, compliance monitoring, and audit and regulatory compliance monitoring. Construction monitoring centres on the environmental effects of a project, and usually keys in on short-term, readily identifiable, direct, construction related effects. In addition, compliance monitoring will be completed by OPG to ensure that the Contractor is meeting their environmental commitments for example with Environmental Compliance Approvals (ECAs) (formally Certificate of Approvals), Canadian Nuclear Safety Commission (CNSC) regulatory limits, etc. and that reporting is accurate. Regulating bodies, like the Ministry of the Environment (MOE), CNSC, World Association of Nuclear Operations (WANO), etc., will complete audits to confirm that OPG is in compliance with all relevant regulatory commitments.

Planning for Environmental Construction Monitoring requires timely summarization of environmental commitments identified for the project as documented in the RFP as agreed to by Contractors and in conditions of environmental approvals. The process should result in a concise Environmental Monitoring Checklist of activities and deliverables which can be verified via field inspection, interview and document review. The checklist may be used by either: (a) a Contractor; (b) OPG Project Manager; or (c) an OPG Environmental Advisor. In addition to providing a detailed monitoring checklist, the Plan should identify how frequently the monitoring is done, by whom, and requirements for corrective action.

☐ The Contractor has an Environmental Compliance Monitoring (Self-Assessment) and Audit Plans.

The Plan should acknowledge the purposes of OPG oversight and audits, such as:

- To ensure and demonstrate compliance with all applicable regulations, licences, permits and guidelines;
- To verify the accuracy of predictions and the effectiveness of mitigation measures committed to in EA documents;
To improve awareness of environmental policies, procedures and requirements;

To ensure ongoing improvement in minimizing adverse effects to the environment; and

To minimize the risk of claims or environmental penalties against OPG for environmental damages.

6.2.2 Spill Prevention and Contingency Plan (SPCP)

Spills are defined according to legislation as the discharge of a pollutant into the natural environment from out of a structure, vehicle or other container that is abnormal in quality or quantity in light of all the circumstances of the discharge. Spills include discharges of materials which are in excess of approved quantity and/or quality, as set out in conditions of relevant ECAs (formally Certificate of Approvals), to sewers, approved discharge facilities or water bodies.

As a Municipal Industrial Strategy for Abatement (MISA) regulated facility (O. Reg. 215/95), the DN site is subject to the Environmental Penalties Regulation (O. Reg. 222/07) and is therefore subject to the SPCP Regulation (O. Reg. 224/07). To meet the requirements of the SPCP Regulation, the DN site has developed a SPCP (D-INS-07290-10000). While working on the DN site, the Contractor is also subject to the SPCP Regulations, if their work has the potential for a spill. As such the Contractor must develop a SPCP to demonstrate the Project-specific commitment to spill prevention, preparedness, response, reporting and clean-up and to serve as a response guide during spill events. It is OPG’s expectation that the SPCP be consistent with the Darlington SPCP (D-INS-07290-10000, Darlington Spill Prevention and Contingency Plan) or it will be returned for revision and the Contractor held liable for any resultant project delays.

The Project-specific SPCP must be geared to the evaluated risk of spill and types of spillable materials at the site. Details on how to prepare an SPCP document are set out in the Guideline for implementing Spill Prevention and Contingency Plans Regulatory Requirements (O.Reg. 224/07) (MOE, 2007). Where projects have more than one Contractor, the principle Contractor must incorporate input from each sub-Contractor to assemble an integrated SPCP for the Project.

The Contractor will use the OPG template for the Spills reporting. This will be made available to the Contractor on request, upon contract award.

☐ The Contractor has a Spills Prevention and Contingency Plan (SPCP)

To meet regulatory requirements, the Project SPCP (where applicable) must include:

- Immediate response procedures;
- Notification requirements;
- Indications of responsibilities and accountabilities;
Inventory of spill containment and control equipment;

Procedures for containment,

Cleanup and disposal of spilled material;

Names, addresses and phone numbers of contact agencies; and

Reporting requirements.

Some of the key features of the SPCP which address emergency preparedness include:

- Containment designed and approved so as to prevent spills, often operated under ECAs (formally Certificate of Approvals).

- Approved site procedures for handling, transporting and transferring materials (e.g. Mobile Fuelling Procedure similar to N-INS-08100-10015).

- Inspection or auditing programs for compliance and environmental management systems.

- Prohibitions on activities or materials likely to be implicated in spills.

- Designated, protected areas and procedures for loading/unloading bulk chemicals and wastes.

- Security devices on valves.

- Regular programs for the inspection of oil, fuel and chemical handling and storage facilities, and spill control equipment.

- Training programs at manager, worker and coordinator levels for spills response.

The SPCP also addresses spill issues relating to the storage, transportation and use of hazardous and other substances and incorporation of information on: human health hazards, hazards associated with the physical or chemical properties of substances; personal protective equipment; immediate response procedures; containment and cleanup procedures; storage and disposal of contaminated material; equipment required for handling and cleanup; and, preventive measures to be used during routine operations involving hazardous substances.

In addition, availability of spill containment and cleanup equipment is an important component of the SPCP. Containers made of compatible materials must be available for the collection, transfer and storage of hazardous materials forming components of cleanup wastes. Spill response kits, drums or trailers will be required at various locations on the work site and the quantities and types of materials will be dictated by the nature and size of the project.
Depending on the size and environmental risk of a Project, the Contractor may also be required to conduct a spills drill and document the results for OPG records. If required, the drill should be planned and costed on the basis of [10 person-hours], involving the Contractor's Emergency Response Contact's cooperation with the OPG Emergency Response Team (ERT) and site contract administrator, based on a scenario provided by the OPG.

6.2.3 Environmental Awareness Training Plan

The Corporate Minimum Standards require assurance of environmental training. The Contractor helps to provide such assurance by preparing and rolling out an Environmental Training Plan.

Part of this requirement is met by the Contractor by submitting a clear and detailed statement of how it proposes to educate staff in environmental compliance and awareness. At minimum, the Plan shall identify how the Contractor will cover the following:

- Training content, delivery schedule and training aids;
- Environment policy;
- Spills;
- Waste Management;
- Orientation and review meetings (tail-gate or toolbox sessions, etc.); and
- How to train new hires

The Contractor shall review the environmental content of all staff training meetings with the Project Manager. The Contractor shall keep training records and make them available to the Project Manager.

✔ The Contractor has an Environmental Awareness Training Plan

It is OPG's expectation that projects with greater than zero environmental risk implement an Environmental Training Plan. The Contractor should provide information on how it plans to train its staff on environmental awareness, regulatory compliance and emergency procedures.

Personnel, who have been adequately trained on the needs and availability of proper mitigation measures and on OPG's requirements for the project prior to construction, are more likely to develop an awareness of potential environmental effects and know how to address them. The Plan for Contractor staff training should identify:

- The potential environmental impacts of the project's construction activities;
- The key project Environmental Requirements;
Constraints and GEPs identified in an EA;

- Conditions of environmental approvals;

- Environmental deliverables;

- Areas of environmental concern;

- Information on newly identified constraints and GEPs;

- How to access environmental information resources (including this Guide);

- Staff roles and actions during emergencies and environmental incidents;

- Staff roles in environmental monitoring, inspection and reporting; and

- Situations in which crew briefing will take place (e.g. new crew members; new work methods, location, etc.)

The Environmental Training Plan should be customized to the actual project activities and the individuals responsible.

6.2.4 Hazardous Materials Management Plan

Because the environmental risk associated with the volumes, types and/or circumstances of use of hazardous materials, it is OPG’s expectation that a Hazardous Materials Management Plan be included in the CEMP, where applicable. The following are OPG’s minimum expectations for the content of the Contractor’s Hazardous Material Control Program:

The general requirement is that the program:

- Is in compliance with all applicable laws;

- Meets or exceeds the OPG Health and Safety (N-GUID-09701-10011); and Environment frameworks, and any additional requirements required by OPG which may be amended from time to time;

- Meets all Industry Standards for the control and assessment of non-radioactive hazardous materials to protect the safety of workers, the environment, and the integrity of nuclear plant materials; and

- Promotes best practices respecting environment, health and safety in a manner that recognizes and minimizes the risks to the Contractor’s personnel, members of OPG and any other persons on or off the sites including the public.
Specifically:

- The **control** aspect must include approval, labelling, handling, storage, inventory information, chemical usage information including plant system/material compatibility, training requirements, disposal details, and access to associated MSDS sheets. All of this information must be electronically available at all times.

- Hazardous Materials must be clearly identified with unique bar codes or equivalent. User must be able to scan the codes and easily retrieve the information specified above, with a portable scanning device.

- Contractors must submit hazardous material reviews for products they are planning to bring on site. These reviews must be signed off by an accredited Industrial Hygienist and forwarded to OPG. All products containing hazardous materials or chemicals must be evaluated for the potential to contain known or suspected carcinogens or designated substances before being purchased and used on site. MSDS Sheets shall be available for all products and be consulted to assess products.

- Whenever possible, hazardous materials and chemicals should be selected from the OPG Approved Suppliers List. These materials have already undergone OPG assessment for safety, environment and material compatibility. Where the Contractor requires hazardous materials not on the OPG ASL, the Contractor’s assessment shall be provided to OPG’s contact for acceptance prior to materials being purchased or brought to site.

- A separate program including provision of qualified staff needs to be specified for transporting hazardous chemicals in accordance with Transportation of Dangerous Goods (TDG) regulations.

- Regular reporting to OPG oversight staff will be established, through the Environmental Monitoring Checklist (established through the Environmental Construction Monitoring process), to ensure the effectiveness of the program. Non-conformances found in any of the areas will require immediate corrective action by the Contractor.

References for processes already in place at OPG for Hazardous Materials Control include:

- N-FORM-10672, Request for Review and Approval of Hazardous Materials
- N-INS-07080-10001, Request and Approval of Hazardous Material
- N-INS-07080-10000, Hazardous Material Control
- N-INS-07080-10002, Labelling, Storage, Use and Disposal of Hazardous Material in the Field
- N-INS-01806-10000, Chemical Colour Classification and Labeling Instruction
The Contractor has a Hazardous Materials Management Plan

The focus is on the development of OPG-equivalent procedures for the use of approved materials, the availability of on-site hazard information (MSDSs, bills of lading, etc.) and the appropriate storage and handling of hazardous materials. There may also be references to specific prohibitions on use of particular products or materials.

Planning for the use of hazardous materials on projects requires the integrated application of Environmental, Chemistry and Health and Safety reviews mainly involving the Workplace Hazardous Materials Information System (WHMIS).

Plans of this type may be necessary for arranging for Polychlorinated biphenyl (PCB) or asbestos removals and disposals.

6.2.5 Waste Management Plan

For projects that may generate either conventional (i.e. non-radiological) or radiological wastes OPG must ensure that a plan to manage the waste component (i.e. waste quantities, waste types, site sensitivity, and/or waste storage or transport risks) of a project. As such, for projects that may generate either conventional or radiological wastes, the CEMP should include a Waste Management Plan.

Conventional waste management activities are to be compliant with applicable provincial requirements, including O. Reg. 102/94 under the Ontario Environmental Protection Act - Waste Audits and Waste Reduction Plans.

Radioactive waste management activities are regulated and to be compliant with the Nuclear Safety Control Act and Transport of Dangerous Goods Act. Radioactive waste is material (liquid, gaseous, or solid) that contains a radioactive “nuclear substance,” (as defined in Section 2 of the Nuclear Safety and Control Act), and which the owner has declared to be waste. In addition to containing nuclear substances, radioactive waste may also contain non-radioactive hazardous substances. The types of radioactive waste that may be generated throughout the Project are generally separated into two levels of waste: intermediate level waste (ILW) and low level waste (LLW). ILWs include fuel channel assembly wastes (i.e., pressure tubes, calandria tubes and related components). Most LLWs resulting from the Project will be similar to operational LLWs (i.e. mop-heads, rags, paper towels, and floor sweepings).

Non-radioactive solid waste and recycling as well as radioactive LLW and ILW must be processed in a manner that follows the concept of Reduce, Reuse, Recycle (3Rs) and minimizes conventional safety hazards, dose, labour, contamination spread, infrastructures demands and meeting the project schedule.

Waste storage and handling requirements for the Darlington NR are stated in NK38-CORR-09701-0410315 Darlington Refurbishment Waste Plan and Strategy. The Waste Management Plan shall address the following:
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- On-site and off-site disposal for specific waste;
- Types and classification of wastes to be generated on the project (including Subject Waste);
- Waste quantity minimization;
- Use of non-hazardous, reusable, recycled materials;
- Waste segregation and recycling; and
- Waste storage, handling and disposal

All waste generated, whether conventional, radioactive, solid or liquid must be handled in accordance with the requirements outlined in the following documents:

- D-PROC-WM-0002, Disposal of Conventional Solid Waste and Recycling at Darlington;
- D-INS-79000-10000, Completion and Processing of MOE Waste Manifests at Darlington
- D-INS-79000-10001, Waste Disposal Guidelines for Oil and Chemical Waste at Darlington;
- D-PROC-WM-0001 Disposal of Oil and Chemical Waste at Darlington; and
- D-PROC-RA-0083, Radioactive Liquid Waste Handling.

Any additional special provisions will be addressed and specified, separately, by the project, and will be requirements over and above these minimum specified requirements.

Prior to mobilization, the Contractor shall co-operate with the Project Manager in preparing documented procedures and reports for tracking and measuring quantities of wastes managed on-site. A specific waste generation metrics may be utilized for the project (where applicable) for which, OPG and the Contractor will agree in advance on any tracking accountabilities required to support the initiative strategy. Typical metrics include volume for solid LLW & ILW radioactive wastes (m³), liquid non-radioactive hazardous wastes (litres), weight (tonnage); for non-radioactive solid waste (conventional waste to landfill & recyclables), solid nonradioactive hazardous wastes (kgs) and the number of Chemical Waste Drums processed.

☑ The Contractor has a Waste Management Plan
The Plan will be reviewed by the Environmental Advisor and Radiation Protection Specialist, where applicable, to ensure regulatory requirements and procedures and considerations for waste storage and handling, and transportation and disposal are met.
# 7.0 ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALARA</td>
<td>As Low As Reasonably Achievable</td>
</tr>
<tr>
<td>BTEX</td>
<td>Benzene, Toluene, Ethylbenzene, and Xylene</td>
</tr>
<tr>
<td>CEMP</td>
<td>Contractor Environmental Management Program</td>
</tr>
<tr>
<td>CLOCA</td>
<td>Central Lake Ontario Conservation Authority</td>
</tr>
<tr>
<td>CNSC</td>
<td>Canadian Nuclear Safety Commission</td>
</tr>
<tr>
<td>DERT</td>
<td>Darlington Environmental Review Team</td>
</tr>
<tr>
<td>DN</td>
<td>Darlington Nuclear</td>
</tr>
<tr>
<td>EA</td>
<td>Environmental Assessment</td>
</tr>
<tr>
<td>ECA</td>
<td>Environmental Compliance Approval</td>
</tr>
<tr>
<td>EMS</td>
<td>Environment Management System</td>
</tr>
<tr>
<td>EPC</td>
<td>Engineering, Procurement and Construction</td>
</tr>
<tr>
<td>EPPs</td>
<td>Environmental Protection Plans</td>
</tr>
<tr>
<td>ERT</td>
<td>Emergency Response Team</td>
</tr>
<tr>
<td>ESDM</td>
<td>Emission Summary and Dispersion Modelling</td>
</tr>
<tr>
<td>GEPS</td>
<td>Good Environmental Practices</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>HRACR</td>
<td>Heating, Ventilation, Air Conditioning, Refrigeration</td>
</tr>
<tr>
<td>ILW</td>
<td>Intermediate Level Waste</td>
</tr>
<tr>
<td>LLW</td>
<td>Low Level Waste</td>
</tr>
<tr>
<td>LUST</td>
<td>Leaking Underground Storage Tanks</td>
</tr>
<tr>
<td>MISA</td>
<td>Municipal Industrial Strategy for Abatement</td>
</tr>
<tr>
<td>MNR</td>
<td>Ministry of Natural Resources</td>
</tr>
<tr>
<td>MOE</td>
<td>Ministry of the Environment</td>
</tr>
<tr>
<td>MOL</td>
<td>Ministry of Labour</td>
</tr>
<tr>
<td>MOT</td>
<td>Ministry of Transportation</td>
</tr>
<tr>
<td>MSDS</td>
<td>Material Safety Data Sheet</td>
</tr>
<tr>
<td>NR</td>
<td>Nuclear Refurbishment</td>
</tr>
<tr>
<td>OPEX</td>
<td>Operating Plant Experience</td>
</tr>
<tr>
<td>PCB</td>
<td>Polychlorinated biphenyl</td>
</tr>
<tr>
<td>PTTTW</td>
<td>Permit to Take Water</td>
</tr>
<tr>
<td>RFP</td>
<td>Request for Proposal</td>
</tr>
<tr>
<td>SOW</td>
<td>Scope of Work</td>
</tr>
<tr>
<td>UTS</td>
<td>Underground Storage Tanks</td>
</tr>
<tr>
<td>VOCs</td>
<td>Volatile Organic Compounds</td>
</tr>
<tr>
<td>WANO</td>
<td>World Association of Nuclear Operators</td>
</tr>
<tr>
<td>WHMIS</td>
<td>Workplace Hazardous Materials Information System</td>
</tr>
</tbody>
</table>
8.0 REFERENCES

8.1 OPG Governing Documents

D-PROC-RA-0083, Radioactive Liquid Waste Handling

D-PROC-WM-0002, Disposal of Conventional Solid Waste and Recycling at Darlington

D-PROC-WM-0001, Disposal of Oil and Chemical Waste at Darlington

N-PROC-OP-0044, Contaminated Lands And Groundwater Management

8.2 Other References


D-INS-79000-10000, Completion and Processing of MOE Waste Manifests at Darlington.

D-INS-79000-10001, Waste Disposal Guidelines for Oil and Chemical Waste at Darlington.


N-FORM-10422, Environmental Impact Worksheet


N-GUID-10120-10001, Inspection Of Groundwater Monitoring Wells.

N-GUID-09701-10011, Darlington Refurbishment - Safety Management Essentials.

N-INS-01806-10000, Chemical Colour Classification and Labeling Instruction.

N-INS-07080-10000, Hazardous Material Control.

N-INS-07080-10001, Request and Approval of Hazardous Material.

N-INS-07080-10002, Labelling, Storage, Use and Disposal of Hazardous Material in the Field.
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

N-INS-08100-10015, Mobile Fuelling Procedure.

N-TMP-10117, Project Charter.


NK38-DRAW-10140-10001, Groundwater Monitoring Wells Location Plan.

NK38-DRAW-10140-10002, Groundwater Monitoring Wells Equipment Tags.
Appendix A: PROJECT-SPECIFIC ENVIRONMENTAL REQUIREMENTS

A.1.0 PROJECT-SPECIFIC EPPS

Project-specific EPPs are documents on special topics such as Erosion and Sediment Control, Air Quality Plans, etc., which guide the Contractor or work crew in carrying out activities which have or may have significant environmental impacts during project execution. They are prepared by the Contractor and where applicable, it is OPG’s expectation that they are included in the CEMP. They are intended to be useful in not only defining project deliverables and communicating the Contractor’s plans to the Project, but also to be working aids during project execution. Sometimes there is a regulatory requirement to submit these plans to government agencies (i.e. Central Lake Ontario Conservation Authority). These plans may also be identified through the review of the Environment Impact Worksheet (N-FORM-10422) by the Contractor or Environmental Advisor.

Project-specific EPPs should be succinct, operationally useful and adaptive in nature such that GEPs are always incorporated. They should be organized to identify why they are needed and how they are to be implemented. Below are examples of potential Project-specific EPPs.

A.1.1 Site Development Plan

A Site Development Plan may be a component of the CEMP if the project requires integration of several EPPs and/or is complex in terms of sub-Contractor accountabilities, site work areas or phased work. A Site Development Plan is useful to draw together all subject-specific Plans and provide overall coherence to environmental management. This need is signalled by projects for which an EA report has been prepared or where there is a perceived need to coordinate a number of Plans.

OPG recommends a Site Development Plan for complex projects including those with comprehensive environmental requirements and approvals, phased activities, involvement of various OPG functional groups, projects with several environmental management plans which need to be coordinated, involvement of various Sub-Contractors, etc.

The Site Development Plan will demonstrate how the Contractor will: (a) develop or refine site design to meet environmental goals; (b) delegate and control subcontracted work; and (c) ensure overall project environmental management. To do this the Contractor shall provide detailed schedules, task lists, contingency plans and site area identification, and delineation using appropriate project management.
(a) Site and Design Considerations

Careful consideration during the design and planning phase should assist in maximizing environmental protection and minimizing the need for mitigation measures to be undertaken during construction. Design of any project component must take into consideration all environmental components and sensitive areas which may witness long-term or adverse effects from a construction project.

Environmentally sensitive areas must be avoided or otherwise accommodated (i.e. mitigation, restoration). They include fish and wildlife habitat, natural heritage areas, wetlands, unique landforms, archaeological and historical sites and areas with rare and endangered species. Discovery of an environmentally sensitive area after commencement of construction may necessitate design changes that are both time-consuming and expensive, particularly if additional property rights or Contractor down time are involved. If these areas cannot be avoided, measures can be taken both during design and construction to prevent or mitigate any adverse effects and may require approvals from regulators.

Examples of potential permitting requirements from regulators for site considerations include (but not limited to): Planning Act; Conservation Authorities Act; Endangered Species Act (ESA); Migratory Birds Convention Act; and Cemeteries Act and are outlined below.

Planning Act

The Municipality of Clarington is subject to site plan control under By-law 2010-139 (administered under Section 41 of the Planning Act). To allow for the timely approval of buildings and structures at the DN site, OPG and Municipality of Clarington have established a 10-year Site Plan Agreement which extends to 2022 (OPG, 2012). This agreement is applicable to developments on the DN site lands outside the DN Protected Areas (PAs). Although the Site Plan Agreement is a planning approval, it interacts with various ECA/permits (i.e. CLOCA) and imposes levies associated with various environmental activities (i.e. disposing of soil within Clarington).

The Site Plan Agreement recognizes that most site plan amendment applications will require only plans/drawings. Examples of developments that would require approval of plans/drawings include minor developments not requiring extensive alteration, parking lots in areas without sensitive natural heritage features, and development in the existing built-up area south of the CN railway tracks. In certain circumstances, the Municipality may require studies/reports in support of an application. For example, if a building is proposed in proximity to a key natural heritage feature, the Municipality may require the submission of a technical report in support of the plans/drawings. The issuance of Building Permits by the Municipality of Clarington is subject to receiving prior Site Plan approval.
Site Alteration Permits may be required, depending on the stage of a project or initiatives. However, where possible, the Municipality of Clarington will work with OPG to circumvent the more expensive and lengthy Site Alteration Permit process and amend the Site Plan Approval (i.e. onsite soil disposal areas). If the construction works activities are outside the Protected Area (PA) and in a CLOCA regulated area, then the CLOCA permit application applies only and no Site Alteration Permit is required. If the construction works activities are outside the PA and it is non-CLOCA regulated, then an amendment to the Site Plan Agreement or Site Alteration Permit applies. The Municipality interfaces with CLOCA as part of the site plan approval/site alteration process.

**Conservation Authorities Act**

A large portion of the DN site is regulated by Central Lake Ontario Conservation Authority (CLOCA). A permit under the Conservation Authorities Act may be required for any work in a CLOCA regulated area for activities that involve:

- Placement or dumping of fill;
- Grading, excavation;
- Construction of a building or structure; and
- Changing or interference with a watercourse or drainage pathway.

The CLOCA regulated areas for the DN site have been mapped (Figure 2) and include:

- Wetlands 0.5 – 2 ha, plus a 30 m perimeter area;
- Wetlands greater than 2 ha, plus a 120 m perimeter area;
- Watercourses plus 15 m either side;
- Shoreline wave up rush area;
- Steep slopes/bluffs; and
- Additional areas may require a permit based upon consultation with CLOCA.

Prior to the submission of an application for a permit, pre-consultation with CLOCA is required to determine if an application is required, what information should be submitted, clarify the general process that is required to obtain the permit. Following the pre-consultation meeting, a summary of the applicable information requirements for a complete application as well as any other preliminary comments will be provided by CLOCA. In the application, CLOCA must be made aware of up-to-date land classification.
Note: Based on detailed discussions with CLOCA, the DN Protected Area is excluded from the Conservation Authorities Act permitting process.

Endangered Species Act (ESA)

The purposes of the provincial ESA is to: identify species at risk (SAR) based on the best available scientific information, including; information obtained from community knowledge and aboriginal traditional knowledge; protect species that are at risk and their habitats, and to promote the recovery of species that are at risk; and promote stewardship activities to assist in the protection and recovery of species that are at risk. If a species is listed on the SAR in Ontario List as an extirpated, endangered or threatened species, it receives protection under the ESA. The ESA does however enables the Minister of Natural Resources (MNR) to issue permits or enter into agreements with proponents in order to authorize activities that would otherwise be prohibited under the ESA (may also require authorizations and/or consultation under other pieces of legislation by other agencies or levels of government).
The endangered species habitats for the DN site are regularly have been mapped (Figure 3) and are updated through on-going OPG Darlington programs such as the Biodiversity Program. It is a Contractor’s responsibility to ensure that all other authorizations are acquired and consultation completed prior to carrying out a proposed activity that has the potential to impact the endangered species habitats, if required.

Specific activities planned for the Darlington Refurbishment have been determined, by the MNR, to be not subject to the ESA, and therefore no authorizations are required under the ESA. However, the Environmental Advisor should be consulted to determine the applicability of the ESA for a specific Project. Should the ESA apply for a specific Project, a strategy has been developed that assists with the permitting process to ensure that projects are not delayed by the ESA permitting process (refer to NK38-REP-07811-10028, OPG Darlington Species at Risk Strategies and Guidance).

Figure 3: Endangered Species Habitat

Green = Bobolink; Orange = Eastern meadowlark; Blue = Least bittern; Purple = Barn swallow

Updated: 2013
Migratory Birds Convention Act

Migratory Birds Convention Act protects all migratory birds and their nests which cannot be disturbed or destroyed and includes all vegetation clearing. In all working areas (including laydown areas) vegetation clearing (i.e. trees, shrubs, anything bigger than turf grass) is prohibited during April 1 to August 15 (migratory bird breeding season), unless clearance is given by a qualified biologist. Once cleared, such working areas are to be maintained clear, as required. As such, where possible, site preparation activities (i.e. vegetation clearing, ground scrubbing) is to take place outside of the migratory breeding bird season window (April 1 to August 15).

Cemeteries Act

The Darlington Refurbishment and Continued Operation EA (OPG 2011) identified the potential presence of an abandoned cemetery (Van Camp) near Park Road, south of the CN Rail (see Figure 4). Because the presence of the cemetery and its precise location, if present, are not known, the following actions are to be taken to protect the potential cemetery:

- Protection and avoidance is the preferred option for archaeological resources with cultural heritage value or interest;

- If the possible Van Camp cemetery location may be impacted, a Preliminary Cemetery Investigation will be carried out. This investigation will involve the mechanical removal of topsoil and fill under the supervision of a licensed archaeologist. The exposed subsoil would then be shovel-shined and examined for the presence of grave shafts; and

- If human remains are identified and impacts are unavoidable, the cemetery will be closed in accordance with the Cemeteries Act and all burial remains re-interred in a local cemetery.

Figure 4: Approximate Location of Van Camp Cemetery
(b) Site Development Scheduling

Construction at OPG facilities frequently involves outdoor work. Schedules are dependent on seasonal and daily weather, particularly as it affects ground conditions and biodiversity. However, it may be necessary to schedule construction during periods of inclement weather or when site conditions are less than optimal. When faced with this prospect, particularly where long-term environmental effects could occur, the timing for the project should be reviewed. If the original timing is confirmed and the effects can be offset by restoration or compensation, then the original timing will do. If long-term effects may occur and cannot be offset, or regulatory prohibitions cannot be waived, the construction schedule should be revised to avoid the most sensitive periods of time. An example is the deferral of construction to avoid spawning periods when water quality or sensitive spawning beds may be impaired.

Terrestrial environmental impacts are least severe when ground is frozen, semi-frozen or dry, when plants are dormant. Summer and fall are also best for scheduling aquatic work, to avoid adverse effects on fish, spawning and fish habitat. There is also a need to schedule around the spring break-up season when extremely wet ground conditions and high water flows may seriously limit field operations and the onset of break-up cannot be predicted much in advance. Work may also be unavoidably interrupted on short notice if a historical or archaeological site is discovered.

Although work in extremely cold weather may result in minimal effect to the natural environment, socio-economic and safety considerations are also important. Worker safety and equipment reliability and productivity may affect scheduling. Noise effects on local communities are usually lessened when outdoor community activities are reduced during cold weather. Economic and technical factors will also require consideration in project scheduling.

From a project logistics viewpoint, scheduling must consider the time both available, and required, for obtaining environmental approvals.

(c) Site Development and Selection of Construction Equipment

Where an environmentally sensitive situation is involved (e.g. clearing trees on erodible slopes), consideration is given to the preferential use of manual labour in selected areas over machines, so as to reduce disturbance. Construction equipment should be selected to minimize the environmental effects of construction when and wherever possible. OPG and its Contractors are usually equipped with both rubber-tired and tracked vehicles to satisfy work requirements dictated by terrain and construction activity.
(d) Minor Flows/Culverts

Information should be collected on watercourse uses upstream and downstream of proposed water crossings and new culvert locations, prior to design and site development. This information should include data on: fish migration, spawning beds; water intakes; upstream and downstream structures and properties; stream bank erosion; and, high and low water level elevations. For new culverts, there are environmental approvals requirements (e.g. MNR Work Permit requirements) involved in design and construction.

A.1.2 Biological Management Plan

This term includes potentially overlapping activities such as:

- Biota protection
- Habitat or population loss compensation
- Restoration and re-vegetation (seeding, sodding, planting, natural regeneration)
- Biota control
- Scientific studies (biological inventories, recovery plans, relocations, fish netting, trapping)

Biological management may be protective, compensatory, restorative or restrictive (e.g. pest control), aimed at individual species or groups of species or habitats. The EA, screening document, project biological survey/study or Darlington Biodiversity Plan may identify terrestrial and aquatic biota and habitats which are significant or sensitive and for which special considerations are needed and/or have already been planned. In some cases control measures for unwanted or nuisance species are involved.

Site specific information should be extracted and integrated with the Plan. For example, within the DN site, most connectivity for wildlife currently exists north of the CN railway. For some species that are able to avoid collisions with trains, the CN railway enhances this connectivity. Small and medium sized mammals, insects and seed dispersal for certain flora may benefit from this connectivity. Increased traffic on the DN site (i.e. Park Road) as the result of Refurbishment and Continued Operations has the potential to disrupt this established east-west wildlife corridor, as identified in the EA (OPG, 2011). GEPs will need to be incorporated into the Plan (i.e. maintain access for wildlife travel on the east-west wildlife corridor on the DN site through protection and enhancement of the existing natural areas along the designated corridor; and consideration for enhance wildlife crossings along the corridor, where feasible and to the extent practicable).
OGP may not be the only organization undertaking biological management. MNR, Conservation Authorities or other stakeholders may have programs, forest or wetland management plans or guidelines for activities scheduled for areas covering or near OPG facilities. These must be considered in the Project-specific EPPs. Elements of the Biological Management Plan include:

a) Terrestrial Biota and Habitat Protection

The major concerns are to protect species at risk, vegetation cover, abiotic wildlife habitat features and wildlife. Biota and habitat protection measures are inherent to GEPs related to the full range of groundwork and work in water activities. Monitoring during and after construction projects and during biodiversity enhancement projects is conducted to determine the extent and nature of vegetation removal and damage and to ensure that rare and endangered species and their habitats are protected.

The Plan may also include measures to minimize the extent and duration of disturbance to wildlife. Monitoring during and after construction may be required to confirm the status of wildlife protection. Wildlife habitat (mainly native plant species) should be considered when developing restoration and other biological plans. Measures should be put in place to train construction and operations staff how to protect wildlife and to discourage wildlife harassment.

b) Fish and Aquatic Habitat Protection

Projects which result in fish or fish habitat loss require Fisheries Act Authorization and a Compensation Plan under the Fisheries Act. Compensation measures, such as habitat restoration, improvement of adjacent habitat or creation of new habitat may be elements of the Plan. Proactive biodiversity projects may incorporate similar measures or expand to include fish rescue, translocation, stocking, etc. MNR staff may or may not need to be involved in the review of the fish and/or habitat loss associated with proposed undertakings. Because the actual effects of significant in-water construction and operations activities on fish populations may not be known until after a facility is commissioned, pre- and post-construction monitoring may be required. Finalization of the monitoring program may be subject to a scoping workshop or discussions with MNR and/or DFO and will be provided in other project documentation at the appropriate time.

c) Vegetation and Pest Control

There may be requirements for controlling noxious or invasive weeds which may negatively affect facility operation and/or biodiversity. Use of biocides (herbicides and pesticides) and possibly other control techniques is often subject to OPG Pesticide Management Programs which must be taken into consideration in developing a Biological Plan. The main uses of biocides are for zebra mussel control, sewage treatment, control of algae (biofouling), suppression of aquatic and terrestrial weeds, and miscellaneous purposes (pesticides, rodenticides, insecticides, larvicides, etc.).
The behaviour of some wildlife is considered a nuisance during project activities and facility operations. Each situation should be evaluated individually and resolved in liaison with the Environmental Advisor. It is noted that many species are protected by federal and provincial laws; animal control may require permits. Chemical and certain other control methods for pests are regulated. Plans may be required to address specific issues such as the following:

- Beaver activity (cutting trees, flooding areas, blocking culverts)
- Bats, squirrels, gulls, pigeons, other birds and mammals (fouling roofs, autos, interference with general activities, vectors, and nesting in structures)
- White-tailed deer (creating road hazards)
- Waterfowl (fouling lawns, nesting, rearing young in lagoons and settling ponds, etc.)
- Raccoon or rodent (mouse, rat) infestations (vectors, material damage and fouling)
- Insect infestations (vectors, material damage and fouling)

A.1.3 Other Project EPPs

There may be a need for other types of Plans not covered off elsewhere. Contractors or the Environmental Advisor would normally identify the need for such plans if required and they would be developed by the Contractor as needed. The following types of Plans are not necessarily issued separately but are grouped together whenever possible. Some grouping suggestions are indicated below:

(a) **Air Quality Plan**

Atmospheric emissions may be broadly categorized as dust, noise (and vibration), and other gaseous or particulate emissions. They are most often combined into one Air Quality Plan or considered along with construction activities as GEPs (see Section B.6.1). The main sources of atmospheric emissions at a nuclear facility, include radiological emissions that are emitted through the contaminated exhaust stacks. Other gaseous emissions are generally limited to vehicular, diesel generator, electrical and miscellaneous equipment sources, and the non-contaminated ventilation systems. Air quality is a pathway to human health, terrestrial and socio-economic receptors.

- Dust Control Plan

A Dust Control Plan identifies the dust sources at the construction site and describes all of the dust control measures to be implemented before, during, and after any dust generating activity for the duration of the Project. Potential fugitive emission sources include paved haul roads, unpaved haul roads, stockpiles, material transfer points, material conveyances, parking lots, staging areas, and other open areas subject to wind erosion.
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Plans for Control of Noise

A Plan for minimizing and otherwise managing noise must accommodate allowances for meeting municipal noise control by-laws in municipalities where such by-laws exist. Where relevant, the OPG/MOE protocol on noise control must be considered in drawing up a Plan (MOE Protocol for Noise Control). In other cases municipal noise control by-laws and/or the MOE Model Noise Control By-Law may be applicable.

- Plans for Control of Other Gaseous and Particulate Emissions

Other air emissions include primarily those from combustion equipment and construction equipment. It is unlikely that a management plan would be required to address these concerns at most nuclear project sites. A vehicle maintenance program should address most of the potential sources of these emissions. There may be some need to address stationary sources from standby or construction related generators or boilers if present.

(b) Soil Management Plan/Groundwater Management Plan

Surplus soil and groundwater resulting from activities such as geotechnical evaluations, building construction, and groundwater pumped from foundation excavations will be handled and disposed of in accordance with regulatory requirements. Depending on the type and quantity of soil and/or groundwater that is required to be removed, a specific Soil Management Plan or Groundwater Monitoring Plan may be required in addition to the Waste Management Plan.

There are areas on the DN site that are currently managed as part of the DN Contaminated Lands Management Program. The objective of the contaminated lands management program is to ensure that suspected or discovered contamination resulting from past or on-going operations is assessed, monitored, and/or remediated, such that adverse effects are mitigated. The areas that are currently managed at DN as part of this program are shown in Figure 5.
Figure 5: Approximate Location of DN Managed Contaminated Lands

1. Former Soil Disposal Area
   Construction waste was deposited at this area. Currently, the closed landfill site is managed as part of the Ministry of Environment’s Certificate of Approval (NOMS) No. A900019.

2. Bowmanville Switchyard Drainage Ditch
   A ditch located within the drainage ditches.

3. Former Concrete Truck Wash Area
   High levels of methane gas present in the surface and subsurface soil due to concrete truck washing activities.

4. The West Spill (Dec 2009) Area
   Elevated levels of contamination in groundwater due to soil - CER No. 2009-0838.

5. UZ MOT Area
   An insoluble oil spill could not be cleaned up completely due to subsurface structures.

6. Protected Area
   Elevated petroleum hydrocarbons in groundwater located inside the Protected Area.

7. Sand Blast/Point Shop
   Contaminated soil in the vicinity of the building was remediated. However, it is possible to encounter additional contaminated soil in previously inaccessible areas.

Updated: 2011
Soil Management Plan

The Soil Management Plan identifies specific safeguards and procedures to manage soil during construction activities. It includes the soil sampling protocol and disposal. Typically a Soil Management Plan is a subcomponent of the Waste Management Plan as soil and waste water sampling and analysis, and disposal requirements/options are referenced in waste guidelines (refer to D-INS-79000-10002, Waste Disposal Guidelines for Solid Waste and Recycling at Darlington) however, a specific Soil Management Plan may be required.

Soil disposal may be managed on-site (i.e. used for future projects, temporary laydown area) or disposed of at an appropriate licensed off-site waste management facility. The Soil Management Plan for minimizing and otherwise managing disposals must include:

- A soil sampling protocol;
- A soil segregation (including volume tracking);
- Approved designated lay-down area(s), which may require approval from CLOCA (outside the Protected Area) (see Figure 2), if applicable;
- Monitoring and active management of contaminated soil (i.e. tritium), if applicable;
- A mobilization plan and schedule for removing the soil from the temporary storage site, if applicable;
- Site CNSC approval, if required; and
- Project funding to manage the soil.

Groundwater Management Plan

The CNSC and MOE administer groundwater management at nuclear facilities through the application of the Nuclear Safety and Control Act and the Environmental Protection Act. OPG has monitored the groundwater quality for both radiological and conventional parameters since the mid-1990’s and has extensively characterized the hydrogeological conditions for the site.

Groundwater may be required to be removed for excavation activities and depending on the volume of water, ECA (i.e. Permit to Take Water) may be required. A Groundwater Management Plan may be required to ensure control measures are implemented before, during, and after any pumping activity occurs for the duration of the Project.
The Groundwater Management Plan includes the groundwater sampling protocol and disposal. Typically a Groundwater Management Plan is a subcomponent of the Waste Management Plan as the waste water sampling and analysis, and disposal requirements/options are referenced in waste guidelines (refer to D-INS-79000-10002, Waste Disposal Guidelines for Solid Waste and Recycling at Darlington), however a specific Groundwater Management Plan may be required.

The following references will aid in developing a Groundwater Management Plan:

- NK38-DRAW-10140-10001, Groundwater Monitoring Wells Location Plan
- NK38-DRAW-10140-10002, Groundwater Monitoring Wells Equipment Tags
- N-GUID-10120-10001, Inspection of Groundwater Monitoring Wells
- N-PROC-OP-0044, Contaminated Lands And Groundwater Management

(c) Erosion and Sediment Control Plan

Construction activities commonly alter the landscapes where they are located, potentially altering natural processes. A common alteration encountered during construction is the removal of the vegetation that stabilizes the subsoil. In the absence of the vegetation, the underlying soils are fully or partially exposed to various natural forces such as rain, flowing water, wind, and gravity. The consequence of movement of sediment from a construction site varies with the characteristics of the drainage pathways and the final area of deposition.

The transport of sediment deposition into surrounding natural areas, including watercourses (i.e. fish habitat) as well as adjacent lands, needs to be prevented through an Erosion and Sediment Control Plan, which may also be a regulatory requirement associated with a permit (i.e. CLOCA permit).

The Erosion and Sediment Control will identify the sedimentation controls that will be put in place, prior to the commencement of construction activities (i.e. filling, grading or other development activities). The controls must be sufficient to prevent sediment from transporting off-site and into adjacent ditches, streams, watercourses, or storm sewers, prior to the commencement of construction activities (i.e. filling, grading or other development activities).
(d) Site Decommissioning Plan

In formulating the Plan, it is necessary to assemble background information on the facility, process operations, on-site treatment and disposal facilities, underground storage, hazardous materials, etc. Other requirements or guidelines, such as MOE's procedures for closure of treatment or waste management facilities may need to be followed or used to guide planning.

Some of the main concerns to draw into the focus of the Plan are to:

- Protect the environment and the health of the public during shutdown, dismantling, or reuse of the site to ensure future use is compatible with previous use
- Remove hazardous substances or register on title the presence of hazardous substances
- Ensure liabilities are known and agreed to when transferring ownership.

During planning, attention should be given to the following site features and principles:

- Inventory storage tanks, settling ponds, pipes and other underground and above ground facilities
- Based on past operating practices, evaluate the need for further sediment, soil and hydrogeological investigations and sampling or monitoring and/or decommission monitoring wells regulated by the MOE
- Evaluate the contaminant levels in site soils compared to guideline and background levels
- Make plans for soil removal, off-site treatment or on-site disposal as appropriate
- Make arrangements for storage tank excavation using experienced Contractors and during the removal, conduct visual and olfactory monitoring and remove/dispose of wastes according to environmental regulations, making sure to make appropriate notifications
- Collect raw materials and use elsewhere, sell or return to the supplier
- Where feasible, use on-site treatment facilities and disposal areas for decommissioning
- Investigate the need for security bonds or other liability protection provisions
A.2.0 REFERENCES


N-GUID-10120-10001, Inspection of Groundwater Monitoring Wells.

N-PROC-OP-0044, Contaminated Lands And Groundwater Management.

NK38-DRAW-10140-10001, Groundwater Monitoring Wells Location Plan.

NK38-DRAW-10140-10002, Groundwater Monitoring Wells Equipment Tags.

NK38-REP-07811-10028, OPG Darlington Species at Risk Strategies and Guidance.


Appendix B: GOOD ENVIRONMENTAL PRACTICES (GEPs) FOR CONSTRUCTION PROJECTS

B.1.0 INTRODUCTION

Specific activities are useful for organizing GEPs, but they form an integral part of the OPG ISO 14001 EMSs. EMS procedures for project management require that specific activities must be identified for each project before environmental aspects and significant aspects are determined. As part of the CEMP, it is OPG’s expectation that the Contractor assess the environmental risks for the project. The assessment of environmental risk is met by evaluating the types and extent of specific activities (and related impacts) relevant to each project. With this knowledge, significant aspects can then be managed to minimize environmental impact, using appropriate environmental management planning and application of GEPs.

In this document, GEPs are intended to be concise statements of constraints or opportunities specific to construction activities. These recommendations are variously aimed at preventing or mitigating adverse impacts, affording beneficial impacts, compensating stakeholders for unavoidable impacts, and enhancing biophysical or socio-economic conditions.

Each of the specific activities covered in this Section is introduced by a short, italicized introduction to identify the main characteristics and environmental issues related to the activity. The specific recommended GEPs, measures or constraints are provided under the subheading "Practices".

In general, the GEPs listed below are for non-radiological construction activities, however, OPG has a managed system in place for minimizing radiological emissions. N-STD-OP-0042, Controlling Radiation Exposure of the Public and the Environment to As Low As Reasonably Achievable, has been developed and establishes the minimum requirements for a Nuclear facility to keep radiological exposures and doses to the public and the environment As Low As Reasonably Achievable (ALARA) taking social and economic factors into account. N-STD-RA-0018, Controlling Exposure as Low as Reasonably Achievable and N-STD-RA-001 is also in place to keep occupational collective dose ALARA, with social and economic factors taken into account. Specific DN refurbishment and continued operation GEPs which focus on a number of critical areas such as removing external radiation sources, minimizing airborne radiological hazards, minimizing inter-zonal boundaries, application of benchmarked and proven ALARA techniques, and Radiation Protection field presence are documented in NK38-REP-09701-10088, Darlington Nuclear Refurbishment - Radiation Protection Strategy.
B.1.1 **Groundwork** (Clearing, Grubbing, Excavating, Aggregate Extraction etc.)

**Clearing** is the cutting and removal of live or dead trees, shrubs and other woody vegetation using chain saws, rubber-tired skidders, loaders or bulldozers with brush grapples, logging trucks and mechanical brush chippers, or by means of controlled burning, use of chemical herbicides, or pruning equipment. These activities may be required for numerous purposes including storage/laydown/camp areas, station facilities, roads, other rights-of-way, or in advance of flooding for a reservoir.

Normally, trees are cut so that a sufficient stump remains to facilitate the grubbing operation if required. In certain locations, such as swamps and future earth fill areas, close cut clearing may be carried out and grubbing may not be necessary. This involves cutting the stump close to the ground.

**Grubbing** is the removal of stumps, roots, embedded logs, rocks and debris from the upper levels of the soil. This operation is performed to prepare for earth grading, to remove unstable organic soil in load carrying zones, and to minimize visual obstacles at roadside.

Small diameter stumps introduce few problems of extraction and are usually pushed out by a bulldozer or winched out. Blasting may be used to remove and/or split very large stumps (to facilitate extraction and off-site transport).

**Stripping** is the removal of topsoil, surficial organic matter and underlying soil. **Grading** is the smoothing of irregular surface deposits of soil or granular material. Major considerations are to minimize stripping and grading and to mitigate erosion in areas where these activities take place.

**Trenching** is the digging of narrow channels in the earth, usually for purposes of installing piping, conduits, foundations, drainage piping, etc.; trenches are generally backfilled after installations are completed. Trenches may be bolstered with timbered or steel vertical sides or may have exposed sides. **Ditching** is a similar activity but for conducting surface runoff; ditches are intended to be left open. **Backfilling** is an activity involving the replacement of earth or granular material: (a) in an area which may have been previously excavated such as a trench, cut or depression, or (b) into a new area or formwork to be built up or filled such as a cofferdam, side-slope, etc.

**Excavating on Land** is the removal and deposition of soils and like materials (except in trenches and ditches) for construction of foundations, berms, level areas (e.g. for laydown, parking), etc.

Environmental aspects of groundwork are discharge to water, air emission, waste, and materials and energy use. Impacts include sediment, equipment and vehicle spills, erosion, dust and noise emissions, waste granular materials, vegetation, fuels, and contaminated soils, damage, disturbance or mortality of biota (habitat loss, buffer zone infringement, fire, noise), and resource use interactions (timber resource allocation, access road use, agricultural land use, cultural artifacts).
Guideline

NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

Practices

B.1.2 General Measures

- With regard to all types of groundwork, avoid work in the following:
  - Areas with rare, endangered or threatened species or obtain regulatory approval (i.e. MNR permit)
  - Areas with key habitat features (nests, denning sites, spawning areas, nurseries, calving grounds, roosts, colonial nesting areas, etc.)
  - Agricultural areas with established infrastructure (fences, hedgerows, windbreaks, drainage tiles, ditches, in-ground water control structures)
  - Agricultural areas during wet or other conditions when use of heavy equipment will result in irreparable damage from rutting, compaction and damage to soil structure and fertility
  - Areas with cultural or industrial infrastructure (cemeteries, ceremonial areas, historical sites, portages, water intakes and discharges, etc.)

- Make repairs to infrastructure as soon as possible or schedule them to take place immediately after construction.

B.1.3 Clearing

B.1.3.1 Timing and Location Constraints

- Apply timing constraints for clearing in areas where special protection is necessary.
- Obtain approval from the Project Manager prior to clearing.
- If feasible, clear from August 15 to April 15 to avoid the primary bird nesting season. Otherwise, regulatory approval (i.e. MNR permit; Letter of Advice) is required.
- When feasible, clear areas in winter to avoid soil disturbance, damage to field drains, and problems of excessive damage and equipment bemiring due to the presence of wetlands and lowland forest.
- Do not excavate, fill, or create push-outs in uncleared vegetated areas using bulldozers or similar equipment.
- Clear areas in conformance with construction limits and buffer strips designated.
- Keep clearing to a minimum and only where necessary. Make use of existing disturbed or pre-cleared areas wherever possible.
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Allow clearing only in designated areas: (e.g. for waste storage, parking, roadways, laydown areas, etc.)

- Provide a buffer zone of at least 30 m when clearing lands adjacent to water bodies and fish habitat.

- Provide fencing or other identification for buffer zones or areas planned for clearing.

- Schedule clearing activities for as late in the project as feasible and ensure clearing takes place in coordination with the development of specific site areas. This will maintain the natural buffer zone and limit erosion for as long as possible. Address timing constraints that may apply to areas where special protection is necessary as early in the project as possible.

- Ensure the development plan fits the topographic, soil, and vegetative characteristics of the area with a minimum of clearing and grading. Retain and protect natural cover wherever possible. Identify critically erodible soils, steep slopes and stream banks.

- Establish access road clearing limits which are of uniform width, parallel to the centre-line, and well marked to avoid unnecessary clearing. Consider a curvilinear edge to the right-of-way while selectively cutting to remove trees susceptible to blowdown; enhance scenic views; and, retain timber that does not threaten safety or the development process. Select clearing limits in accordance with MNR and Ministry of Transportation road class standards and specifications.

- Specify maximum clearing widths on site drawings to allow sufficient space for construction equipment to manoeuvre without disturbing standing trees or other sensitive features.

- Flag, fence and avoid environmentally sensitive areas in order to deter vehicle interference and prevent other types of disturbance during clearing operations. Such areas include fish habitat, wetlands, areas of rare, threatened and endangered plants or wildlife, hazard lands, heritage resource sites, and special wildlife habitat (including snags used by cavity nesting birds, colonial bird roosts, dens, calving grounds, deer yards, etc.).

- Monitor and adapt where necessary (use "adaptive management" techniques to guide changes in managing an area based on lessons learned).

**B.1.3.2 Selective Clearing, Pruning, Prescribed Burns**

- Consider selective cutting and/or hand clearing under the following circumstances:
  - Where some or many trees are so located that they do not present an obstacle or hazard to the development.
To remove herbaceous and tree species which are incompatible with planned land use in the construction area, such as noxious species (e.g. poison ivy) or fast growing trees such as willow, soft maple, elm and poplar.

To remove vegetation which will interfere with planned pole lines and to remove vegetation which at maturity could interfere with in situ overhead conductors.

In flood zones of areas to be impounded and on erodible slopes that do not require grading.

Avoid clearing above the high-water line in reservoir areas to prevent destabilization of soils and adverse effects on wildlife.

Minimize tree cutting on the banks of water bodies.

Do not leave felled material in major stream channels or below high-water mark, or where it may be washed into a channel during a flood event, or for a distance of 30 m up-gradient of culverts.

Do not use chemical vegetation control to clear vegetation for construction project purposes.

Clear by controlled burning only in accordance with the MNR prescribed burning policy and procedures, and in consultation with MNR personnel. Clear without creating fire hazards (e.g. by proper stockpiling of timber or slash).

Prune trees and shrubs to preserve windbreaks or to address aesthetic concerns.

Cleanly prune frayed tree branches damaged by construction activities.

Fell trees towards previously cleared areas or toward areas planned for upcoming clearing in order to minimize perimeter damage.

Cut off trees and undergrowth at ground level or leave a stump if grubbing is planned.

Tree Skidding/ Machine Clearing

Use machine clearing to remove trees and brush while minimizing disturbance to organic cover through the use of "V" blades, "K-G" blades or similar equipment.

Keep clearing machines (e.g. skidders) at least 15 m from high water mark of water bodies, and try to ensure that trees fall away from water bodies and slash is piled so it will not enter water bodies during peak flow periods.

Limit skid trails to slopes of less than 35%.
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Ensure that logs are not skidded across streams or driven into any watercourse. Always concentrate skidding of timber in the centre of the skid trail right-of-way.

- Position skid trails at an angle to the slope, not straight up and down a hill.

- Avoid use of wide track vehicles or more than one machine on a skid trail at a time.

- To minimize sedimentation, divert water off skid trails before the trail enters a riparian area or stream crossing.

- Till compacted skid trails with appropriate equipment (e.g. self-drafting winged subsoiler).

B.1.3.3 Log Landings and Slash Management

- Select log landings to avoid sensitive areas, springs, seeps and sinkholes. Maintain a buffer zone between landings and sensitive areas. Locate them on slightly sloping ground to facilitate drainage and minimize erosion.

- Consider aesthetics when planning log landings near roadways.

- Apply coarse stone or other stabilizing cover as needed at log landings.

- Pre-cut landings for temporary timber storage on high ground and if possible, in scrub brush areas which will hold up under use by heavy equipment.

- Remove by hand, any slash which lands in water bodies.

- Do not leave slash in the buffer zone within 15 m of the high water mark.

- Dispose of cleared materials in accordance with a Waste Management Plan and/or GEPs for disposal of wood, brush and herbaceous material.

B.1.4 Grubbing

- Minimize grubbing and do not proceed so far ahead of construction as to induce lengthy periods of soil exposure.

- Limit grubbing in agricultural areas to removal of stumps and stones larger than 25 cm but exclude removal of smaller stones (which are normally the responsibility of the landowner).

- Avoid grubbing or else time and minimize this activity as a precaution against erosion (e.g. by avoiding wet weather periods and by matching this activity with the progress of other components of the Work).

- Obtain the approval of the Project Manager before starting grubbing operations after completion of clearing.
Avoid grubbing operations, if possible, adjacent to any water body or wetland or on slopes or in other areas subject to erosion.

Implement preventative erosion and sediment control measures before grubbing occurs.

To minimize blowdown, do not grub stumps within 2 m of standing timber at the edge of the cleared area.

Avoid damaging adjacent trees by keeping grubbing to the minimum area required and restricted to within 2 m of any right-of-way edge or trench, especially on erodible slopes.

Ensure grubbing conforms to the construction limits and buffer strips identified on the Site Development Plan, if available.

Leave areas not planned for grubbing, even if standing trees and vegetation are dead, since these provide good wildlife habitat.

Do not block drainageways with grubbed material.

Minimize rutting by avoiding grubbing in fine grained soil areas during wet weather.

Use blade shoes, skid shoes, and brush rakes to minimize surface disturbance and loss of topsoil when grubbing. Leave some organic material in place to facilitate rapid revegetation.

### B.1.5 Stripping and Grading

Provide details on where and when stripping and grading activities are permitted in the Site Development Plan or in descriptions of groundwork.

Obtain approval of the Project Manager for stripping on completion of clearing and grubbing.

Confine stripping and grading to designated areas such as roads, camp, storage and laydown facilities, landfills, borrow pits, powerhouse area, reservoir, dyke areas, power canals, diversions, and stockpile areas.

Minimize surface areas to be stripped and graded.

Segregate topsoil and subsoil for later replacement in their original horizons; add fertilizers if the soil has lost its fertility during storage.

Selectively remove organic soils from the flood zone of prospective reservoir areas or use other techniques such as the removal or covering over of areas with organic soils (where methyl mercury production may otherwise become problematic after inundation).
Guideline

NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Minimize erosion on areas that have been stripped and graded by considering the following:
  - Minimize extent and duration of exposure;
  - Stockpile and reuse stripped topsoil, preferably within one year and without compaction;
  - Develop or stabilize exposed areas, especially slopes, as soon as possible via compaction, or application of granular materials or geotextiles, or by other means; and
  - Control runoff by diverting flow, terracing, roughening or cultivating the soil.
- Confine grading to areas planned for excavation or for construction related to access roads, laydown areas or work areas.
- Stockpile stripped soil separately on site for future use in restoration. Protect the stockpiles and stripped areas from erosion. Obtain Project Manager approval or follow plans regarding stockpile locations.
- Do not push graded soils into forested or wetland areas nor into established buffer areas.

B.1.6 Trenching, Ditching, and Backfilling

- Minimize the surface area cleared for trenching.
- Shore up trenches to preserve their functionality (prevent slumping and sediment mobilization) and to protect people and wildlife.
- Do not deposit excavated material on ice.
- Plan trench locations and safeguards by taking surface and subsurface drainage patterns into consideration.
- Avoid trenching near wetlands, watercourses, lakes, ponds or other natural sensitive areas.
- Specify in the construction drawings protective measures which will both stabilize berm materials and encourage the establishment of new vegetation if berm erosion is likely.
- Locate trenches so as to avoid root losses caused by closely approaching large or heritage trees and to prevent destabilizing trees by making them susceptible to blowdown.
Guideline

NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Install temporary flumes when trenching across small active streams or drainage ditches.

- To protect workers and wildlife, properly shore and fence trenches that must be left open.

- Dewater trenches to ensure the stability of side slopes where terrain instability is encountered. Direct discharge water from within the trench and from side drainage into settling basins before allowing it to enter a water body. Ensure that appropriate ECAs (i.e. Permit to Take Water (PTTW) from the MOE required if water taking requires greater than 50,000L/day) are obtained prior to dewatering activities.

- When pumping to dewater trenches, ensure that the pumping rate does not cause trench walls to collapse. Monitor local structures for integrity when pumping to avoid damage due to settling.

- Provide trenches with adequate cross-drainage and prevent erosion where surface or subsurface flows exist.

- Use other guidelines from the pipeline industry as best management practices in construction of extensive trench systems.

- Protect stockpiled excavation materials from disturbance, runoff and erosion.

- Should the need to import backfill arise, prior to the placement of any imported fill, the Project will request laboratory analysis of the material from an accredited laboratory demonstrating that the quality of the backfill is suitable for its intended use.

- Use excess inert fill as backfill during landscaping if suitable. Stockpile this material for later use or level and trim to surrounding contours so as to reduce the amount of material that must be disposed of off-site. Replace stockpiled trench soil layers sequentially without mixing or compaction, to facilitate revegetation.

- Keep work areas dry by directing surface runoff away from trenches using ditches and berms. Ensure material intended for backfill is not susceptible to excessive seepage and hence washout.

- Design and use a ditch maintenance program.

- Provide ditch protection in newly constructed ditches, especially those which receive significant sediment inputs and carry high-velocity flows (using riprap, straw bales, rock check-dams, filter cloth, etc.).

- To establish the stability of backfill slopes, place riprap or coarse non-erodible gravel on the slope, limit the slope grade, and revegetate the area.
B.1.7 Excavating on Land

- Plan the phases of development so that only areas which are actively being developed are exposed at any one time.

- Ensure excavation is performed during seasons when the ground surface can best support equipment with a minimum of damage.

- Post signs and place physical barriers and fences or patrol significant excavations to protect workers, wildlife and the public.

- Avoid excavations in wetlands where possible, and especially in provincially significant wetlands. Carry out excavations under frozen conditions or low water conditions, use tracked equipment, corduroy ground support, clean granular fill for access roads and working platforms, equalizing culverts and retention of vegetation where possible.

- Do not remove aggregate from streams.

- Do not place fill near public water supply intakes.

- Leave areas of unstable clays undisturbed.

- Perform foundation excavation in the dry where possible.

- Plan and schedule the sequencing of the excavating and disposal work and determine disposal area requirements and heights of fills within the designated inert materials disposal areas.

- Follow OPG procedures for the management of surplus and contaminated excavated soil.

- OPG normally determines whether a given soil volume or other material is considered contaminated or uncontaminated and Contractors shall proceed accordingly. Carefully and neatly stockpile excavated uncontaminated soil for potential reuse. Start a separate pile for uncontaminated but water-saturated soil in order to allow the material to drain prior to potential reuse. At the request of OPG, make another separate pile for material deemed "potentially contaminated" and place the material on a continuous plastic tarp of 6 mil minimum thickness.

- Report cultural artifacts found during the work to the Project Manager, protect them from damage, and refrain from further excavation until cleared to do so by the Project Manager.

- Balance the requirements for disposal of excavated materials with work area needs for excavation and with the requirements for facility construction and restoration.
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Ensure bulldozers are equipped with full U-blades when excavating slopes. These blades minimize the quantity of material that can escape to the side of the cut and slide downhill.

- Install permanent or temporary sediment traps, basins, or ponds before construction begins.

- Avoid steep slopes on stockpiles in order to prevent erosion.

- Terrace extensive excavated slopes and corrugate smaller slopes (e.g. using bulldozer treads facing horizontally) to prevent erosion and to encourage revegetation.

- Reduce the amount of erosion by rounding the tops of excavated slopes.

- Reserve topsoil and organic soils from excavated areas of uplands and wetlands for subsequent application to areas requiring revegetation.

- Where feasible, use excavated granular soils on-site. Use granular material for surfacing laydown areas or making berms. Use rock in cofferdams, defining parking or other use areas, shoreline stabilization, or for landscaping or habitat enhancement so as to reduce waste disposal requirements.

B.1.8 Aggregate Extraction and Use and Pit Rehabilitation

- Market merchantable timber during pit establishment or use during construction.

- Apply dust control in pits and on access roads as needed.

B.2.0 REPAIRS, INSTALLATION AND REHABILITATION

B.2.1 Demolition and Dismantling

This activity is generally governed by technical specifications (e.g. within tender documents). Demolition and dismantling involves the removal of temporary or long-term man-made structures or components made of materials such as structural steel, timber, rock, concrete, wood frame and composite materials. On larger scale projects, entire buildings may be removed. Heavy equipment may on occasion be used (wrecking balls, cranes, bulldozers, and other compressive and hydraulic equipment). On smaller scale projects, jack-hammers, torch cutting, sawing, and non-destructive disassembly may be used.

Environmental aspects of demolition and dismantling are discharges to water (sediments, chemical and equipment spills, asbestos, and land contaminants), air emissions (noise, dust, and fire), waste and hazardous waste (construction debris, asbestos, lead painted wastes, regulated wastes). Impacts include water quality impairment (contaminant mobilization), soil contamination, resource use interaction (lowered cultural value of area due to removal of structures or damage to cultural amenities, agricultural damage, etc.).
Practices

B.2.1.1 General Measures

- Plan to minimize the requirement to demolish structures by supplying facilities made of readily removable materials (trailers and other mobile items, collapsible sheds, modular items, transportable waste bins, etc.).

- Prior to moderate or large scale demolition, carry out a planning exercise aimed at defining the scope of the job, including an engineering survey, and assessments of manpower requirements, special environmental issues (asbestos, lead, contaminated soils, flammable materials, or other hazardous materials, sampling and analysis of unknown materials, etc.), scheduling, supply of waste bins, sequencing of activities, waste disposal options, etc.

- The pre-demolition engineering survey is to evaluate the condition of framing, floors and walls so that measures can be taken if needed, to prevent premature collapse of the structure. The Project Manager may require a documented survey, inclusive of photographs.

- When demolishing special structures such as chimneys, stacks, or pre-stressed concrete structures, ensure that inspection and planning are carried out by an experienced person, consult engineering drawings, examine the condition of the structures, allow for management of falling debris and scaffolding and resort to technical procedures (MOL, etc.) specific to demolition of these materials.

- When carrying out demolition with use of explosives, conduct a blasting survey with documented report made by a qualified person to evaluate adjacent improvements and underground features. Carry out preparatory work such as removal of structural elements, and fire precautions prior to blasting.

- Remove, reuse or recycle all temporary structures when no longer required, including: work and fabrication shops, housing, paint booths, concrete batch plants, storage sheds, trailers, etc.

- Remove, reuse, recycle or otherwise dispose of wooden construction materials such as planking; formwork; plywood; decking; poles, etc.

- Remove, reuse, recycle, store or otherwise dispose of metal construction materials such as signs; formwork; gates; fencing; piping, culverts, etc.

- Remove, reuse, recycle, store or otherwise dispose of construction materials such as erosion and sediment control materials (geotextiles, straw bales, etc.); plastic wrappings; paper bags; cardboard; walls; roofing; flooring; cladding; brick; bridges, etc.
• Clean, remove or reuse wastes and hazardous materials or containers used for storage, including: gasoline and oil tanks and containers, privies, lighting fixtures, etc.

• Break up and attempt to reuse or recycle material from concrete footings or slabs on-site. If this is not possible, remove it off-site or if clean, bury or constructively use it on-site as inert fill.

• Restore the site (including the water body and flood plain) to pre-construction conditions as much as possible, by using GEPs associated with grading, applying surface amendments, soil stabilization and restoration/rehabilitation.

• Ensure that waste debris cannot enter any water body, either directly or indirectly (i.e., from runoff). Use appropriate sediment control measures to contain fine materials generated during demolition.

B.2.2 Chipping and Cutting Concrete

This activity is generally governed by technical specifications (e.g. within tender documents). Chipping of concrete results in rubble of various dimensions, from dust through large slab sizes. In addition to slabs and chips, concrete cutting also may result in slurries of concrete pastes.

Uncontaminated concrete chips and slabs are considered as inert fill and usually disposed of off-site. Uncontaminated slurries and liquid concrete are not considered inert fill until or unless solidified. OPG accepts no liability for a Contractor’s off-site disposal at locations which are not approved by MOE.

Environmental aspects of chipping and cutting concrete are discharges to water (equipment spills, liquid concrete, and solid concrete), air emissions (dust, noise), and waste (concrete and slurries). Impacts include water quality impairment (high pH, suspended solids from liquid concrete, chemicals and fuels from equipment), damage or mortality of biota (e.g. from turbidity effects on sediment dwelling organisms, fish).

Practices

B.2.2.1 General Measures

• Follow established Waste Management Plan for management of waste concrete materials.

• Carry out concrete chipping in a way that facilitates rubble collection.

• Cut exposed embedded rebar or other metals and cables from concrete and recycle or dispose of separately before concrete disposal.

• Prevent concrete rubble, fines and slurries from entering water bodies.

• Minimize excessive dust creation using appropriate methods (e.g. water spray).
Guideline

- Collect and remove concrete slurries and fines from work areas. Either directly contain and dispose of these materials or direct them to a settling or filtration basin followed by collection and disposal.

- Dispose of uncontaminated waste concrete chips as inert fill either on-site (on OPG owned lands with Project Manager approval and conditions), on public or leased public lands with MNR approval), or off-site at an approved MOE landfill (at OPG request or to meet MNR requirements).

- Use concrete and waste aggregate in the construction of roads and parking lots when these project components will be required for longer periods of time or for heavier traffic. Do not mix sand or gravel from chemical storage or fuelling areas with clean sources of waste aggregate.

- Store concrete rubble on-site if there is a need for the material to be used as fill, provided that adjacent water bodies, including groundwater supplies, will not become impaired from mobilization of associated fines.

- Drum oil-soaked or otherwise contaminated concrete chips and slurries, test for leachate characteristics and dispose of according to OPG construction guidelines for waste management.

- Grade and if necessary compact on-site inert fill areas to a flattened profile, cover with soil and revegetate.

B.2.3 Concrete, Rebar, Dowel, Steel and Wood Work

This activity is generally governed by technical specifications (e.g. within tender documents). Concrete may be processed on site making use of a portable cement mixer, mixing (batch) plant and aggregate storage facilities, or may be brought into the site ready-mixed in cement trucks. Chemical additives or chemical truck washout products may be used and may require special disposal. Rebar and most related reinforcements are assembled prior to concrete pouring. Wood and metal formwork is assembled in conjunction with concrete pours. Additional woodwork for temporary supports, signage, and numerous other applications makes use of a wide variety of dimensional lumber, plywood, composites, and chemically treated lumber and undressed materials. Doweling and steel work may involve placement of siding, roofing, piping, pier nosings, gratings, concrete capping, rock anchors, rivets, bolts or other fasteners, railings, tracks, etc.

Environmental aspects of concrete, rebar, metal and wood work are discharges to water (equipment fuel and lubricant spills, liquid concrete spills, treated lumber contaminants), air emissions (dust, noise), and waste. Impacts are water quality impairment (pH, suspended solids from washwater, liquid concrete, and leachate from treated lumber) and damage or mortality of biota (e.g. contamination or physical damage to sediment dwelling organisms, fish).
Practices

B.2.3.1 General Measures

- Prior to construction, the Contractor shall provide a design for the on-site liquid concrete disposal basin facilities and a procedure for decommissioning.

- Dispose of spilled or excess waste uncured concrete or concrete cutting slurries along with concrete truck and mixer washout and unused cementitious grout according to OPG construction guidelines for waste management.

- Prevent water and chemically treated water used to clean concrete trucks and mixers from entering any surface waters. Do not allow cement, lime or any other substance which will substantially affect water quality to enter water bodies.

- Investigate recycling and reuse markets for waste products including concrete before disposal.

- If subsoils are excavated in agricultural areas to install concrete foundations (including augured foundations), remove this infertile material off-site.

- Store cement indoors, or if outside, cover with plastic sheeting and place on raised platforms to keep it dry and prevent contaminated runoff.

- Conserve cement and concrete constituents by incorporating the following, where feasible:
  - Maximize the use of fly ash components in concrete, thus displacing use of portland cement, which is produced at the expense of high CO₂ emissions (compensation for slow setting time of such mixes can be made by using super plasticizers or other means).
  - Use coarse aggregate for making concrete (sourced from construction and demolition waste) so as to minimize use of virgin aggregate
  - Use super plasticizers and textile composites on the interior and an impermeable membrane on the exterior of fresh concrete applications to minimize use of curing water
  - Use slow hardening cements to increase durability of concrete, and to reduce shrinking and cracking potential, thus reducing the long-term need to replace concrete structures on rehabilitation projects (and reducing cumulative environmental impacts)
  - Avoid the use of treated lumber, especially when the wood will be in permanent contact with water or in high use areas where leached contaminants may affect human populations.
• Inorganic arsenical pressure-treated wood (including CCA = chromated copper arsenate; "Wolmanized"), ACA and ACZA) is pressure-treated with a pesticide to protect it from insect attack and decay and should be used only where such protection is important. To minimize the release (and effects) of contaminants into the environment, use the following precautions in its use:

• Clean up sawdust and cutoffs and dispose of after construction (non-hazardous solid industrial waste) as described in OPG construction guidelines;

• Do not burn treated wood;

• Do not use where the preservative may become a component of food, animal feed or drinking water (e.g. mulch, cutting boards, food containers, beehives);

• Avoid prolonged inhalation of sawdust during sawing, sanding, etc., and perform these activities in well ventilated conditions (and wear a dust mask); and

• Wear gloves when working with the wood and after working, wash exposed areas and clothing (work clothing may have to be laundered separately from other clothes).

• Use the following GEPs for reducing environmental risks from treated CCA wood now in use:

• Coat CCA wood with paints, stains or sealants (e.g. polyurethane or polyurea) formulated for such use, and recoat as required.

• Keep children and pets out of areas made of this product.

• Line interior of raised beds (decorative planters and flower gardens) constructed using CCA wood with plastic.

• Consider the use of alternative pressure-treated wood products such as "Natural Select" (copper azole) or "NatureWood" and "ACQPreserve" (both with copper and quarternary organic biocide) or which have somewhat lower chemical hazard. However, the same use precautions cited for arsenic based product also apply to these.
B.2.4 Grouting

This activity is generally governed by technical specifications (e.g. within tender documents). Grouting is carried out to fill cracks and voids in concrete, to fill voids partly occupied by materials of several different types (e.g. metals, concrete, rock, etc., such as metal pier nosings and concrete piers), to seal water flows through structures, to seal a dam to its foundations, stabilize rock anchors, and to provide new exterior surfaces to structures. The aim in grouting is to confine the installed material in enclosed voids, while minimizing the quantities which escape into the water column or elsewhere. In many applications, successful grouting depends on injection of amounts over and above those which are retained in the target structure; excess material escapes via "venting," usually to the water column. Various types of grouting include blanket, curtain, consolidation and contact grouting.

Cementitious grouts (i.e. made of similar constituents as cement) find most application in sealing of cracks and resurfacing concrete structures. Chemical grouts, primarily made of polyurethane or epoxy (2-part mixes), are often used in smaller quantities for more specialized purposes. Equipment used in grouting includes a water meter, pressure gauges, high speed grout mixer, holding tanks with agitators, pump, flow meters, circulation lines and standpipe fittings.

Extensive use of chemical grouts in areas adjacent to water bodies may require toxicity testing and regulatory approval. Specific spill prevention, preparedness and response measures would be addressed in the SCPC. In addition to discharges at the point of grout delivery, spills can also occur at grout pump locations. A spill in this context is considered to be the release of cementitious grout, individual grout components (e.g. A or B components of a mixable epoxy grout product), or uncured mixed chemical grouts, into the natural environment.

Environmental aspects are discharges to water (equipment spills, liquid or powdered grout spills), air emissions (dust), and waste (including hazardous wastes from chemical grout components). Impacts vary by chemical makeup, applicability and ecotoxicity and include water quality impairment (pH, suspended solids) and damage or mortality of biota (e.g. sediment dwelling organisms, spawning bed damage, fish toxicity).

Practices

B.2.4.1 General Measures

- Before doing extensive cementitious grouting, and in situations where chemical grouting is to take place, prepare an environmental hazard analysis for intended grouting operations (including types of grout and equipment) and submit to the Project Manager for review. Do not commence grouting until the Project Manager has reviewed and validated the analysis.

- Use only OPG approved grouts and follow OPG procedures for their use.

- For hazardous materials approval, provide the Project Manager with a list of grouts planned for use along with copies of MSDSs.
• Comply with grout storage and handling requirements, including OPG and WHMIS specifications.

• Dispose of unused or waste chemical grouts, and grout components as liquid industrial and hazardous waste.

• Follow waste management procedures for waste cementitious grout, chemical grout and components, and respective containers as identified in OPG’s construction guidelines for waste management.

• Ensure that procedures are in place to monitor and control the grout delivery system and consider grout collection systems in situations where grout is emerging from cracks into the water body (i.e. venting) during uncontrolled (spill) situations.

• Consider the following GEPs for control, containment and treatment of vented grouts but note that some of these may require regulatory approval (contact an Environmental Advisor for advice):
  • Seal vent/ discharge point
  • Pump grout from venting location to a treatment facility
  • Use filter fabric in pond arrangement to filter grout and allow carrier water discharge
  • Dilute grout at discharge point and pump to discharge
  • Use a settling box or pond to allow settlement of cement materials before discharge
  • Use a grout screen (porous fabric similar to filter fabric but without pond arrangement)
  • Adjust grout pump flow rate and pressure to control vented volume
  • Introduce sand into grout mix to minimize grout use and venting volume
  • Stop grouting to allow grout to partially set, thus minimizing volumes of vented grout
  • Use additional downstream drill holes to collected smaller volumes of vented grout
  • Use a cofferdam upstream and/or downstream, dewater area and collect vented grout in dry
  • Dewater headpond and collect vented grout in dry
B.2.5 Coating Applications

This activity is generally governed by technical specifications (e.g. within tender documents). This activity includes the application and removal of coatings of the following types:

- Roofing membranes combined with tars, gravels or shingles (sometimes including asbestos, lead or other components in associated grouts and sealants)
- Concrete coatings such as polyurethanes, epoxies and polyureas
- Highway marker paints (thermoplastics with lead chromate)
- Paints (including lead-based, zinc chromate, oil-based, water-based, epoxy, etc.)
- Siding including stucco, aluminum, steel, etc.
- Asphalt (for roads, etc.).

Coal tar epoxy touch-ups are frequently done in the field although the main applications are done in the fabrication shop (generally off-site). There may be some hazardous materials issues in addition to health and safety concern regarding field activities of this nature.

Numerous coating applications must be preceded by abrasive blasting or steamcleaning, powerwashing, vacuuming, or washing with trisodium phosphate (TSP), hydrochloric acid or phosphoric acid, to remove grease, dirt, old coatings, and to allow surficial repairs, priming or surface roughening to achieve a “profile” (rough surface condition) to get best adherence of coatings. Other methods of coating removal covered in this section include:

- Removal by welding, burning and torch cutting
- Heat-gun removal
- Chemical stripping
- Encapsulation
- Power-tool cleaning
- Manual scraping and sanding
- Removal of lead-painted plaster walls or other building components
Removal of lead paint by welding, burning or torch cutting results in volatilization of lead. The activity is not recommended for use on any but the smallest surface areas and/or areas which are difficult to access by other means, or in situations where effective ventilation and filtration can be applied. Special environmental approvals may be needed.

Heat-guns direct hot air at localized areas where lead based paint is partially volatilized and the coating separates and is scraped off.

Chemical stripping makes use of manual or spray gun application of solvent or caustic strippers, followed by a time lag to allow penetration (from 5 minutes to 48 hours), followed by mechanical scraping, vacuuming or pressurized water removal, and followed then by wet-vacuuming, with or without vibrating brushes to clean the surface. Some chemical strippers are toxic (e.g. methylene chloride). Disadvantages are that containment and waste collection may be difficult, productivity may be lower than for conventional abrasive blasting since only paint is removed and not rust, and a “profile” is not provided to facilitate further coating.

Encapsulation involves covering or sealing of lead-painted surfaces using sheet-rock walls, fibreglass or recoating with non-lead based paint. It provides long term protection and low maintenance.

Power-tool cleaning involves use of impact, grinding or brushing tools including needle guns, disc Sanders, grinders, power wire brushes, rotary hammers, rotary peelers and scarifiers, each of which may be operated with or without exhaust ventilation and vacuuming or shrouded attachments.

Environmental aspects of coating applications are discharges to water (equipment spills, liquid coating (chemical product) spills, spills of removed coating materials), air emissions (dust, noise, off-gassing of coating constituents such as volatile organic compounds (VOCs), lead from paint removal), waste and hazardous waste (residual coatings not used, lead paint debris). Impacts include water quality impairment (lead from paint removal, chemical product contamination and damage or mortality of biota (e.g. lead or chemical contamination effects).

Practices

B.2.5.1 Applying Coatings

- When applying coatings, use recommended procedures and note precautions consistent with the OPG product approvals process, MSDS recommendations, technical specifications and waste management procedures.

- Unless otherwise directed by MOE staff, dispose of waste asphalt coating materials in an approved landfill site as non-hazardous industrial waste.

- Consider retroactive coating of existing treated wood structures with environmentally appropriate sealers (e.g. encapsulation using polyureas, etc.) to slow the leaching of contaminants into water bodies or groundwater.
Do not coat surfaces with hydrophobic coatings (e.g. polyurethanes or epoxies) until assured that they have fully dried or cured (e.g. for some concretes curing may take up to 28 days at 21°C). Use polyureas to advantage under some humid or wet conditions.

When possible, use non-lead based primers and paints in lieu of red lead primers and paints. Replace lead chromate with zinc.

If required to apply lead-based paint, do so by brush or roller rather than by spray methods.

Use local exhaust ventilation with proper filtration when spraying lead-based paint.

### B.2.6 Welding

This activity is generally governed by technical specifications (e.g. within tender documents). Welding also includes torch metal cutting, and a variety of specialized techniques, equipment (gas based and electric arc), gas mixtures, and welding rods, ribbons, etc., of various composition. Some techniques involve underwater use. Waste materials are generated in varying quantities and types, including spent welding rods, fluxes, etc.

Associated activities are soldering and brazing, usually in plumbing applications. These may involve the use of tin/lead filler metal which can volatilize and otherwise discharge to the environment.

Other activities involving the use of molten metals, although not associated with welding, are also discussed here. They involve melting of lead or tin for electrical cable splicing, cast iron soil pipe installation, and babbitting for various applications such as Electrical cable splicing may involve use of lead pots to melt lead, with volatilization or spillage of lead to the environment. Repair and maintenance operations can also result in environmental exposures when pipe or cable joints are heated to melt lead caulking and then pulled apart.

Environmental aspects of welding are discharge to water (oil from air compressor supplying air to underwater welders), air emissions (from fuel powered compressors and welding equipment: dust, noise, welding gases, fluxes, burning or cutting of coated metals, and metals including lead), waste (welding rods and pressurized containers). Impacts include air quality impairment, water contamination and waste discharge (welding rods).

### Practices

#### B.2.6.1 General Measures

Ensure that Emission Summary and Dispersion Modelling (ESDM) associated with the ECA (Air), for indoor ventilation systems such as trunk exhausts used for discharge of welding emissions, is updated to include sources.
Ensure that portable welding fume extractors have the following characteristics:

- minimum exhaust volume flow rate of 1000 cfm (cubic feet per minute)
- integral filters are capable of removing 99.97% of 0.3 micron dioctyl phthalate droplets for use in highly toxic welding fume environments
- have a pressure differential gauge to measure pressure drop across the filters
- sound levels do not exceed 80 dBA within 1 m of the unit

Do not use compressed air to clean out welding extractor filters.

For environmental reporting purposes, ensure that welding activities are tracked (i.e. type and amount of welding rods consumed) so that emissions can be reported to the MOE/Environment Canada, if applicable.

Collect used welding rods and other welding wastes for recycling or disposal at an MOE- approved landfill.

During refuelling, ensure that gas or diesel-powered portable generators used to power outdoor welding equipment are provided with drip trays to collect oil leaks and contain fuel spillage.

Carry out those underwater welding activities which make use of compressed air delivered to electrodes or torches such that compressor lubricating oil is prevented from entering the airstream and being discharged to water. If an oil sheen is observed on the water, report the discharge as a spill.

Ensure that regulatory approvals (both environmental and industrial health and safety approvals) are obtained for the burning off of lead-based paint and primers from metal surfaces using welding equipment. Consider alternatives of solvent stripping and physical removal.

Use portable local exhaust ventilation to remove metal fumes and gases associated with brazing and soldering.

When doing cable splicing using lead, use the following controls:

- A portable local exhaust ventilation system mounted on or near the lead pot
- A thermostatic control device on the lead pot to prevent overheating and reduce lead fumes
- Rubber or plastic connectors instead of lead
When babbitting/re-cabling using tin or lead babbitt material, melt the babbitt material in a thermostatically controlled pot to keep the temperature below that at which it fumes. Alternatively use thermoplastic/epoxy mixtures to avoid use of lead based material.

B.2.7 Vegetation, Fish, Wildlife and Habitat Protection and Control

These activities vary considerably depending on the intent of the activity (protection, control or enhancement). Many activities for fish and wildlife centre on habitat (which frequently involves vegetation management but also management of abiotic habitat features).

The environmental aspects related to protection are mainly considered beneficial unless the measures are not implemented correctly or fail, while those related to control are associated with discharge to water (equipment spills, pesticide spills), air emissions (pesticides), or waste, (granular material, vegetation, pesticide containers). Impacts include, damage or mortality of biota (e.g. pesticide effects on sediment dwelling organisms, fish, soil organisms, vegetation and physical damage effects on buffer zone, vegetation, from burning, clearing, etc.).

Practices

B.2.7.2 Biota Protection

1. Protection of Vegetation and Habitats

- Identify areas containing rare, endangered, threatened or otherwise sensitive species or habitats, making use of OPG environmental databases and reports, government (MNR and Canadian Wildlife Service) information sources, or other mapping and GIS sources.

- Define work area perimeters with ground markings, flagging or fencing to protect sensitive species, individual trees or clumps, or habitats.

- Where required by site conditions (e.g. on slopes) or to enhance biodiversity, use special seed mixtures and/or ground stabilizing methods such as mulches, hydro seeding, netting, sod placement, erosion control blankets and other treatments to control erosion and promote growth.

- Avoid the establishment of barriers to fish and wildlife movement such as temporary stream crossing devices, windrows or trenches (especially if in place for lengthy periods of time), or linear corridors through forested areas.

- Maintain access for wildlife travel on the east-west wildlife corridor of the DN site through protection and enhancement of the existing natural areas along the designated corridor.

- Enhance wildlife crossings along the east-west corridor of the DN site, where feasible and to the extent practicable (OPG 2011)
• Specify methods for minimizing disturbance, especially in protected areas or during sensitive time periods (e.g. by defining access routes, limiting turnaround zones, imposing noise controls during breeding periods, making stockpiling restrictions, etc.).

• Include options for collecting and reusing excavated substrate and plant materials (i.e., trees removed by tree spade; soil banks from wetlands, etc.) to benefit biodiversity and to ensure recovery of modified habitats following construction.

• Use signage and on-site communications and ensure that equipment operators confine activities within limits defined by boundary fencing to protect vegetation, wetlands, watercourses, and wildlife habitats beyond the construction zone.

• Do not damage trees or other vegetation outside of defined work areas. If trees are accidentally damaged, trim broken branches flush with the trunk.

• Avoid vegetation damage by limiting trenching near large or heritage trees (which cause root loss and structural instability), and when using heavy machinery near trees (which causes soil compaction).

• Where appropriate, establish and maintain quantitative reserve, buffer or protection zones around key habitat features (e.g. a 200 m work restriction area around osprey or bald eagle nests and a 120 m reserve around wildlife aquatic feeding areas, mineral licks and calving sites).

• In riparian areas where there are overhead wires and towers, place towers in locations where they are visible to migrant passerines or place bird flight diverters or reflective objects on lines to make them visible to birds which typically fly in low trajectories in such habitats.

• Do not smother tree roots by adding layers of soil onto the existing soil profile.

• Avoid clearing methods which result in excessive fragmentation of habitat.

• Protect shoreline areas, retaining features such as in situ rocks, stone, rooted vegetation (emergents and submergents), overhanging vegetation, shrubs, fallen limbs and tree trunks.

• Retain the natural habitat features on slopes in the riparian zone (leaf litter, twigs, shrubs, grasses and other low foliage) to act as filters to nutrient flows and physical buffers to gravitational effects of falling/rolling materials (logs, rocks) and of rainfall runoff.

• Conduct work site inspections to ensure integrity of protected areas.
2. Wildlife Management and Habitat Enhancement

- During groundwork, specify wildlife and habitat protection methods to avoid nesting, denning and migration periods.

- Instruct construction workers to report all sightings of significant wildlife features such as eagle nests, owl nests, colonial nesters, wolf packs, moose, caribou, bear, etc., to the Project Manager or site administrator.

- Where required by site conditions (e.g. on slopes) or to enhance biodiversity, the Contractor shall use special seed mixtures and/or ground stabilizing methods such as mulches, hydro seeding, netting, sod placement, erosion control blankets and other treatments to control erosion and promote growth.

- Establish or enhance buffer zones around temporary work sites, areas which will remain under developmental pressure, along shorelines of lakes, ponds and watercourses and at the edges of wetlands.

- Consider options for direct interventions to enhance wildlife (terrestrial or semi-aquatic) biota, such as:
  - Intensive beaver trapping before impoundment
  - Relocation of beaver before impoundment
  - Relocation of raptor nests located in awkward areas
  - Repair windbreaks or similar features damaged by construction or re-establish in another compatible area.

- Consider the following enhancements to existing wildlife habitat:
  - Add to existing habitat areas to increase habitat value and size
  - Diversify habitats to benefit a wider variety of wildlife
  - Add vegetation to habitat edges (ecotones)
  - Maintain access for wildlife travel on the east-west wildlife corridor of the DN site through protection and enhancement of the existing natural areas along the designated corridor
  - Enhance wildlife crossings along the east-west corridor of the DN site, where feasible and to the extent practicable (OPG 2011)
  - Construct treed fencerows, windbreaks, shelterbelts and buffer strips to connect existing "islands" of habitat and establish wildlife corridors (e.g. use raspberry as a living fence to restrict disturbance and provide food and shelter)
Retain or supply new sources of snags (dead trees, best with cavities); create new habitat by girdling poor quality trees if needed), and retain downed logs (of a range of sizes and distribution) and brush for ground cover

Retain or supply mast trees and shrubs (providing nuts and acorns), and catkin trees and shrubs (e.g. birch, alder, poplar) for wildlife food

Undertake restoration techniques, where required:

- Design for self-sustainability (minimize need for continuous maintenance such as water supply, vegetation management, repairs)
- Use passive restoration when appropriate (natural regeneration)
- Restore native species (avoid non-native, or invasive species)
- Use natural fixes and bioengineering techniques (for erosion control and stabilization, flood mitigation, and water treatment)
- Monitor and adapt where necessary (use "adaptive management" techniques to guide changes in managing an area based on lessons learned)

Wetland habitat enhancement:

- Establish new wetlands, or managing existing ones by providing buffers or diversifying them
- Provide buffers or diversity them by adding additional plant species
- Leave dead standing trees and downed logs in swamps (e.g. turtle basking sites)
- Install beaver bafflers through beaver dams to maintain flows and control flooding
- Install water control structures (berms, spillways or engineered structures) to control water levels and flooding, and thus manage wetland vegetation to benefit waterfowl, wintering muskrat and fish and amphibians, marsh birds, fish, etc.
- Improve habitat diversity by cutting openings (ditches, ponds or channels) in dense cattail stands or other homogeneous habitats in late summer
- Control nuisance species such as purple loosestrife or carp
- Do over-ice mowing in winter to help manage cattail and purple loosestrife
- Plant marsh vegetation
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Provide artificial muskrat domiciles (e.g. from pieces of steel culvert)
- Create vegetated hummocks for spawning pike
- Import native plant sources (propagules) from other wetlands

- Add non-biological habitat features in the following ways:
  - Choose natural materials rather than man-made ones
  - Provide piles of stones or brush to enhance habitat for mustelids, fox, rabbits, songbirds, snakes (e.g. hibernacula) and game birds
  - Create rock and brush piles using largest materials at the base and in the centre to ensure openings are maintained when piled together
  - Create stone and brush piles near other areas used by wildlife
  - Locate stones on north shore of a pond or watercourse to maximize exposure to sunlight and allow them to warm up and provide wildlife basking sites
  - Add nesting structures for bats, wood ducks, mallards, swallows, etc., in optimal locations near sources of food and water and away from disturbances; use wood that resists weathering (e.g. cedar), protect them from the sun if possible, protect them from predators, provide nest box ventilation, match sizes of holes and structure to target species, and seasonally change nest box materials

- In introducing plant species which offer wildlife food and shelter, consider the following:
  - Use native species where possible
  - Choose low-maintenance plants (e.g. ground covers rather than lawns)
  - Use cuttings from woody plants (dogwood, willow, poplar)
  - Collect seeds and roots and plant them
  - Match plants to site conditions
  - Avoid planting in hot, dry or cold conditions (early spring and mid fall are best for most plants)
  - Use plants in combinations which provide vertical layers for maximum cover and diversity
3. **Aquatic Biota and Habitat Management**

Consider options for direct interventions to enhance aquatic biota, such as:

- Intensive and selective fishing or netting to manage fish populations, selecting for or against target species
- Capture and relocation of fish
- Stocking of fish
- Enhance aquatic habitat by making efforts (upon the advice and approval of regulatory agencies) by reducing turbidity, water temperature, pesticide input and nutrient loading, and by improving substrate quality, increasing habitat diversity and maintaining flows and water levels as close to the natural hydrograph as possible.

Use the following GEPs for improving in-water habitat:

- Collect or flush excess sediments from channels or near-shore areas by using sediment traps or by increasing current velocities through the narrowing of channels
- Remove excess woody debris which restricts flows, creates barriers to fish movement, etc.
- Create edge by cutting channels through submerged aquatic plants or cattails and depositing material on land
- Install bottom-draw outlets in ponds and plant trees/shrubs around the pond (to keep downstream water temperatures cooler in summer and benefit certain species)
- Place boulders or baffles in water bodies to improve fish habitat and increase habitat diversity and edge
- Build riffles and pools (in part using shoreline deflectors) to improve oxygen levels, productivity and spawning success
- Install fish-ways
- Install lunker structures (submerged structures to provide fish with overhead cover and protection from currents and waves), using natural materials, often in association with bank stabilization and erosion protection works
- Create/improve spawning sites by adding gravel/cobble in shallow water areas
• Install tree and brush shelters to provide cover, feeding and spawning habitat (floating structures, downed trees or stumps or root wads; using existing or new materials winched to shore and anchored)

• Create water level control structures, making allowance for fish passage

In creating in-stream habitat enhancement features from logs, do not source logs from within the riparian or buffer zone, so as to maintain the integrity of these areas.

During channel dewatering activities, use fish rescue techniques such as wading through shallow waters and pools in largely dewatered zones, and/or live netting using boats for net deployment.

Use fish protection techniques to reduce fish entrainment at intake structures or dewatering pumps, including shrouded pump intakes, or systems which create countercurrents or make use of behavioural deterrence and attraction techniques, if shown to be effective for the target species (acoustic, electric, lighting).

B.2.7.3 Pest Control

1. Control of Nuisance Species

• Verify the nature of the nuisance by observing the species, its tracks or signs, or by consulting wildlife specialists.

• Evaluate the extent and cost of damage, the possible costs for problem solving, the potential for the problem to get worse, and any spinoff effects of using control measures, prior to instigating controls.

• Report nuisance wildlife to the Project Manager; use control measures only with Project Manager approval.

• Provide waste collection facilities suitable to prevent access by bears, raccoons, skunks or other wildlife and store food waste securely in closed containers pending disposal.

• Encourage construction staff not to harass or feed wildlife.

• Trim tree limbs away from buildings so animals cannot use them for access.

• Use scare techniques such as using scare-eye balloons or raptor or owl silhouettes to control congregations of gulls, pigeons, etc.

• If raptor nests must be removed to protect electrical infrastructure, time the work for the fall or winter when the nests are inactive and obtain appropriate approvals.

• Modify habitat to discourage nuisance species:
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Discourage Canada Goose by maintaining buffer strips around ponds or wetlands with tall grasses and dense shrubs rather than lawns
- Remove trees or branches used by rodents or raccoons to access buildings
- Remove cover and control weeds and brush around buildings
- Cap wooden utility posts with sheet metal cones to eliminate perching by raptors
- Provide raptor perches and/or nesting boxes in safe areas
- To deal with animals inhabiting or invading buildings (e.g. pigeons, raccoons, rodents, woodchucks, squirrels, bats, etc.), consider the following:
  - Install bright lights, generate noise, use cotton balls soaked in ammonia, or set live traps
  - If an animal has nested or is raising a litter, wait until the young are mobile and able to leave the building
  - After removing nuisance animals from a building, seal entrances; confirm that they have left by monitoring for noise, nesting areas, droppings, claw marks, etc.
  - Repair holes and cracks in buildings, screen vents, cap chimneys and replace loose shingles and rotted wood; seal openings with concrete, galvanized sheet metal or heavy-gauge hardware cloth.
- Make use of techniques such as:
  - Use tree guards to protect young trees from being girdled by rodents
  - Install fences of mesh size appropriate to the nuisance animals (ensuring that they are anchored well into the ground to prevent burrowing under)
  - Deploy netting to protect fruit trees or other areas from birds
  - Place wire on ledges to discourage birds from roosting
  - Use taste, odour and tactile repellents on tree trunks or elsewhere
  - Illuminate areas with bright lights or strobe lights
  - Play music or use fireworks, noisemakers or tape-recorded bird distress calls
- Use techniques such as live trapping, lethal trapping, shooting and poisoning only after consulting MNR and Canadian Wildlife Service (for migratory bird control):
Consider hiring a licensed trapper for certain removals (e.g. beaver), since only farmers and licensed trappers can legally use body-gripping traps.

Only use poisons for small rodents such as mice, rats or woodchucks, since it is illegal to poison other wildlife; ensure that the persons using the poison(s) have applicator training if required.

2. Use of Pesticides

Except for insecticides used for personal protection, do not use pesticides without authorization by the Project Manager.

The use of most biocides is regulated by MOE by requirements for an Operator's and other licences. Certain pesticides, set out in schedules to the legislation, may be used without licence but they must be used, transported, stored and disposed of appropriately. Use licensed personnel to conduct larger scale exterminations when using restricted pesticides.

Use of sodium hypochlorite for zebra mussel control is subject to regulatory controls associated with ECA (formally Certificate of Approval). Injection points should be as close as possible to water intakes to minimize the amount of chlorine required. The system may include on-line analysis and the capability for variable injection rate of chlorine or hypochlorite. This will allow for control of residual chlorine concentration in the water. Allow for adequate mixing via the injection system to enhance the efficacy of the biocide.

Use, transport and store chlorine and related products and other chemicals according to MOE and MOT guidelines. Waste pesticides and their containers, generally classified as hazardous or severely toxic, require special waste management procedures under O. Reg. 347/12.

Time pesticide use to minimize impacts on non-target fish and wildlife or their habitats, by avoiding spraying during critical life stages of beneficial insects and other desired wildlife species.

Do not spray pesticides if rain or heavy winds are predicted.

Use bait stations for rodent control and spot rather than broadcast treatments where possible to minimize quantities of pesticide used and areal extent of potential contamination.

Use pesticides at recommended rates to prevent increased pesticide resistance in target pests.

Avoid non-target habitats such as wetlands, ponds, woodlands, fencerows or buffer strips.

B.2.7.4 Installing/ Maintaining Laydown and Parking Areas and Work Camps
A laydown area (or marshalling yard) is a general term for a location where various overlapping activities take place, such as staging, loading, assembly and storage. A staging or assembly area is used for temporary deposition or storage or assembly of materials and equipment or components. A loading area is a location where vehicles may load or unload materials and equipment. This may be in the same location as the staging area. Parking areas may be temporary or permanent. They may be associated with laydown areas or may be separate. Other areas for work trailers or work camps are also included.

Work camps are generally considered to be multi-purpose, relatively self-sufficient facilities located at or near the project site. Associated features, including roads, water supply, wastewater treatment, and waste disposal are treated elsewhere in this Manual.

Aspects and impacts may be very diverse, depending on the range of activities carried out in the laydown area and work camp. At minimum, the environmental aspects are discharges to water (equipment and storage materials spills, erosion, sedimentation, de-icers), air emissions (dust, noise), and waste (of all types, including granular material, vegetation, hazardous waste. Impacts include damage or mortality of biota (e.g. buffer zone disruption, soil biophysical condition, vegetation, etc.) and resource use interaction (work camp worker hunting, fishing activities, demands on local services etc.).

Practices

B.2.7.5 Laydown, Parking and Associated Areas

To the extent feasible, select sites with the following preferred characteristics:

- Near established roads and highways to facilitate deliveries
- At least 30 m from water bodies (unless otherwise constrained or approved by the Project Manager and/or regulatory authorities
- Relatively flat and discrete (i.e. rather than several separate sites)
- Of low value relative to other land uses
- Non-forested
- Easily policed
- Serviced (power, phone, sewer, water)
- Unconstrained by overhead wires or obstructions or aesthetics
- To ensure continued conformance with land use requirements, during the project maintain liaison with agencies having jurisdiction over access roads to site areas.
Set up laydown, parking and associated areas with clear boundaries, restricted to specified uses as indicated in the site delineation report, technical specifications, drawings or sketches.

Follow site parking restrictions as identified on-site by the OPG or Project Manager.

Minimize the overall size and consequently the amount of vegetation removal required for the construction of these areas. Retain view-scape buffers or screens between the site and highways, etc.

If new laydown or parking areas are required, use rock fill or compacted earth fill to level new areas and place and maintain a granular base to a minimum thickness of 15 cm as a working surface. Provide a 2% to 5% slope in these areas to ensure adequate drainage and maintain the areas to prevent rutting and ponding.

Ensure that adequate parking for personal vehicles is available or make arrangements for off-site parking and/or group transportation to site. Define and signpost parking restrictions.

Provide area fencing and remove it during demobilization as required in drawings or technical specifications.

Provide roadway loops or backing up areas to minimize the need to maneuver vehicles and potentially damage surrounding vegetation and soils.

Establish and maintain perimeter ditching and erosion control around laydown/parking areas and establish buffer zones between these areas and adjacent water bodies. Adjust the width of the buffer zone to account for slope gradients.

The stormwater management facilities associated with laydown/parking area have the potential to add contaminants to the groundwater system, such as chloride and sodium from road salt and petroleum hydrocarbons from paved areas. Conventional stormwater treatment methods such as stormwater management ponds and oil-grit separators may be required (and subject to ECA).

The use of road salt or other de-icers should be consistent with OPG’s salt management practices, except as approved by the Project Manager.

Periodically clean laydown and work areas of all construction materials and debris and restore such areas during demobilization.

For loading areas or launching barges at shorelines, use temporary facilities such as stone-filled cribs and concrete modules for removable docks to support heavy equipment and protect substrate. Remove these facilities as soon as possible when no longer required.
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- If appropriate, adapt parking and other areas to public parking following project completion. In this case, consult MOT, MNR or local road authorities to ensure that required standards are met.

- For closure of laydown areas, remove all structures, equipment and stored goods, garbage, fences, treated wood and poles and if required, sample for contamination. Stabilize soils and revegetate the site according to GEPs described OPG construction guidelines relating to erosion control.

### Practices

#### B.2.7.6 Fabrication Shops

- Use OPG construction guidelines relating to erosion and sediment control at these facilities (or an Erosion & Sediment Control Plan).

- Locate shops which generate emissions or discharges near planned treatment facilities and distant from environmentally sensitive areas.

- Locate fabrication shops such that they do not cause odour and noise problems in nearby living or sleeping areas.

- Remove all temporary facilities from the site on completion of the Work.

#### B.2.8 Abrasive Blasting (sand, steam, etc.)

Abrasive blasting and high energy water blasting are covered in this category. Abrasive blasting is primarily done for the purpose of removal of paint (often lead-based) from metal surfaces.

High energy abrasive blasting involves the removal of surface materials, exposing steel substrate, and conditioning of the substrate (creating a "profile") to improve the adherence of new coatings. This is followed soon afterward by compressed air cleaning and application of a primer (to prevent surface rust from quickly forming). Some forms of blasting are more effective for these purposes than others.

Environmental aspects of abrasive blasting are discharge to water (equipment spills, spills of abrasives and removed coating materials including lead), air emissions (dust, noise, lead from paint removal), and waste and hazardous waste (lead paint debris, scale, oils and greases, aqueous wastes from water-based blasting). Impacts include water quality impairment (lead from paint removal, oils), damage or mortality of biota (e.g. lead contamination effects) and waste generation/disposal.

The main categories of abrasive blasting are described below.
Standard open abrasive blasting is effective in removal of loose and tight paint and rust and creates a profile. It is done with pressurized equipment which projects abrasive media such as steel shot/grit, sand or slag through a hose via compressed air. Most open abrasive blasting requires use of partial or full containment using tarps, screens or other flexible or rigid materials; containment is required for blasting of lead based paints. Blast cleaning with recyclable abrasive requires specialized equipment for vacuuming or collecting abrasive, separating the lead and other dust and fines, and maintaining clean dry air to avoid rusting of the abrasive.

Vacuum-blast cleaning involves use of a blast nozzle with local containment (a shroud) and a built-in vacuum component beyond the shroud but within the outer periphery of a set of outer brushes. It has limitations in non-flat areas with irregularities and angles or edges and is more time consuming, less effective and more difficult to use than standard blasting.

Wet abrasive blast cleaning uses compressed air and water injection. Disadvantages are that it may induce flash rusting, requires use of chemical corrosion inhibitors (possible contaminants), generates larger waste volumes, and requires specialized containment to capture water and debris.

High pressure water jetting (6,000 to 25,000 psi) involves a pressure pump, specialized lance and nozzle, in some cases inhibitor chemical to prevent rusting, and collection for liquid and solid debris. It will remove loose paint and rust but is not effective in removing tight paint or rust or mill scale, or in creating a profile. However, if the original surface was previously blast cleaned, this technique will remove old paint and restore the original profile.

High pressure water jetting with abrasive injection uses an expendable abrasive, virtually eliminates airborne lead exposure, results in substantial waste volumes, and requires use of rust inhibitors. Soluble (sodium bicarbonate) or insoluble abrasives (sand or slag) may be used. The former can be filtered out but is somewhat less efficient in removal of surface material.

Ultrahigh pressure water jetting (over 25,000 psi) can remove tight paint and rust and results in less use of water but waste collection is more difficult, and requires use of chemical inhibitors.

Sponge jetting involves abrasives (steel or garnet) encased in a soft sponge (foam) which is absorptive and when dampened, reduces the dust generated without extensive wetting of the surface. Some screening and tarping is required. However, productivity is lower than for open abrasive blasting.

Carbon dioxide blasting injects CO₂ pellets (at -79°C) at high velocity; the carbon dioxide sublimes, leaving only waste to be cleaned up. The technique is costly, productivity is sometimes lower than conventional blasting and it does not produce a profile.

Practices
B.2.8.1 General Measures

- Conduct sandblasting only with Project Manager and regulatory approval.

- Provide containment/ ventilation systems so as to create a negative pressure within structures subjected to sandblasting, to reduce the dispersion of lead into the environment. Filter dust laden air before releasing it to the environment.

- Do not use silica sand in power-blasting applications (usually defined as materials containing more than 1% crystalline silica).

- Ensure that an appropriate level of monitoring and maintenance is conducted on equipment used to recycle blasting abrasive.

- Do not conduct sandblasting of lead painted objects without an ECA (formally Certificate of Approval) or other regulatory approval.

- Use the following or similar methods for sandblasting and coating of in situ head gate gains in order to minimize waste and avoid regulatory issues:
  - perform a leachate test for heavy metals (esp. lead and cadmium; also, for PCBs)
  - suspend splash curtains or hoardings on the downstream side of service gates
  - install temporary catch basins and pumps at the bottom of each intake to prevent leakage and to afford working in the dry on the sill
  - set up scaffolding, temporary lights and approved enclosures for abrasive blasting
  - clean surfaces of grease or oil with solvent before blasting and collect/ recycle/ dispose of spent solvent as subject waste
  - blast steel surfaces using recyclable steel abrasive if appropriate, with separating, reclaiming and dust collecting equipment
  - blast embedded carbon steel surfaces prior to vacuum cleaning and application of epoxy putty

- Dispose of sandblasting waste according to regulatory requirements.

B.2.8.2 Washing/ Power-washing Electrical, Mechanical and Other Equipment
In this section, low pressure power-washing (no abrasives) is covered along with other means of manual, low pressure or injection cleaning using water, soaps, phosphates, solvents or other reagents. This category also includes other structural cleaning procedures such as injection crack cleaning (mainly using phosphoric acid solutions) for removing compacted fines in cracks due to drilling, calcium deposits, etc., prior to injecting resins. This may apply to wooden penstocks, concrete areas of dams and powerhouses, canals, foundations, etc.

Environmental aspects of low pressure washing are discharge to water (oils, salts, particulates and chemicals, equipment spills, sediments (turbidity), spills of cleaners and removed coating materials), air emissions (dust, noise), and waste and hazardous waste (scale, oils and greases, solvents, aqueous wastes). Impacts include water quality and water quantity impairment, damage or mortality of biota (toxicity from cleaners mixed with displaced materials), and waste discharge/disposal.

**Practices**

**B.2.8.3 Vehicle and Equipment Power-washing**

- Ensure environmental approvals are in place for containment of contaminated wash water or other discharges.

- Perform truck and equipment washing for removal of collected dirt, grease, oil and other contaminants only in service areas suitably protected with an impermeable liner and berm, to the satisfaction of the Project Manager. Allow water to settle or filter and treat before disposal. Treat washwater and underlying materials contained by the liners as potentially hazardous waste.

- Wash mud off all construction equipment and vehicles prior to travelling on paved roads.

- Do not wash equipment (e.g. concrete trucks) near or in water bodies.

- Do not wash equipment with obvious surface contamination by oils, surfactants, flaking paint, greases, etc., in work areas or near open water or watercourses.

- Provide for an engineered system and ensure environmental approvals are in place for containment of contaminated washwater or other discharges such as oily water discharges, garage washwater collection systems, etc.
B.2.9 Waste Management

The Waste Management Plan addresses the waste quantities, waste types, site sensitivity, and/or waste storage or transport risks inherent to the project. Various wastes arising from refurbishment activities including fuel channel assemblies, calandria tubes, feeder piping and various miscellaneous low and intermediate level wastes from refurbishment activities will be generated and require management. GEPs associated with the management of radioactive are documented in OPG’s existing procedures (referred to in Section 6.2.5). In addition, specific construction activities will also generate non-radioactive waste. The GEPs associated with these non-radioactive waste streams are documented below:

**Excavated Soils and Granular Material**

- Use inert fill (defined in Environmental Protection Act O. Reg. 347/12) including uncontaminated excavated materials (soils, granular material, rock) or similar surplus imported material constructively and with respect to aesthetic effects and revegetation requirements, on OPG controlled lands or dispose of in designated areas on-site or as backfill.

- Stockpile stripped overburden for later reuse.

- Segregate topsoil and subsoil or granular material by type and do not mixed unless directed by the Project Manager.

- Protect all disposal area fill and stockpiles against erosion.

- Minimize volumes of contaminated materials by careful excavation and segregation of contaminated and uncontaminated materials.

**Domestic and Office Waste**

- Use reusable products and containers (rather than disposable) and products made from recycled or reclaimed materials rather than virgin materials (e.g. certain papers, cardboards).

- Conduct source separation (organics, paper, cardboard, cans, bottles, etc.) and recycle those components generated in suitable quantities and if local infrastructure is available, as determined by the Project Manager prior to construction.

- Do not mix domestic and office waste with other construction or industrial wastes.

**Non-hazardous Construction Waste**

- Use previously used or reusable products (e.g. skids, reusable or metal formwork, etc.).
Guideline

NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Conduct source separation (organics, paper, cardboard, cans, bottles, building materials, etc.) and recycle those components generated in suitable quantities and if local infrastructure is available, as determined by the Project Manager prior to construction.

- Minimize use of "disposable" materials (including packaging).

- Do not burn plastics, treated wood, product containers or mixed wastes on-site.

- Specify location(s) and area perimeters for disposal of these wastes on-site or off-site, including details of constructive use as appropriate.

- Treat concrete waste (rubble) resulting from demolition as inert fill in accordance with the Ontario Environmental Protection Act and approved for onsite disposal by OPG, or dispose of at an MOE-approved landfill.

- Dispose of empty cementitious grout containers and solidified grouts as construction wastes.

- Obtain permissions prior to on-site disposal on leased public or private lands.

  Remove embedded rebar from concrete demolition rubble and separately dispose of or recycle, prior to disposal of the rubble.

Uncured Concrete, Slurries and Cementitious Grout and Concrete Mixer Washout

- Obtain formal (documented) or informal (e.g. documented personal communication) approval from regulatory agencies for on-site disposal of significant quantities of uncured concrete, slurries (from wetted concrete dusts or slurries, or water-assisted concrete cutting) or cementitious grout or concrete truck and/or mixer washings.

- Provide a design prior to construction for an on-site collection system or basin(s) for receiving uncured concrete and similar wastes, including a system for drainage/disposal of filtered water and later removal and disposal of accumulated dried materials.

- Obtain approval from the Project Manager for the collection system before any waste uncured concrete or similar wastes are to be generated or at a time specified by the Project Manager if regulatory approval is required.

- Locate the settling basin(s) in work or laydown areas or elsewhere as specified by the Project Manager and protect them with berms to prevent runoff to water bodies. Prevent disposal of other types of waste in these basins.

- If required by the Project Manager, for safety reasons and to properly delineate disposal areas, provide temporary fencing at the perimeter of the settling basin(s).
When basins reach capacity and excess concrete and cementitious grout have hardened, do one of the following:

- With Project Manager approval (and government agency approval if necessary), fill the basins to blend with existing contours prior to restoration (and remove synthetic geo-membranes and structural components for separate disposal as non-hazardous solid industrial waste), or
- Remove solidified materials along with synthetic geo-membranes and structural components for disposal as non-hazardous solid industrial waste.

Rebar and Metal

- Separate ferrous versus non-ferrous metals for recycling.
- Collect iron and steel wastes including rebar recovered during demolition or as by-products of construction.
- Remove extruding portions of rebar and other metals from concrete rubble and recycle.
- Clearly identify lead and mercury wastes and other metallic wastes coated with lead paint when sold or sent for recycling.
- Disallow on-site removal of lead-based coatings (e.g. by sandblasting, burning or chemical means) without regulatory approvals.

Waste Asphalt

- Since waste asphalt is not considered inert fill, do not dispose of it on-site without formal (documented) or informal (documented personal communication) approval from regulatory agencies.
- When large quantities of waste asphalt will be generated on site, contact the MOT to determine alternative disposal and recycling methods available for use in the region.
- Consider the alternative of recycling waste asphalt by:
  - Providing it to facilities which reincorporate this material into recycled hot mix
  - Providing it to a facility for stockpiling in future recycling
  - Disposal at a local MOE-approved landfill as solid non-hazardous industrial waste.

Waste Operating Fluids, Product Containers and Packaging
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Segregate by waste class, all operating fluid wastes (mainly lubricating oil) obtained from vehicles and construction equipment by waste class and collect in drums with sealable lids for recycling or disposal as O. Reg. 347/12 subject waste. Give preference to recycling.

- At all times, store wastes properly and label according to WHMIS regulations.

- Drain oil filters when hot and dispose of used filters, oil cans and grease tubes according to government guidelines and O. Reg. 347/12 class of the products which they contain or contained.

- Do not remove underground storage tanks until the Project Manager has confirmed that government agency notifications have been made and other precautions taken.

- Manage storage tanks, used oils and contaminated soils or sediment according to OPG Procedures, MOE requirements and The Fire Code or the Liquid Fuel Handling Code. Dispose of these materials at an MOE-approved landfill or other facilities. Remove remnant product according to government guidelines and O. Reg. 347/12 class.

Miscellaneous Washwater

- If treatment of washwater is necessary to reduce the concentration of lime, suspended solids or other potential contaminants, determine if the treatment system requires an amendment to the ECA (Sewage).

- Collect the following information prior to discussing with OPG the need for a ECA (Sewage) for truck wash or other washwater settling ponds:
  - Frequency of truck washings or other discharges
  - Estimated maximum volume of water to be retained (allowing for precipitation)
  - Design basis for size of the settling pond
  - Expected volume of pond pump-outs per unit time

- Reduce the volume of water used by using high pressure, low-volume power-washing and automatic shutoff valves on equipment washing hoses.

- Do not allow washwater used for cleaning of trucks, especially the interior of concrete trucks, to freely enter any watercourse. Direct it into a settling basin and reuse it as much as possible only after adequate settling has taken place.
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Locate washwater settling ponds close to areas where wash, waste and turbid waters are generated and do not allow uncontaminated runoff to enter the pond. Trap and allow sediment to settle or naturally infiltrate the soil before allowing runoff to reach a watercourse.

- Recycle washwater after settling or treatment (e.g. use uncontaminated sedimentation pond water for dust control on roads and laydown areas, etc.).

Liquid Industrial and Hazardous Waste

- Notify the Project Manager and meet OPG and regulatory waste management requirements if quantities in excess of the O. Reg. 347/12 minimal registerable quantities are generated.

- Dispose of Contractor generated mixed wastes, unidentifiable wastes and materials contaminated as a result of Contractor action or inaction, in a manner approved by the Project Manager and at the Contractor's expense, including costs of leachate and chemical analysis to determine waste classes.

- Store subject wastes on-site for no more than 90 days.

- Store and dispose of individual subject waste types as defined in OPG procedures.

Common Subject Waste Classes Used

- Confirm if an OPG O. Reg. 347/12 Waste Generator credentials are to be used on the project or if project-specific credentials will be obtained, and take the following actions:

- If OPG credentials are to be used, document the agreement with Project Manager in writing, along with a statement of the classes of subject waste, approximate quantities to be generated, and if required by the OPG, analytical information (e.g. leachate test results, other analyses).

- If project-specific credentials are to be obtained by the Contractor, identify or provide:
  - waste collection and storage sites
  - external waste haulers (provide copy of ECA)
  - receiving landfill site(s) or waste processing facilities (provide copy of ECAs)
  - Waste Generator Number (provide copies of Acknowledgement of Subject Waste and Waste Generator Reports)
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Prior to disposal, evaluate containers with remnant chemical grout components, resins or other chemical products for waste registration status under O. Reg. 347/12.

- Package waste asbestos (if any) according to O. Reg. 347/12 and WHMIS requirements and dispose of it in the stipulated manner at an MOE-approved landfill.

- Provide copies of all documentation relating to the actual disposal of subject wastes to the Project Manager within two working days of disposal.

- Provide copies of all documentation relating to the actual disposal of subject wastes to the Project Manager prior to disposal.

B.2.10 Site and Contamination Cleanup (incl. tank removal)

Site and contamination cleanup may involve cleanup of materials at a site where previous activities have resulted in an untidy or potentially contaminated or definitely contaminated situation. The Project itself could be a Phase II contamination cleanup. Alternatively, it might involve a post-project cleanup.

A special case is the removal of underground storage tanks (USTs) or leaking underground storage tanks (LUSTs) which have more complex regulatory requirements.

Environmental aspects and impacts of site and contamination cleanup are mainly positive, although there may be some mobilization of contaminants during cleanup and transport. Aspects include discharges to water (contaminated soils, leaks from underground storage tanks and other sources during removal), air emissions (dust, noise), waste and hazardous waste (excavated material, contaminated wastes or various types). Impacts include water quality and air quality impairment.

Practices

B.2.10.1 Provisions for Identification and Cleanup of Contaminated Materials

It is possible/is known that some soil contaminated with environmentally harmful substances may be found on the site and, in this event, the Contractor shall remove and dispose of this material. Disposal of contaminated soil shall be in a manner acceptable to the Project Manager and in accordance with the provisions of established Soil Management Plan or the Waste Management Plan.

Contaminated lands include waste materials, and contaminated soils and sediments. Previous soil samples have/have not been performed or have/have not demonstrated soil contamination. If contaminated soils are found or suspected during construction, the Contractor shall inform the Project Manager immediately prior to further excavation or other work. Disposal of contaminated soils or sediment shall be in a manner acceptable to the Project Manager and regulatory authorities.
To the extent possible, use existing on-site treatment facilities and disposal areas for decommissioning activities (e.g. approved treatment facilities for wastewater or areas for managed disposal of inert fill, stormwater settling and discharge, etc.)

Monitor treatment facilities to prevent and quickly identify upset conditions from use of high strength clean-up materials (e.g. industrial cleaners, solvents, abrasives, etc.).

When an OPG property is sold, ensure the purchase agreement protects OPG from liability with respect to potential contaminated lands. If material is sold as part of assets, a security bond may be necessary to ensure that the future owner will comply with obligations.

Inform the Project Manager immediately if during excavation, contaminated or potentially contaminated soils or other materials are found or suspected, prior to carrying out further excavation or other work as regulatory approvals may be required.

Dispose of contaminated soil or materials in a manner acceptable to the Project Manager, regulatory authorities, and in accordance with the provisions of established waste management procedures, the Waste Management Plan, and OPG procedures.

Determine whether a given soil volume or other material is considered contaminated or uncontaminated, with appropriate third-party and analytical input, and perform waste segregation and/or cleanup actions accordingly.

During excavation, separately stockpile contaminated materials, uncontaminated materials and potentially contaminated materials pending confirmation of status and prior to disposal. Provide additional stockpiles for uncontaminated but water-saturated material if required. Place contaminated and potentially contaminated material on a continuous plastic tarp of 6 mil minimum thickness and protect it from infiltration of water from precipitation or runoff.

B.2.10.2 Removal of Uncontaminated Facilities

During normal cleanup, remove all temporary structures such as housing, work and fabrication shops, storage sheds, docks, boardwalks, cement and concrete mixing plants, temporary road signs, lighting facilities, gates and fences, fuel or water storage tanks and septic systems.

Break up, bury or remove footings or concrete slabs. Obtain government approval to retain and cover concrete foundations.

Loosen soils that have been compacted to promote natural regeneration or pre-existing land use.
• Leave access roads in a state that will meet established requirements for control, prevention or discouragement of further use, or for encouragement of regeneration/rehabilitation in consultation with local stakeholders and regulatory authorities.

**B.2.10.3 Removal of Storage Tanks and Technical Cleanup Options**

• Ensure that staffs who remove storage tanks are licensed according to government legislation. Do not remove waste or product (including gasoline, diesel, waste oil, other) fuel and non-fuel tanks without Project Manager confirmation and government notifications.

• Use well points for groundwater dewatering purposes, especially in areas with porous foundations. This is applicable in decontaminating groundwater which has been exposed to contaminants such as from leaking underground fuel tanks or spills. Ensure environmental approvals are in place when pumping out groundwater contaminants.

• Contractors may be requested to clean up and dispose of on-site wastes prior to starting a project as a first priority upon mobilization in accordance technical specifications.

• For more complex site cleanup efforts involving decontamination or attenuation of materials such as gasoline, diesel, PCBs, VOCs, BTEX (benzene, toluene, ethylbenzene, and xylene), chlorinated compounds, nitrogen based compounds, heavy metals, etc., consider using consultants and specialized Contractors.

• Consider options of "pump and treat" or installation of Permeable Reactive Barriers (PRBs) for remediation of contamination resulting from leaking USTs or other sources. Both have associated regulatory requirements including monitoring, assessment and results reporting.

• PRB installations may require cut and fill, trenching, bio-slurry, shoring, injection, hydrofracting or well installations, most of which have relevant GEPs covered in the OPG guidelines.

• Where possible, monitor parameters at the wellhead (e.g. conductivity, pH, alkalinity, dissolved oxygen, etc.); where this is not possible, collect samples for off-site analysis according to established sampling protocols.

• Establish with regulators the need for site cleanup to MOE guideline criteria or alternatively, for defined post-treatment site uses, and Site Specific Risk Assessment (SSRAs) criteria.
B.3.0 MATERIAL STORAGE AND HANDLING

B.3.1 Stockpiling of Materials

The types of materials typically stored on a temporary basis include granular materials, topsoil, dredge spoils, debris (concrete chips, logs, rock), fuel oil, gasoline, lubricating oils, diesel fuel, possibly transformer oils, construction materials (cement, wood, piping, wiring, aggregates, etc.) and miscellaneous chemicals and waste chemicals.

Environmental aspects of material storage and handling are discharges to water (variety of solid and liquid products during storage; sedimentation, erosion, etc.), and air emissions (dust, noise). Impacts relate to the types of material stockpiling, but usually limited to water quality impairment.

Practices

B.3.1.1 General Measures

- Protect stockpiles against erosion or other physical disturbance, or vandalism.
- Pre-determine stockpile locations with approval of the Project Manager.
- If possible, store cement, grout bags, pesticides and fertilizers indoors; keep them off the ground and covered to keep dry. Store treated wood product off the ground to avoid contaminant leaching.
- Use enclosures, covers or other precautions to curtail dusts when handling cement, grout and similar materials.
- Slash and stockpiles should be situated so as to not disrupt or obstruct wildlife movement, or nature and hiking trails which traverse the site area.

B.3.2 Storing and Handling Chemicals, Oils and Fuels

There are many types of chemicals and chemical based products used on construction projects and potentially handled and stored on the job. Materials may be in product storage, transit, or in facility equipment (e.g. transformers). The list ranges from hazardous materials such as explosives, pesticides and solvents to relatively benign household cleaners. Various controls are in place for chemical storage both in terms of individual containers and cabinets or storage zones, indoor and outdoor. Handling and storage requirements are indicated on MSDSs and specified in OPG Manuals on PCBs, Waste Management, and Transportation of Dangerous Goods.

Handling activities involve decanting, pumping, equipment draining, refuelling, drum handling, dispensing, mixing, rinsing, repackaging, and transporting of materials. Transformers and similar equipment are generally shipped without oil but filled with dry air or nitrogen under positive pressure.
Oils are usually stored in drums or large tanks ready for use, or delivered by pumper trucks. Most fuels are stored in drums in outdoor containment areas or in storage tanks. Containment systems may be engineered for retention of products or wastes. These may consist of impervious membranes or concrete-filled geoweb/geocell systems for pond or other containment. Spill containment systems include a variety of ground protection materials, containers, trays, berms, cabinets, etc., made of various materials.

Environmental aspects of storage and handling of fuels, chemicals and oils are discharges to water (variety of liquid products such as gasoline, diesel, insulating and lubricating oils, solvents, etc.); and air emissions (welding and other pressurized gases, volatile organic compounds, etc.). Impacts include water quality impairment and damage to biota.

Practices

**B.3.2.2 Identifying Materials and Choosing Alternative Products**

- Provide the Project Manager with a list of fuels, oils and chemical products planned for use on a project for hazardous materials approval prior to mobilization (all consumables must be pre-approved or specified by OPG), listing such products by cat ID (if one exists) material code, product name, broad product category and manufacturer.

- Do not use hazardous products until or unless approved, and all products must be pre-approved by OPG, even if they have essentially equivalent function to other approved products.

- Provide the Project Manager with copies of MSDSs for all products to be used, before execution begins.

- While conforming to the requirements of the OPG product approval system, consider the use of alternative products which have been demonstrated by EPRI, OPG and other utilities to be effective and environmentally compatible. Several examples include:
  - vegetable-based biodegradable non-toxic hydraulic oil for trash rake mechanism lubrication
  - citrus-based cleaners
  - petroleum based solvents (rather than chlorinated products)

**B.3.2.3 Containment Facilities and Storage Conditions**

- To establish large impermeable basins (e.g. permanent settling ponds or contaminated waste sediment retention areas) or platforms, consider the use of plastic liners, bentonite liners, or concrete-fillable high-density polyethylene geoweb/ geocell systems.
Minimize the quantities of chemicals, fuels and oils stored on site.

Make monitoring of storage status an important inspection and compliance assessment element on all projects which use or store significant quantities of chemical based products, fuels or oils.

Store, handle, label and use products in conformance with WHMIS (MSDS recommendations) and OPG procedures.

Provide spill containment to the satisfaction of the Project Manager by using modular containment systems including catch-pans or trays, curbing made of concrete or other impermeable material, or impervious berms.

Use special measures, including regulatory requirements, pertaining to storage of explosives, including:

- accounting for quantities of explosives in inventory at all times
- retaining explosives in a locked, dry, well-ventilated, bullet-resistant storage magazine which meets government criteria
- prohibiting use of sparking metal tools to open wooden cases
- using oldest stock first to minimize the chance of deterioration from long storage
- segregating and disposing of loose explosives or broken, defective or leaking packages according to manufacturer instructions and government regulations
- storing detonators in a separate magazine from other explosives

B.3.2.4 Specifications for Storage Facilities

1. Indoor or Outdoor Storage

- Provide secure double containment for small containers of fuel and other chemical products and protect at all times against accidental spillage in accordance with regulatory requirements (WHMIS, Liquid Fuel Handling Code, etc.).

- Provide spill containment in the form of floor curbing or catch pans, etc., (refer to N-STD-OP-0026, Spill Management, Appendix F 1.0 and F2.0 which further describe storage spill containment requirements (flammable, non flammable, long term, short term, etc.).

- Locate fuel, oil and chemical storage facilities either inside or outside of buildings in ways that will minimize leakage, prevent freezing of chemicals, prevent interactions of incompatible materials or limit spill potential (e.g. store on materials of low permeability such as clay, asphalt or concrete with suitable containment).
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Use chemical storage cabinets with the following characteristics:
  
  - locked door
  - warning sign stating "Chemical Storage"; speed limit signs
  - ventilation to outside
  - heated and insulated
  - sealed floor without drain
  - located in well drained area far from surface water
  - original labelled containers
  - posted emergency phone numbers
  - protective clothing, respiratory equipment and first aid materials available
  - chemical inventory and MSDS information available
  - deluge systems
  - security devices for valves, decanting, spark arrest grounding

- Use bulk containers (to minimize the number of containers).

- Use small container storage shelves with lips to keep containers from sliding off.

- Use steel shelves for storage rather than wooden ones for ease of cleaning.

- Store dry products above liquids to prevent wetting from spills.

- Store waste chemicals separately from new chemicals.

- Ensure that all bulk storage units have level indicators.

- Store drums on pads or catch-pans with impermeable surfaces and adequate perimeter and volumetric containment.

- Install leak and spill detection, alarm and sprinkler (deluge) systems for large or complex hazardous and/or flammable materials storage facilities and storage tanks.

- Do not use chemical containers that are rusted, damaged or leaking.
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Size indoor chemical and oil storage containment areas to hold the maximum storage capacity plus deluge water equivalent to at least 10 minutes' flow.

- Protect storage area floors against upheaval or subsidence.

- Block or secure drains located within concrete containment areas in accordance with design sketches or drawings.

- Provide separate containment and collection facilities for mutually incompatible materials. Store and transport hazardous wastes and products of different types with regard to their mutual compatibility. For example, do not store oxidizers (e.g. chlorates, nitrate fertilizers) near fuels, wood or petroleum products).

- Regularly check spill enclosures for precipitation, spills, leaks and structural integrity, and maintain them in a clean and serviceable condition.

2. Outdoor Storage

- For fuel tanks of any type, meet the following requirements:

  - locate at least 90 m from a well
  - provide inventory control
  - lock fuel nozzles when not in use and use automatic shut-off nozzles
  - constantly supervise pumping
  - have an emergency plan available
  - post warning signs and have a fire extinguisher available.

- For above-ground fuel tanks, meet the following requirements:

  - ensure they are covered with a protective coating to prevent rusting and painted white to reduce evaporation
  - provide impervious containment capable of holding 110% of the tank volume
  - locate at least 3 m from any building, 7.5 m from a source of ignition and 0.9 m from another fuel tank
  - remove rainwater to maintain the capacity of the dyked area
  - pump fuel from the top of the tank (not gravity fed) to prevent leakage

- For underground fuel tanks, meet the following requirements:
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- registered and approved by Technical Standards and Safety Authority (TSSA)
- locate at least 1 m from a building and 0.6 m from another fuel tank
- if unused, remove and report to TSSA

- Size outdoor oil and chemical storage and oil-filled equipment containment areas to hold the maximum storage capacity plus precipitation and deluge water of standard duration.

- Drain surface water to a confined area around storage areas so that in the event of a fire or spill, surface water can be collected more readily and more safely.

- Provide overhead protection from precipitation if requested by the Project Manager or on projects having significant inventories of hazardous materials in storage (e.g. in excess of 5-10 drums) or smaller quantities if stored for more than 3 months.

- Distinctly mark equipment fuel lines and keep them clear of snow and debris to allow for routine inspection for leaks.

- Site outdoor storage areas to make use of the natural topographic and soil characteristics to provide initial leak/spill containment and cleanup.

- Provide laydown area spill containment according to specifications and drawings, or as described below in outdoor areas where oil, fuel and chemical handling occurs:
  - one-piece high density polyethylene geomembrane having a nominal thickness of 0.75 mm, Terrafix Grundline HD or equivalent acceptable to the Project Manager with an appropriate cushion of sand or other suitable fine material on each side of the liner as a precaution against puncture.

- Fill drums susceptible to freezing only to 80% capacity when stored outside and check periodically for leakage.

**B.3.2.5 Mixing and Refuelling**

- Mix or decant only the amount of chemical or fuel required for the use at hand.

- On projects where mixing and refuelling activities are frequent, provide spill containment at mixing and refuelling areas according to specifications, drawings and SPCP, locating such areas at least 30 m from a water body or well and preferably close to the storage area to minimize the distance that chemicals are carried.
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Provide product mixing areas with curbed concrete pads and runoff containment. Use separate water tanks as water supply, and use anti-backflow devices when drawing mixing water to prevent chemicals from siphoning back into the water supply.

- When mixing pesticides, use the following procedures:
  - Pressure-rinse or triple-rinse chemical containers immediately after use (residue can be difficult to remove after drying), depositing rinsate into a spray tank for mixing subsequent loads;
  - Leave an air gap of 15 cm between the water hose and the top of the sprayer tank; never put the hose into the sprayer tank;
  - Supervise sprayer filling;
  - Puncture waste rinsed containers prior to off-site disposal at an approved landfill to ensure they are not inadvertently reused;
  - Use older products first to keep inventory current and effective but make sure older products are still valid for continued use; and
  - Do not mix or load pesticides near a well.

- Use returnable and bulk containers where possible.

- Refuel readily mobile highway vehicles off-site.

- Develop and designate equipment servicing and refuelling area(s) for non-highway motorized mobile equipment and machinery in the laydown area or elsewhere as approved by the Project Manager. Ensure it is on flat terrain in a dyked area well away from water bodies.

- In the refuelling area provide a granular mat overlying an impermeable liner or equivalent to contain leaks and spills. For the liner use a one-piece high-density polyethylene geomembrane with a nominal thickness of 0.75 mm, Terrafix Grundline HD or an equivalent acceptable to the Project Manager and an appropriate cushion of sand or other suitable fine material on each side of the liner as a precaution against puncture.

- Bring large quantities of oil or excess fuel to a collection area and save for future use, or return to the supplier.

- Provide and maintain drip trays at manual fuel transfer locations.

- Ensure that mobile refuelling crews carry a supply of sorbent material and drip trays to meet all needs in containing and/or soaking up all spills during refuelling operations.
If an on-site fuel truck is used, use preventive measures such as sealing open catch basins, having spill response equipment on hand, monitoring and inspecting fuel lines during fueling, etc.

Supervise oil and fuel extractions from storage areas and routinely inspect and maintain these areas. Use approved fuel containers for transport and storage.

Critically limit refuelling of equipment when it is within a water body, on a dam, or in temporarily dewatered stream, lakebed or shoreline, but if it is absolutely necessary, provide drip containment and ensure that spill prevention and cleanup materials are on hand during refuelling.

Avoid mixing and loading on gravel driveways or other surfaces that allow spills to sink quickly through the soil.

**B.3.2.6 Draining and Filling Transformers**

- Prepare detailed procedures for transformer draining prior to the activity.
- Monitor and record observations of transformer draining activities.
- If a vacuum truck is used in combination with drainage and product return lines, prevent spills by sealing open catch basins, having spill response equipment on hand, frequent monitoring and inspecting of fuel lines, etc.
- Ensure that suppliers contracted for transformer oil have certification or other qualifications for the proffered treatments (i.e. PCB removal, filtration, gasification, retro-filling).

**B.4.0 EQUIPMENT AND MATERIAL USE**

**B.4.1 Operating Environmental Systems - Atmospheric**

This activity includes the operation of systems and equipment which may or may not be subject to environmental approvals (with limits for controlled parameters such as certain gases, vapours, particulates or noise), or which typically generate dust or noise. Examples of systems subject to environmental approvals ECA (Air) (formally Certificate of Approval - Air) include HVAC (heating, ventilation and air conditioning) systems, ventilated indoor welding facilities, specialized sandblasting, etc. Other systems may be subject to approved levels for noise generation (e.g. noise by-laws). System equipment may be stationary or mobile.

Sources of dust partially or typically not subject to environmental approvals include the following:

- Road surfaces during construction and from vehicle passage
- Clearing and use of laydown and parking areas
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Mobilization from vehicles carrying earth and other fine materials or being loaded/unloaded
- Stockpile blow-off
- Mud moved by vehicles, then re-suspended after desiccation
- Blasting, drilling, crushing, screening, demolition, stripping, grubbing
- Particulate emissions from vehicle exhaust.

The regulatory basis for hearing protection and noise control is via OHSA requirements, municipal by-laws, and for construction equipment and blasting, the MOE Model Municipal Noise Control By-Law, municipal by-laws, or OPG protocol for Noise Control.

Environmental aspects of operating atmospheric environmental systems are air emissions (diesel or gasoline combustion, particulates, noise, dust from welding, vehicles, generators, ventilation systems, sandblasting, etc.). Impacts include air quality impairment and resource use interaction (air shed discharge limits and local stakeholder issues).

Practices

B.4.1.1 Approved Systems: Emitting Gases, Vapours and Particulates

- Operate equipment, monitor, sample and report according to conditions of Operations Manuals and ECA (Air) (formally Certificates of Approval (Air)).

B.4.1.2 Emitting Dust

Dust control may be achieved through various measures as defined in Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities (Cheminfo, 2005). This includes activities such as:

- Dust suppressants (e.g. water) applied to roads and surfaces, as required.
- Dust suppressants, other than water, may require an ECA issued by the MOE to control the use of waste material as a dust suppressant.
- On-site haul road maintenance, including maintaining gravel using coarse washed gravel.
- Cleaning truck tires, or use of a trackout control device to avoid trackout on paved roads, particularly prior to vehicles leaving the site.
- Where a project is of long duration, plant temporary grasses in unused areas adjacent to construction zones where dust nuisance is likely to be high.
B.4.1.3 Generating Noise

- Unless otherwise stipulated, plan noisy activities for weekdays between 07:00 and 20:00 h. If an extension of this period is needed, notify and seek concurrence in advance from local residences and regulators.

- Use the following means of reducing the effects of noise in local areas:
  - Ensure that construction equipment has approved, well maintained muffler systems;
  - Construct berms or noise fences;
  - Route and time vehicle movements to minimize traffic noise;
  - Avoid blasting and other impulsive noise activity when wind and temperature inversions are likely to exacerbate the effect of the noise;
  - Where possible, inform local residents of any abnormal noise-generating construction activities and schedule these activities to minimize disruption to local residents;
  - Keep noisy equipment as far as possible from site boundaries; and
  - Where possible, move or replace some noisy operations (e.g. off-site concrete mixing, prefabrication, electric motors versus internal combustion engines).

- Make workers aware of the noise constraints applicable to the work.

- Make use of guidelines and requirements as applicable for ambient noise levels for road traffic, impulsive sound and blasting.

B.4.2 Operating Environmental Systems - Liquid Industrial Discharges

This activity includes use of systems and equipment with regulatory approvals and other requirements. Included are oil skimmers, oil/water separators, transformer oil containment systems, flow and plug systems, active liquid waste etc., including subsystems such as water or air cooling components.

Other systems involve chlorination and biological treatment and related waste and water treatment processes. All such systems require ECA (Sewage) (formally Certificate of Approval (Sewage)) and must be constructed, operated and maintained according to conditions of approval.

Oil containment and treatment systems or projects are of the following main types:

- Transformer oil spill containment with oil/water separators or flow and plug systems
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

• Sump oil skimmer installations

• Replacement of single-walled cooling coils with double-walled in water-cooled transformers

• Replacement of water-cooled transformers with air-cooled transformers

• Replacement of oil-filled transformers with dry type transformers

*Environmental aspects of operating industrial sewage environmental systems are discharge to water (oils, fuels, chlorine, PCBs, phenols, total suspended solids, etc.). Impacts include water quality impairment, damage to biota, etc., due to spills.*

**Practices**

**B.4.2.1 General Measures**

• Operate, monitor, sample and report according to the terms of valid environmental approvals - i.e., ECA (Sewage (formally Certificate of Approval (Sewage)), MISA, and approved Operations Manuals.

• Design containment systems with leak detection and alarm systems.

• Ensure that noticeable leaks from equipment are reported and repaired as soon as possible.

• Review and ensure the Project Manager approves activities which will or may interfere with operation of existing water and effluent treatment systems prior to construction.

**B.4.3 Vehicle Use, Maintenance and Associated Systems**

*Construction vehicles required to access, or work on project components may include front-end loaders, tandem trucks, skidders, pickup trucks, cement trucks, tailored equipment, cranes, backhoes, excavators, pump/vacuum trucks, graders, ATVs, snow machines, bulldozers and other specialized vehicles.*

*There may be minor and short-term effects on air quality, wildlife and human disturbance during the construction period due to noise from equipment operations. Maintenance carried out in garages may involve oil collection and separation and use of solvents (parts cleaners) and possibly treatment systems requiring ECA (formally Certificate of Approval). All highway vehicles are required to adhere to relevant regulatory requirements and guidelines for emission and noise control.*
Environmental aspects of vehicle use and maintenance, etc., include discharge to water, air emissions, and material and energy use. Impacts include soil compaction, water contamination from vehicle spills, solvent use; sedimentation; erosion; poor air quality, noise and dust from vehicle emissions; interactions with resource users (accessibility, sharing of granular resources, depletion of hydrocarbon fuels and vehicle raw materials), biota effects (vegetation damage, road-kill).

Practices

B.4.3.1 General Measures

- Select the actual types, sizes and number of machines to be used on a project based on the following:
  - Soil loading and compaction characteristics;
  - Amounts of earth and rock to be moved and distances involved on-site;
  - Typical weather conditions and seasonal restrictions;
  - Time allowed to complete the project;
  - Grade magnitude and direction of grade;
  - Bedrock and other geological conditions; and
  - Type and size of project.

- Schedule vehicle operation near water bodies during those periods when disruption to the fishery resource and recreational users can be kept to a minimum.

- Use periods of low flow and low precipitation to perform work near or in water bodies.

- Do not operate heavy equipment outside of site boundaries.

- Do not obstruct access roads needed for routine OPG staff operations such as for accessing the powerhouse or other key areas.

- Restrict equipment movement on temporarily dewatered stream or lake beds.

- Allow equipment to run only when necessary.

- Evaluate on a continuing basis, new transport and work equipment (such as air cushion vehicles) for potential field application.

- Regularly inspect vehicle air conditioning, filtering, fuel injection, exhaust and lubrication systems including pollution control devices.
NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

- Inspect regularly for oil or fuel leaks and use a drip tray or make immediate repairs when required.

- Use tracked equipment rather than rubber-tired vehicles when adverse ground conditions require the avoidance of soil compaction, rutting, mixing and erosion.

Soil Loadings for Various Vehicles

- Do not allow heavy steel-tracked construction vehicles to travel on those portions of public roads or as defined in the technical specifications or regulations.

- Use wheeled equipment across slopes to compact the soil and create ridges of soil parallel to the slope’s contour and slow runoff velocity, especially on slopes with exposed soil or fill with an angle greater than 10%. Use extra wide tracked equipment on sloped surfaces whenever possible.

- Avoid working in conditions of wet or saturated ground as any rutting can disturb the soil profile and may lead to channelized runoff, compaction and erosion damage.

- To reduce air emissions, minimize the use of equipment with 2-stroke engines (i.e. some ATVs or lawnmowers) when equipment using 4-stroke engines are available. Consider early, permanent retirement of equipment using 2-stroke engines.

- Ensure that equipment is clean and free of any materials that could contaminate the water body, either directly through in-stream use, or indirectly as a result of runoff.

- Install culverts, bridges or fords such as wooden mats or crushed rock to protect against disturbance of the stream bed and bank, when numerous crossings of streams by heavy equipment are required.

- Ensure that third parties take responsibility for damage to public roads resulting from their operations and make good all damage to the satisfaction of the Project Manager. This includes damage to public road asphalt surface pavement, road base, sub-base and sub-grade from the heavy loading of construction traffic.

B.4.4 Altering Flows/ Levels/ Water Velocities

Altering flows, levels and water levels is largely an operational activity affected by adjusting water passage. However, this activity can also occur to meet certain construction purposes. Operating at specified water levels or flow rates is often associated with regulatory or other requirements defined or referenced by operational control documents (Water Management Plans, agreements, etc.).
Environmental aspects of altering flows, levels and water velocities include discharge to water, water flows and levels, and material and energy use. Impacts may include turbidity, flooding, low water levels, water level fluctuations, dangerous flows, biota effects (fish impingement and entrainment; wetland and aquatic furbearer effects); and, interactions with resource users (flooding, low water level effects on infrastructure, accessibility, and competitive demands for water-taking).

**Practices**

**B.4.4.2 General Measures**

- During project planning, refer to Water Management Plans for facilities located upstream and downstream of the project site and incorporate restrictions into the technical specifications or Water Use Plan.

- Seek Fisheries Act Authorization and/or negotiate compensation with DFO for destruction, disruption or alteration of fish habitat or if water level reductions may cause a reduction of flow in fish spawning areas during a critical period.

**B.5.0 REFERENCES**


N-STD-OP-0026, Spill Management.

N-STD-OP-0042, Controlling Radiation Exposure of the Public and the Environment to As Low As Reasonably Achievable.

N-STD-RA-0018, Controlling Exposure as Low as Reasonably Achievable.

Appendix C: NR ENVIRONMENTAL COMPLIANCE PERFORMANCE METRICS

C.1.0 ENVIRONMENTAL COMPLIANCE PERFORMANCE METRICS

In order to ensure OPG and Contractors meet the performance targets and expectations for the NR, Table 1 shows the environmental compliance measurement reporting metric that will be used on the project (refer to NK38-REP-09701-10185, Darlington Refurbishment – Chemistry & Environment Metrics).

The Environmental Metrics for the Project will assist OPG in meeting its responsibilities as the Constructor, along with Contractors supporting OPG in fulfilling its role. Also, it will provide valuable data to Project Managers to assist with oversight and proof of Contractor capability for managing environmental requirements. Key Environmental metrics include the high impact areas: spills, radioactive emissions, environmental infractions, hazmat non-compliances, and waste non compliances. Annual targets for approved metrics are to be established for the expected duration of the Project. Targets shall be set to reflect world class environment performance for refurbishment projects.

<table>
<thead>
<tr>
<th>Environment Area</th>
<th>Description of Measure</th>
<th>Frequency/Venue/Colour Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Total # of Spills</td>
<td>Spills targets will be established based on best outage performance balanced with consideration for all work that is planned. Given the requirement for strict compliance to mitigation plans, spills targets are expected to be very tight. Cat A/B (Very Serious/Serious) spills target =0 Cat C spills having i.e. spills that are not considered “very serious” or “serious” for environmental impact (&lt; 10 /yr but will be adjusted based on a review of risk at the time)</td>
<td>Nuclear Refurbishment Environment index (NREI) could be reported out monthly. A similar colour scheme to the chemistry measures above could be used. If performance is converted to percentage, points could be deducted from full points based on extent of deviation from “target” performance.</td>
</tr>
<tr>
<td>Target for Cat A/B=0 Cat C Spills TBD based on assessed risk at the time. Target will be modified based on review of risk at the time. Reductions in points for below target performance will be assessed and applied.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emissions</td>
<td>A Radioactive Emissions Plan will be produced. Keeping emissions down below target levels during both the primary side fill and drain operations at the beginning and near the end of the NR outages, will be challenging. Tight targets are in place to encourage good practices, including recovery of tritium, and good human performance management and oversight during procedure execution to minimize spills.</td>
<td></td>
</tr>
<tr>
<td>(3) Moderate Environmental Event (MEE) classified as Infractions</td>
<td>This includes deviations from approved Certificates of Approval, failure to meet CLOCA commitments, MISA infractions, and other infractions as outlined in OPG-PROC-0041 sect 3.</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Target = TBD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every infraction would result in a specified point deduction for the entire year. For example, if 2 points were deducted for each infraction, it would take 10 infractions to achieve a colour of Red if 80 pts represented Red</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(4) Other Non-Compliance Events</th>
<th>There are events that are considered below the threshold of a Moderate Environmental Event. This would include TDG non-compliances, or improper storage of solid or liquid chemical wastes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target = TBD</td>
<td></td>
</tr>
<tr>
<td>Every event would result in a specified point deduction for the entire year. Once 20 points cumulative are deducted, the indicator would go Red</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(5) Low and Intermediate Level Radioactive Waste (LILRW)</th>
<th>Generation of low and intermediate level waste needs to be controlled and minimized. Failure to do so, results in large lifetime costs associated with storage processing and final future disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target will be set following an assessment of the refurbishment plans.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total= NREI</th>
<th>Nuclear Refurbishment Environmental Index is comprised of the 5 sub-measures above weighted equally and with a target TBD</th>
</tr>
</thead>
</table>

*The above targets would be cumulative performance across all projects/vendors. The contribution/targets of each vendor would be set closer to execution when scope and risk of the work is better quantified and number of workers is known.*
Appendix D: DN REGULATORY ENVIRONMENTAL REPORTING

OPG commits to comply with relevant legislation, regulations, and other requirements. Table 1 documents a summary of some of the regulatory environmental reports and correspondence submitted to regulators on a routine basis relating to activities that occur at the DN site. Project activities may be required to provide data for these regulatory environmental reports, where applicable. To ensure regulatory environmental reporting requirements are met, a tracking checklist of regulatory environmental reporting deliverables will need to be developed as part of the CEMP.

A sample tracking checklist for providing the reporting data to OPG for managing environmental reporting requirements is provided in Table 2. When finalized in the CEMP, the regulatory reporting tracking checklist, which can be incorporated into the Environmental Monitoring Checklist, will provide oversight and surveillance for ensuring OPG meets its regulatory environmental reporting requirements.
Table 1: Listing of Routine Regulatory Environmental Reports for DN

<table>
<thead>
<tr>
<th>Report Title</th>
<th>Purpose</th>
<th>Regulator</th>
<th>Frequency</th>
<th>Submission Date</th>
<th>Required By</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Pollutant Release Inventory (NPRI)/Ontario Regulation 127 Report</td>
<td>Provide quantities of substances released into the air, water, and land that have the potential to adversely affect human (i.e. nitrogen oxide, sulphur dioxide, chromium).</td>
<td>Environment Canada/ MOE</td>
<td>Annual</td>
<td>Jun 1</td>
<td>CEPA Sect. 48. O. Reg. 127/01</td>
</tr>
<tr>
<td>Sub-Chronic Toxicity Test Report (Darlington)</td>
<td>Provides the results of quarterly chronic toxicity test results.</td>
<td>MOE</td>
<td>Semi-Annual</td>
<td>Feb 28, Aug 30</td>
<td>O. Reg. 215/95</td>
</tr>
<tr>
<td>Registration of Wastes to MOE (hazardous wastes)</td>
<td>Hazardous waste Generators registration.</td>
<td>MOE</td>
<td>Annual</td>
<td>Feb 15</td>
<td>O. Reg. 347/12</td>
</tr>
<tr>
<td>Waste Reduction Work Plan</td>
<td>Waste Audit Summary for solid non-hazardous waste (including quantities generated, reused/recycled and disposed) and Waste Reduction Work Plan</td>
<td>MOE</td>
<td>Annual</td>
<td>Apr 15</td>
<td>O. Reg. 102/94</td>
</tr>
<tr>
<td>Annual Water Taking and Use Report</td>
<td>Annual water taking/use rates for the site.</td>
<td>MOE</td>
<td>Annual</td>
<td>Mar 31</td>
<td>O. Reg. 387/04 [related to Permit to Take Water ECA # 81-P-3017].</td>
</tr>
<tr>
<td>Environmental Compliance Approval (Water) (formally Certificate of Approval Industrial Sewage Works) Annual Performance Report</td>
<td>Summary of annual monitoring, analytical and flow data to the effluent objectives, discharge limits and monitoring requirements.</td>
<td>MOE</td>
<td>Annual</td>
<td>Jun 1</td>
<td>ECA (Water) (formally CofA (Sewage)) [ECA # 4720-6QALBY]</td>
</tr>
<tr>
<td>Environmental Compliance Approval (Air) (formally Certificate of Approval (Air)) Written Summary</td>
<td>Written summary of activities undertaken in the previous calendar year relating, including modifications that have been implemented at the site and have resulted in a change in the air emissions.</td>
<td>MOE</td>
<td>Annual</td>
<td>June 1</td>
<td>ECA (Air) (formally CofA (Air)) [ECA # 1008-65KNPY]</td>
</tr>
</tbody>
</table>
### NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE

<table>
<thead>
<tr>
<th>Report Title</th>
<th>Purpose</th>
<th>Regulator</th>
<th>Frequency</th>
<th>Submission Date</th>
<th>Required By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landfill Inspection</td>
<td>Summarizes the settling pond water quality (i.e. Coot's Pond), a summary of visual inspections of the landfill site and a description of any repairs or corrective actions taken.</td>
<td>MOE</td>
<td>Annual</td>
<td>Jun 30</td>
<td>Provisional ECA (Waste) (formally CofA (Waste)) [ECA # A390319] Closure Plan as per NK38-REP-15400-000 (Section 5)</td>
</tr>
<tr>
<td>Requirement</td>
<td>Required by</td>
<td>Information Required</td>
<td>Frequency Reported to OPG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>----------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>---------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signed annual statement of accuracy and effectiveness of the EMS.</td>
<td>EMS</td>
<td>The Contractor annually conducts a review of its EMS to evaluate the system’s continuing suitability, adequacy and effectiveness</td>
<td>Annually – Provide to OPG by Jan 1st</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signed annual statement of accuracy and effectiveness of the SPCP.</td>
<td>O.Reg. 224/07</td>
<td>The Contractor annually conducts a review of the administrative and technical content of the SPCP to ensure it is in current compliance with O.Reg. 224/07 and that the risk assessment is up-to-date.</td>
<td>Annually – Provide to OPG by Jan 1st</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Report halocarbon releases of 10 kg/release from refrigeration, air-conditioning and chiller systems.</td>
<td>Federal Halocarbon Regulations (2003)</td>
<td>Halocarbon releases in excess of 10 kg/release. Typical halocarbon refrigerants are R-11, R134a, R123 and R407c. Note: Halocarbon releases of 100 kg or more are also considered reportable spills.</td>
<td>Quarterly</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Provide quantities of substances released into the air, water, and land that are regulated by NPRI/O. Reg.127 (i.e. sulphur dioxide, nitrogen oxide, chromium and volatile organic compounds (VOCs)). | National Pollutant Release Inventory (NPRI)/O. Reg.127/01 | There are annual reporting thresholds for substances regulated by NPRI/O. Reg. 127/01. OPG will report the release, if the substance meets the reporting threshold for the entire DN site. Examples of data include:  
  - consumable welding - weight of standard welding rods/wire consumed (including applicable MSDSs)  
  - fuel type and consumption in stationary combustion equipment (e.g. for power generation)  
  - paint consumed (including applicable MSDSs to determine VOC releases) | Monthly |
**NUCLEAR PROJECTS - ENVIRONMENTAL REQUIREMENTS GUIDELINE**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Required by</th>
<th>Information Required</th>
<th>Frequency Reported to OPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to making any modifications, to conventional air emissions, the ESDM</td>
<td>O. Reg. 419/05 ECA (Air)</td>
<td>Details of the modification including specifications of equipment, worst-case</td>
<td>Monthly</td>
</tr>
<tr>
<td>Report must be updated to document that the facility, after the proposed</td>
<td>(formally CofA (Air))</td>
<td>emission scenario (i.e. kg/half-hour). Examples of modifications include adding</td>
<td></td>
</tr>
<tr>
<td>modification has been conducted, will continue to be in compliance with the</td>
<td>[ECA # 1008-65KNPY]</td>
<td>modifying: welding bays, paint spray booths, ventilation equipment (i.e. dust</td>
<td></td>
</tr>
<tr>
<td>ECA.</td>
<td></td>
<td>collector), diesel fired pumps, standby generators.</td>
<td></td>
</tr>
<tr>
<td>Prior to making any modifications, to conventional water discharges (i.e.</td>
<td>O. Reg. 255/11 ECA (Water)</td>
<td>Details of the modification including specifications, flow rates, etc.</td>
<td>Monthly</td>
</tr>
<tr>
<td>treatment, design), the ECA (Water) must be reviewed to ensure that after</td>
<td>(formally CofA (Water))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the proposed modification has been conducted, will continue to be</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in compliance with the ECA.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Report water taking and uses related to PTTW ECAs for the Project, where</td>
<td>O. Reg. 387/04 [related to</td>
<td>Water taking and uses related to PTTW ECAs to confirm ECA limits are not exceeded.</td>
<td>Monthly</td>
</tr>
<tr>
<td>applicable.</td>
<td>Permit to Take Water ECA]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Reduction Work Plan</td>
<td>O. Reg. 102/94</td>
<td>Waste Audit Summary for solid non-hazardous waste (including quantities generated,</td>
<td>Annually – Provided to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reused/recycled and disposed) and Waste Reduction Work Plan</td>
<td>OPG by Mar. 15</td>
</tr>
<tr>
<td>If OPG is handling, disposing of, or otherwise managing Subject Wastes</td>
<td>O. Reg. 347/12</td>
<td>Providing data on waste classes, approximate quantities to be generated.</td>
<td>Annually – Provided to</td>
</tr>
<tr>
<td>generated by the Contractor (using OPG’s Generator Registration), provide</td>
<td></td>
<td>Provide to OPG copies of all documentation relating to the disposal of hazardous,</td>
<td>OPG by Jan 1</td>
</tr>
<tr>
<td>documentation relating to the disposal of hazardous, subject and</td>
<td></td>
<td>subject and contaminated wastes.</td>
<td>Within 2 working days of</td>
</tr>
<tr>
<td>contaminated wastes.</td>
<td></td>
<td></td>
<td>disposal</td>
</tr>
</tbody>
</table>
Darlington Refurbishment - Chemistry & Environment Metrics

NK38-REP-09701-10185 -R000
2013-05-07

Order Number: N/A
Other Reference Number:

Internal Use Only

Prepared by: Elio Fracalanza
Sr. Advisor (Contract)
Chemistry & Environment
Nuclear Refurbishment

Recommended by: Roger Daly
Manager, Chemistry & Environment
Nuclear Refurbishment

Approved by: Kendra Flagler
Director, Environmental Reporting
Environment

Approved by: Michael Brett
Manager, Chemistry Metallurgy & Welding

Accepted by: Frank Guglielmi
Director, Operations and Maintenance
Nuclear Refurbishment
Table of Contents

Page

Reviewers Listing........................................................................................................................  3
Revision Summary...................................................................................................................... 4

1.0 INTRODUCTION.......................................................................................................... 5

2.0 ASSUMPTIONS........................................................................................................... 5

3.0 PURPOSE.................................................................................................................... 6

4.0 PROPOSED CHEMISTRY AND ENVIRONMENT METRICS............................... 7

5.0 REPORTING FORMAT.............................................................................................. 10

6.0 REPORTING TIMELINE............................................................................................. 11

7.0 DEFINITIONS............................................................................................................. 11
Title: DARLINGTON REFURBISHMENT - CHEMISTRY & ENVIRONMENT METRICS

Reviewers Listing

SME Reviewers

Name: D. Brown
Title: Section Manager
Site: Environment Programs Department

Name: J. Price
Title: Section Manager
Site: DND Chemistry Technical
Revision Summary

<table>
<thead>
<tr>
<th>Revision Number</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>R000</td>
<td>2013-05-07</td>
<td>Initial issue.</td>
</tr>
</tbody>
</table>
1.0 INTRODUCTION

The refurbishment project will require a customized set of Chemistry & Environment metrics and reporting requirements. Metrics have been proposed in this document that meet legal, corporate, external comparison and internal OPG senior management reporting needs. The metrics will assist OPG NR in meeting its responsibilities as the Constructor, along with Vendors supporting OPG NR in fulfilling their role. Also, they will provide valuable data to NR Project Managers to assist with oversight and proof of Vendor capability for managing both Chemistry and Environmental requirements.

Per N-GUID-09701-10013: Nuclear Projects –Environment Requirements Guideline, Nuclear Refurbishment and its Vendors will be required to “track compliance with Environmental Control and Commitments”

Key Environmental metrics include the high impact areas such as spills, radioactive emissions, and Moderate Environmental Events.

For Chemistry, the metrics include familiar measures such as percentage of samples in specification, percentage of samples taken within required intervals, and quality of sample measurement. In addition, some metrics common for chemistry lay-up management have also been incorporated such as systems outside allotted maintenance window, and percentage of systems running exemption free. All of these measures will assist in getting a quick picture of health for both vendors and for OPG oversight.

Vendors will be required to report metrics and performance for their staff working at OPG facilities.

Targets for approved metrics will need to be established year over year for the expected duration of the project. They will be set to reflect industry leading chemistry and environment performance, for refurbishment projects. Targets shall be reviewed annually and adjusted as required.

2.0 ASSUMPTIONS

Environmental Safety is a core value for DN Refurbishment. Both OPG and its Vendors understand that success to the project requires tracking and reporting of metrics. Both OPG and its vendors want DN Refurbishment to achieve industry leading environmental performance.

In addition, protecting the asset with excellent Chemistry Control is a key factor to achieving value for money, as well as enabling plant components and equipment to last another life cycle.
These metrics have been previously established, are simple to apply and can be easily done at minimal cost to the vendor or OPG. Vendors will be asked to report against these metrics.

3.0 PURPOSE

The purpose of this report is to document the Chemistry and Environment metrics for use at DND Nuclear Refurbishment.

The Chemistry and Environment metrics and reporting requirements contained within assist with the purpose of meeting legal requirements, and project management needs.
## 4.0 PROPOSED CHEMISTRY AND ENVIRONMENT METRICS

Chemistry and Environment Surveillance Plan

<table>
<thead>
<tr>
<th>Chemistry Area Surveillance Measures</th>
<th>Description of Measure</th>
<th>Frequency/Venue/Colour Scheme</th>
</tr>
</thead>
</table>
| (1) % samples taken (target >99%)     | Samples taken over samples specified e.g. 25 per/ week required and only 22 taken would yield 22/25 or 88% (Red). | The 5 individual measures listed in the left column will be rolled up into one index called NRCI or Nuclear Refurbishment Chemistry Index. This index would be reported on a weekly basis to senior oversight. The following target values would determine the colour of the NRCI metric:  

- ≥99 Green  
- 95-99 White  
- 90-95 Yellow  
- ≤90 Red  

NRCI should be broken out when reported to show the areas of concern (one of the five areas on the far left of the table) and actions taken with committed dates to rectify. For example if the NRCI is below 99%, say 87% (red) because two systems are without approved exemptions within the allotted time frame, then the action may be on the Central Chemistry Manager to provide the exemption expeditiously and may result in an escalated action. |
| (2) % within specification (target >99%) | For all systems measured in lay-up that are not in the maintenance state, this measure indicates how many of these measured samples (control parameters) were in the correct in-specification range. Weighting factor will double the penalty for boilers since they have to last 2 lifetimes | See above |
# DARLINGON REFURBISHMENT - CHEMISTRY & ENVIRONMENT METRICS

<table>
<thead>
<tr>
<th>Chemistry Area Surveillance Measures</th>
<th>Description of Measure</th>
<th>Frequency/Venue/Colour Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>(3) % of systems running either exemption free or with authorized exemptions as permitted per the OM.</td>
<td>Since goal will be to run without exemptions as much as possible, full marks are given for no exemptions. When an exemption on a system, is required, it is needed within 48 hrs or 7 days depending on the action level. A penalty will be applied for systems not having proper exemptions in place beyond these prescribed periods</td>
<td>See above</td>
</tr>
</tbody>
</table>
| (4) Systems outside allotted maintenance window | For systems where minor maintenance is going on to replace a component, maintenance is generally limited to a 30 day time frame. To encourage not going beyond this time period, a penalty will be applied as a percentage of time beyond the 30 days or beyond the time prescribed in an exemption | Green= 0  
White =1  
Yellow =2  
Red  = 3 |
| (5) Quality of Sampling Technique or Sample Result | If any of the following information is discovered during field observations, then a penalty will need to be applied:  
- Not following either proper sampling or analytical procedures/protocols including failure to perform proper QA/QC prior to reporting results  
- Incorrectly reported sample results | See above |

Total =NRCI  
Nuclear Refurbishment Chemistry Index. Comprised of 5 key sub measures above with an overall target of white with each category equally contributing 20% to the total score
### DARLINGTON REFURBISHMENT - CHEMISTRY & ENVIRONMENT METRICS

<table>
<thead>
<tr>
<th>Environment Area</th>
<th>Description of Measure</th>
<th>Frequency/Venue/Colour Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surveillance Measures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Total # of Spills</td>
<td>Spills targets will be established based on best outage performance balanced with consideration for all work that is planned. Given the requirement for strict compliance to mitigation plans, spills targets are expected to be very tight. Cat A/B (Very Serious/Serious) spills target = 0 Cat C spills having i.e. spills that are not considered “very serious” or “serious” for environmental impact (&lt; 10 /yr but will be adjusted based on a review of risk at the time)</td>
<td>Nuclear Refurbishment Environment index (NREI) could be reported out monthly. A similar colour scheme to the chemistry measures above could be used. If performance is converted to percentage, points could be deducted from full points based on extent of deviation from “target” performance.</td>
</tr>
<tr>
<td></td>
<td>Target for Cat A/B=0 Cat C Spills TBD based on assessed risk at the time Target will be modified based on review of risk at the time. Reductions in points for below target performance will be assessed and applied.</td>
<td></td>
</tr>
<tr>
<td>(2) Emissions</td>
<td>A radioactive Emissions plan will be produced. Keeping emissions down below target levels during both the primary side fill and drain operations at the beginning and near the end of the NR outages, will be challenging. Tight targets are in place to encourage good practices, including recovery of tritium, and good human performance management and oversight during procedure execution to minimize spills risks. Main risk for emissions is expected to be airborne tritium particularly during the Shutdown and Start-up phases. Though all air and water emissions will be will be tracked normally, until systems are drained and emptied, the lead parameters will be airborne tritium, tritium to water and gross activity to water.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Target= emit within the planned release limits. Otherwise: &gt;5% above (-10 pts) white 6-10% above (-15 pts) yellow &gt;10% above (-20 pts) red</td>
<td></td>
</tr>
<tr>
<td>Environment Area Surveillance Measures</td>
<td>Description of Measure</td>
<td>Frequency/Venue/Colour Scheme</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>(3) Moderate Environmental Event (MEE) classified as Infractions</td>
<td>This includes deviations from approved Certificates of Approval, failure to meet CLOCA commitments, MISA infractions, and other infractions as outlined in OPG-PROC-0041 sect 3.</td>
<td></td>
</tr>
<tr>
<td>Target = TBD</td>
<td>Every infraction would result in a specified point deduction for the entire year. For example, if 2 points were deducted for each infraction, it would take 10 infractions to achieve a colour of Red if 80 pts represented Red</td>
<td></td>
</tr>
<tr>
<td>(4) Other Non-Compliance Events</td>
<td>There are events that are considered below the threshold of a Moderate Environmental Event. This would include TDG non-compliances, or improper storage of solid or liquid chemical wastes.</td>
<td></td>
</tr>
<tr>
<td>Target = TBD</td>
<td>Every event would result in a specified point deduction for the entire year. Once 20 points cumulative are deducted, the indicator would go Red</td>
<td></td>
</tr>
<tr>
<td>(5) Low and Intermediate Level Radioactive Waste (LILRW)</td>
<td>Generation of low and intermediate level waste needs to be controlled and minimized. Failure to do so, results in large lifetime costs associated with storage processing and final future disposal</td>
<td></td>
</tr>
<tr>
<td>Target will be set following an assessment of the refurbishment plans.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total= NREI</td>
<td>Nuclear Refurbishment Environmental Index is comprised of the 5 sub-measures above weighted equally and with a target TBD</td>
<td></td>
</tr>
</tbody>
</table>

*The above targets would be cumulative performance across all projects/vendors. The contribution/ targets of each vendor would be set closer to execution when scope and risk of the work is better quantified and number of workers is known.*

### 5.0 REPORTING FORMAT

Currently, Nuclear Refurbishment does not possess an integrated environment performance reporting tool capable of OPG NR and vendor recording, tracking and reporting against the proposed metrics; however, some software tools are under consideration at this time.
6.0 REPORTING TIMELINE

A proposed timeline for the commencement of reporting of Refurbishment Chemistry and Environment Metrics is when OPG assumes the role of Constructor. This is anticipated to be when R&FR Vendor (Aecon) occupies the DEC/TMB in May 2014. As refurbishment vendors begin to occupy OPG facilities and/or refurbishment activities commence they will be added.

7.0 DEFINITIONS

CAT Category
CLOCA Central Lake Ontario Conservation Authority
DEC Darlington Energy Centre
DLM Daily Leadership Meeting
Hazmat Hazardous Materials
HU Human Performance
H&S Health and Safety
MISA Municipal Industrial Strategy for Abatement
NRCI Nuclear Refurbishment Chemistry Index
NREI Nuclear Refurbishment Environment Index
OM Operating Manual
POND Plan of the next Day
QA/QC Quality Assurance/Quality Control
RF&R Re-Tube and Feeder Replacement
SCR Station Condition Record
TBD To Be Determined
TDG Transportation of Dangerous Goods
TMB Training Mock-up Building
NUCLEAR PROJECTS RISK MANAGEMENT PROCESS

Nuclear Projects Risk Management Process

N-MAN-00120-10001-RISK-R001
2012-11-22

Order Number: N/A
Other Reference Number: N/A

Internal Use Only

Reviewed by: N. Smith
Manager, Project Infrastructure
Nuclear Refurbishment

Approved by: G. Rose
Director, Planning and Controls
Nuclear Refurbishment

Approved by: R. Habib
Director, Miscellaneous Projects
Projects & Modifications

© Ontario Power Generation Inc., 2012. This document has been produced and distributed for Ontario Power Generation Inc. purposes only. No part of this document 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 Ontario Power Generation Inc.
NUCLEAR PROJECTS RISK MANAGEMENT PROCESS

Table of Contents

Page

REVISION SUMMARY ............................................................................................................... 3

1.0 DIRECTION.................................................................................................................. 4
1.1 Applicability .................................................................................................................. 4
1.2 Risk Management Overview ......................................................................................... 4

2.0 RISK MANAGEMENT PROCESS ................................................................................ 5
2.1 Risk Management Plan ................................................................................................ . 5
2.2 Risk Identification ......................................................................................................... 6
2.3 Risk Assessment .......................................................................................................... 7
2.4 Risk Response Planning ............................................................................................... 7
2.4.1 Contingency and Management Reserve ....................................................................... 8
2.5 Risk Monitoring and Control ....................................................................................... 8
2.6 Risk Management Lessons Learned ............................................................................. 9

3.0 DEFINITIONS AND ACRONYMS................................................................................. 9
3.1 Definitions ..................................................................................................................... 9
3.2 Abbreviations and Acronyms ..................................................................................... 10

4.0 RECORDS AND REFERENCES.................................................................................. 11
4.1 Records ...................................................................................................................... 11
4.2 References .................................................................................................................. 11
4.2.1 Performance References ....................................................................................... 11
4.2.2 Developmental References .................................................................................. 11

5.0 REVISION SUMMARY ............................................................................................... 11
# NUCLEAR PROJECTS RISK MANAGEMENT PROCESS

## REVISION SUMMARY

<table>
<thead>
<tr>
<th>Revision Number</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>R001</td>
<td>2012-10-30</td>
<td>Updated for alignment with all Nuclear Projects</td>
</tr>
</tbody>
</table>
1.0 DIRECTION

This document is established to provide direction on risk management for Nuclear Projects, ensuring risks are identified, assessed, analyzed for risk response, and monitored to a robust and consistent standard to ensure that project objectives are achieved.

1.1 Applicability

This document is applicable to all Nuclear Projects, and provides direction for their risk management process throughout the project lifecycle. This manual complies with N-STD-AS-0028, Project Management Standard.

1.2 Risk Management Overview

Figure 1 illustrates the key component of an iterative risk management process. Risk management provides projects with forward-looking actions and metrics to reduce the likelihood and minimize the impact of undesirable events during the project life cycle. The goal of risk management is to remove obstacles to project success before they occur in order to minimize their consequential effect on project costs, schedule, quality, and safety targets.

Proactive risk management is used to understand the characteristics of the risk, how to manage them, and plan for contingency based on the residual risks. As such, risk management can have a significant impact on the financial health of the project.

Risk management should be performed with a graded approach. The intent of this approach is to match the level of effort with the impact to safety, cost, schedule and success of the project.
2.0 RISK MANAGEMENT PROCESS

2.1 Risk Management Plan

(a) Projects shall prepare a Risk Management Plan (RMP) as a stand-alone document or as part of an overall Project Management Plan (PMP) to document how risk management will be performed for the project.

(b) This RMP should contain or reference the following elements:

- Project description
- Risk management methodology, including contingency management
- Roles, responsibilities and authority
- Risk management tools
- Thresholds and corresponding definitions
- Risk register Template(s)
- Risk communication plan

(b) RMPs should be revised when:

- Changes are made to the risk management strategy or methodology
- At each request for decision gate approval
2.2 Risk Identification

Risk identification is the process of determining and documenting the risks and their characteristics that can affect the project. It is an iterative process as new risks may be identified throughout the project lifecycle and previously identified risks may not have realized and are closed. The risks must be defined in relation to project objectives and it is important to distinguish a risk from its causes and consequences.

(a) Risks should be identified through:

- Facilitated brainstorming sessions or risk workshops
- Individual project team member or stakeholder input
- A review of experience (OPEX) and lessons learned from other internal and external projects
- Any other relevant techniques or sources (e.g. Delphi technique, checklists, Project Definition Rating Index (PDRI)).

(b) Identified risks should be clearly and unambiguously described, so that they can be understood by those responsible for risk assessment and risk planning. Elements of the risk statement should include a description of the risk event, the consequences of such event occurring, the project objectives impacted, the potential causes of risk realization and expected time period of the risk occurring.

(c) The project risks should be grouped into logical risk categories. This aids in the identification of project risks and the assignment of ownership and serves as a method of grouping of risks for assessment, analysis, monitoring and reporting. This also allows the project to consider related risks that have the potential to produce a greater consequence than the individual risks.

(d) The projects shall document and update risks in a risk register. A risk register is the document containing the results of risk analysis, and risk response planning. The risk register details all identified risks, including description, category, cause, probability of occurring, impact(s) on objectives, proposed responses, owners, and current status. The risk register shall be updated as per the RMP.

(e) A Risk Owner should be identified for each risk, who is accountable to ensure that an appropriate response strategy is selected and implemented.

(f) Each risk shall at a minimum have:

- Risk identification number
- A concise risk title
- Risk category
2.3 Risk Assessment

Risk assessment is carried out to determine the overall probability and consequence of each risk and to improve overall manageability of the risks. Risks can be assessed qualitatively, quantitatively, or both.

Qualitative analysis involves the subjective scoring of probability and consequence against predefined criteria. Quantitative analysis is a numerical analysis of the probability and consequence, and often involves the use of software or other modelling applications (e.g. Monte Carlo Analysis). Quantitative analysis can often provide a confidence level that will enable the project manager to adjust the contingency and schedule float to suit the risk tolerance of the project sponsor or owner.

(a) The predefined criteria for which the risks are evaluated against should include:

- Nuclear Safety
- Health & Safety
- Environmental
- Regulatory/Legal
- Corporate Reputation
- Quality
- Schedule
- Cost

(b) The rationale of probability and consequence assignment (qualitative or quantitatively assignment) should be documented.

(c) The urgency of risks should be documented to assist in risk prioritization.

2.4 Risk Response Planning

Risk Response Planning involves determining the actions to be taken to address the risk identified and assessed. The project may choose to avoid, transfer, mitigate, or to accept the risk.

(a) A risk response must be documented for each risk in the risk register.
NUCLEAR PROJECTS RISK MANAGEMENT PROCESS

(b) For each risk response, the actions required to mitigate, monitor and control the risk must be documented. At a minimum, the risk response plan for each risk should include:

- The actions to minimize the risk probability and/or impact
- *Risk Action Owner*, whose function is to carry out the approved risk response action
- How and when the risk will be monitored or controlled
- Resources required to execute the risk response
- *Residual risk* remaining after execution of the risk response plan
- *Secondary risks* that may be generated by execution of the risk response plan
- Contingent response plan (including resources required) should the response strategy selected be ineffective

(c) Projects shall ensure risk response plan actions are incorporated into the project scope, and be assigned project budget and schedule, as appropriate.

2.4.1 Contingency and Management Reserve

Based on the RMP, project shall identify, assess and record risks in the risk register. After quantitative and qualitative risk analysis and development of the risk response plans, *contingency* shall be developed based on the *residual risks* of the updated risk register.

*Contingency* is defined as the amount of funds or time needed above the estimate, to address *residual risks* that may materialize. This is to reduce the risk of overruns of project objectives to a level acceptable to the organization. *Contingency* determination is a part of the risk management process and is calculated using the applicable tools.

*Management reserve* is added over and above *contingency* reserves, and is usually controlled at a portfolio or program level. *Management reserve* is similar to *contingency*, but is used to account for “unknown-unknowns” in a project, including, but not limited to major estimating or scheduling errors and natural disasters. *Management reserve* should not be used to cover scope changes, but only to ensure predictability.

2.5 Risk Monitoring and Control

Risk monitoring is essential as projects are dynamic and project risks will evolve over time. Risk monitoring and control involves the tracking of identified risk, monitoring of *residual risks*, identification of new risks, monitoring the execution of risk response
NUCLEAR PROJECTS RISK MANAGEMENT PROCESS

plans and evaluation of risk response effectiveness. *Contingency* reserves should also be periodically monitored.

(a) Projects should review the project risks and update the risk register to document any changes and new risks as per the RMP.

(b) It is recommended that risks are not deleted from the risk register. If a risk is deemed to be irrelevant, the risk should be statused as “Closed”. Risks can be closed (and the rationale documented) for any of the following reasons:

(1) Risk matured, the expected time for risk realization has passed.

(2) The *risk trigger* does not exist anymore and there is no other risks related to this condition.

(c) Projects should prioritize the project risks, and communicate any changes to project stakeholders, including risks that have been triggered or a risk that has increased significantly in *probability*.

2.6 Risk Management Lessons Learned

(a) The project manager should conduct a risk management lessons learned as a part of the project lessons learned process (e.g. the end of the first unit of a multi-unit project). The evaluation should include the review of:

- Effectiveness of the risk management process
- Effectiveness of the risk response plans, including *contingency*
- Effectiveness of the risk monitoring and control process

3.0 DEFINITIONS AND ACRONYMS

3.1 Definitions

*Accept* is one of the risk responses, whereby the project team is not going to take any specific action to *transfer*, mitigate, or *avoid* the risk. This strategy is used when the impact is low or the cost to mitigate or *avoid* the risk exceeds the cost to rectify the impact of the realized risk, or if the risk is not easily managed.

*Avoid* is one of the risk responses that eliminates of the risk entirely by selecting alternatives, designs, methods that do not expose the project to the risk at all.

*Consequence* is the effect or impact on a project objective if a risk occurs. It can be expressed numerically or stated qualitatively. The effect may be in any of the following areas: Cost, Schedule, Quality, Corporate Reputation, Regulatory/Legal, Health and Safety, Quality, Nuclear Safety and Environment.
**Contingency** is the amount of funds, budget, or time needed above the estimate to address residual risks that may materialize and thus reducing the risk of overruns of project objectives to a level acceptable to the organization. Contingency reserves are usually set aside to address known and identified residual risks.

**Management Reserve** is added over and above contingency reserves used to account for “unknown-unknowns” in a project, including, but not limited to major estimating or scheduling errors and natural disasters.

**Probability** is the likelihood of a risk event occurring. It can be expressed qualitatively or numerically as probability (rate of an event expressed as a fraction of the total number of events) or as frequency (the rate at which events occur over time).

**Residual Risk** is the risk remaining after the mitigation actions in the risk response plan have been executed. The probability and impact of the risk may have been reduced but not completely eliminated, thus may still materialize.

**Risk Action Owner**, is the individual assigned to carry out the approved risk action for responding to a given risk.

**Risk Owner** is the individual assigned to be accountable for ensuring that an appropriate response strategy is selected and implemented, and for determining suitable risk actions to implement the chosen strategy.

**Risk Trigger** is an event or indicators that specify when a risk is imminent and that mitigation needs to be taken.

**Secondary Risk** is a new risk that may be generated as a result of executing the risk response plan.

**Transfer** is the risk response involving the shifting of some or all of the negative impacts, along with ownership of the response, to a third party. Transferring simply gives another party the responsibility for management of the risk – it does not eliminate the risk.

### 3.2 Abbreviations and Acronyms

- **OPEX** - Operational Experience
- **PDRI** - Project Definition Rating Index
- **PMP** - Project Management Plan
- **RMP** - Risk Management Plan
4.0 RECORDS AND REFERENCES

4.1 Records

Any controlled documents which may be produced as a result of this document should be managed in accordance with N-PROC-AS-0003, Controlled Document Management.

Any records which may be produced as a result of this document should be managed in accordance with N-PROC-AS-0042, Records and Document Management. The following records may be generated by use of this document and shall be registered in the appropriate document managed system in accordance with the following table.

<table>
<thead>
<tr>
<th>Record Created</th>
<th>Associated Form Number</th>
<th>QA Record?</th>
<th>Filing Information/Retention (Asset Suite) Type/Sub Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Internal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Assessment Reports</td>
<td>N-TMP-10010</td>
<td>N</td>
<td>Indexed in Asset Suite Controlled Document N-REP-SCI-xxxxx Retention T20</td>
</tr>
</tbody>
</table>

4.2 References

4.2.1 Performance References

- N-STD-AS-0028, Project Management Standard

4.2.2 Developmental References

- Project Management Body of Knowledge (PMBok) 4th edition by PMI
- Practice Standard for Project Risk Management by PMI

5.0 REVISION SUMMARY

- This is an intent revision
- This document was revised to align work processes for all Nuclear Projects
LOW Interrogatory #005

Ref: Darlington Nuclear Refurbishment and Continued Operation Environmental Assessment Follow-up Program.

Issue Number: 4.9
Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project) appropriate?

Interrogatory
For each of the following studies described in the Follow-up Program:

(a) 2.1 Program Element 1: Effluent Characterization Program
(b) 2.2 Program Element 2: Stormwater Control Study
(c) 2.3 Program Element 3: Thermal Monitoring Program
(d) 2.4 Program Element 4: Entrainment and Impingement Mortality Monitoring

Please address the following:

(e) Has OPG begun to implement the Program?
(f) Please provide a detailed budget of expenses expected to implement the Program.

Response

The follow-up monitoring program consists of program elements which are executed at various stages of the refurbishment project. OPG’s approach to conducting the environmental studies identified in program elements 2.1, 2.2, 2.3 and 2.4 is to confirm its understanding of the objectives and targets, develop sampling plans, obtain regulatory acceptance of the plans and then execute and report on the studies. The studies will confirm if the environmental effects are as predicted in the EA and whether the proposed mitigation measures are effective, and determine if new mitigation strategies are required.

In most instances the data required to support these studies are collected over multiple periods and during various station configurations. To date OPG has confirmed its understanding of the objectives and targets for most of these program elements with the Canadian Nuclear Safety Commission (“CNSC”) and Environment Canada (“EC”) and have begun developing sampling plans which will be submitted to the CNSC for approval. Following the approved schedule, the first sampling campaign will be for program element 2.1 which is slated to commence in 2015. The budget for each of these studies is provided in the response to LOW Interrogatory # 001 (Ex. L-4.9-12 LOW-001).
**LOW Interrogatory #006**

Ref: Darlington Nuclear Refurbishment and Continued Operation Environmental Assessment Follow-up Program.

**Issue Number:** 4.9

**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Project) appropriate?

**Interrogatory**

For the impingement and entrainment monitoring under part of Program Element 4:

(a) What compensatory mechanisms will OPG pursue to offset biota and habitat losses resulting from DNGS operations?

(b) Please provide a detailed budget of expenses related to these compensatory measures.

**Response**

The compensatory mechanisms to provide offsets for biota losses due to impingement and entrainment from DNGS operations are currently being assessed and will be included in the submission for the Fisheries Act authorization. Detailed budget of expenses will not be available until after the application is approved by Fisheries and Oceans Canada ("DFO"). There are no habitat losses resulting from DNGS operations.
LOW Interrogatory #007

Ref: Darlington Nuclear Refurbishment and Continued Operation Environmental Assessment

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project) appropriate?

Interrogatory

Please provide a detailed budget of expenses related to planning and implementing adaptive management programs during the test period and continuing operation of the DNGS.

Response

The environmental risk assessment process as defined in CSA N288.6, Environmental Risk Assessment (“ERA”) informs the environment monitoring program that applies to current DNGS operations. The environmental risk assessment process includes adaptive management.

In the Follow-up Program for the environmental assessment of the Darlington NGS refurbishment and continued operations, OPG commits to planning and implementing a program of environmental effects monitoring that targets confirmation of the results of the environmental assessment. The monitoring programs include effluent monitoring, storm water monitoring, cooling water monitoring.

Should the results of these monitoring programs exceed established thresholds, OPG will investigate whether additional confirmatory monitoring is required and review mitigation options to determine if additional technically and economically feasible opportunities are available to further reduce the potential effects.

Budgets are established as part of the annual business planning process where new requirements are identified. As additional monitoring or mitigation measures are defined, budgets will be developed and approved to support work program activities.
LOW Interrogatory #008

Ref: Canadian Nuclear Safety Commission, Record of Proceedings Including Reasons for Decision, Environmental Assessment Screening, Darlington Refurbishment

Issue Number: 4.9
Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project) appropriate?

Interrogatory

Paragraph 43 referenced a Best Available Technology Economically Achievable (BATEA) study drafted by OPG and reviewed by Canadian Nuclear Safety Commission staff and the Department of Fisheries and Oceans (DFO). Please provide a copy of this study.

Response

Attached is a copy of NK054-REP-01210-00093, R002, “Condenser Cooling Water Option Assessment Report – OPG Darlington New Nuclear Project”, January 31, 2013 (Attachment 1). Also attached is the correspondence from CNSC staff, “OPG Decision on the Condenser Cooling Water Option for the Darlington New Nuclear Project,” dated March 28, 2013 [NK054-CORR-00531-00253] (Attachment 2), in which they conclude that there are no fundamental barriers to licensing a once through cooling water system subject to certain conditions being achieved.

These documents were previously made publicly available by OPG on its internet site.
# Condenser Cooling Water Option Assessment Report - OPG Darlington New Nuclear Project

**Title:** CONDENSER COOLING WATER OPTION ASSESSMENT REPORT - OPG DARLINGTON NEW NUCLEAR PROJECT

© Ontario Power Generation Inc., 2013. This document has been produced and distributed for Ontario Power Generation Inc. purposes only. No part of this document 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 Ontario Power Generation Inc.

## Condenser Cooling Water Option Assessment Report - OPG Darlington New Nuclear Project

**Document Number:** NK054-REP-01210-00093-R002

**Date:** 2013-01-31

**Project ID:** 10-27600  
**Order Number:** N/A  
**Other Reference Number:** N/A

**Internal Use Only**

---

**Prepared by:** [See Attached]  
**Reviewed by:**  
Kristy Mohan  
Technical Engineer/Officer  
Darlington New Nuclear

**Accepted by:**  
Don Williams  
Senior Manager, Design Review  
Darlington New Nuclear

---

Associated with REP

N-TMP-10179-R002 (Microsoft® 2007)
Condenser Cooling Water Option Assessment Report

OPG Darlington New Nuclear Project

D0077/RP/001 R00

OPG Ref. NK054-REP-01210-00093 R02

January 29, 2013

Prepared by:
Mark Gerchikov
Manager
Environment and Radioactive Waste Management
AMEC NSS

Verified by:
Damien Moule
Associate Analyst
Refurbishment and New Build Support
AMEC NSS

Reviewed by:
Stan Harvey
Senior Advisor
Technical Support Services
AMEC NSS

Approved by:
Ronald Henry
Director
Site Implementation Services
AMEC NSS

AMEC NSS Limited
Form 114 R03
Revision Summary

<table>
<thead>
<tr>
<th>Rev</th>
<th>Date</th>
<th>Author</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>R00</td>
<td>January 2013</td>
<td>M. Gerchikov</td>
<td>Updated report D0061/RP/003/R01 to address CNSC, MOE and DFO comments</td>
</tr>
</tbody>
</table>

Copyright and Intellectual Property Notice 2012.

This document has been produced by AMEC NSS Limited under an Agreement with the client(s).

Rights of copying and of ownership and use of the intellectual property in or embedded in this document are solely determined by the terms of this Agreement.

No part of this document shall be used, 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) other than in accordance with and subject to such Agreement.

If you are not the intended recipient please notify the Contracts Manager, AMEC NSS, (416) 592 4094 or return by post to AMEC NSS Limited, 700 University Avenue H4, Toronto, Ontario M5G 1X6.
Executive Summary

AMEC has performed an evaluation of the condenser cooling options for the Darlington New Nuclear Project (DNNP) in response to the Joint Review Panel (JRP) recommendations using the Best Available Technology Economically Achievable (BATEA) approach. BATEA is a formalized, comprehensive decision-making technique for selecting the best technology to minimize negative environmental impact within reasonable costs. This report presents the BATEA methodology and its application to determine the preferred condenser cooling option for the DNNP.

The BATEA option assessment methodology presented in this report is based on a multi-attribute assessment approach. It was selected as the most appropriate on the basis of a comprehensive review of Canadian and international guidelines, as well as a number of recent studies of a similar nature. The methodology is comprised of the following ten steps:

1. Define objectives,
2. Identify technologies,
3. Identify attributes,
4. Define scoring scheme,
5. Evaluate options,
6. Define "key" attributes,
7. Repeat evaluation for enhanced design,
8. Select initial BATEA,
9. Consult stakeholders, and
10. Select the final BATEA.

The following two condenser cooling technologies were evaluated based on the previous Environmental Assessment (EA) analysis and the subsequent recommendations of the JRP:

- Once Through Cooling (OTC), and
- Mechanical Draft Cooling Towers (MDCT)\(^1\).

All effects were evaluated for the cooling technology, excluding impacts from the power block so that the net effects from OTC and MDCT could be compared and contrasted against each other. The assessment was conducted for two sets of conceptual designs: before and after enhancements. The latter included a number of cost-effective enhancements developed to mitigate potential environmental impacts related to the key attributes. From this evaluation of the enhanced designs, OTC is recognized as the better performing option in the following areas:

\(^1\) Plume abatement is assessed as a design enhancement.
• **Visual Effect**
  
  OTC - No visual impact.
  
  MDCT – Visual plume impact extending up to 3.5 km off site and occurring 46% of the time in winter as well as 3-15% of the time during other seasons.

• **Local Climate Change**
  
  OTC - No risk of occasional fogging and icing off-site.
  
  MDCT – Occasional off-site icing and fogging.

• **Terrestrial Habitat**
  
  OTC - Bank Swallow habitat will not be affected by the condenser cooling system².
  
  MDCT – On-site Bank Swallow habitat will be completely eliminated.

• **Excavated Materials**
  
  OTC - Minimal excavation; no off-site soil management is required.
  
  MDCT – Additional excavation, resulting in significant off-site traffic during construction.

For the MDCT option, the above impacts are only partially mitigated with design enhancements. The residual differences in option performance for these attributes are significant.

It was recognized that there are several attributes, relating to potential impacts on fish, for which the MDCT design performs better. However, the assessment demonstrated that the difference in performance between the two options for these factors is minimal. This difference does not compensate for the better environmental performance of the OTC system for the following reasons:

• **Fish Impingement**
  
  Current DNGS OTC intake design is performing well and there would be an additional reduction in fish impingement due to the proposed design enhancements. It is estimated that impingement would be reduced by over 90% compared to the baseline³. This is comparable to the performance of a MDCT intake.

• **Fish Entrainment**
  
  Fish entrainment would also be reduced by enhancements to the DNGS intake design, which is also performing well to minimize entrainment. It is conservatively estimated that the enhanced intake design will reduce entrainment by over 60% compared to baseline².

---

² Approximately 20% of the Bank Swallow habitat will be affected by the reactor block footprint regardless of the condenser cooling system choice.

³ Baseline is defined as the quantity of fish, larvae and eggs impinged or entrained by withdrawing water from Lake Ontario at the rate required for a Once Through Cooling system assuming a shoreline intake with no mitigation measures in place.
The dominant fish species whose eggs and larvae could be entrained are represented throughout Lake Ontario. The quantity of potential entrainment for these species would only be a small fraction of their overall population. The exception is Round Whitefish whose population is more concentrated along the north shore of Lake Ontario. Entrainment of Round Whitefish eggs and larvae would be expected to be reduced further as described below.

- **Reduction of the intake approach velocity to 6 cm/s (larval fish as small as 3.8 mm can attain avoidance burst speeds of 6 cm/s, juvenile and adult fish can achieve speeds well above this velocity), and**
- **Placement of intake based on additional surveys of fish habitats. It is expected that the intake can go deeper than 10m to avoid habitats at which Round Whitefish eggs and larvae are typically found but not so deep as to impact the Sculpin habitat.**

**Thermal Discharge to Lake**

As demonstrated by operating experience at Darlington Nuclear Generating Station (DNGS), the current diffuser design is performing well and the resulting thermal discharge does not result in adverse effects on aquatic species.

While it is recognized that both cooling technologies are acceptable as neither option would result in environmental consequences that exceed regulatory limits, the OTC option is considerably less expensive. The OTC design with an enhanced intake was estimated to cost $543M while the MDCT design with plume abatement was nearly triple the cost at $1,412M. These costs include loss of Net Present Value of Power Generation Revenue Costs for the life of the project.

Option performance for the non-key attributes further supports selection of the OTC as the preferred option. This is because the OTC option does not involve use of chemicals, consumes less water and has smaller aquatic habitat footprint. The OTC option also has slight technical performance advantage as there is little experience with plume abatement in the nuclear industry.

Consideration of other factors either provides further support for selecting the OTC as the preferred option or has no impact on selection. In particular:

- Both options can be implemented in such a manner that public and worker health and safety are maintained.
- Although space utilization remains dependent on the reactor technology selected and efforts to optimize site layout, use of the MDCT in combination with the reduction of the lake infill to the 2m depth mark, will likely constrain the total number of units that could fit onto the site.
- Both technologies could be impacted by future environmental changes. The OTC is more susceptible to changes in the aquatic environment and ambient water temperature while the MDCT technology would be impacted by increases in air temperature as well as frequency and intensity of extreme weather events.
- The OTC option was strongly favoured by local stakeholders.
Selection of the BATEA cooling option was made following a systematic quantitative evaluation of each option's performance against a comprehensive set of attributes. In accordance with the best international practice, this selection was based on determining major discriminating factors, as summarized above, and analyzing the underlying reasons for the differences rather than using aggregated weighted scores as the basis for the decision.

The systematic assessment documented in this report concludes that Once Through Cooling is the Best Available Technology Economically Achievable for the DNNP. Sensitivity analysis demonstrates that this is a robust finding. It is also consistent with recent international guidance and experience in identifying cooling strategies for plants adjacent to large water bodies. The selected BATEA is recommended for consideration by OPG as the basis for the decision on condenser cooling system for the DNNP. OPG will use this information to make the final decision on condenser cooling technology in accordance with their mandate, corporate values and interests.
Acknowledgements

The author would like to thank OPG, Paul Patrick (SENES Consultants) and the following AMEC NSS staff for their contribution to this project and technical report: Irvin Benovich, Caitlin O’Grady, Joshua Guin, Jeremy McEachern and Jimin Peng.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOSSARY</td>
<td>15</td>
</tr>
<tr>
<td>ACRONYMS</td>
<td>17</td>
</tr>
<tr>
<td>1.0 INTRODUCTION</td>
<td>19</td>
</tr>
<tr>
<td>1.1 Background</td>
<td>19</td>
</tr>
<tr>
<td>1.2 Structure of the report</td>
<td>20</td>
</tr>
<tr>
<td>2.0 OVERVIEW OF BATEA AND EQUIVALENT METHODOLOGIES</td>
<td>22</td>
</tr>
<tr>
<td>2.1 Review of the Key Features of BATEA and Similar Studies</td>
<td>22</td>
</tr>
<tr>
<td>2.2 Summary of the Applicable Methodologies</td>
<td>26</td>
</tr>
<tr>
<td>2.3 Recent Developments in Selection of Cooling Systems in Europe and US</td>
<td>27</td>
</tr>
<tr>
<td>2.4 Most Relevant Current Guidance</td>
<td>27</td>
</tr>
<tr>
<td>3.0 OVERVIEW OF SIMILAR STUDIES</td>
<td>29</td>
</tr>
<tr>
<td>3.1 Hinkley Point, UK, 2011</td>
<td>29</td>
</tr>
<tr>
<td>3.2 Oldbury Study, UK, 2009</td>
<td>31</td>
</tr>
<tr>
<td>3.3 Nine Mile Point EIS, USA, 2008</td>
<td>33</td>
</tr>
<tr>
<td>3.4 Oak Creek-Elm Road Study, USA, 2008</td>
<td>35</td>
</tr>
<tr>
<td>3.5 North Anna, USA, 2006</td>
<td>37</td>
</tr>
<tr>
<td>3.6 Indian Point Study, USA, 2010</td>
<td>39</td>
</tr>
<tr>
<td>3.7 Review summary</td>
<td>41</td>
</tr>
<tr>
<td>4.0 DNNP CONDENSER COOLING WATER BATEA METHODOLOGY</td>
<td>44</td>
</tr>
<tr>
<td>4.1 Ten Assessment Steps</td>
<td>44</td>
</tr>
<tr>
<td>4.2 How Assessment Methodology Addresses JRP Concerns on Methodology</td>
<td>48</td>
</tr>
<tr>
<td>5.0 DEFINITION OF OBJECTIVES, TECHNOLOGIES AND EVALUATION SCORING SCHEME</td>
<td>49</td>
</tr>
<tr>
<td>5.1 Step 1 – Definition of the Objective</td>
<td>49</td>
</tr>
<tr>
<td>5.2 Step 2 - Identification of Cooling Technologies (Without Enhancements)</td>
<td>49</td>
</tr>
<tr>
<td>5.2.1 Once Through Cooling System</td>
<td>49</td>
</tr>
<tr>
<td>5.2.2 Mechanical Draft Cooling Tower</td>
<td>50</td>
</tr>
<tr>
<td>5.2.3 Assumptions</td>
<td>50</td>
</tr>
<tr>
<td>5.2.4 Site Layout and Excavation Assumptions - Reactor Block Baseline</td>
<td>51</td>
</tr>
<tr>
<td>5.3 Step 3 - Identification of Attributes</td>
<td>52</td>
</tr>
<tr>
<td>5.4 Step 4 - Definition of Scoring Scheme</td>
<td>54</td>
</tr>
<tr>
<td>5.4.1 Public Health and Safety</td>
<td>55</td>
</tr>
<tr>
<td>5.4.2 Worker Health and Safety</td>
<td>57</td>
</tr>
</tbody>
</table>
6.0 OPTION EVALUATION

6.1 Step 5 – Initial Evaluation of Cooling Options (Stage 1)

6.1.1 Evaluation Procedure

6.1.2 Evaluation Summary

6.1.2.1 Risks to Public Health and Safety

6.1.2.2 Risks to Worker Health and Safety

6.1.2.3 Water Quality/Emission to Water

6.1.2.4 Air Quality/Emission to Air

6.1.2.5 Noise Level

6.1.2.6 Water Consumption

6.1.2.7 Local Climate Change

6.1.2.8 Visual Effect

6.1.2.9 Excavated Materials

6.1.2.10 Fish Impingement

6.1.2.11 Fish Entrainment

6.1.2.12 Thermal Discharge to Lake

6.1.2.13 Aquatic Habitat

6.1.2.14 Terrestrial Habitat

6.1.2.15 Technical Performance

6.1.2.16 Cost

6.2 Step 6 – Definition of the “Key” Attributes

6.3 Step 7 – Evaluation of Enhanced Designs (Stage 2)

6.3.1 Evaluation Procedure

6.3.2 Identification of Design Enhancements

6.3.2.1 Noise Abatement

6.3.2.2 Plume Abatement

6.3.2.3 Intake Enhancement

6.3.2.4 Outfall Enhancement
6.3.2.5 Use of Larger Trucks ........................................................................................................ 100
6.3.2.6 Other Considered Enhancements .......................................................................................... 101
6.3.3 Evaluation of DNNP Condenser Cooling Options with Enhancements ................................ 103
6.3.3.1 Risks to Public Health and Safety ....................................................................................... 103
6.3.3.2 Risks to Worker Health and Safety ...................................................................................... 104
6.3.3.3 Water Quality/Emission to Water ......................................................................................... 104
6.3.3.4 Air Quality/Emission to Air .................................................................................................. 105
6.3.3.5 Noise Level ......................................................................................................................... 106
6.3.3.6 Water Consumption ........................................................................................................... 106
6.3.3.7 Local Climate Change ......................................................................................................... 107
6.3.3.8 Visual Effects ...................................................................................................................... 107
6.3.3.9 Excavated Materials ............................................................................................................ 108
6.3.3.10 Fish Impingement .............................................................................................................. 109
6.3.3.11 Fish Entrainment ............................................................................................................... 111
6.3.3.12 Thermal Discharge to Lake ............................................................................................... 112
6.3.3.13 Aquatic Habitat ................................................................................................................ 113
6.3.3.14 Terrestrial Habitat ............................................................................................................ 113
6.3.3.15 Technical Performance ...................................................................................................... 114
6.3.3.16 Cost .................................................................................................................................... 114
6.4 Adaptability to Future Changes ................................................................................................. 117
6.4.1 Potential Changes .................................................................................................................. 117
6.4.1.1 Climate Changes ................................................................................................................ 117
6.4.1.2 Changes in Aquatic Populations in Lake Ontario .............................................................. 118
6.4.1.3 Changes in Regulatory Requirements ................................................................................ 118
6.4.2 Adaptable of the Cooling Options ......................................................................................... 119
6.4.3 Costs for Various Mitigations ................................................................................................. 119
6.4.4 Summary ................................................................................................................................. 120

7.0 STEP 8 - INITIAL SELECTION OF THE BATEA FOR DNNP CONDENSER COOLING ......................................................................................................................... 124

8.0 STEP 9 –STAKEHOLDER CONSULTATION .................................................................................. 125

9.0 STEP 10 - FINAL SELECTION OF THE BATEA FOR DNNP CONDENSER COOLING ................................................................................................................................. 128

10.0 UNCERTAINTY AND SENSITIVITY ANALYSIS .................................................................... 132
10.1 Option design uncertainty ......................................................................................................... 132
10.2 Uncertainty in Selection of Evaluation Attributes ...................................................................... 136
10.3 Uncertainty in Evaluation of Options’ Performance .................................................................. 137
10.4 Uncertainties in Attribute Importance ....................................................................................... 138
10.5 Uncertainties Due to Potential Changes in the Environment or Regulatory Changes .................. 139

11.0 CONCLUSIONS .......................................................................................................................... 140
# REFERENCES

APPENDIX A: OVERVIEW OF BATEA EQUIVALENT METHODOLOGY IN OTHER JURISDICTIONS

APPENDIX B: DESCRIPTION OF THE TWO COOLING OPTIONS SUBJECT TO BATEA ASSESSMENT

APPENDIX C: LINKAGE BETWEEN JRP RECOMMENDATIONS AND ATTRIBUTES SELECTED

APPENDIX D: THE RATIONALE FOR EXCLUSION OF SOME ASPECTS

APPENDIX E: ATTRIBUTES USED IN OTHER REFERENCE STUDIES

APPENDIX F: PNGS FISH BARRIER STUDY, CANADA, 2009

APPENDIX G: ATTRIBUTE EVALUATION SHEETS

APPENDIX H: BASELINE DESIGN PARAMETER SET

APPENDIX I: DESIGN ENHANCEMENTS

APPENDIX J: ENHANCED DESIGN PARAMETER SET

APPENDIX K: EVALUATION ALTERATIONS FROM STAKEHOLDER SESSIONS

APPENDIX L: EA PUBLIC PERCEPTION
LIST OF TABLES AND FIGURES

Table 1: Summary of Three Key Methodologies Contributed to the Proposed Approach...........26
Table 2: Methodologies Used in Similar Studies .................................................................42
Figure 1: Location of Hinkley Point A and B .................................................................29
Figure 2: Location of Oldbury Nuclear Power Station ....................................................32
Figure 3: Location of Nine Mile Point Nuclear Station ....................................................34
Figure 4: Location of Oak Creek Power Plant .................................................................36
Figure 5: Location of Dominion Nuclear North Anna .......................................................38
Figure 6: Location of Indian Point Energy Center ..........................................................40
Figure 7: Assessment Steps ...........................................................................................44
Figure 8: DNNP Site Layout ..........................................................................................52
Table 3: Attributes Considered for Evaluation of the Two Cooling Options ......................54
Table 4: Likelihood and Severity of Risks (Public) ........................................................56
Table 5: Chart Illustrating Risks .....................................................................................57
Table 6: Scoring Scheme for Risks to Public Health and Safety ......................................58
Table 7: Likelihood and Severity of Risks (Workers) ....................................................58
Table 8: Scoring Scheme for Worker Health and Safety ..............................................59
Table 9: Scoring Scheme for Water Quality/Emission to Water ....................................60
Table 10: Scoring Scheme for Air Quality/Emissions to Air .........................................60
Table 11: Scoring Scheme for Noise Level ....................................................................61
Table 12: Scoring Scheme for Water Consumption .....................................................62
Table 13: Scoring Scheme for Local Climate Change ...................................................63
Table 14: Scoring Scheme for Visual Effect ....................................................................64
Table 15: Scoring Scheme for Excavated Materials ......................................................65
Table 16: Scoring Scheme for Fish Impingement ..........................................................68
Table 17: Scoring Scheme for Fish Entrainment ...........................................................69
Table 18: Scoring Scheme for Thermal Discharge to Lake ..............................................70
Table 19: Scoring Scheme for Aquatic Habitat .............................................................71
Table 20: Scoring Scheme for Terrestrial Habitat .........................................................72
Table 21: Scoring Scheme for Technical Performance ..................................................73
Table 22: Evaluation Results of the Stage 1 and Stage 2 Assessment (4 Units) ....................116
Table 23: Potential Future Changes, Impacts on Two Cooling Options and Mitigation Measures ..................................................................................................................................................................................121
Table 24: Estimated Order-of-Magnitude Costs for Additional Mitigation Measures ..........123
Table 25: Key Attribute Evaluation Summary (enhanced)* ............................................128
Table 26: Sensitivity of Attribute Scores to Heat Rejection (enhanced) .........................134
Table 27: Sensitivity to Selection of Enhancements .....................................................135
Table 28: Sensitivity of Attribute Scores to Evaluation Uncertainties (enhanced)* ..............137
Figure B-1: Schematic of the Circulating Water System at Darlington Nuclear Generating Station (Adapted from [2]) ..........................................................153
Figure B-2: Schematic of a Cooling Tower Circulating Water Chemical Conditioning System (Adapted from [2]) ..........................................................156
Table C-1: Linkage Between JRP Recommendation and the Attributes Used for the BATEA Assessment of Condenser Cooling Technology ..................................................158
Table D-1: Rationale for Exclusion of Some Aspects from the Final Attribute List ..........181
Table E-1: Attributes Used in Other Reference Studies ..................................................185
Figure G-1: Estimated Plume Concentration for Cooling Tower Option .......................216
Table G-1: Ambient Air Quality Criteria .............................................................................. 219
Table G-2: Chemical Usage for Circulating Water Chemical Conditioning (Section 3.11 [2]) .. 221
Figure G-2: Receptor Locations (Section 5.4 [54]) ............................................................. 221
Table G-3: Receptor Locations for Residents Surrounding DNGS and DNNP (Section 5.4 [54]) ..................................................................................................................... 222
Table G-4: Predicted Emission Rates - Ranged Percentage Increase from Overall DNNP – No Cooling Towers (Section 6.2.5 [54]) ................................................................ 222
Table G-5: Predicted Maximum 24-Hour and Annual Maximum Percentage Increase of Particulates Over Background – Overall DNNP Site with Cooling Towers during Operational Phase [54] .............................................................................................................. 223
Table G-6: Predicted Emission Concentration Increments for Cooling Towers [54] ........... 224
Table G-7: Sensitivity Scoring for Cooling Towers .............................................................. 224
Table G-8: Predicted 24-Hour and Annual SPM Concentrations at the Nearest Residential Receptors During Operational Phase – Overall DNNP Site (Section 6.2.2 [54]) .... 225
Table G-9: Predicted 24-Hour and Annual PM10 Concentrations at the Nearest Residential Receptors During Operational Phase – Overall DNNP Site (Section 6.2.2 [54]) ..... 226
Table G-10: Predicted 24-Hour and Annual PM2.5 Concentrations at the Nearest Residential Receptors During Operational Phase – Overall DNNP Site (Section 6.2.4 [54]) .... 226
Table G-11: Minimum Sound Level Limits by Time of Day – Stationary Sources (Section 3.2 [54]) .............................................................................................................. 228
Table G-12: Applying Recommended Sound Level Limits to Residential Land Use Developments ..................................................................................................................... 229
Figure G-3: Receptor Locations (Section 5.4 [54]) ............................................................. 230
Table G-13: Off-Site Receptor Locations ............................................................................ 231
Figure G-4: Minimum One-Hour Daytime Sound Levels - Stationary Sources During Operation ..................................................................................................................... 233
Table G-14: One-Hour Equivalent Sound Level Due to Stationary Sources: 2026-Full Operation with Cooling Towers (Table G.1-2 [54]) ........................................................... 234
Table G-15: Summary of Sound Level Effects for Stationary and Non-Stationary Sources in Maximum One-Hour Timeframe – Cooling Towers (Table 6.4-1 [54]) .......... 235
Table G-16: Sensitivity Scoring for Cooling Towers ............................................................. 236
Figure G-5: Predicted Annual Hours of Fogging for Mechanical Draft Cooling Towers – Linear Configuration (Section E.3.1 [54]) ................................................................. 245
Figure G-6: Predicted Annual Hours of Icing for Mechanical Draft Cooling Towers – Linear Configuration (Section E.3.2 [54]) ................................................................. 246
Table G-17: Mechanical Draft Cooling Tower Vapour Plume Scenarios (Section 3.2.1.2 [33]) 251
Table G-18: Visible Plume Frequency - Mechanical Draft Cooling Tower Comparison (Presentation Page 4 [71]) .......................................................................................... 251
Figure G-7: Views from Potentially Sensitive Locations in Bowmanville - Within 3 km of the DN Site Property (Figure 4.3-7 [33]) ................................................................. 252
Figure G-8: Views from Key Transport Corridors in the Local and Regional Study Areas – 4.5 km away from DN site Property (Figure 4.3-12 [33]) ......................................... 252
Figure G-9: Views from Key Locations in the Local and Regional Study Areas – Greater than 10 km Away from DN Site Property (Figure 4.3-10 [33]) .............................. 253
Figure G-10: Views from Lake Ontario and Lake Ontario Waterfront – Location is over 10 km from DN Site Property (Figure 4.3-17 [33]) ................................................. 253
Table G-19: Uncertainty Scoring for Mechanical Draft Cooling Tower .............................. 254
Table G-20: Mechanical Draft Cooling Tower Vapour Plume Scenarios (Enclosure 2, Table 3 [71]) .............................................................................................................. 255
Table G-21: Visible Plume Frequency - Mechanical Draft Cooling Tower Comparison (Presentation Page 4 [71]) ...................................................................................... 255
Table G-22: Mechanical Draft Cooling Tower Dimension [71] ................................................................................................................................. 256
Figure G-11: Views from Potentially Sensitive Locations in Bowmanville - Within 3 km of the DN Site Property (Figure 3.1-1 [71]) ................................................................................................. 257
Figure G-12: Views from Key Transport Corridors in the Local and Regional Study Areas – 4.5 km away from DN Site Property (Figure 3.1-6 [71]) ........................................................................ 257
Figure G-13: Views from Key Locations in the Local and Regional Study Areas – Greater than 10 km away from DN Site Property (Figure 3.1-4 [71]) ...................................................... 258
Figure G-14: Views from Lake Ontario and Lake Ontario Waterfront – Location is over 10 km from DN Site Property (Figure 3.1-11 [71]) ................................................................. 258
Figure G-15: DNNP Site Layout and Reactor Block Baseline ................................................................................................................................. 264
Figure G-16: Depth Distribution of Larvae at DNGS (Section 2.1.1.2 [24]) ................................................................................................................................. 276
Figure G-17: Proposed Mixing Zone - Maximum Extent of Exposure within the Mixing Zone [37] ................................................................................................................................. 283
Table G-23: Summary of Intake Parameters ...................................................................... 287
Figure G-18: Existing Locations of Discharge/Diffuser Tunnels [76] ................................. 288
Figure G-19: Site Study Area for Assumed Locations of New Build Intake and Outfall Diffuser (Section 2.2.2 [75]) ................................................................................................................................. 289
Table G-24: Summary of Parameters for Abated Intake Structure ....................................... 294
Figure G-20: Predicted Annual Salt Deposition (g/m²/month) – Mechanical Draft – Linear Configuration (Figure E.3.8-1 [54]) .................................................................................. 301
Figure G-21: Pilot Bank Swallow Habitat ............................................................................ 306
Table G-25: Review of Case Studies .................................................................................. 307
Table G-26: Cost Items for Condenser Cooling Options ..................................................... 316
Table G-27: Cost Estimate for Cooling Options without Enhancements (Four Units) .......... 317
Table G-28: Cost Estimate for Cooling Options without Enhancements (Two Units) .......... 319
Table G-29: Cost estimate for Cooling Options with Enhancements (Four Units) .......... 320
Table G-30: Cost Estimate for Cooling Options with Enhancements (Two Units) .......... 322
Table G-31: TAC for Cooling Options without Enhancements ......................................... 323
Table G-32: TAC for Cooling Options with Enhancements ................................................. 323
Table H-1: Baseline Design Parameter Set ...................................................................... 325
Table I-1: Dimension of the MDCT with Plume Abatement [71] ........................................... 333
Figure I-1: Design of DNGS Porous Veneer Intake .......................................................... 334
Figure I-2: Close-up of Porous Module Showing Location of 14 cm Slots ....................... 334
Table I-2: Comparison of the Intake Parameters .............................................................. 336
Figure I-3: Cylindrical Wedgewire Screen ........................................................................ 337
Table J-1: Enhanced Design Parameter Set ..................................................................... 339
Table K-1: Stakeholder Feedback and Responses ............................................................. 345
Glossary

**Attributes**
Means of measuring and comparing the safety, environmental, technological, social and cost characteristics and consequences of each of the condenser cooling options.

**BATEA**
Best Available Technology Economically Achievable (BATEA) is a formalized, comprehensive decision-making technique for selecting the best technology to minimize negative environmental impact within reasonable costs.

**Cost-benefit**
A framework to aid in economically-efficient decision making.

**Key attributes**
The dominant attributes contributing to the overall decision making process.

**Multi-attribute Analysis**
Multi-attribute analysis is a popular decision-making tool in many environmental, economical and managerial contexts. It applies multiple assessment criteria to decision-making.

**Options**
Technologies considered as part of the assessment process.

**Scoring**
Placing a numerical value on an option in relation to a particular attribute.

**Stakeholder**
Any group who has an interest in the decision making process. Stakeholders may include the general public, environmental and industry groups and regulators.

**Uncertainty**
Lack of definite information on a matter relevant to an option assessment study.
Weighting

An element of the overall option assessment process, which involves emphasizing the contribution of some attributes of a technology when making a final selection.

Weighting Factors

Numerical factors which can be applied to attribute scores to obtain an overall sum of weighted scores for an option. Weighting Factors are sometimes used in option appraisal to implement Weighting. Not used in the current assessment.
## Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AACE</td>
<td>American Association of Cost Engineering</td>
</tr>
<tr>
<td>AAQC</td>
<td>Ambient Air Quality Criteria</td>
</tr>
<tr>
<td>BACTEA</td>
<td>Best Available Control Technology Economically Achievable</td>
</tr>
<tr>
<td>BAT</td>
<td>Best Available Technique/Technology</td>
</tr>
<tr>
<td>BATEA</td>
<td>Best Available Technology Economically Achievable</td>
</tr>
<tr>
<td>BATNEEC</td>
<td>Best Available Techniques Not Entailing Excessive Cost</td>
</tr>
<tr>
<td>BPEO</td>
<td>Best Practical Environmental Option</td>
</tr>
<tr>
<td>BPM</td>
<td>Best Practicable Means</td>
</tr>
<tr>
<td>BTA</td>
<td>Best Technology Available</td>
</tr>
<tr>
<td>CAD</td>
<td>Canadian Dollar</td>
</tr>
<tr>
<td>CCW</td>
<td>Condenser Circulating Water</td>
</tr>
<tr>
<td>CEAA</td>
<td>Canadian Environmental Assessment Act</td>
</tr>
<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
</tr>
<tr>
<td>CGSB</td>
<td>Canadian General Standard Board</td>
</tr>
<tr>
<td>CNSC</td>
<td>Canadian Nuclear Safety Commission</td>
</tr>
<tr>
<td>CT</td>
<td>Cooling Tower</td>
</tr>
<tr>
<td>CWIS</td>
<td>Cooling Water Intake Structures</td>
</tr>
<tr>
<td>CWW</td>
<td>Cylindrical Wedgewire</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Costs</td>
</tr>
<tr>
<td>DCO</td>
<td>Development Consent Order</td>
</tr>
<tr>
<td>DFO</td>
<td>Department of Fisheries and Oceans Canada</td>
</tr>
<tr>
<td>DNGS</td>
<td>Darlington Nuclear Generating Station</td>
</tr>
<tr>
<td>DNNP</td>
<td>Darlington New Nuclear Project</td>
</tr>
<tr>
<td>EA</td>
<td>Environmental Assessment</td>
</tr>
<tr>
<td>ECA</td>
<td>Environmental Compliance Approval</td>
</tr>
<tr>
<td>EIA</td>
<td>Environmental Impact Assessment</td>
</tr>
<tr>
<td>EIS</td>
<td>Environmental Impact Statement</td>
</tr>
<tr>
<td>ESP</td>
<td>Early Site Permit</td>
</tr>
<tr>
<td>GCM</td>
<td>Global Climate Models</td>
</tr>
<tr>
<td>IC</td>
<td>Indirect Costs</td>
</tr>
<tr>
<td>I&amp;E</td>
<td>Impingement and Entrainment</td>
</tr>
<tr>
<td>IPC</td>
<td>Infrastructure Planning Commission</td>
</tr>
<tr>
<td>IPEC</td>
<td>Indian Point Energy Centre</td>
</tr>
<tr>
<td>IPPC</td>
<td>Integrated Pollution Prevention and Control</td>
</tr>
<tr>
<td>JRP</td>
<td>Joint Review Panel</td>
</tr>
<tr>
<td>LSA</td>
<td>Local Study Area</td>
</tr>
<tr>
<td>MDCT</td>
<td>Mechanical Draft Cooling Tower</td>
</tr>
<tr>
<td>MOE</td>
<td>Ministry of the Environment</td>
</tr>
<tr>
<td>NAPS</td>
<td>North Anna Power Station</td>
</tr>
</tbody>
</table>
NDCT  Natural Draft Cooling Tower
NGS  Nuclear Generating Station
NI  No Impact
NPV  Net Present Value
NRC  Nuclear Regulatory Commission
NSF  National Science Foundation
NSIP  Nationally Significant Infrastructure Project
NYSDEC  New York State Department of Environmental Conservation
OOM  Order-of-Magnitude
OPEX  Operating experience
OPG  Ontario Power Generation
OTC  Once Through Cooling
PM  Particulate Matter
PMA  Polymaleic Anhydride
PNERP  Provincial Nuclear Emergency Response Plan
PNGS  Pickering Nuclear Generating Station
PNNL  Pacific Northwest National Laboratories
PPE  Personal Protection Equipment
PPWD  Parallel Path Wet-Dry
PSEG  Public Service Enterprise Group
PTTW  Permit to Take Water
PWQO  Provincial Water Quality Objectives
PWR  Pressurized Water Reactor
RC  Recovery Credits
RCEP  Royal Commission on Environmental Pollution
RSA  Regional Study Area
SCR  Station Condition Records
SPDES  State Pollutant Discharge Elimination System
SPM  Suspended Particulate Matter
SPWD  Series Path Wet-Dry
SSA  Site Study Area
TAC  Total Annual Costs
TBM  Tunnel Boring Machine
TRC  Total Residual Chlorine
TSD  Technical Support Document
US EPA  United States Environmental Protection Agency
VEC  Valued Ecosystem Component
WHMIS  Workplace Hazardous Materials Information System
1.0 INTRODUCTION

1.1 Background

On September 21, 2006, Ontario Power Generation (OPG) submitted to the Canadian Nuclear Safety Commission (CNSC) an “Application for Approval to Prepare a Site for the Future Construction of a Nuclear Power Generating Facility in the Province of Ontario, Regional Municipality of Durham, Municipality of Clarington”. Pursuant to the Canadian Environmental Assessment Act (CEAA) and related regulations, the Environmental Assessment (EA) for the DNNP was conducted. An Environmental Impact Statement (EIS) [1] and the associated Technical Support Documents (TSD) for the EIS were prepared.

As part of the EA work, a separate assessment of the different condenser cooling system options was conducted and considered various options including Once Through Cooling and six different cooling tower/cooling pond options [2]. This screening level study, based on United States Environmental Protection Agency (US EPA) 316b Clean Water Act rules, recommended Once Through Cooling (OTC) for the DNNP with Mechanical Draft Cooling Tower (MDCT) technology being identified as the second most desirable option. The principles and screening criteria used in that assessment included environmental considerations, operation and maintenance, intractable issues and costs.

The EA included a series of public consultations. Information on condenser cooling technology alternatives, including MDCT and OTC options, was presented to the public. The feedback was documented in the EIS and supporting documentation within the framework of the EA.

The EIS and all related supporting documents were submitted to the JRP for review. To supplement the JRP’s review of the submissions related to alternative means of condenser cooling for the DNNP, the CNSC, on behalf of the JRP, contracted Pacific Northwest National Laboratory (PNNL). PPNL performed an independent evaluation of the adequacy of the EIS assessment of cooling towers for condenser cooling [3].

Taking into account the results of the PNNL review and the DNNP EA submission, the CNSC and the Department of Fisheries and Oceans Canada (DFO) concluded that the assessment was insufficient for the purpose of subsequent approvals or authorizations. The CNSC and DFO recommended to the JRP that OPG undertake a formal quantitative cost-benefit analysis for the condenser cooling water options, applying the principle of Best Available Technology Economically Achievable (BATEA) [4].

In accordance with the JRP recommendations [5] and subsequent decision by the Government of Canada [6], the following two cooling options were to be assessed:

1. Once Through Cooling, and

It was also recognized that for the second option the design would incorporate plume abatement technology, although the extent of abatement wasn’t specified.

Upon receipt of the JRP recommendations, OPG recognized the need for a transparent study without prejudice to either of the two remaining options and retained AMEC-NSS
to perform an evaluation of the cooling options for the DNNP (hereinafter referred to as “the Project”). The BATEA methodology selected for the assessment was based on a multi-attribute decision-making approach, using quantitative comparisons of different aspects, taking into account a comprehensive set of potential impacts. In accordance with best international practice [7], BATEA was identified by using evidence based approach which provided a systematic comparison of the options; rather than by attempting to determine the preferred option by using numerical comparison alone via summing up of weighted scores.

An independent third-party review of this methodology was conducted by an expert in decision-making approaches [8]. It concluded that:

- The basic methodology is fit for purpose in decision making terms, and is in general consistent in terms of rigour and transparency with equivalents commonly used elsewhere.
- The choice of a Multi Attribute framework rather than a more limited cost-benefit analysis is appropriate.
- The decision not to rely on a weighted/summed method to rank the options is appropriate.

A number of recommendations were made to improve clarity and consistency of the proposed approach. Subsequently, the methodology was updated to incorporate the recommendations from that review, which are reflected in the current document. Following that, the BATEA methodology was implemented and an initial preferred condenser cooling option was identified.

The Condenser Cooling Water Option Assessment for DNNP report was subject to a stakeholder consultation program. Feedback received during that program was used to finalize the methodology and assessment. It should be noted that the preliminary assessment was issued during the stakeholder consultation program. The report has been subsequently revised to the current document to include feedback from the stakeholder sessions and to address additional comments provided by the regulatory authorities.

The report provides BATEA selection on the basis of a comprehensive, transparent and systematic evaluation of the two condenser cooling options. OPG will use this information to make the final decision on condenser cooling technology for the DNNP in accordance with their mandate, corporate values and interests.

1.2 Structure of the report

This report describes the assessment used to determine the DNNP condenser cooling technology that has the best practicable environmental performance with the consideration of cost. The report is structured as follows:

Section 2.0 Provides an overview of BATEA-type methodologies and identifies significant similarities and differences in approaches.
Section 3.0  Describes example studies relating to selecting condenser cooling options for power plants in the UK and US and identifies major decision-making criteria.

Section 4.0  Briefly describes the assessment methodology steps for selecting the best cooling technology for the DNNP.

Section 5.0  Identifies the objectives, options, and cooling technology attributes. It also describes the metrics (scoring scheme) for the evaluation of each attribute (Steps 1, 2, 3 & 4).

Section 6.0  Provides an initial evaluation of the cooling options and describes the selection of the key attributes. It also identifies and evaluates the design enhancements and their adaptability to environmental or regulatory changes (Steps 5, 6 & 7).

Section 7.0  Describes the initial selection of the BATEA for DNNP Condenser Cooling (Step 8).

Section 8.0  Gives a summary of the stakeholder consultation program (Step 9).

Section 9.0  Describes the Final selection of the BATEA for the DNNP Condenser Cooling System (Step 10).

Section 10.0 Provides analysis of the sensitivity in the BATEA findings to uncertainties in parameters and the number of generating units included in the Project (Step 10).

Section 11.0  Provides the overall assessment conclusion (Step 10).
2.0 OVERVIEW OF BATEA AND EQUIVALENT METHODOLOGIES

2.1 Review of the Key Features of BATEA and Similar Studies

BATEA is a formalized, comprehensive decision making technique for selecting the best technology to minimize negative environmental impact while not entailing unreasonable costs. The specific term comes from Alberta, where it was first introduced by the Clean Air Strategic Alliance’s Electricity Project Team in 2003 [9]. It was defined as a “technology that can achieve superior emissions performance and that has been demonstrated to be economically feasible through successful commercial application across a range of regions and fuel types”.

Essentially the same concept is used in different jurisdictions across Canada and in other countries, such as Great Britain, the US, and across the European Union. The process typically includes the following steps:

1. Selection of appropriate objectives.
2. Identification of alternative technologies (options). Typically this is required to ensure the list of options for consideration is as comprehensive as possible.
3. Screening of the options by selecting only those that can be applied in a particular geographical context, for specific application, are legally permissible and technically feasible.
4. Option evaluation against a predetermined set of environmental and technical criteria (attributes).
5. Evaluation of capital and operational costs for each of the options, and
6. Selection of the best option on the basis of findings from the previous steps.

There is no single fit-for-all purposes methodology for implementing an option selection approach. It may be established by reference to previous studies, or as an independent comparison of detriments and benefits. The general rule is that the level of effort expended to identify and implement the best available technology should be proportionate to the scale of the issue to be resolved [9]. However, investment in analysis, process and stakeholder involvement often needs to be proportionate to the greater of the technical or public significance of the decision. There are some differences in the way the approach is applied in different jurisdictions and even within the same jurisdiction, depending on the specific purpose. The most significant variations are summarized below:

- **Stakeholder involvement**

  Single or multiple stakeholders may be involved in the decision making process [9] [7] [10] [11]. This may include the general public, environmental and industry groups as well as local or federal authorities.

  These views can be taken into account by developing an appropriate set of evaluation criteria. Furthermore, stakeholder involvement may be appropriate as a means to confirm the accuracy of underlying assessment assumptions.
Public perception is rarely used as an attribute because it cannot be easily measured or placed on a scale. However, public perception issues should be included in the eventual decision logic [8].

- **Use of prescribed technologies versus multi-attribute analysis for option selection**

  In some jurisdictions there are comprehensive technology databases which explicitly identify a prescribed technology for various applications [9]. Such databases are most often used in the US by the EPA and other agencies but can also be used elsewhere if appropriate. This straightforward approach is most often used for simple applications, such as the selection of air particulate filters. A variation of this approach is when a specific performance level is postulated against a single attribute [11]. This approach cannot be applied directly to strategic decisions or complex systems with a large number of design alternatives and multifaceted impacts which depend on a particular environmental setting.

  Strategic decisions with multifaceted impacts should be developed using a holistic appraisal of factors associated with the practicability of implementing alternatives. It should be geared towards identifying a preferred overall strategy “from the perspective of the environment as a whole, as opposed to detailed optimisation of the selected scheme” [10]. This is best achieved by using a multi-attribute assessment.

  Once the overall concept has been established, prescribed approaches can be used to refine and optimize the design. For example, the European Union developed a “Best Available Techniques” guide for cooling options on the basis of the Integrated Pollution Prevention and Control directive [12].

- **Use of cost-benefit versus multi-attribute analysis to select the best option**

  Cost-benefit analysis is a clear and extensively used process [9] [7] [10] [13]. It requires monetization of all the relevant benefits and negative impacts so that these can be directly compared against the cost of implementing respective options. This is only possible for simple assessments which do not require evaluation of such parameters as public perception of different options. A number of other parameters important for selecting the best option for condenser cooling, such as impact on fish or visual impact do not have an agreed monetary value that can be assigned to them, rendering this approach unsuitable, at this point in time.

  Multi-attribute analysis is an alternative option evaluation technique which is also extensively used for this purpose and is judged to be the most appropriate in this case.

- **Economic assessment requirements**

  Although slightly different methods are used in different jurisdictions, the Government of Alberta BATEA [9] and Best Available Control Technology Economically Achievable (BACTEA) Guidelines [13] provide consistent, comprehensive and concise instruction for estimating the costs in such a
manner that they can be used to compare alternative options. It is required to take account of capital and all types of operating costs, of discount rate and to use a baseline year for the evaluation.

An alternate approach is to base a decision purely on environmental performance and to only consider costs if they are “grossly disproportionate” or “excessive”.

For example, a recent US assessment on condenser cooling technology selection states that costs must not be “wholly out of proportion” [11]. This is understood to mean that the facility should still be able to compete on the local energy markets.

- **Level of formalization**

In some jurisdictions there is no formal legal or regulatory guidance for implementing such an assessment. The only available guidelines in Ontario were published in 2005 and have a narrow application [13]. On the other hand, in the UK the first set of technology evaluation guidelines against environmental criteria were published in 1874 as part of the Alkali Act, which was brought in to reduce air pollution in urban areas. Since then the requirement for “Best Practicable Environmental Option” (BPEO) studies and other similar assessments have been incorporated into several legal and regulatory documents in the UK [7] [10]. Additional background information on the BPEO assessment approach is provided in Appendix A.

Generally, the requirements are specified in terms of generic steps which have to be implemented, although the Ontario guidelines for mitigating Nitrogen Oxides and Sulphur Dioxide emissions prescribe a clear set of submission requirements [13].

Although there are no prescriptive instructions for implementing BATEA assessments for selecting condenser cooling options in Ontario, the proposed methodology has been adapted for the required application to combine the best aspects of Canadian and international approaches, including BATEA, BACTEA, BPEO and Best Available Technology/Technique (BAT).

- **Involvement of third parties in the assessment**

An independent third party review is often recommended or, in some cases, required as part of the option evaluation (e.g. [13]). The independent third party review provides additional assurance that the overall assessment approach is unbiased and comprehensive, technically sound and scientifically defendable.

- **Uncertainty analysis**

Uncertainty has to be addressed in any option study [9] [10] and there has to be a clear statement setting out the way in which different sources of uncertainty have been dealt with, and for transparent and realistic treatment of its implications within the analysis.

Within the general framework of an option study, the areas where uncertainty has to be taken explicitly into account include the following:
• Detailed design of strategic options,
• Selection of evaluation criteria,
• Evaluation of option performance against individual criteria,
• Project implementation risks, and
• Cost, practicality and timescales.

Assumptions that might have a significant impact on the conclusions have to be made explicit and be supported, including the reasons for the degree of confidence expressed in those assumptions. There is no prescriptive way to evaluate uncertainty [7] [10] [11] [12] and this can involve a substantial numerical sensitivity analysis. Alternatively, additional rankings may be added to the scoring scheme to reflect uncertainty in performance against certain criteria. For conceptual decisions, numerical sensitivity analysis should not take precedence over providing robust justification of assumptions and more qualitative arguments that influence the conclusions [7].

**Decision-making**

Multi-attribute analysis involves evaluation of the options against the attributes, using qualitative and quantitative information, and expert opinion where necessary, to score each of the options against every attribute using the predefined scoring scheme [7] [10].

Selection of the best option for complex holistic assessments should follow a logical process and can be presented using a logical flowchart [7]. Once the evaluation is completed, selection of the ‘best’ option is often clear-cut. This occurs when one of the feasible options performs best or is comparable to the others against all evaluation attributes and is at the same time associated with the lowest cost. In other cases the importance of different attributes has to be factored in, as well as relative performance of the options. Sometimes this requires application of alternative weighting schemes to the options, as well as sensitivity analysis, usually as a mechanism of accounting for different stakeholders’ views and achieving stakeholder consensus.

Whichever method is used, it is important to ensure that the “scores” and “weightings” are not mechanically added as the sole basis of decision-making. If scores are numerically added and weighted, the highest scoring option may be the starting point, but the conclusion may still be that it is not the best [7]. Even if a sophisticated approach is adopted to weighting in order to identify BATEA, the conclusions that are derived from the aggregation of weighted scores are “rather less important to the final decision than the reasoning used in identifying key discriminating factors between options” [10]. This is consistent with the primary aim of such studies, which is to reveal systematically the arguments, assumptions, issues and preferences that underpin decisions.

It is also possible that BATEA is selected by using other factors, such as alternative compliance mechanisms (e.g. offsets and emission trading) where it is deemed appropriate as part of a management and regulatory framework.
A correctly implemented BATEA methodology will provide a comprehensive, systematic set of results which lends itself to logical justification of selecting the best option.

### 2.2 Summary of the Applicable Methodologies

Taking the forgoing considerations into account, a proposed approach was developed that is optimized for the specific CCW options evaluation. The features that influenced the proposed approach are summarized in Table 1.

#### Table 1: Summary of Three Key Methodologies Contributed to the Proposed Approach

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application</strong></td>
<td>Development of technology-based standards.</td>
<td>Selection of the best available nitrogen oxides (NOX)/ sulphur dioxide (SO₂) control Technologies.</td>
<td>Selection of waste management and emission minimization strategies.</td>
</tr>
<tr>
<td><strong>Stakeholder involvement</strong></td>
<td>Permits a variety of engagement processes, including “multi-stakeholder” consultations.</td>
<td>Proponent submits evaluation for acceptance by the regulatory body.</td>
<td>The extent of stakeholder input or consultation may vary depending on the project and approach selected by the proponent.</td>
</tr>
<tr>
<td><strong>Submission format</strong></td>
<td>Not specified</td>
<td>Specified</td>
<td>Not specified</td>
</tr>
<tr>
<td><strong>Decision-making approach</strong></td>
<td>Offers the alternatives of benefit-cost, cost reasonableness or cost effectiveness analysis.</td>
<td>Proponent can select any technology with removal efficiency within 15% of the most efficient technology.</td>
<td>Multi-attribute analysis, logical flowchart.</td>
</tr>
</tbody>
</table>
2.3 Recent Developments in Selection of Cooling Systems in Europe and US

The key European document that identified BATEA for cooling systems at power stations was published by the European Commission in December 2001. This document [12] is known as the Industrial Cooling BREF Note.

The BREF Note sets out the standards expected for cooling at conventional power stations regulated under the Integrated Pollution Prevention and Control (IPPC) Directive (2008/61/EC, previously known as Directive 96/61/EC). It defines both OTC and MDCT technologies as viable alternatives, provides evaluation criteria and evaluates specific technologies for a range of feasible applications. In addition it prescribes specific requirements for implementing both OTC and alternative cooling tower technologies. The Industrial Cooling BREF Note considers OTC as the preferred option for large power plants in coastal locations, provided that the aquatic environment is not adversely impacted, due to the overall reduction in emissions of greenhouse gases that can be achieved. See Appendix A for further details on the BREF Note.

Recently the identification of OTC as BATEA has come under challenge, mainly because of legal action in the United States, where cooling towers were identified as best technology available (BTA) for new power plant cooling facilities under EPA Clean Water Act, Regulation 316b. Litigation in the US has been on-going and further changes can be expected.

US EPA regulation 316b identifies that cooling towers may be the best available technology for new power plant, but provides for the option to complete a study to confirm the best technology based on site-specific parameters where there is no substantive difference between a cooling tower system and a once-through system.

2.4 Most Relevant Current Guidance

In the UK the validity of OTC as the best option for a new 2,000 MWe combined cycle gas turbine power station was investigated for the European Natura 2000 (Protected Environmental Area) site on behalf of the Countryside Council for Wales. A key conclusion of this investigation was that the Industrial Cooling BREF Note was out of date. The Environment Agency of England and Wales therefore commissioned a scientific report [14] to consider cooling water options for the new generation of nuclear power stations in the UK. This report is considered to be the most relevant guidance currently available. The report compares the advantages and disadvantages of the different cooling options and Section 7 of the report recommends that the following four factors should be considered to select the most suitable type of cooling system:

1. The sensitivity of the source waters to abstraction impacts (entrapment and impingement); MDCT require less water and therefore reduce these types of impacts,

2. The heat sink capacity of the receiving water, with lower capacities favoring MDCT methods,
3. Planning limitations on the use of MDCT (aesthetics, visible plumes, fog formation), and

4. Comparative lower thermal efficiencies of cooling towers, therefore increasing carbon emissions per unit of electricity produced.

The first two factors favour cooling towers, the second two favour OTC. Further factors that need to be considered are whether:

- Predicted abstraction and thermal related impacts exceed an acceptable level, and
- Impacts can be mitigated by use of available techniques or compensated for, e.g. by provision of replacement habitat.

Once through cooling is used at all UK and European coastal sites. This is because coastal sites do not suffer the same thermal capacity limits as estuaries. Given the better thermal efficiency of Once Through Cooling, it is recommended as the preferred option in the UK, provided that impacts on fish stocks are acceptable.
3.0 OVERVIEW OF SIMILAR STUDIES

A brief overview is provided for several sites in the UK and US, describing the option selection methodology, any standards that were referenced, the assessment criteria (attributes) and assessment results. Two option studies were selected in the UK and four in the US, based on how recently the studies were completed and the availability of information.

The purpose of reviewing international experience was to identify the attributes and approaches that were deemed to be relevant for the selection of condenser cooling technologies at nuclear power plants.

3.1 Hinkley Point, UK, 2011

Background

The Hinkley Point A and B nuclear power stations are located in Somerset, UK on the Bristol Channel coast. The plant is facing a large open water body, as shown in Figure 1. In 2011 EDF carried out an option study to select the best cooling system for the new nuclear power plant to the west of these reactors [15].

Figure 1: Location of Hinkley Point A and B

Source: Google Maps
Methodology overview

The methodology that was followed is the one prescribed by the Environment Agency for England and Wales that is specific for selecting cooling water options for new nuclear power plants [14].

This is essentially a multi-attribute analysis which balances advantages and disadvantages of each alternative for site-specific conditions and design alternatives. The initial assessment was completed using a quasi-legal process involving a “jury” of EDF experts. For the preferred option the residual impacts, following design mitigation, were evaluated and it was concluded that they were acceptable.

Attributes studied

The attributes studied included:

- Water quality impacts,
- Operating experience,
  
  For this attribute relative operating experiences of cooling towers and OTC systems at coastal reactor sites were considered.
- Energy efficiency,
- Waste generation, including radioactive waste and sediment waste,
- Thermal capacity and efficiency (technical performance),
  
  This attribute was used to evaluate whether the receiving and source water body was able to manage heat removed from the reactor and provide adequate cooling without excessive heating in the marine environment.
- Fish impingement and entrainment,
  
  The intake design and location were optimized and mitigation measures developed to minimize flow velocity and resulting impingement and entrainment.
- Thermal plume impacts,
  
  Outfall headworks were designed to improve mixing and minimize temperature differential.
- Visual impact,
- Noise,
- Footprint, and
- Potential vulnerability to extreme weather hazards.

Results

Once through cooling was selected as the BAT, taking into account intake and outfall design optimization to minimize impact on fish and temperature differential.

The reasons for selecting the OTC system in preference to the cooling towers included:
• Operating experience for coastal sites in the UK:
  There are no coastal nuclear power plants in the UK which use cooling towers. Conversely there is extensive operating experience with the OTC system.

• Space requirements:
  The land required to construct cooling towers was an issue in this particular location.

• Aesthetics (visual impact, plume, fog generation):
  This issue related to MDCT was of significant concern to the local community.

• Lower waste generation:
  Operation of the cooling towers would have required desalination and sediment removal, resulting in significant waste generation compared to the OTC system.

• Noise:
  Operation of the cooling towers results in additional noise, particularly in the case of MDCT designs.

• Better ability to cope with extreme weather conditions:
  The cooling towers were determined to be more vulnerable to extreme weather conditions.

3.2 Oldbury Study, UK, 2009

Background
Oldbury nuclear power station is located on the south bank of the River Severn, close to the village of Oldbury-on-Severn in South Gloucestershire, England; see Figure 2. The utility is planning to install either two 1,650MW Areva EPR reactors or up to three 1,100MW Westinghouse AP1000 reactors. Up to four cooling towers, between 70m and 200m in height, are also proposed. Both mechanical and natural draft cooling will be considered [16].
Figure 2: Location of Oldbury Nuclear Power Station

Source: Google Maps

Methodology overview

A qualitative argument has been made to rule out OTC [16]. See “Results” below. The EU BAT will be used to assess the cooling options (cooling towers only). The assessment is not yet complete.

The development of a new nuclear power station will be classified as a nationally significant infrastructure project (NSIP) and will require a Development Consent Order (DCO) from a new independent Infrastructure Planning Commission (IPC). The DCO replaced a number of approvals normally required for a project of this type. A formal Environmental Impact Assessment (EIA) will be required as part of the request for a DCO [16].

Attributes studied

It is assumed that the BAT, when complete, will consider impacts to aquatic biota as a key attribute given the location of the plant on an estuary. This attribute was used to rule out OTC as described below under “Results”.

The following attributes were identified for the BAT study:

- Environmental impact,
- Performance,
- Efficiency,
• Sustainability,
• Technical aspects, and
• Commercial aspects.

Other attributes listed in the Environmental Impact Assessment (EIA) as candidates for future study include:
• Geology, hydrogeology and soils,
• Surface water and flooding,
• Landscape and visual amenity,
• Ecology and nature conservation,
• Archaeology and cultural heritage,
• Traffic and transport,
• Noise and vibration,
• Air quality and dust,
• Public access and recreation, and
• Socio-economics.

Results

The existing Magnox station uses OTC, passing water from the River Severn directly through its condensers and back to the river. The new station may have over eight times the electrical capacity of the current station. If it were to use OTC, it would therefore need to extract and discharge of the order of eight times the quantity of water to the river. The warm water discharge would impose an unacceptable heat load on the river and the estuary. A new station would therefore need to use cooling towers to cool the water circulating through the condensers [16].

3.3 Nine Mile Point EIS, USA, 2008

Background

Nine Mile Point Nuclear Station is a two-unit nuclear power plant located in the Town of Scriba, approximately five miles northeast of Oswego, New York. As seen in Figure 3, the station is located on the shores of Lake Ontario. The EIS study was for a proposed new third unit at the same site [17].
Methodology overview

The assessment of cooling tower impacts is done as part of an Environmental Assessment. The methodology is simply to describe whether mitigation beyond current design features is warranted on the basis of low impact from the operation of the cooling system. Key aspects included the following [17]:

- A model study was conducted to determine design characteristics of the intake facilities. The model evaluated alterations to the ambient flow field and was utilized to determine the design horizontal and vertical approach velocities and geometry of intake canals,
- US Clean Water Act Section 316(b), which applied here, required that cooling water intakes represent "Best Technology Available" with regards to cooling system and intake structure location, design, construction and capacity,
- Use of local impingement and entrainment statistics based on several years of monitoring, and
- For the discharge, size and configuration of the thermal plume and dilution rates, were estimated by computer modeling.
Attributes studied

The key attributes studied were fish entrainment and impingement.

Secondary attributes studied were:

- Physical changes (attraction of fish to the thermal plume, cold shock, blockage to movement and migration, changes in benthic species composition, growth of nuisance species, alteration of reproductive patterns),
- Chemical effects of biocides,
- Noise, and
- Cooling tower plume impacts (icing, fog, additional precipitation and salt deposition) [17].

Other attributes that were indirectly relevant to the present report included:

- Land use impacts (focused on socio-economic and cultural concerns),
- Water consumption and quality impacts from both radioactive and toxic sources,
- Radiation doses to public and non-human biota, and
- Transmission system impacts on ecosystems and the public.

Results

- The physical impacts of the intakes for the Cooling Water System will be small and will not warrant mitigation measures beyond the design features already implemented at Nine Mile Point.
- A similar conclusion is made for fish impingement/entrainment, physicochemical and thermal impacts to aquatic communities.
- The impact of the visual intrusion by the cooling tower plume is anticipated to be small because the site is already aesthetically altered by the presence of the existing Unit 2 cooling tower plume.
- Fogging and icing would occur for only a small percentage of the time and would occur most frequently on-site. Impacts from the cooling tower from fogging and icing, therefore, would be small and would not require mitigation.
- Modeling predicts salt deposition at rates below the NUREG-1555 significance level where visible vegetation damage may occur for both on-site and off-site locations. Likewise for noise, cloud shadowing/increased precipitation and ground level humidity increases [17].

3.4 Oak Creek-Elm Road Study, USA, 2008

Background

Oak Creek Power Plant, also known as South Oak Creek, is a base load, coal- and natural gas-fired, power station. Figure 4 shows that the plant is located on Lake Michigan in Oak Creek, Wisconsin. The expansion project is also known as the Elm Road Generating Station, though it is on the same property as the Oak Creek Power Plant [11].
Methodology overview

This study was performed to fulfill US regulatory requirements under US EPA’s Phase I, Section 316(b) regulations [11]. The approach taken was to show that compliance with the requirement at issue would result in:

- Compliance costs “wholly out of proportion” to the costs EPA considered in establishing the requirement, or
- Significant adverse impacts on:
  - Local air quality,
  - Local water resources other than impingement or entrainment, or
  - Local energy markets.

To fulfill these requirements, a BTA approach was taken [11].

![Figure 4: Location of Oak Creek Power Plant](source: Google Maps)

Attributes studied

The key attributes studied included fish impingement and entrainment, as well as technical performance and ease of operation and maintenance (including capital costs, operation and maintenance costs, energy penalty, and administrative costs). Secondary attributes included air and water quality [11].
Results

The results indicated that an OTC water system with an offshore intake equipped with screens would minimize adverse environmental impacts to a level comparable to a closed-cycle cooling system with an onshore intake. This was demonstrated by estimating the impingement mortality and entrainment for both cases (based on age-1 equivalents and production foregone) [11].

A cost benefit analysis was also undertaken that showed that the cost of installing the closed-cycle cooling system would be wholly out of proportion to the costs which the US EPA considered for such a system when it promulgated the applicable Phase I regulations. It was also shown that such a system would cause significant adverse impacts, including significant adverse impacts on local air quality and water resources [11].

3.5 North Anna, USA, 2006

Background

Dominion Nuclear North Anna, LLC submitted the final revision of its application for an Early Site Permit (ESP) in September 2006 to the Nuclear Regulatory Commission (NRC). The proposed ESP site is wholly within the confines of the existing North Anna Power Station (NAPS) site, which is located on a peninsula on the southern shore of small man-made Lake Anna in Virginia; see Figure 5. The existing reactors on-site (Units 1 & 2) are Westinghouse Pressurized Water Reactors (PWR). The purpose of the ESP application is to demonstrate the suitability of the ESP site for construction and operation of up to two new units (Units 3 & 4) [18].
Methodology overview

As a part of the ESP application, an option study was conducted to select condenser cooling method for Units 1 and 2. Separate evaluations took place for Units 3 & 4. The focus of these evaluations was to identify feasible, legislatively compliant, and environmentally preferable technology for heat dissipation.

A combination of dry and wet cooling towers was used as the base case for the Unit 3 evaluation, whereas dry towers were used as the base case for Unit 4. The following alternatives were also considered [19]:

- OTC,
- OTC with helper tower,
- Natural Draft Cooling Towers (NDCT),
- MDCT, and
- Spray ponds.

Attributes studied

The primary attributes used in the assessment were as follows [19]:

- Onsite land considerations,
- Terrain considerations,
• Water use,
• Radiation dose to workers,
• Regulatory restrictions,
• Atmospheric effects,
• Thermal and physical effects,
• Human health impacts (exposure to thermophilic micro-organisms),
• Noise levels,
• Aesthetics and recreational benefits,
• Operating and maintenance experience, and
• General efficiency penalty.

Results
For Unit 3 the following options were found to be acceptable:
• Combination of dry and wet cooling towers,
• NDCT,
• MDCT, and
• Dry towers.

A combination of dry and wet cooling towers was selected as the preferred option for Unit 3. For Unit 4, dry towers were found to be the only acceptable option [19].

3.6 Indian Point Study, USA, 2010

Background
Units 2 and 3 at the Indian Point Energy Centre (IPEC) are both owned and operated by Entergy. The IPEC site is located in Buchanan, New York on the east bank of the Hudson River, as shown in Figure 6. Both Units 2 and 3 are Westinghouse Pressurized Water Reactors (PWRs) and were designed, constructed, and licensed, and are operated to withdraw cooling water from the Hudson River via two shoreline OTC cooling water intake structures (CWIS) [20].
Methodology overview

Entergy had previously submitted a renewal application for a State Pollutant Discharge Elimination System (SPDES) for IPEC Units 2 & 3. Upon review of the application, the New York State Department of Environmental Conservation (NYSDEC) indicated that a closed-loop cooling system was the site-specific BTA to minimize the adverse environmental impacts of the cooling water intake structures with respect to fish impingement and entrainment. Based on this information, the NYSDEC proposed modifications to the SPDES permit which included the possible construction and operation of cooling towers in a closed-loop cooling configuration.

Entergy undertook an assessment of alternative cooling technologies to determine whether there was an existing alternative technology that could minimize adverse environmental impact to a level equivalent to that which can be achieved by cooling towers [20]. For the purposes of comparison, one hybrid cooling tower per unit was selected as the preferred closed-loop cooling design [21].

A BTA approach was followed, triggered by a pollutant discharge limit reapplication. During the process of evaluating alternative intake technologies, the following standards/guidelines were used [20]:

- 6 NYCRR 704.5, New York statutory equivalent of Clean Water Act 316(b),
- Clean Water Act 316(b), and
Attributes studied

The key attributes used in the assessment were as follows [20]:

- Technical/engineering feasibility,
- Comparative effectiveness in terms of impingement and entrainment losses (I&E), and
- Estimated cost based on a detailed site-specific conceptual design.

Additional investigation into economic and environmental impacts associated with the NYSDEC recommendation included [21] [22]:

- Operational and maintenance costs,
- Parasitic losses attributable to new components,
- Costs due to new condenser operating parameters,
- Water treatment costs,
- Cooling tower plume,
- Cooling tower noise,
- Site aesthetics,
- Construction activities,
- Reduced intake flow,
- Economic and power losses,
- Archaeological considerations, and
- Spoils removal.

Results

The results indicated that cylindrical wedge wire screens were a technically feasible alternative to closed-loop cooling. Cooling water intake wedge wire screens are used to mitigate fish impingement (see Appendix I for details). Through installing cylindrical wedge wire screens to enhance the existing cooling system, reductions in I&E comparable to what would be achieved by closed-loop cooling could be expected [20].

Initial capital costs associated with the installation of cylindrical wedge wire screens are highly dependent on the mesh size and the through-slot velocity. The study considered mesh sizes of 2.0 mm and 9.0 mm and through-slot velocities of 0.25 ft/s and 0.5 ft/s. At a minimum, estimated capital costs for the scenarios analyzed were within the range of $36.5 million to $63.3 million [20]. In comparison, initial capital costs associated with converting Units 2 & 3 from OTC to MDCT were estimated to be a minimum of $1.19 billion [22].

3.7 Review summary

Table 2 summarizes the assessment methodologies used in the various recent studies described in Section 3.0.
Table 2: Methodologies Used in Similar Studies

<table>
<thead>
<tr>
<th>Project/Site</th>
<th>Assessment Methodology</th>
<th>Use of Numerical Weightings</th>
<th>Stakeholder Consultation</th>
<th>Applicable Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinkley Point, UK, 2011</td>
<td>Best Available Technology (BAT) approach through a quantitative Multi-Attribute Analysis</td>
<td>No</td>
<td>Yes</td>
<td>• Guidance for the Environment Agencies' Assessment of Best Practicable Environmental Option Studies at Nuclear Sites.</td>
</tr>
<tr>
<td>(OTC)</td>
<td></td>
<td></td>
<td></td>
<td>• The Environmental Permitting (England and Wales) Regulations 2010 (SI 2010 No. 675).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Water Resources Act 1991</td>
</tr>
<tr>
<td>Oldbury Study, UK, 2009</td>
<td>The assessment is ongoing and a BAT approach through a quantitative evaluation is planned.</td>
<td>No available information</td>
<td>Yes</td>
<td>• Guidance for the Environment Agencies' Assessment of Best Practicable Environmental Option Studies at Nuclear Sites.</td>
</tr>
<tr>
<td>(Cooling Towers)</td>
<td></td>
<td></td>
<td></td>
<td>• The Environmental Permitting (England and Wales) Regulations 2010 (SI 2010 No. 675).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Water Resources Act 1991</td>
</tr>
<tr>
<td>Nine Mile Point EIS, USA,</td>
<td>Best Available Technology (BAT) approach by demonstrating regulatory compliance with respect to fish entrainment and impingement</td>
<td>No</td>
<td>Yes</td>
<td>US Clean Water Act Section 316(b)</td>
</tr>
<tr>
<td>2008 (Cooling Towers)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oak Creek-Elm Road Study,</td>
<td>Best Available Technology (BAT) approach by demonstrating regulatory compliance with respect to fish entrainment and impingement, technical performance and ease of operation and maintenance</td>
<td>No</td>
<td>Yes</td>
<td>US Clean Water Act Section 316(b)</td>
</tr>
<tr>
<td>USA, 2008 (OTC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Anna, USA, 2006</td>
<td>BAT approach through a qualitative Multi-Attribute Analysis</td>
<td>No</td>
<td>Yes</td>
<td>US Clean Water Act 316(b)</td>
</tr>
<tr>
<td>(Cooling Towers)</td>
<td></td>
<td></td>
<td></td>
<td>An extensive list is given in Table 1.2-1 of the Early Site Permit Application</td>
</tr>
<tr>
<td>Indian Point Study, USA,</td>
<td>BAT approach through a quantitative Multi-Attribute Analysis for both economic and environmental considerations</td>
<td>No</td>
<td>No</td>
<td>6 NYCRR 704.5, New York statutory equivalent of Clean Water Act 316(b)</td>
</tr>
<tr>
<td>2010 (Cooling Towers)</td>
<td></td>
<td></td>
<td></td>
<td>US Clean Water Act 316(b)</td>
</tr>
</tbody>
</table>
It can be seen that in general, a multi-attribute analysis approach was used to
determine the best available cooling technology. Appendix E lists attributes
considered in the current DNNP cooling option study and correlates them with the
attributes used in the reviewed studies. Note that certain attributes were considered
but excluded from DNNP condenser cooling BATEA option selection. For rationale see
Appendix D. In some cases, particularly in the US, regulatory compliance was also
used as the principle basis of selecting the best available cooling technology.
Numerical weighting factors have not been used in any of the considered studies, but
consultations with stakeholders have been performed in nearly all cases.

The two UK studies applied the Environment Agency guidelines [10] and focused on
location-specific characteristics. The studies balanced:

- Availability of water to manage the amount of thermal output produced and
  sensitivity of ecosystems to impingement and entrainment, both of which favour
  the cooling tower option, and
- Economic efficiencies, amount of waste generated, space requirements and
  visual impact attributes, which favour the OTC option.

All of the four US studies that were reviewed were conducted in compliance with the
US EPA regulation 316b. They used a variety of different attributes, with the main
focus being on impingement and cost. However, a wide range of other attributes
were also considered.

Considered studies resulted in various outcomes as summarized below:

- Hinckley Point (UK, new plant located on an estuary) – selected the Once
  Through Cooling option.
- Oldbury Study (UK, new plant located on a river bank) – selected the Cooling
  Tower option.
- Nine Mile Point (US, existing plant located on the shores of Lake Ontario) – uses
  Cooling Towers.
- Oak Creek-Elm Road (US, new plant located on the shores of Lake Michigan) –
  selected Once Through Cooling option.
- North Anna (US, existing plant located on a small lake) – selected Cooling
  Tower option.
- Indian Point (US, new plant located on a river bank) – selected Cooling Tower
  option.

Overall, recent international experience in selecting best cooling technologies and
associated guidance do not provide a single “fit for all” solution but rather
demonstrate that selection of condenser cooling water system should be a site specific
evaluation.
4.0 **DNNP CONDENSER COOLING WATER BATEA METHODOLOGY**

4.1 **Ten Assessment Steps**

The methodology for selecting the BATEA for the DNNP condenser cooling water system was developed on the basis of the reviewed methodologies discussed in Section 2.0 and taking into account experience from recent projects of a similar nature as described in Section 3.0.

Selection of the cooling option is a conceptual problem requiring holistic evaluation of alternatives as opposed to design optimization. As described in Section 2.1, a multi-attribute assessment is the most suited approach for such studies. For this project, as illustrated in Figure 7, the proposed BATEA methodology involves the following main steps:

**Figure 7: Assessment Steps**
1. Definition of the objective for BATEA evaluation

The objective of BATEA was clearly defined to provide a focus for the assessment and to help establish a basis for the subsequent option evaluation by setting out the primary boundary conditions to allow the selection of the ‘best’ option.

2. Identification of available technologies

At this step, available technologies or the technologies remaining from the previous screening were identified. The description of the technologies was provided, including some key technical specifications.

3. Identification of attributes

A series of ‘attributes’ was defined for the purpose of evaluation. Attributes were defined as the means of measuring and comparing the key safety, environmental, technological, social and cost characteristics and consequences of each of the options that are thought to be important and relevant at the level of detail being considered. Attributes were chosen to reflect a wide variety of issues of potential concern to different stakeholders.

Stakeholders for the current project include: industry, regulatory bodies, local community, first nations, local and provincial government representatives, and Non-Governmental Organizations.

The ability of attributes to be objectively scored was also an important factor in their selection.

It should be noted that only attributes directly associated with the potential impacts from operating condenser cooling system alternatives were selected. Other potential impacts on the environment, which result from reactor operation, were not considered.

Once selected, the choice of attributes was compared against parameters used in other assessments as described in Section 3.0 and summarized in Appendix E.

4. Definition of scoring scheme

A scoring scheme was defined, allowing the attributes to be applied to the different options in a way that facilitates their various technological and environmental characteristics and allows consequences to be compared and contrasted. The scoring scheme for a particular attribute fell into one of the following two categories:

- Ranking based on quantitative criteria: different scores were assigned based on regulatory limits or constraints.
- Ranking based on relative comparison: when limits or constraints were not available for a specific attribute.

Weighting factors were not used to differentiate attribute importance because they can be subjective and in any case, attribute scores were not added in order to select BATEA. Instead judgement based on stakeholder opinion...
gathered during the EA process was used to determine relative significance of attributes in a transparent manner as described further (see Step 6).

5. **Evaluation of different options (Stage 1)**

Following the four steps discussed above, an evaluation was carried out to score each of the options against every attribute using the defined scoring scheme. The evaluation was performed in two stages. An initial assessment (Stage 1) was conducted for the options without any enhancements to the basic technology. A design consistent with DNGS was used for the initial assessment of the OTC system. A typical MDCT design without any additional plume abatement was evaluated for the initial assessment of the cooling tower option.

This approach establishes a non-enhanced baseline for an unbiased initial Stage 1 comparison of the two cooling technologies. Also, by establishing the non-enhanced baseline and then subsequently evaluating MDCT with the maximum plume abatement in Stage 2, the full range of MDCT abatement performance will be assessed thereby satisfying the JRP recommendation.

All project phases, including site preparation, construction, operation, and decommissioning were considered as appropriate for the selected attributes. During this process, quantitative and qualitative information was used to provide a basis for scoring. This included historical data and modelling results, insights derived from the DNNP EA hearings and, where appropriate, expert opinions.

Attribute uncertainty that can potentially impact the overall conclusion was qualitatively reviewed and clearly identified.

6. **Define “Key” Attributes**

The results for the initial assessment attributes were reviewed to determine if there were any significant differences in performance between the two options. This review, and the importance of each parameter were also considered in selecting the Key Attributes. The key attributes were determined on the basis of the outcome of Step 5 (Stage 1). These were the dominant contributors to the overall evaluation, i.e. for which there is a wide margin in scoring.

7. **Repeat evaluation for enhanced designs (Stage 2)**

Cost-effective design or technological enhancements were considered at Stage 2 of the assessment. If significant differences in performance were identified, enhancements were considered for the key attributes only and the option assessment was repeated based on the enhanced designs.

Further mitigation of the effects on the environment is available for the protection of species habitat, primarily through compensation.

Note that while habitat offsets and mitigation improvements are considered in this assessment, they are not quantified within the Stage 2 evaluation given that:
• their impact on performance is less certain and it would be some time before the full realisation of any improvements would be known;

• the nature of compensatory measures, for example, establishing colonies offsite, is such that these would generally apply to both options, so the benefits would not provide distinction between the two options.

Instead these improvements are considered qualitatively in the Stage 2 evaluation and taken into account in the final conclusions.

8. Initial selection of BATEA option

Once a comprehensive, systematic and consistent assessment of options against all attributes was completed, it was possible to identify the BATEA. The decision was based on a logical analysis of relative advantages and disadvantages of the enhanced options taking cost into account.

There were three possible scenarios for selecting the best option:

• If one of the two options were to perform better across all attributes, it would be selected as the BATEA.

• If there is no substantive difference in performance against non-financial attributes between the two options then cost will be the deciding factor.

• If one option were to perform better against certain attributes but not others then the BATEA will be selected on the basis of attribute importance, the differences in attribute performance for each cooling technology and cost.

9. Consultation with stakeholders

A consultation program was implemented to provide the public and stakeholders with information regarding the assessment and initial selection, and to review and confirm the factual basis and assumptions used in the evaluation of attributes. The feedback and inputs from the consultation program have been factored into the assessment and have been included in this report.

10. Final Selection of BATEA option

The BATEA, initially selected in Step 8 was reviewed to consider stakeholder feedback from Step 9. A number of changes were introduced including changes to the list of attributes, the attribute scoring schemes, and facts and assumptions in the basis of evaluation. This resulted in a new iteration of the assessment and steps 3 to 7 were repeated to reflect the changes. A sensitivity study was conducted to evaluate the impact of various uncertainties on the BATEA selection. This provided a sound technical basis for selecting the BATEA condenser cooling option for the DNNP. The selected BATEA is the recommended option. OPG will subsequently consider this recommendation as the technical basis for making the decision on the Condenser Cooling system for DNNP in accordance with their mandate, corporate values and policies.
Steps 1 through 4, which define objectives, technologies and the evaluation scheme, are implemented in Section 5.0. Steps 5 through 7, including the Stage 1 assessment, definition of key attributes and Stage 2 assessment of enhanced designs are described in Section 6.0. The initial recommendation for selection of the BATEA option (Step 8) is made in Section 7.0. Step 9 (Stakeholder Consultation) is presented in Section 8.0 and Step 10 (Final Selection) is presented in Section 9.0.

4.2 How Assessment Methodology Addresses JRP Concerns on Methodology

CNSC and the Department of Fisheries and Oceans Canada recommended to the JRP that OPG undertake a formal quantitative cost-benefit analysis for the range of condenser cooling water options, applying the principle of Best Available Technology Economically Achievable (BATEA), and this was incorporated in the JRP report as Recommendation #3 [5]. JRP expressed a concern that a “definitive comparison of alternative options with respect to environmental effects” is needed because the original EIS did not provide “appropriate weighting for factors that related to loss of biota and effects on aquatic habitat, socio-economic considerations, capital cost and energy consumption”. The Government of Canada accepted that the intent of this recommendation was “to require OPG to conduct a formal quantitative cost-benefit analysis for cooling tower and once-through condenser cooling water systems, as recommended,” but acknowledged that this analysis “may be required earlier than indicated in the recommendation given the relationship between site layout and the choice of condenser cooling technology” [6].

The methodology described in Section 4.1 provides the basis for a comparison of alternatives based on quantitative assessment of different environmental and cost aspects (“attributes”). These attributes are defined in Step 3. They are used for quantitative assessment of the options in Steps 5.

The process of weighting involves emphasizing the contribution of some attributes of a technology on a final selection. This is incorporated within the methodology by the selection and use of “Key Attributes” to conduct the final assessment (Steps 6 and 7).

Application of the multi-attribute assessment methodology described in Section 4.1 is consistent with the approaches used in several recent international studies (see Section 3.0). Pure cost-benefit analysis assigns a dollar value to each parameter involved in the assessment that pertains to the stated objective. Such an analysis would be less capable of addressing circumstances with multiple and complex impacts for each option, some of which cannot be evaluated in terms of costs. The approach described in Section 4.1 addresses the JRP requirement for a quantitative cost-benefit analysis by incorporating quantitative assessment of benefits and costs associated with each option (Steps 5 and 7).
5.0 DEFINITION OF OBJECTIVES, TECHNOLOGIES AND EVALUATION SCORING SCHEME

5.1 Step 1 – Definition of the Objective

The objective of this assessment is to determine the DNNP condenser cooling technology that has the best practicable environmental performance with the consideration of cost.

5.2 Step 2 - Identification of Cooling Technologies (Without Enhancements)

For the DNNP, the following cooling technologies have been previously considered, see Reference [2]:

- OTC technology,
- Cooling Tower technologies, which include;
  - Natural draft cooling tower (NDCT),
  - Fan assisted cooling tower,
  - Mechanical draft cooling tower (MDCT),
  - Hybrid wet/dry cooling tower,
  - Dry cooling tower, and
  - Spray/cooling pond.

These options have been evaluated against a range of criteria [2]. The assessment found that further consideration of cooling/spray ponds is not recommended due to site boundary limitations. NDCT were similarly eliminated due to their off-site impact.

Taking into account the earlier evaluation of the cooling tower options [2] and subsequent JRP recommendation #3 as described in Section 1.1, it is understood that the expectation is to evaluate only the following two cooling options:

- Once Through Cooling, and
- Mechanical Draft Cooling Towers\(^4\).

Brief descriptions of the two systems are provided below. Further details can be found in Appendix B.

5.2.1 Once Through Cooling System

Once Through Cooling removes excess heat to a large water body. For the DNNP, withdrawn lake water flows through heat exchangers (condensers) once to remove the excess energy of the exhaust steam. The water is then returned to its source. The amount of heat removed during this process depends on the flow rate and the temperature rise of the water passing through the condenser.

\(^4\) As noted in Section 4.0, MDCT plume abatement will be considered in Step 7 – Repeat Evaluation for Enhanced Designs.
In order to undertake the initial evaluation of the Once Through Cooling system, it was assumed that the intake and discharge structures would be placed at similar depths to the existing Darlington Nuclear Generating Station (DNGS) system. Furthermore, both the intake and discharge would be sized to account for the higher heat rejection anticipated for the DNNP design.

5.2.2 Mechanical Draft Cooling Tower

Mechanical Draft Cooling Towers remove excess heat to the atmosphere. The technology re-circulates water in a closed cycle. After passing through heat exchangers to remove excess energy from the exhaust steam, water is pumped to the Cooling Towers, where it is cooled by drawing air across fins to transfer heat to the atmosphere. To achieve the designed heat transfer, Mechanical Draft Cooling Towers utilize industrial fans. Chemicals are added to prevent corrosion and biological fouling. Removal of some cooling water (or “blowdown”) into the lake following treatment is used to control the buildup of dissolved materials and other contaminants. Water has to be drawn in from the lake to compensate for blowdown and evaporative losses.

The initial evaluation considered a modern Mechanical Draft Cooling Tower design without plume abatement technology. It was assumed that both the intake and discharge placement would be consistent with the existing DNGS and would be sized to account for the lower water intake requirement associated with this technology.

5.2.3 Assumptions

Each of these options is evaluated based on heat rejection to the condenser. As the reactor technology to be used for the DNNP is not yet determined, the assessment will be reactor technology neutral with assumed reference heat rejection of 8836 MWt and 4418 MWt, corresponding to four and two Westinghouse AP1000 Units respectively. These values are considered to be representative of the potential reactor technologies which may be implemented at the Darlington site.

The following design assumptions were initially applied to both cooling options, i.e. for the Stage 1 assessment:

- The intake depth will be consistent with the current DNGS design and will be located at a depth of 10 m,
- The discharge tunnel will initiate release at a depth of 10 m, consistent with the current Darlington NGS discharge. The size and nature of the discharge system will differ based on the flow requirements of each system and will be scaled accordingly,
- The placement of the intake structure and discharge tunnel will be consistent with the current DNGS design while preventing the potential interaction with the existing discharge and intake structure,
- Effluent discharge from either system or flows that connect to the system will be treated to ensure the discharge is within regulatory limits, and
- The intake tunnel for smaller heat rejection rate will be sized to the maximum number of units of equal power generation, capable of fitting on-site to allow for future expansion.

As discussed in Section 4.0, design and/or technological enhancements will be considered as necessary for the Stage 2 assessment.

5.2.4 Site Layout and Excavation Assumptions - Reactor Block Baseline

The existing Darlington site is approximately 485 ha in size, 70 km east of Toronto and located in the Municipality of Clarington, within the Region Municipality of Durham. The site is bounded to the north by the South Service Road of Highway 401 and to the south by Lake Ontario. Solina Road and agricultural lands bound the site to the west and St. Mary’s Cement, a large industrial limestone plant, is on the east. An operating Canadian National (CN) railway extends east-west across the site.

The DNNP development will primarily occupy the eastern one-third of the overall DNGS site. The DNNP would be bounded by the Darlington site property limits on the east and north boundaries, Lake Ontario to the south, and by Holt Road (including its southerly projection to Lake Ontario) on the west (Section 1.1.2 [1]).

During the site preparation phase, soil and rock would be excavated for the construction of a four unit reactor block and a condenser cooling water system. The excavation required for the reactor block, independent of the chosen cooling technology, has been established as a baseline for the assessment.

Excluding all cooling technology land requirements, the reactor block and supporting facilities would require a total of 41.6 ha. This takes into account a partial 2 m lake infill just west of Maple Grove Road, which would be constructed to accommodate different reactor types and is independent of the chosen cooling option [23]. Note that as the lake infill would inevitably change the surrounding environment of the Darlington site, a 2 m lake infill depth (as recommended by the JRP) would minimize any potential adverse effects. See Figure 8 for layout details.

The total volume of excavated soil for the four-unit reactor block is 8.77 Mm$^3$, regardless of the cooling options. For soil management, 4.5 Mm$^3$ of the excavated materials would be stored at the North-East soil stockpile and 0.457 Mm$^3$ will be placed in a partial 2 m lake infill, see Figure 8. The remaining 3.81 Mm$^3$ of excavated material will be transferred for off-site management.

Note that the total area occupied by the DNNP would depend on the chosen reactor technology and cooling option. Although space utilization remains dependent on the reactor technology selected and efforts to optimize site layout, use of the MDCT in combination with the lake infill to the 2m depth mark, will likely constrain the total number of units that could fit onto the site. Conceptual layouts indicating potential problem for some of the considered technologies are illustrated in OPG’s response to JRP’s request for Undertaking 29 (24). The MDCT option, considered in this response, was estimated to require up to 8 ha above and beyond the 2m lake infill, depending on the selected reactor technology. For the purposes of the current assessment, it is assumed that both cooling technologies would fit within the DNNP site.
The excavation requirements associated with the cooling technologies will vary depending on the selected option. Comprehensive information on the excavation requirements for each cooling option is discussed in Appendix G.

**Figure 8: DNNP Site Layout**

5.3 **Step 3 - Identification of Attributes**

The attributes considered for the evaluation of the two cooling options are discussed below and are summarized in Table 3. These attributes are organized into groups and reflect a wide variety of potential issues of concern raised by various stakeholders during the EA. The attribute selection was initially made at a technical workshop on the subject matter. It was finalized following the stakeholder consultation program. The attributes were selected based on the understanding of the two technologies, preliminary analysis of potential effects associated with their implementation, review of the Environmental Assessment documentation and professional judgement of technical experts. Canadian and international guidance and experience have been analyzed to ensure that all relevant factors were considered [7] [10] [11] [12] [13]
[24]. In the assessment stage, options were scored against all attributes taking into account the effects of the full life cycle of the DNNP. A single exception is the attribute “risks to worker health and safety” (Attribute 1.2 listed in Table 2). The evaluation of this attribute excludes the construction phase given that construction related risks apply equally to both options and are not considered to be a significant differentiating factor.

The JRP recommendations reflecting a wide involvement of concerned parties and inputs from multiple stakeholders have been taken into account during the attribute selection process. The linkage of the JRP recommendations and the attributes selected, which demonstrate how the JRP’s concerns are addressed, is provided in Appendix C.

Attribute Groups:

i. **Health and safety**: This group reflects the confidence that an option could protect human health. Two attributes were identified in this group: public health and safety, and worker health and safety.

   It should be noted that radiological aspects of health and safety are not included under this group as the cooling systems do not give rise to release of radioactivity. Radionuclide releases are associated with vendor-specific reactor technologies, which are independent from the cooling options. All radiological requirements and guidelines will be met throughout the project irrespective of the selected cooling option.

ii. **Physical environment**: This group reflects the consequences of the cooling technology of the physical environment. Seven attributes are identified in this group.

iii. **Habitat and ecosystems**: This group reflects the consequences of the cooling technology on habitat and ecosystems. Five attributes are identified in this group.

iv. **Technical performance**: This attribute group addresses an option’s ability to perform its planned function. The attribute will be assessed from the perspectives of maturity of technology, operation and maintenance complexity, reliability, and past experience with the technology.

v. **Financial cost**: This attribute group measures the cost of implementing each option. One attribute is identified in this group. The costs are presented as Total Annual Costs (TAC), which includes direct and indirect costs as specified in the Ontario BACTEA guidelines [13] and in terms of Net Present Value (NPV).

It should be noted that a single consideration may impact more than one of the above five identified attribute groups. In such cases, the relevant aspects will be discussed and assessed under each of the applicable headings (e.g. Bank Swallows have both an environmental impact and a financial cost due to habitat relocation).

There are some other aspects which are considered as candidate attributes during the early stage of the attribute selection process. However, these aspects either overlap with the attributes identified in Table 3 or are not considered to be significant to this
project and therefore are not used as attributes. The rationale for exclusion of these aspects as attributes is presented in Appendix D.

Table 3: Attributes Considered for Evaluation of the Two Cooling Options

<table>
<thead>
<tr>
<th>Attribute Group</th>
<th>Attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Health and safety</td>
<td>1.1 Risks to public health and safety</td>
</tr>
<tr>
<td></td>
<td>1.2 Risks to worker health and safety</td>
</tr>
<tr>
<td>2. Physical environment</td>
<td>2.1 Water quality/emission to water (concentration of waterborne contaminants)</td>
</tr>
<tr>
<td></td>
<td>2.2 Air quality/emission to air (concentration of airborne contaminants)</td>
</tr>
<tr>
<td></td>
<td>2.3 Noise level (noise levels at receptor locations)</td>
</tr>
<tr>
<td></td>
<td>2.4 Water consumption (consumption rate)</td>
</tr>
<tr>
<td></td>
<td>2.5 Local climate change (fog, icing, temperature, humidity, precipitation)</td>
</tr>
<tr>
<td></td>
<td>2.6 Visual effect (views and vista)</td>
</tr>
<tr>
<td></td>
<td>2.7 Excavated materials</td>
</tr>
<tr>
<td>3. Habitat and ecosystems</td>
<td>3.1 Fish impingement (impingement reduction rate/ quantity of fish mortality)</td>
</tr>
<tr>
<td></td>
<td>3.2 Fish entrainment (entrainment reduction rate/ number of eggs and larvae entrained)</td>
</tr>
<tr>
<td></td>
<td>3.3 Thermal discharge to lake (size of the thermal plume/mixing zone and temperature of release to water)</td>
</tr>
<tr>
<td></td>
<td>3.4 Aquatic habitat (area of aquatic habitat)</td>
</tr>
<tr>
<td></td>
<td>3.5 Terrestrial habitat (area of terrestrial habitat)</td>
</tr>
<tr>
<td>4. Technical performance</td>
<td>4.1 Technical performance (maturity, reliability and operating experience)</td>
</tr>
<tr>
<td>5. Cost</td>
<td>5.1 Cost (TAC and NPV)</td>
</tr>
</tbody>
</table>

The attribute groups and attributes themselves are consistent with parameters recommended in European, British and US guidance and used in recent studies of a similar nature as described in Sections 2.0 and 0. Correlation between attributes in the current study and other recent assessments is provided in Appendix E in a tabular format.

5.4 Step 4 - Definition of Scoring Scheme

The method of scoring each option against the attributes identified for this assessment uses a simple system, which is based on an integer scale from zero to five. It should be noted that the Cost attribute is the single exception to this scoring given that it is already a numeric parameter, it does not benefit from assigning an integer score.
To make the scoring system consistent and to relate the numerical scores to meaningful measures of performance, ‘calibration schemes’ were devised for each attribute.

Scores of 0 and 5 carry a special meaning. If the performance of the option is considered to be “intolerable”, then a score of 0 is awarded. This would typically occur when a regulatory limit is exceeded. If the performance of an option is considered to be “ideal” then a score of 5 is awarded. Intermediate scores (2 to 4) are then assigned to complete the range of “acceptable” performances.

Note that in some cases, it may not be possible to assign a score of 0 because no intolerable performance can be envisaged for a particular attribute.

This scoring scheme, defined based on quantitative criteria or relative comparison, is in general consistent with the recommendations made in the PNNL report [3]. For example, the scales are, where possible, anchored from the “ideal” situation (the score of 5) to the “intolerable” level of impact based on regulatory criteria (the score of 0). The intermediate scales, dependent on the characteristics of each attribute, reflect impact on the environment in relation to the minimal acceptable level of performance, as follows:

1. Minimal acceptable performance.
2. Small improvement in performance.
4. Large improvement in performance.

The justifications for a score of 0 to 5 for each attribute are summarized below. The attribute scoring scheme and supporting information is presented in Table 4 through Table 21. Whenever possible, the ranking scheme was selected to be consistent with international guidance [7] [10].

5.4.1 Public Health and Safety

The public health and safety attribute considers the potential risk of injury or even death from an accident. The possible accident scenarios considered are listed below:

- Traffic accidents,
- Airborne contaminates,
- Structure collapse,
- Noise\(^5\),
- Fire,
- Explosion,
- Spill,

\(^5\) Only health and safety-related implications of noise are considered here (e.g. loss of hearing). Nuisance-related aspects of noise are considered in Section 5.4.3.3 under the Noise attribute.
- Emission of hazardous chemicals, and
- Boating related accidents.

The most limiting risk will be used for the evaluation of this attribute.

For scoring purposes, the likelihood of occurrence of accidents and severity of the consequence are categorized in Table 4. The approach is consistent with the existing OPG risk assessment guide [25] and uses severity categorization that is similar to that used by the Ontario Ministry of Transportation [26].

**Table 4: Likelihood and Severity of Risks (Public)**

<table>
<thead>
<tr>
<th>Frequency of Events</th>
<th>Likelihood</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10^{-4} per year</td>
<td>Almost Impossible</td>
<td>1</td>
</tr>
<tr>
<td>between 10^{-3} and 10^{-4} per year</td>
<td>Unlikely</td>
<td>2</td>
</tr>
<tr>
<td>&gt;10^{-3} per year</td>
<td>Possible</td>
<td>3</td>
</tr>
<tr>
<td>&gt;10^{-2} per year</td>
<td>Probable</td>
<td>4</td>
</tr>
<tr>
<td>&gt;10^{-1} per year</td>
<td>Likely</td>
<td>5</td>
</tr>
<tr>
<td>&gt;0.5 per year</td>
<td>Very Likely</td>
<td>6</td>
</tr>
</tbody>
</table>

**Severity**

- Nil (No risk of injury or exposure to hazardous substance) 1
- Negligible (Public exposed to accident consequences, no medical attention) 2
- Minor (Public exposed to accident consequences, requiring minor medical attention, e.g. minor abrasions, bruising etc.) 3
- Moderate (Non-life threatening physical or chemical injuries e.g. person went to the hospital was treated in the emergency room but was not admitted.) 4
- Serious (Critical physical or chemical injuries, e.g. person was admitted to a hospital) 5
- Catastrophic (Fatality, e.g. person killed immediately or within 30 days of the accident) 6

The risk was defined as the product of likelihood and severity. A chart illustrating the scoring scheme is also presented below, in Table 5. The scoring scheme for accidents is summarized in Table 6.
### Table 5: Chart Illustrating Risks

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Severity</th>
<th>nil</th>
<th>Negligible</th>
<th>Minor</th>
<th>Moderate</th>
<th>Serious</th>
<th>Catastrophic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost Impossible</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Unlikely</td>
<td></td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Possible</td>
<td></td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>12</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Probable</td>
<td></td>
<td>4</td>
<td>8</td>
<td>12</td>
<td>16</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Likely</td>
<td></td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Very Likely</td>
<td></td>
<td>6</td>
<td>12</td>
<td>18</td>
<td>24</td>
<td>30</td>
<td>36</td>
</tr>
</tbody>
</table>

### Table 6: Scoring Scheme for Risks to Public Health and Safety

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Potential risk &gt;12</td>
</tr>
<tr>
<td>1</td>
<td>Potential risk in the range of 11 to 12</td>
</tr>
<tr>
<td>2</td>
<td>Potential risk in the range of 9 to 10</td>
</tr>
<tr>
<td>3</td>
<td>Potential risk in the range of 7 to 8</td>
</tr>
<tr>
<td>4</td>
<td>Potential risk in the range of 5 to 6</td>
</tr>
<tr>
<td>5</td>
<td>Potential risk ≤4</td>
</tr>
</tbody>
</table>

#### 5.4.2 Worker Health and Safety

The worker health and safety attribute considers the potential risk of injury or even death from an accident. Again, relevant accident scenarios considered in this instance include structure collapse, fire, noise, explosion, falling, slipping, spill, boating accidents and emission of hazardous chemicals. The most limiting risk was used for the evaluation of this attribute.

For scoring purposes, the likelihood of occurrence of accidents and severity of the consequence summarized in Table 7 was used. Likelihood is based on annualized frequency. The approach is consistent with the existing OPG risk assessment guide [25].
Table 7: Likelihood and Severity of Risks (Workers)

<table>
<thead>
<tr>
<th>Frequency of Events</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10^-4 per year</td>
<td>Almost Impossible</td>
</tr>
<tr>
<td>between 10^-3 and 10^-4 per year</td>
<td>Unlikely</td>
</tr>
<tr>
<td>&gt;10^-3 per year</td>
<td>Possible</td>
</tr>
<tr>
<td>&gt;10^-2 per year</td>
<td>Probable</td>
</tr>
<tr>
<td>&gt;10^-1 per year</td>
<td>Likely</td>
</tr>
<tr>
<td>&gt;0.5 per year</td>
<td>Very Likely</td>
</tr>
</tbody>
</table>

Severity

<table>
<thead>
<tr>
<th>Severity</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil (no risk of injury)</td>
<td>1</td>
</tr>
<tr>
<td>Negligible (No medical attention)</td>
<td>2</td>
</tr>
<tr>
<td>Minor (Some injury including medical attentions)</td>
<td>3</td>
</tr>
<tr>
<td>Moderate (Lost time injury &lt;40 days, Critical injuries less serious in nature, e.g. broken bone)</td>
<td>4</td>
</tr>
<tr>
<td>Serious (Lost time injury &gt;40 days, Critical injuries more serious in nature, e.g. amputations)</td>
<td>5</td>
</tr>
<tr>
<td>Catastrophic (Fatality)</td>
<td>6</td>
</tr>
</tbody>
</table>

The risk is defined as the product of likelihood and severity. The scoring scheme for worker health and safety is summarized in Table 8.

The acceptability of risk to workers is judged to be higher than that to members of the public due to direct benefit and voluntary nature of their exposure to risk.

Table 8: Scoring Scheme for Risks to Worker Health and Safety

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Potential risk &gt;20</td>
</tr>
<tr>
<td>1</td>
<td>Potential risk in the range of 18 to 20</td>
</tr>
<tr>
<td>2</td>
<td>Potential risk in the range of 15 to 17</td>
</tr>
<tr>
<td>3</td>
<td>Potential risk in the range of 12 to 14</td>
</tr>
<tr>
<td>4</td>
<td>Potential risk in the range of 9 to 11</td>
</tr>
<tr>
<td>5</td>
<td>Potential risk ≤8</td>
</tr>
</tbody>
</table>

For the purposes of the BATEA selection, the evaluation of this attribute was limited to the operational phase. While it is recognized that construction poses a relatively higher risk, it is considered to be consistent with any major construction activity within the province and would be comparable for the two technologies.
5.4.3 Physical Environment

5.4.3.1 Water Quality/Emission to Water

The emissions into the surface water from cooling systems could consist of the following chemicals:

- Applied cooling water additives for water treatment and their reactants,
- Airborne substances entering through the cooling system,
- Corrosion products caused by corrosion of the cooling systems’ equipment, and
- Leakage or spills of process chemicals (product) and their reaction products.

The water quality, reflected by the concentrations of contaminants in water or other parameters such as pH and total suspended solids, could be adversely affected due to the release of these chemicals.

In Ontario, discharge to water is regulated by the Ministry of the Environment (MOE) through an Environmental Compliance Approval (ECA)\(^6\) process for water.

For the evaluation purposes, if the option can improve the quality of the receiving water body, the option would merit a score of 5. Conversely, if the contaminants in the effluent from the cooling water system exceed the regulatory limits, a score of 0 would be assigned. The intermediate scores are derived from these two extremes as shown in Table 9.

### Table 9: Scoring Scheme for Water Quality/Emission to Water

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Significant and widespread change to water quality (exceeding substance-specific concentration limits)</td>
</tr>
<tr>
<td>1</td>
<td>Moderate and widespread changes to water quality</td>
</tr>
<tr>
<td>2</td>
<td>Moderate and localized changes to water quality</td>
</tr>
<tr>
<td>3</td>
<td>Marginal and localized changes to water quality</td>
</tr>
<tr>
<td>4</td>
<td>No discernible change to water quality</td>
</tr>
<tr>
<td>5</td>
<td>Improved water quality</td>
</tr>
</tbody>
</table>

5.4.3.2 Air Quality/Emission to Air

Air quality could be affected by the operation of cooling water systems due to the emission of the following substances:

- Chemicals used for water treatment if there is a leak of product, and

---

\(^6\) Note that the ECA is a new instrument of environmental approval that replaced the Certificate of Approval (C of A), as of October 2011.
Water treatment chemicals, microbes or corrosion products contained in plumes.

Air quality criteria are defined by both the Ontario Ministry of the Environment and Environment Canada [27] [28] [29]. Also, in Ontario, emission to air is regulated by the MOE through an Environmental Compliance Approval (ECA) process for air [30].

For evaluation purposes, if the option could result in an improvement of the air quality, the option would merit a score of 5. On the other end, if the airborne emissions due to the operation of the cooling water system exceed the regulatory criteria over extended periods of time at multiple points of impingement, a score of 0 was assigned. Points of impingement will be consistent with receptor locations as evaluated in the Environmental Assessment. The intermediate scores are derived from these two extremes as shown in Table 10.

**Table 10: Scoring Scheme for Air Quality/Emissions to Air**

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The concentrations of airborne contaminants continuously exceed MOE Air Quality Criteria at multiple points of impingement</td>
</tr>
<tr>
<td>1</td>
<td>The concentrations of airborne contaminants at point of impingement increase by over 20% above baseline concentration over extended periods of time</td>
</tr>
<tr>
<td>2</td>
<td>The concentrations of airborne contaminants at point of impingement increase by 10% to 20% (inclusive) above the baseline concentration over extended periods of time</td>
</tr>
<tr>
<td>3</td>
<td>The concentrations of airborne contaminants at point of impingement increase by 5% to 10% (inclusive) above the baseline concentration over extended periods of time</td>
</tr>
<tr>
<td>4</td>
<td>There is no discernible increase of airborne contaminants (increase at point of impingement by &lt;5% above the baseline concentration) over extended periods of time</td>
</tr>
<tr>
<td>5</td>
<td>Improved air quality</td>
</tr>
</tbody>
</table>

5.4.3.3 Noise Level

The operation of some cooling systems could result in elevated noise level. Fans, pumps and falling water are the major sources of noise.

For this project, if the incremental sound level at off-site receptor locations is more than 16 dBA, which represents a “very serious noise problem” as indicated in the National Guidelines [31], a score of 0 was assigned. If there is no increase of sound level over the background value at off-site receptor locations, the option would merit a score of 5. The intermediate scoring scheme, as shown in Table 11, was derived from the provincial and federal guidance [31].

It should be noted that only off-site nuisance related impacts of noise are evaluated under this attribute. Public health impacts of noise are evaluated under the attribute...
“Risks to Public Health and Safety”. On-site impacts on workers are evaluated under the attribute “Risks to Worker Health and Safety”.

Table 11: Scoring Scheme for Noise Level

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The incremental sound level at off-site receptor locations (over background level) is more than 16 dBA</td>
</tr>
<tr>
<td>1</td>
<td>The incremental sound level at off-site receptor locations (over background level) is in the range of 10 to 16 dBA (inclusive)</td>
</tr>
<tr>
<td>2</td>
<td>The incremental sound level at off-site receptor locations (over background level) is in the range of 5 to 10 dBA (inclusive)</td>
</tr>
<tr>
<td>3</td>
<td>The incremental sound level at off-site receptor locations (over background level) is in the range of 3 to 5 dBA (inclusive)</td>
</tr>
<tr>
<td>4</td>
<td>The incremental sound level at off-site receptor locations (over background level) is in the range of 0 to 3 dBA (inclusive)</td>
</tr>
<tr>
<td>5</td>
<td>There is no increase of sound level over the background value at receptor locations off-site</td>
</tr>
</tbody>
</table>

* The noise level of up to 3dBA (over background level) is considered to be hardly perceptible and 3-5 dBA noticeable; 5-10 dBA represents a definite noise problem and 10-16 dBA a serious noise problem [31].

5.4.3.4 Water Consumption

Lake Ontario contains about 1.64 trillion m$^3$ of fresh water and has a water inflow of approximately 7,000 m$^3$/s from Lake Erie through the Niagara River, Lake Ontario basin tributaries, precipitation, and runoff directly from New York State and the Province of Ontario [32].

Water consumption from the lake is subject to several provincial, national and international agreements and regulations. In particular the International Joint Commission was created to help Canada and the US to carry out the provisions of the Boundary Waters Treaty which was signed in 1909 to prevent and resolve disputes over the use of the waters shared by Canada and the United States and to settle other transboundary issues. Although a permit for water withdrawal from Lake Ontario would have to be secured, there is no specific regulation, guideline or standard limiting water consumption. Therefore a score of “0” was not considered applicable to this attribute.

For the purposes of scoring this attribute, the consumption rate of 4.5 m$^3$/s was selected as minimally acceptable corresponding to the score of “1”. It corresponds to the bounding water consumption rate evaluated in the Environmental Assessment [1]. A perfect score of “5” would be assigned to a technology not requiring any water consumption. The intermediate scores are derived from these two extremes as shown in Table 12.

Higher consumption rate can result in higher operating cost for water extraction and treatment. This will be assessed separately.
Table 12: Scoring Scheme for Water Consumption

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>1</td>
<td>Water consumption rate is ≥4.5 m³/s</td>
</tr>
<tr>
<td>2</td>
<td>Water consumption rate is ≥3 but &lt;4.5 m³/s</td>
</tr>
<tr>
<td>3</td>
<td>Water consumption rate is ≥1.5 but &lt;3 m³/s</td>
</tr>
<tr>
<td>4</td>
<td>Water consumption rate is &gt;0 but &lt;1.5 m³/s</td>
</tr>
<tr>
<td>5</td>
<td>No water consumption rate due to evaporation</td>
</tr>
</tbody>
</table>

5.4.3.5 Local Climate Change

As a result of operating condenser cooling systems for some technologies there is an increase in humidity and temperature in the local environment due to evaporation. This could lead to changes in the local climate, for example, high humidity, more precipitation, ice, fog and warmer local temperatures. There is no specific regulation, guideline or standard associated with local climate change. The duration of the adverse anthropogenic (man-made) effects on the climate from fogging and icing was used for the assessment of this attribute.

There is no specific regulation, guideline or standard associated with this concern. However, it was judged that any icing on highway 401 will be unacceptable. Therefore, a score of “0” would be assigned to option resulting in such condition. It was judged that the following adverse local climate conditions would constitute minimal acceptable technology performance, corresponding to a score of “1”:

- For fogging – 30 additional days per year off-site. This would more than double the duration of fogging in certain off-site locations.
- For icing - An extra day of icing in the off-site areas, not reaching 401.

In contrast, if the technology has no adverse anthropogenic effects on the climate, it would be assigned a score of 5. Using expert judgement, the intermediate scores are derived from these two extremes as shown in Table 13.
Table 13: Scoring Scheme for Local Climate Change

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Any technology-induced presence of icing on Highway 401</td>
</tr>
</tbody>
</table>
| 1     | • Either >30 days of additional off-site fogging or  
       |   • >24 hours of off-site icing (no icing on Highway 401) |
| 2     | • ≥20 but <30 days of additional off-site fogging or  
       |   • ≥16 but <24 hours of off-site icing, (no icing on Highway 401) |
| 3     | • ≥10 but <20 days of additional off-site fogging or  
       |   • ≥8 but <16 hours of off-site icing (no icing on Highway 401) |
| 4     | • >0 but <10 days of additional off-site fogging or  
       |   • >0 but <8 hours of off-site icing (no icing on Highway 401) |
| 5     | No adverse effect |

*If an option obtains different scores for fogging and icing impacts then the lower of the two scores will be used.

5.4.3.6 Visual Effect

Construction of a cooling system which may involve construction of high structures may change the appearance of the site and surrounding area. During operation, a condensation plume could be rising for a period of time due to water evaporation or there could be a visual disturbance on the surface of Lake Ontario. This could have visual effects in the vicinity of the site. Correspondingly, the quality of views and vistas and enjoyment of lands could be affected. It may also impact the quality of views and vistas from Lake Ontario which may affect recreational opportunities and use and enjoyment of the lake.

Since there is no specific regulatory limit on this issue, a score of 0 was not considered applicable to this attribute. Instead, if the negative visual effect can be observed at a distance of over 10 km from the site, the related technology would be assigned a score 1. At the other end of the spectrum, if the visual effects are considered a positive change to views and vistas, the option would receive a score of 5. The intermediate scores are derived from these two extremes as shown in Table 14.

For evaluation purposes, it was assumed that the presence of any visual plume at any time, regardless of weather conditions, or at night if lit by the facility or from the lighting of adjoining facilities is a negative visual effect. The size of the plume is accounted for in the distance at which it remains visible.
Table 14: Scoring Scheme for Visual Effect

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>1</td>
<td>Negative changes to the visual aesthetics observed &gt;10 km from the site</td>
</tr>
<tr>
<td>2</td>
<td>Negative changes to the visual aesthetics observed 3 to 10 km from the site</td>
</tr>
<tr>
<td>3</td>
<td>Negative change to the visual aesthetics observed in the vicinity of the site (&lt;3 km)</td>
</tr>
<tr>
<td>4</td>
<td>No discernible reduction in visual aesthetics</td>
</tr>
<tr>
<td>5</td>
<td>Improvement of visual aesthetics</td>
</tr>
</tbody>
</table>

*The distance range for the scoring scheme (<3km, 3 to 10km and >10km) is consistent with the distances used for the assessment in the EA [33].

5.4.3.7 Excavated Materials

During the site preparation phase, soil and rock need to be excavated for the construction of the four unit reactor block and condenser cooling water system. The total amount of excavated materials would be dependent on the combination of the particular reactor technology and the cooling option selected. While some of these materials would be stored onsite, any excess materials would have to be transferred to off-site storage or sold. While the direct environmental effects on terrestrial and aquatic biota associated with excavation will be discussed separately (see Sections 5.4.4.4 and 5.4.4.5), the management of these extra excavated materials, including off-site relocation and storage, would have adverse effects on the environment which should be considered appropriately.

The reactor block baseline would require a total excavation of 8.77 Mm$^3$, regardless of the chosen cooling option. The available on-site storage locations include:

1. 4.5 Mm$^3$ placed in the north-east soil stockpile, and
2. Partial 2 m lake infill at 0.457 Mm$^3$.

The remaining 3.81 Mm$^3$ of excavated material will be transferred off-site. See Section 5.2.4 for more detail.

The requirements on the availability of land or space by different cooling technologies could be significantly different. For DNNP, the lake infill is required to accommodate different reactor types and condenser cooling options. However, the lake infill will inevitably change the surrounding environment of the Darlington site. To minimize any potential adverse effects, a constraint of the lake infill to a 2 m depth has been established by the JRP for the DNNP.

Soil excavated for either cooling option in addition to the 3.81 Mm$^3$ resulting from excavation of the power block will have to be transported off-site and require additional off-site management. Off-site transportation of excavated material is associated with such nuisance effects as truck traffic, noise and dust, as well as
environmental effects such as emissions and roadkill. There is also an indirect economic effect due to road maintenance requirements resulting from the additional traffic. These indirect effects of excavation, which will occur over a limited period of time during construction, are not captured under any of the other attributes. For example the “Noise Level” attribute only reflects noise due to operation of the cooling technology. Evaluation of the volume of additional excavation provided a transparent method for capturing these indirect effects.

Therefore, the “ideal” scenario would be that there is no additional excavated material requiring off-site transfer beyond the 3.81 Mm$^3$ resulting from excavation of the power block. As such there would be no adverse environmental effect associated with the management of these materials. A score of 5 would be assigned to such a scenario.

A score of 0 was not assigned, as there was no mandatory limit on this attribute. If a cooling technology requires off-site soil management in the excess of 2.6 Mm$^3$ above the baseline scenario, then it is assigned a score of 1. Note that the volume of 2.6 Mm$^3$ represents the bounding estimated value for the two options considered. Intermediate scores are assigned based on the reduced volume of the excavated materials requiring off-site management, as summarized in Table 15.

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>1</td>
<td>Exceeds the estimated volume of 2.6 Mm$^3$ of additional excavated materials which requires off-site management</td>
</tr>
<tr>
<td>2</td>
<td>1.7 Mm$^3$ to 2.6 Mm$^3$ (inclusive) of additional excavated materials which requires off-site management</td>
</tr>
<tr>
<td>3</td>
<td>0.87 Mm$^3$ to 1.7 Mm$^3$ (inclusive) of additional excavated materials which requires off-site management</td>
</tr>
<tr>
<td>4</td>
<td>Less than 0.87 Mm$^3$ of additional excavated materials which requires off-site management</td>
</tr>
<tr>
<td>5</td>
<td>No additional excavated materials requiring off-site management (all being used for 2 m lake infill and on-site storage)</td>
</tr>
</tbody>
</table>

5.4.4 Habitat and Ecosystems

5.4.4.1 Fish Impingement

Impingement occurs when fish and other aquatic species are drawn into the station with the cooling water and become trapped on the intake screens. A significant amount of cooling water may be withdrawn from Lake Ontario at varying flow rates. This could potentially result in high mortality of fish and other aquatic species due to impingement.

Section 32 of the Canadian Fisheries Act states that “no person shall destroy fish by any means other than fishing except as authorized by the Minister or under
regulations made by the Governor in Council under this act” [34]. There are no provisions in this Act for proposed technologies to meet specific goals in impingement reduction. Recently, the CNSC gave the PNGS a target to reduce fish impingement by 80% (resulting in the installation of and an effectiveness study of a barrier net in 2010) and this was based on the guidance of the US EPA 316b. Improvements were identified on the basis of a study which is detailed in Appendix F. This reduction is to be achieved over “baseline” which is the quantity of fish impinged by extracting water from the lake at the rate required for an OTC technology and assuming no mitigation measures are in place (e.g. screens, flow reduction, placement of intakes into locations with low fish production).

US EPA regulation 316(b) US EPA 316b Phase I regulation for “new” facilities recommends using cooling towers (Track I) or best technology available (Track II) to minimize adverse effects due to impingement and entrainment. Requirements for USEPA 316b Phase I, Track I include reducing the intake flow, at a minimum, to a level commensurate with that which can be attained by a closed-cycle recirculating cooling water system, effectively stipulating the cooling tower condenser cooling technology.

Requirements for Track II include demonstrating that the cooling technology will reduce both impingement mortality and entrainment of all life stages of fish to 90% or greater of the reduction that would be achieved through Track I. Under Track II requirements a “baseline” was required to be defined against which the improvements were measured, and according to which the cooling water intake structure was a shoreline structure and “at the surface.” Furthermore, under the regulation, which has since been rescinded, it was permitted to consider impacts other than impingement mortality and entrainment, such that the measures taken will maintain the fish and shellfish in the waterbody at a substantially similar level to that which would be achieved through Track I.

Although requirements of the US EPA regulation 316(b) do not apply in Canada, the impingement evaluation framework described below is generally based on the overall approach specified in that regulation. Specifically:

- As, noted above, impingement is measured in terms of reduction versus “baseline”, which is defined as an unmitigated shoreline OTC intake. This is consistent with the manner in which US EPA regulation 316(b) has been applied (e.g. [11]).

- There is no requirement to reduce impingement by 90% vs. baseline. This is because the 90% reduction in Regulation 316(b) is specified in relation to the Track I Technology, which itself may not achieve 100% reduction vs. the baseline.

- The 90% reduction can be achieved by a combination of condenser cooling technology and other means of maintaining the fish and shellfish in the waterbody. The impingement and entrainment reduction targets in EPA Regulation 316(b) are specified in terms of total quantities, rather than individual species. Note that Regulation 316(b) includes a separate requirement to evaluate impacts on individual species and considers shellfish as well as fish. The latter requirement concerning shellfish will not be applied.
in the context of the current assessment as Zebra and Quagga mussels are considered to be invasive species in Lake Ontario.

For the purposes of this assessment, a “perfect” score of 5 would be assigned if the technology does not result in any fish mortality due to impingement. It is understood that impingement reduction of less than 80% compared to baseline would not be acceptable for a new nuclear power plant in Ontario\(^7\). Therefore, a score of 0 would be assigned to options with equivalent or lower reduction rates.

A score of 1 would be assigned to the technology with a reduction rate equal or greater than 80% but less than 85% for impingement compared to an OTC system without mitigation.

Reduction of impingement mortality of at least 95% will be assigned a score of 4. Score of 3 and 2 would be assigned based on lower reduction rates on impingement as shown in Table 16.

For the assessment purpose, the quantity of fish mortality due to impingement, in units of kg per annum, would be used as the measuring parameter for this attribute as well as percentage reduction. The approach of using biomass to measure improvement vs. baseline is consistent with that used in Regulation 316(b). However it is also recognized that the actual distribution of impacted fish species between the options may be important and this information should be considered in the evaluation.

If it were to be determined that valuable fish species are impacted disproportionately, then this factor should be taken into account during decision-making.

\(^7\) Based on DNGS intake performance being the minimally acceptable. In the version provided for Stakeholder review, reduction ≤80% for impingement compared to a Once Through shoreline intake system without fish protection mitigation was assigned a score of 0. Calibration has been modified based on Stakeholder feedback. It is understood that an intake system such as at PNGS would no longer be acceptable for a new facility.
### Table 16: Scoring Scheme for Fish Impingement

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Reduction &lt;80% for impingement compared to a Once Through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>1</td>
<td>Reduction ≥80% but &lt;85% for impingement compared to a Once Through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>2</td>
<td>Reduction ≥85% but &lt;90% for impingement compared to a Once Through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>3</td>
<td>Reduction ≥90% but &lt;95% for impingement compared to a Once Through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>4</td>
<td>Reduction ≥95% for impingement compared to a Once Through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>5</td>
<td>No impingement</td>
</tr>
</tbody>
</table>

#### 5.4.4.2 Fish Entrainment

Entrainment occurs when larvae, eggs and other aquatic species are drawn into the intake with the cooling water and pass through the intake screens. A significant amount of cooling water may be withdrawn from Lake Ontario at varying flow rates. This could potentially result in high mortality of fish and other aquatic species due to entrainment, in addition to impingement.

Section 32 of the Canadian Fisheries Act states that “no person shall destroy fish by any means other than fishing except as authorized by the Minister or under regulations made by the Governor in Council under this act” [34]. There are no provisions in this Act for proposed technologies to meet specific goals in entrainment reduction.

A “perfect” score of 5 would be assigned if the technology does not result in any fish mortality due to entrainment. A reduction of less than 60% for entrainment compared to an OTC system without mitigation is judged to be unacceptable for a new nuclear power plant in Ontario. Therefore, a score of 0 would be assigned to such options. A reduction of 60% to 70% for entrainment compared to an OTC system without mitigation is considered to be the minimal acceptable performance for this application.

---

8 Based on DNGS intake performance being minimally acceptable. In the version provided for Stakeholder review, a system without protection for entrainment was assigned a score of 0. Calibration has been modified based on Stakeholder feedback. It is understood that an intake system such as at PNGS would no longer be acceptable for a new facility.
and would be assigned a score of 1. Reduction of entrainment of more than 90% would be assigned a score of 4. Score of 3 and 2 would be assigned based on reduced reduction rate on entrainment as shown in Table 17. It should be noted that the percentage reductions selected for fish entrainment are slightly lower than for fish impingement as it is much harder to achieve entrainment reductions than impingemnt reductions.

In contrast to impingement, entrainment results are normally presented only as counts and not as biomass. For assessment purpose, the estimated number of entrained eggs and larvae per annum was used as the measuring parameter for this attribute as well as percentage reduction. The Equivalent Adult Model was used to express entrainment losses at all life stages as an equivalent number of age 1 individuals [35].

**Table 17: Scoring Scheme for Fish Entrainment**

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Reduction of &lt;60% for entrainment compared to a Once Through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>1</td>
<td>Reduction of ≥60% but &lt;70% for entrainment compared to a Once Through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>2</td>
<td>Reduction of ≥70% but ≤80% for entrainment compared to a Once Through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>3</td>
<td>Reduction of ≥80% but &lt;90% for entrainment compared to a Once Through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>4</td>
<td>Reduction of ≥90% for entrainment compared to a Once Through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>5</td>
<td>No entrainment</td>
</tr>
</tbody>
</table>

5.4.4.3 Thermal Discharge to Lake

The temperature of cooling water after passing through the condenser system would rise and the heat absorbed by the cooling water would be released to the environment. The emissions of heat into the surface water can have adverse effects on the receiving water body. Factors of influence include the available cooling capacity of the receiving surface water, the actual temperature and the ecological status of the surface water.

The maximum temperature increase over ambient lake temperature would take place immediately at the diffuser discharge ports with temperature decreasing sharply with distance from discharge ports due to diffuser design. The impact on fish of such temperatures is negligible, as the fish avoid areas in the immediate proximity to the diffuser discharge points.

According to the Provincial Water Quality Objective [36], “the maximum temperature of the receiving body of water, at any point in the thermal plume outside a mixing zone, shall not exceed 30°C or the temperature of a representative control location plus 10°C or the allowed temperature difference, whichever is the lesser temperature.”
As this requirement relates to temperature outside of the mixing zone and there are no current permit requirements for DNGS in relation to the maximum temperature of discharge, size of the mixing zone is selected as the primary criterion for evaluating thermal discharge to Lake Ontario, as opposed to the maximum temperature at the point of release.

The maximum size of thermal plume/mixing zone resulting from the DNNP was estimated in the EA study. The mixing zone was defined as the area in the plume where the water temperature is within 2ºC of ambient lake temperature [37]. The mixing zone is made up of three zones: the turbulent mixing zone; the transitional zone; and the laminar mixing zone [38].

If the size of this mixing zone, as estimated in the EA study, was exceeded, a score of 0 would be assigned. If there is no thermal plume/mixing zone or short-term temperature elevation from discharges associated with the DNNP, an “ideal” scenario, the technology employed would merit a score of 5. The intermediate scores were derived from these two scenarios as shown in Table 18.

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Exceeds maximum size of the thermal plume/mixing zone from the EA study (“baseline”)</td>
</tr>
<tr>
<td>1</td>
<td>Less than or equal to baseline plume/mixing zone</td>
</tr>
<tr>
<td>2</td>
<td>Reduction of &gt;25% but ≤50% in thermal plume/mixing zone from baseline</td>
</tr>
<tr>
<td>3</td>
<td>Reduction of &gt;50% but ≤75% in thermal plume/mixing zone from baseline</td>
</tr>
<tr>
<td>4</td>
<td>More than 75% reduction in thermal plume/mixing zone from baseline</td>
</tr>
<tr>
<td>5</td>
<td>No thermal plume/mixing zone</td>
</tr>
</tbody>
</table>

5.4.4.4 Aquatic Habitat

The construction and operation of condenser cooling water systems would potentially have negative effects on aquatic habitat.

It was determined that a lake infill up to the depth of 2 m would be required, but the options varied as to the extent of the infill along the shore. The reactor block would require a partial 2 m lake infill, a total of 12.2 ha. Further loss of aquatic habitat could be caused as a result of the placement of water intake and outfall systems and the possible extension of the lake infill. Although these may be in part or fully mitigated by such measures as shoreline improvement, the “Aquatic Habitat” attribute was designed to reflect differences in option performance as a result of placement and operation of the intake and outfall.

In addition to the physical loss of habitat, impact of contaminant discharges and offshore shunting due to currents induced by the condenser cooling system may
impact aquatic habitats. In general contaminant discharges to water was evaluated under the attribute “Water Quality/Emission to Water” (see Section 5.4.3.1). The issues associated with the induced changes in lake currents are discussed below.

The discharge water causes local warming and the high release flowrate re-directs the natural shoreline lake currents and bottom sediments. The shoreline lake currents contain naturally drifting fish eggs, small fish larvae, plankton and invertebrate organisms which themselves may be redirected offshore. This type of effect could displace these organisms from their normal living spaces, or habitats, into alternative areas that are sub-optimal and limiting to their survival, reproduction and growth [39]. This is because larval fish shunted offshore into unsuitable environmental conditions are exposed to more hazards than nearshore (e.g. colder temperature, lower prey densities; higher predation) that could reduce growth and survival. It is known that colder temperatures can negatively impact growth rates and survival of fish larvae (e.g. [40]). This may occur only when drifting larvae/eggs are in the area and during periods of low current velocity.

At present it is not possible to reliably predict biological effects of larval offshore shunting until ongoing research provides a better cause-effect basis. Thus this effect could not be used to evaluate the two options, since the relationship between the effect on populations of non-human biota in the lake and local turbulence is impossible to evaluate. Therefore, the attribute was evaluated on the basis of physical loss of habitat alone.

A score of 0 was not assigned as there is no mandatory limit on loss of habitat. A score of 1 would be assigned to an option associated with the maximum estimated loss of habitat of approximately 8 ha (See Appendix G). A score of five would be assigned if the placement and operation of the condenser cooling systems will not result in any loss of aquatic habitat. The intermediate scores were derived from these two extremes on a linear basis as shown in Table 19.

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>1</td>
<td>The loss of aquatic habitat is in the range of ≥6 ha to 8 ha</td>
</tr>
<tr>
<td>2</td>
<td>The loss of aquatic habitat is in the range of ≥4 ha to 6 ha</td>
</tr>
<tr>
<td>3</td>
<td>The loss of aquatic habitat is in the range of ≥2 ha to 4 ha</td>
</tr>
<tr>
<td>4</td>
<td>The loss of aquatic habitat is &lt; 2 ha</td>
</tr>
<tr>
<td>5</td>
<td>There is no loss of aquatic habitat</td>
</tr>
</tbody>
</table>

5.4.4.5 Terrestrial Habitat

The construction and operation of condenser cooling water systems would potentially have negative effects on terrestrial habitats for species of concern. Although these effects may be in part or fully mitigated, the “Terrestrial Habitat” attribute was
designed to reflect differences in option performance as a result of construction and operation of condenser cooling water systems.

The loss of habitat area for species of concern, such as Bank Swallows, was used for the assessment of this attribute.

A score of 5 would be assigned if no additional loss of sensitive species’ habitat is required from the baseline. The baseline is defined as habitat loss due to reactor block construction as described in Section 5.2.4. A score of 0 was not assigned as there was no mandatory limit on this attribute. A score of 1 would be assigned if an option would lead to significant loss of all habitats of species of concern in the site study area, with less than 25% preserved. The intermediate score was derived from these two extremes as shown in Table 20.

Table 20: Scoring Scheme for Terrestrial Habitat

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>1</td>
<td>&lt;25% of additional habitat of species of concern in the local study area is preserved.</td>
</tr>
<tr>
<td>2</td>
<td>≥25% but &lt;50% of additional habitat of species of concern in the local study area is preserved.</td>
</tr>
<tr>
<td>3</td>
<td>≥50% but &lt;75% of additional habitat of species of concern in the local study area is preserved.</td>
</tr>
<tr>
<td>4</td>
<td>≥75% but &lt;100% of additional habitat of species of concern in the local study area is preserved.</td>
</tr>
<tr>
<td>5</td>
<td>No additional loss of habitat from the baseline for species of concern in the local study area</td>
</tr>
</tbody>
</table>

5.4.5 Technical Performance

5.4.5.1 Technical Performance

This attribute provides an evaluation of different condenser cooling technologies in terms of maturity of the technology, complexity and reliability of operation and maintenance of the technology. The operating experience with the use of the technology is also factored in. It reflects the ability of the technology to cope with the local environmental hazards, including algae, zebra mussels, frazil ice, tornadoes, hurricanes and extreme temperatures.

If the technology has never been used on an industrial scale, the technology is considered unacceptable and a score of 0 will be assigned. If, on the other hand, the technology is mature and has been widely used with good track record, is easy to operate and maintain, and there is extensive operating experience in the nuclear industry, the technology is considered to be “ideal” and the highest score of 5 will be given. The intermediate scores were derived from these two extremes as shown in Table 21.
### Table 21: Scoring Scheme for Technical Performance

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The technology has never been applied on an industrial scale</td>
</tr>
<tr>
<td>1</td>
<td>Novel technology with limited application on an industrial scale</td>
</tr>
<tr>
<td>2</td>
<td>The technology is mature but limited an industrial use</td>
</tr>
<tr>
<td>3</td>
<td>The technology is mature and has been widely used with good track record, but operation is complex and requires frequent maintenance</td>
</tr>
<tr>
<td>4</td>
<td>The technology is mature and has been widely used with good track record, is easy to operate and maintain, but there is no experience with the technology in the nuclear industry</td>
</tr>
<tr>
<td>5</td>
<td>The technology is mature and has been widely used with good track record, is easy to operate and maintain and there is extensive experience with the technology in the nuclear industry</td>
</tr>
</tbody>
</table>

#### 5.4.6 Cost

Cost data was based on budget estimates currently available [2] [24] and is purely for the purposes of judging the options against each other. Scoring is not required for this attribute as the costs will be used to determine BATEA in a manner that is different from the other attributes (see Section 6.0).

There are two main types of costs, capital and operating costs. Capital costs are one-time expenses that provide a service over an extended period of time. Capital costs are comprised of [9]:

- Equipment purchase,
- Installation/construction costs, and
- Design and project management costs.

Operation costs are recurring expenses incurred to operate equipment. Operation costs are comprised of:

- Ongoing material costs - raw materials, utilities, waste treatment/disposal, labour and maintenance,
- Insurance, administrative and other ongoing costs related to the operation and maintenance of the equipment,
- Compliance costs (could be borne by regulators, industry, or other third party),
- Infrequent component replacement costs,
- Water consumption cost,
- Energy requirements of the system, including loss of thermal efficiency cost,
- Chemical treatment consumption costs, and
- Cost of seasonal de-rating.
Note that consideration of costs also took into account resolution of pertinent JRP recommendations to the extent applicable.

Analysis of cost was carried out using the TAC [9] which was evaluated in accordance with the methodology described in the BACTEA Guidelines [13]. Costs were also presented in terms of NPV.

For the purposes of this guideline, TAC has three elements: direct costs (DC), indirect costs (IC) and recovery credits (RC). The following equation expresses the relationship between these elements:

\[ TAC = DC + IC - RC \]

Where

- DC includes costs of equipment, taxes, labour, site preparation, installation, etc.
- IC includes costs that the facility owner would incur even if the system were shut down. An example of indirect cost would be overhead costs (e.g., property taxes, insurance, etc.). Also includes one-time costs such as engineering, performance tests, etc.
- RC includes the materials or energy recovered by the control system that are sold, recycled into the process or reused on-site.

The general annualized cost formula used to calculate TAC is as follows:

\[ TAC = [(O&M - SAV) x (1-T)] + [(K x (I/(1 - (I+1)^{-n})) x (1 - T)] - [REV x (1 - T)] \]

Where

- TAC = total annualized cost
- O&M = operating and maintenance costs
- SAV = cost savings
- T = income tax rate
- K = capital cost
- I = long-term bond rate
- n = life of abatement equipment or system
- REV = revenues from by-products or co-product sales

where T = 0, TAC represents the "before tax" net cost which is also the cost to society; and where T > 0, TAC represents "after tax" cost which is borne by the industrial facility or operator.

If some of the information identified in the above equation was considered to be irrelevant or no information was available, then a clear disposition statement was made in the cost evaluation worksheet in Appendix G.
5.5 Public Perception

Issues important to the public were considered in the selection of Attributes (Step 3) and in the identification of Key Attributes (Step 6, see Section 6.2). A separate “Public Perception” attribute was initially considered, however it was not included in the final assessment based on stakeholder feedback (Step 9, see Section 8). A separate “Public Perception” Attribute was removed to avoid “double counting” of the issues because public concerns result from other impacts, such as plume visibility and potential impacts on fish. These issues are already addressed by other attributes.

The Environmental Assessment was used as the source of information on public views concerning their priorities and preferences. This included views on condenser cooling options, expressed by Darlington site users, the community at large and elected officials which were solicited during the EA preparation and JRP hearings [1] [5]. Information relating to public views on condenser cooling systems expressed during the EA has been retained and is summarized below.

Public perception of the cooling options is captured and evaluated in two EA Technical Support Documents (TSDs) [41], [42]. The Environmental Assessment also described previously solicited input of stakeholders [1] and Intervener submissions during the JRP hearings [5].

It was found that there is a wide range of views on cooling system options from a variety of stakeholders, including:

- The Community at Large
- Darlington Site Users (Individuals at nearby park areas)
- Elected Officials
- Environmental Groups
- Aboriginal Groups

**Once Through Cooling System**

There was no objection to the installation of an OTC system for the DNNP from local community and elected officials. This was likely because the system would have no substantial change in the visual character of nearby park areas, would cause no noticeable changes in Lake Ontario, and would have no affect on the tourism industry or the housing market. Since there is no strong “stigma” against the OTC, it would be accepted by the public [42].

**Cooling Towers**

Environmental Assessment analyzed Natural Draft Cooling Towers rather than the Mechanical Draft Cooling Towers as considered in this assessment. There may be differences in public perception of the two designs due to MDCT dimensions being significantly smaller. However a lot of other concerns expressed during the EA in relation to such impacts as visual plume would still apply to the MDCT option. The latter was confirmed via stakeholder feedback, which was specific to the MDCT option.

Key concerns which were raised by elected officials and representatives of the local community in relation to such issues as visual plume, the additional construction traffic
nuisance and potential for fogging and icing associated with the cooling towers. These public views were taken into consideration for the initial selection of Attributes and identification of Key Attributes.

Further details on views expressed by the public during Environmental Assessment are provided in Appendix L. Stakeholder consultation specific to the Condenser Cooling Water Option Assessment study and the two considered options was conducted within the framework of Step 9 (See Section 8.0).
6.0 OPTION EVALUATION

6.1 Step 5 – Initial Evaluation of Cooling Options (Stage 1)

This section describes the assessment of the two cooling options described in Section 5.2, namely OTC and MDCT without enhancements. In accordance with the methodology described in Section 4.0, the results of this assessment were used to select the key attributes and potential enhancements for both technologies identified in Sections 6.2 and 6.3.2, respectively. Following that, the evaluation was repeated (Stage 2) using the enhanced designs for the key attributes (Section 6.3.2.5).

6.1.1 Evaluation Procedure

The initial assessment of the two options was carried out against the attributes using the scoring schemes described in Section 5.4. Expert evaluation against each attribute was conducted by AMEC using standardized worksheets. The worksheets provide a detailed basis which supports the selection of scores for each attribute. The DNNP EIS and subsequent studies were used as sources of information. The following information is included in each of the attribute worksheets:

- Scoring scheme,
- Summary of the assessment,
- Scores for each option,
- Supporting information, and
- Available information on parameter performance ranges and uncertainty.

Initial scores and supporting data were presented by AMEC at an Evaluation Workshop attended by AMEC staff, OPG technical experts and OPG management.

The justifications for the scores for each option against each ranked attribute are presented in detail in Appendix G. These justifications include source material that was already available or generated as part of the study, together with expert judgment. The latter was based on expert specific knowledge of the DN site, the DNNP, and implementation of various cooling technologies as adopted elsewhere.

The detailed attribute evaluation process adopted the following approach:

- When scoring against attributes that relate to quantitative characteristics of an option (e.g. Noise), for which numerical information was available, the quantitative values for each option were derived and the scoring was performed according to the relevant scoring scheme described in Section 5.4.

- When scoring against attributes that relate to qualitative characteristics of a cooling option (e.g. Technical Performance) the scores were estimated on the basis of the qualitative definitions of each score as described in Section 5.4.

6.1.2 Evaluation Summary

Using the above approach, scores were derived for the cooling options and are presented below. Each attribute includes facts, assumptions and scores for options
without enhancements. See Section 10.0 for a detailed sensitivity analysis on the uncertainties associated with each attribute. Comprehensive information on the evaluation basis for each attribute is provided in Appendix G.

It should be noted that no scores of “0” were assigned (intolerable performance). It can be concluded that both options meet the minimum acceptable criteria and neither exceed any specified regulatory limits.

6.1.2.1 Risks to Public Health and Safety

Facts

Once Through Cooling

- No biocides (e.g. chlorine) are required for operation.
- Does not require the use of vehicles to transport materials (e.g. chemicals).
- In the unlikely event of a ship grounding right over the intake structure, it would not be possible for it to block the entire intake area. The resulting intake water capacity would be sufficient to supply Emergency Service Water if required. Therefore, a nuclear accident resulting from such an event is not a credible event.
- There are no impacts on recreational boating since intake flow rates are low.
- The designated shipping routes are located offshore in the middle of Lake Ontario and will not be affected by the operation of the condenser cooling system. The only plausible shipping hazard is from large vessels docking at St. Mary’s Cement Plant wharf.
- The Transportation Safety Board of Canada has not identified any issues with respect to safety in the area.
- Not a source of fire/explosion.

Mechanical Draft Cooling Tower

- No reported incidents of the public contracting Legionnaires’ disease or similar respiratory illnesses from Cooling Towers due to improper maintenance.
- No reported chemical spill that affected the public.
- All chemical handling containers would be built to Canadian General Standards Board regulations and would pass a drop test.
- In the event of a ship suffering an accident and blocking the whole water intake area, sufficient water can still be provided by recirculation to supply Emergency Service Water if required. Therefore, a nuclear accident resulting from such an event is not considered to be a credible event.
- There are no impacts on recreational boating since intake flow rates are low.
- The designated shipping routes are located offshore in the middle of Lake Ontario and are not expected to be affected by the operation of the condenser cooling system. The only plausible hazard is from large vessels docking at St. Mary’s Cement Plant wharf.
The Transportation Safety Board of Canada has not identified any issues with respect to safety in the area.

Not a source of fire/explosion.

Assumptions

**Once Through Cooling**

- The basic concept design and operation of the OTC system is consistent with the current practice at the existing DNGS. There are no identified hazards to the public from operation of the cooling system.

**Mechanical Draft Cooling Tower**

- When operated properly, chemical releases to the air are minimal.
- Proper maintenance would occur and all safety regulations would be in place.
- MDCT would require chemical treatment of about 16,032 L/day or 224,448 L/biweekly; with biweekly deliveries.
- An increase in the number of truck deliveries of chemicals is required; this increases the likelihood of an accident involving a delivery truck. This risk is considered to be small.

Score

**Once Through Cooling**

- No plausible accident scenarios affecting public health and safety were identified.
- A score of 5 was assigned to this option.

**Mechanical Draft Cooling Tower**

- A traffic accident involving a member of the public and a truck containing chemicals required for cooling tower operation was identified as the limiting hazard for the cooling tower option.
- A score of 4 was assigned to this option.

6.1.2.2 Risks to Worker Health and Safety

**Facts**

**Once Through Cooling**

- No plausible accident scenarios were identified; supported by Operating experience (OPEX) searches.
- No biocides (e.g. chlorine) are required for operation.
- Does not produce a plume and does not cause slippery conditions.
- Not a source of fire/explosion.
**Mechanical Draft Cooling Tower**

- No incidents of the workers contracting Legionnaires’ disease from Cooling Towers due to improper maintenance were identified.
- Requires the use of chemicals for maintenance and operation.
- One chemical spill that required very minor medical attention of a worker in 15 years was determined from OPEX searches.
- All containers will be built to Canadian General Standards Board regulations and would pass a drop test.
- MDCT fans would produce a noise level of ≥80dBA on-site.
- Would produce a vapour plume of excess moisture which would lead to periodic icing on-site, resulting in slipping hazards for workers.
- No record of a structure collapse for a modern cooling tower design was identified.
- Not a source of fire/explosion.

**Assumptions**

**Once Through Cooling**

- Maintenance/cleaning of the intake structure to remove zebra mussels would be carried out in accordance with procedures.

**Mechanical Draft Cooling Tower**

- MDCT would require chemical treatment of 16,032 L/day or 224,448 L/biweekly; with biweekly deliveries.
- All personal protection equipment would be worn at all times and fall protection would be used during maintenance.
- It is expected that elevated noise levels would not be a source of significant risk to workers.
- Salt or another de-icing agent would be used during excess icing conditions to decrease the chances of a worker slipping.
- The safety management system would be consistent with those in place for other OPG nuclear facilities.

**Score**

**Once Through Cooling**

- No plausible accident scenarios affecting the worker health and safety were identified.
- A score of 5 was assigned to this option.

**Mechanical Draft Cooling Tower**

- Chemical spills were identified as the limiting risk to worker health and safety.
- A score of 4 was assigned to this option.
6.1.2.3 Water Quality/Emission to Water

Facts

*Once Through Cooling*
- The operation of the OTC has no adverse effect on water quality chemistry.
- No biocides (e.g. Chlorine) are required for operation.

*Mechanical Draft Cooling Tower*
- Water within the Cooling Tower system is recirculated and the water bled off from the system would contain contaminants. The intake water contaminants would be concentrated to four times those in the original Lake Ontario water due to evaporation and re-circulation.
- Treatment systems would ensure that the discharge meets applicable water quality objectives (non-toxic) before it is released into Lake Ontario.
- Cooling water discharge will be affected due to the addition of chemicals for MDCT maintenance and operation.

Assumptions

*Once Through Cooling*
- None.

*Mechanical Draft Cooling Tower*
- When operated properly, releases to Lake Ontario are minimal and below regulatory release limits.

Score

*Once Through Cooling*
- No discernible change in water quality.
- A score of 4 was assigned to this option.

*Mechanical Draft Cooling Tower*
- Marginal and localized changes to water quality.
- A score of 3 was assigned to this option.

6.1.2.4 Air Quality/Emission to Air

Facts

*Once Through Cooling*
- OTC does not emit any kind of airborne contaminants, as it does not produce a vapour plume.
- No biocides (e.g. chlorine) are required for operation.
**Mechanical Draft Cooling Tower**

- MDCT requires a number of different chemical treatments for operation and maintenance.
- Modelling results predict that the airborne emission rate for Particulate Matter with a 10 micrometers size (PM10) is to be approximately 3.8 g/s, based on U.S. Environmental Protection Agency calculations.
- When compared to the overall DNNP site airborne emissions with no cooling towers, the inclusion of MDCT in the maximum predicted 24-hour and annual Suspended Particulate Matter (SPM), PM10 and PM2.5 concentrations did increase emissions of contaminants to the atmosphere but did not exceed the Ambient Air Quality Criteria (AAQC).

**Assumptions**

**Once Through Cooling**

- None.

**Mechanical Draft Cooling Tower**

- When operated properly, releases to atmosphere are minimal and below regulatory release limits.

**Score**

**Once Through Cooling**

- There is no discernible increase of airborne contaminants (increase at point of impingement by <5% above the baseline concentration) over extended periods of time.
- A score of 4 was assigned to this option.

**Mechanical Draft Cooling Tower**

- The concentrations of airborne contaminants at point of impingement increase by 5% to 10% (inclusive) above the baseline concentration over extended periods of time
- A score of 3 was assigned to this option.

6.1.2.5 Noise Level

**Facts**

**Once Through Cooling**

- Does not require any additional equipment other than what is standard for a conventional condenser cooling water system; therefore, there would be no additional noise levels arising from the operation of this system.
- It was determined that during construction the noise levels for both cooling options will not exceed those expected for a standard construction site.
Mechanical Draft Cooling Tower

- Requires the use of additional equipment in the form of industrial fans.
- Model predictions conclude that noise levels would not exceed regulatory background sound levels.
- A simulation at full power operation modelled the MDCT as a:
  - Stationary source: All off-site receptor locations did not indicate any plant noise levels over background level.
  - Stationary and non-stationary source: One resident receptor location (South Service Road) exceeded the background level during the night for a one hour timeframe by 3.3 dBA.
- Noise from condenser circulating water pumps are not considered in this evaluation, since they are required for both cooling systems.
- It was determined that during construction the noise levels to construct both cooling options will not exceed those expected for a standard construction site.

Assumptions

Once Through Cooling

- None.

Mechanical Draft Cooling Tower

- None.

Score

Once Through Cooling

- There is no increase of sound level over the background value at receptor locations off-site
- A score of 5 was assigned to this option.

Mechanical Draft Cooling Tower

- The incremental sound level at off-site receptor locations (over background level) is 3.3 dB.
- A score of 3 was assigned to this option.

6.1.2.6 Water Consumption

Facts

Once Through Cooling

- The net water consumption from OTC is minimal. The discharge is submerged off-shore and most evaporative losses will be returned to Lake Ontario.

Mechanical Draft Cooling Tower

- Net consumption is due to evaporation.
- The rate of water being lost to evaporation will be 4.5 m$^3$/s.

**Assumptions**

**Once Through Cooling**
- Potential evaporation losses cannot be measured but are known to be negligible.

**Mechanical Draft Cooling Tower**
- Water vapour present in the cooling tower plume discharge would not return to Lake Ontario.

**Score**

**Once Through Cooling**
- There is no measurable water consumption for Once Through Cooling due to evaporation.
- A score of 5 was assigned to this option.

**Mechanical Draft Cooling Tower**
- The rate of water being lost to evaporation would be 4.5 m$^3$/s due to operation of MDCTs.
- A score of 1 was assigned to this option.

6.1.2.7 Local Climate Change

**Facts**

**Once Through Cooling**
- The OTC system will not produce a vapour plume or have any releases to the atmosphere. It does not impact the local climate.

**Mechanical Draft Cooling Tower**
- Since MDCT will release a vapour plume to the atmosphere, it does affect the local climate by increasing the occasions of fogging and icing.
- Modelling predictions for the amount of excess fog/ice are as follows:
  - **Fog**
    - On-site fog up to 20 hours per year.
    - Highway 401 would have approximately 10 hours per year.
    - The fog predictions are only an indication of the weather conditions that may result in fog, but do not indicate fog conditions which may be hazardous (dense fog).
  - **Ice**
    - Predicted to occur only southeast of the MDCT for about 1-2 hours per year.
- No icing of Highway 401 is predicted.
- Icing is expected to be minimal and remain mostly on-site. Ice loads on structures and transmission lines are not considered to be significant.

Assumptions

Once Through Cooling
- None.

Mechanical Draft Cooling Tower
- None.

Score

Once Through Cooling
- No adverse effect on local climate change.
- A score of 5 was assigned to this option.

Mechanical Draft Cooling Tower
- Predicted fogging effects of up to 20 hours/year and predicted icing effects of up to 2 hours/year.
- A score of 4 was assigned to this option.

6.1.2.8 Visual Effect

Facts

Once Through Cooling
- There are no discernible visual effects associated with the operation of OTC.

Mechanical Draft Cooling Tower
- Visual plumes can be seen at distances greater than 10 km from DN site property.
- An evaluation was completed of the potential visual plume, modeled predictions are as follows:
  - The worst case vapour plume dimensions:
    - Length – 10,000 m
    - Height – 1,000 m
    - Radius – 500 m
  - The frequency of a noticeable plume for the four seasons:
    - Winter – 99%
    - Spring – 93%
    - Summer – 66%
- Fall – 93%

Assumptions

Once Through Cooling
- None.

Mechanical Draft Cooling Tower
- Any visual plume at any time, regardless of weather conditions, or at night if lit by the facility or from adjoining facilities, is a negative visual effect.
- Four linear banks of MDCTs measuring 16 m tall by 37 m wide by 316 m long are planned.\(^9\)
- MDCT structures would be visible when heading west on Highway 401, and on the new extension of Highway 407.
- The MDCT plume would be visible from the lake.

Score

Once Through Cooling
- No discernible reduction in visual aesthetics.
- A score of 4 was assigned to this option.

Mechanical Draft Cooling Tower
- Negative changes to visual aesthetics can be observed beyond 10 km from the site.
- A score of 1 was assigned to this option.

6.1.2.9 Excavated Materials

Facts

Once Through Cooling
- No additional off-site soil management is required beyond the reactor block baseline.

Mechanical Draft Cooling Tower
- An estimated 2.89 Mm\(^3\) is required to be excavated for the MDCTs.
- An estimated 0.268 Mm\(^3\) will be used to extend the 2 m lake infill beyond Maple Grove road.
- An estimated 2.62 Mm\(^3\) will be moved for off-site soil management in addition to that required for the reactor block.

Additional excavation would lead to the following nuisance and environmental effects (Section 6.0 [43]):

\(^9\) A four unit station with MDCT may impose development constraints on the site.
• Green house gas emissions from the equipment involved in excavation and from the vehicles used to transport excavated soil for disposal.
• Degradation of road and infrastructure used for the off-site disposal of the soil.
• Redesign of access roads and possible road repairs.
• Increase in the amount of dust in the surrounding DNNP area during excavation.
• Noise and traffic issues for the public for the off-site disposal of the soil.
• Impacts on the local wildlife with the increase of road activity.

However, excavation and off-site soil management would only occur during the site preparation period of two to three years, which is a relatively short time span in relation to the plant life. Excavation and off-site transfer would not have any adverse long-term effects on the surrounding land and wildlife.

Assumptions

Once Through Cooling
• Excavation of the OTC intake tunnel is not considered, as this would consist of rock that would be used elsewhere on-site for things such as roads and parking lots.
• No additional off-site trucks would be required to accommodate construction of OTC.

Mechanical Draft Cooling Tower
• Off-site transportation and disposal results in both nuisance and environmental impact, proportional to the quantity of moved soil.
• A “conventional truck” with a capacity of 10 m$^3$ would be used for off-site transfers; however, larger trucks may be used for some of the transfers.
• An additional 262,000 off-site truck loads would be required to accommodate the excavated materials for MDCT.
• The location and route for the soil disposal has not yet been identified, but it is assumed that the trucks will have a 25 km radius from DNNP for disposal travel. This 50 km return trip would cause nuisance effects for neighbours and road ways.

Score

Once Through Cooling
• No additional excavated materials requiring off-site management.
• A score of 5 was assigned to this option.

Mechanical Draft Cooling Tower
• 2.62 Mm$^3$ of additional excavated materials will require off-site management.
• A score of 1 was assigned to this option.
6.1.2.10 Fish Impingement

Facts

Once Through Cooling

- The intake flow rate would be 228 m$^3$/s with a mean water intake velocity of 12.2 cm/s.
- An assessment was completed to determine the fish impingement reduction compared to a OTC shoreline water intake system with no fish protection showed an 80% reduction.
- Alewife and round goby comprise the majority of fish impinged by the current DNGS intake (in 2006-07: 88% alewife, 7% goby, 5% other; in 2010-11: 55% goby, 42% alewife, 2% smelt, 1% other) [44].
- The intake structure will be designed to protect bottom dwelling fish and fish in the water column.

Mechanical Draft Cooling Tower

- The intake flow rate would be 6 m$^3$/s with a mean water intake velocity of 12.2 cm/s.
- An assessment was completed to determine the fish impingement reduction compared to a OTC shoreline water intake system with no fish protection showed a >90% reduction.
- The intake structure will be designed to protect bottom dwelling fish and fish in the water column.

Assumptions

Once Through Cooling & Mechanical Draft Cooling Tower

- The baseline was established by using fish impingement data from PNGS pre-barrier net installation which was used as a representative comparison to DNGS as the two facilities have similar flow rates and are located approximately 35 km away.
- The number of fish impinged is proportional to the intake flow rate.
- Assuming similar distribution of fish species in the future, alewife and round goby will continue to comprise the vast majority of impinged species.

Score

Once Through Cooling

- 80% reduction in fish impingement as compared to a OTC shoreline water intake system with no fish protection.
- A score of 1 was assigned to this option.

Mechanical Draft Cooling Tower

- >90% reduction in fish impingement as compared to a OTC shoreline water intake system with no fish protection.
• A score of 3 was assigned to this option.

6.1.2.11 Fish Entrainment

Facts

Once Through Cooling

• The intake flow rate would be 228 m$^3$/s with a mean water intake velocity of 12.2 cm/s.
• An assessment completed to determine the fish entrainment reduction compared to a OTC shoreline water intake system with no fish protection showed a 60% reduction.
• The intake structure will be designed to protect bottom dwelling fish and fish in the water column.

Mechanical Draft Cooling Tower

• The intake flow rate would be 6 m$^3$/s with a mean water intake velocity of 12.2 cm/s.
• An assessment completed to determine the fish entrainment reduction compared to a OTC shoreline water intake system with no fish protection showed a >90% reduction.
• The intake structure will be designed to protect bottom dwelling fish and fish in the water column.

Assumptions

Once Through Cooling & Mechanical Draft Cooling Tower

• The DNGS entrainment reduction baseline was established by a review of available data including entrainment studies conducted in DNGS in 2004 and 2006 as well as larval tow data collected in 1986-88, 1990, 2009 and 2011. The majority of larvae (relative percentage 44%) can be found at approximately the 5 m depth. Approximately 90% of all larvae were collected within the 2-10 m depth range.
• The amount of fish entrained is proportional to the increased intake flow rate.

Score

Once Through Cooling

• 60% reduction in fish entrainment as compared to a OTC shoreline water intake system with no fish protection.
• A score of 1 was assigned to this option.

Mechanical Draft Cooling Tower

• >90% reduction in fish entrainment as compared to a OTC shoreline water intake system with no fish protection.
• A score of 4 was assigned to this option.
6.1.2.12 Thermal Discharge to Lake

Facts

**Once Through Cooling**
- Discharge design would target less than 2°C temperature differential at the surface at a distance of 50 m from the diffuser centerline.
- Discharge flow rate is 228 m³/s.

**Mechanical Draft Cooling Tower**
- Additional cooling will result from the treatment of the cooling tower blowdown.
- Temperature effects of the thermal plume would extend to a maximum of 15 m from the discharge.
- Mixing zone is about 1% of that for the OTC.
- Discharge flow rate is 1.5 m³/s.

Assumptions

**Once Through Cooling**
- Performance would be equivalent to the thermal plume/mixing zone of the existing DNGS.

**Mechanical Draft Cooling Tower**
- None.

Score

**Once Through Cooling**
- Thermal plume is equal to the EA study baseline.
- A score of 1 was assigned to this option.

**Mechanical Draft Cooling Tower**
- Thermal plume is 1% of the EA study baseline.
- A score of 4 was assigned to this option.

6.1.2.13 Aquatic Habitat

Facts

**Once Through Cooling**
- The intake structure requires 7,593 m² (0.76 ha) of aquatic habitat
- The discharge structure requires 51 m² (0.0051 ha) of aquatic habitat.

**Mechanical Draft Cooling Tower**
The intake structure requires 50.3 m² (0.005 ha) of aquatic habitat.
The discharge structure requires 0.47 m² (0.00005 ha) of aquatic habitat.
Additional lake infill required to construct the MDCT is 72,000 m² (7.2 ha).

Assumptions

Once Through Cooling
- No additional lake infill beyond that required for the reactor block is needed.

Mechanical Draft Cooling Tower
- None.

Score

Once Through Cooling
- A total of 7,644 m² (0.76 ha) of aquatic habitat is required.
- A score of 4 was assigned to this option.

Mechanical Draft Cooling Tower
- A total of 72,050 m² (7.2 ha) of aquatic habitat is required.
- A score of 1 was assigned to this option.

6.1.2.14 Terrestrial Habitat

Facts

Once Through Cooling
- OTC preserves Bank Swallow, with the exception of that affected by the reactor block footprint.

Mechanical Draft Cooling Tower
- MDCT plume will produce a salt deposition of 0.1-0.2 g/m²/month, which is below the guideline criteria and not damaging to plants.
- MDCT will require a full 2 m lake infill, which would extend past Maple Grove Road; this would result in no preservation of the Bank Swallow habitat.

Assumptions

Once Through Cooling
- Bank Swallows are the primary species of concern.

Mechanical Draft Cooling Tower
- Bank Swallows are the primary species of concern.

Score

Once Through Cooling
- No additional loss of Bank Swallow habitat (20% loss due reactor block).
• A score of 5 was assigned to this option.

**Mechanical Draft Cooling Tower**

• No preservation of the Bank Swallow habitat (100% loss due to reactor block and MDCT excavation requirements).
• A score of 1 was assigned to this option.

### 6.1.2.15 Technical Performance

#### Facts

**Once Through Cooling**

• Both technologies have been widely used in both the nuclear and other industries with good track records. For example, in the U.S., 38% of nuclear plants utilize OTC, 44% use Cooling Towers, and 18% use cooling ponds.
• A number of potential issues have been identified with each technology. However these have been demonstrated to be manageable through design mitigation and operating/maintenance procedures.
• OTC systems are susceptible to high water temperature events. Temperature of water in Lake Ontario, at the depth of water intake, is less susceptible to changes than air.

**Mechanical Draft Cooling Tower**

• Both technologies have been widely used in both the nuclear and other industries with good track records. For example, in the U.S., 38% of nuclear plants utilize OTC, 44% use Cooling Towers, and 18% use cooling ponds.
• A number of potential issues have been identified with each technology. However these have been demonstrated to be manageable through design mitigation and operating/maintenance procedures.
• MDCT are susceptible to high air temperatures and atmospheric events (tornadoes and hurricanes). Air is more susceptible to temperature changes.

#### Assumptions

**Once Through Cooling**

• None.

**Mechanical Draft Cooling Tower**

• None.

#### Score

**Once Through Cooling**

• The technology is mature and has been widely used with a good track record, is easy to operate and maintain, and there is extensive experience with the technology in the nuclear industry
• A score of 5 was assigned to this option.
Mechanical Draft Cooling Tower

- The technology is mature and has been widely used with a good track record, is easy to operate and maintain, and there is extensive experience with the technology in the nuclear industry.
- A score of 5 was assigned to this option.

6.1.2.16 Cost

Facts

Once Through Cooling

- Capital Costs include:
  - Intake and discharge structures including pumps and piping
  - Tunnelling/excavation of intake and discharge
  - Lake bottom procurement
  - Implementation of JRP recommendations
  - Tax shield credits
- Operation and Maintenance Costs include:
  - Maintenance, e.g. cleaning of the intake and discharge structures
  - Water usage
  - Net power loss generation due to condenser cooling water pumps

Mechanical Draft Cooling Tower

- Capital Costs include:
  - Cooling towers including pumps
  - Intake and discharge structures including piping
  - Excavation of land required for cooling towers
  - Tunnelling/excavation of intake and discharge
  - Lake bottom/Shoreline procurement
  - Implementation of JRP recommendations
  - Tax shield credits
- Operation and Maintenance Costs include:
  - Bi-annual inspections and maintenance of the cooling towers
  - Water usage
  - Chemicals
  - Major component replacement for mid-life reconstruction of cooling towers
Net power loss generation due to condenser cooling water pumps, cooling tower fan loads and thermal efficiency losses.

Assumptions

Once Through Cooling & Mechanical Draft Cooling Tower

- The following costs have been excluded:
  - Discounted decommissioning costs (60 to 90 years) are relatively small and comparable between the OTC and MDCT.
  - The procurement and operation costs of the MDCT make-up pumps are relatively small.
  - The condenser designs are dependent on the final reactor technology selected and are therefore not consider in the cooling technology costs.

Costs

Once Through Cooling

- NPV = $538.5M
- TAC = $38.4M

Mechanical Draft Cooling Tower

- NPV = $1,123.9M
- TAC = $80.1M

6.2 Step 6 – Definition of the “Key” Attributes

Key attributes were identified based on the results of the initial (Stage 1) assessment as summarized in Section 6.1.2 and discussed in Appendix G. The key attributes are considered to be dominant contributors to the overall evaluation. These are the attributes that typically display a wide scoring margin between the cooling technologies and/or are considered to be important issues to stakeholders as identified by the previously solicited stakeholder input as described in the EA [1], the intervener submissions during the JRP hearings [5] and the public consultation program conducted for the current study [45]. On this basis, the following key attributes were identified:

2.3 Noise Level

  Included because of slightly elevated noise levels at off-site locations for the MDCT option.

  This issue was also identified as important to stakeholders.

2.5 Local Climate Change

  Although the amount of time resulting in additional local fogging and icing associated with the MDCT option is limited, this is considered important to stakeholders as it may result in an increase risk to both members of the public and workers.
2.6 **Visual Effect**

Included because there is a significant difference in scoring between the options. This attribute was also identified as important to stakeholders.

2.7 **Excavated Materials**

Included because it was estimated that construction of MDCT would lead to an additional 262,000 truck loads with excavated material having to be transported off-site over and above the number of trips associated with the OTC option.

This issue was identified as important to stakeholders.

3.1 **Fish Impingement**

Both options result in a significant reduction in impingement compared to a shoreline OTC intake without fish protection. This attribute was included because the estimated reduction in the mass of fish impinged for the MDCT option is twice that of the OTC option.

This issue was also identified as important to stakeholders.

3.2 **Fish Entrainment**

Both options result in a significant reduction in entrainment compared to a shoreline OTC intake without fish protection. This attribute was included because the estimated reduction in the number of organisms entrained by a MDCT system is at least 30% more than that of the OTC option.

This issue was also identified as important to stakeholders.

3.3 **Thermal Discharge**

Included because there is a significant difference in scoring between the cooling options.

This issue was also identified as important to stakeholders.

3.5 **Terrestrial Habitat**

Included because there is a significant difference in scoring between the cooling options.

This issue was also identified as important to stakeholders.

5.1 **Cost**

Included because the estimated costs for the MDCT option are significantly higher.

This issue was also identified as important to stakeholders.

The following attributes were not identified as key attributes:

1.1 **Risks to Public Health and Safety**

Both MDCT and OTC were identified as having a low risk to public health and safety. Public safety can be assured for both options.
1.2 Risks to Worker Health and Safety

Although OTC was identified to have a lower risk to worker health and safety, both options perform well against this attribute. Worker safety can be assured for both options.

2.1 Water Quality/Emission to Water

Although a higher score was assigned to OTC for this attribute, MDCT would result in only minimal releases, well below regulatory requirements.

2.2 Air Quality/Emissions to Air

Although a higher score was assigned to OTC for this attribute, MDCT would result in only minimal releases, well below regulatory requirements.

2.4 Water Consumption

Although a higher score was assigned to OTC for this attribute, both OTC and MDCT result in water consumption rates that are negligible compared to the Lake Ontario inflow rate.

3.4 Aquatic Habitat

Although a higher score was assigned to OTC for this attribute, the total area of affected aquatic habitat for either cooling options represents a very small fraction of coastal habitat in Lake Ontario.

4.1 Technical Performance

Both the OTC and MDCT options are mature technologies and have been widely used within the nuclear industry.

6.3 Step 7 – Evaluation of Enhanced Designs (Stage 2)

6.3.1 Evaluation Procedure

For key attributes the following steps were followed:

- A range of potential design or technological enhancements for both options was identified,
- Performance benefits were assessed,
- The impact on costs was estimated,
- Cost-effective design/technological enhancements for each of the attributes to mitigate any negative consequences were selected. These are summarized in Section 6.3.2.
- A comparative evaluation of enhanced designs against the key attributes was conducted.

Finally, a confirmation that enhancements did not impact the non-key attributes was conducted. All attributes were re-evaluated using the considerations described below.
6.3.2 Identification of Design Enhancements

A number of supporting studies were carried out to determine potential design enhancements to improve performance of each option against the key attributes [44], [46], [24]. Enhancements were evaluated taking into account technical feasibility and cost reasonableness. Given that a particular enhancement is technically feasible, cost reasonableness was judged based on the following three scenarios:

1. If the same effect, mitigating negative impacts, could be achieved by both technological alternatives A and B, but the cost of implementing technology B was judged to be less, then the cost of using technology A was judged to be unreasonable.

2. If the benefits from using a given technological enhancement are lacking or highly uncertain and the cost of implementation is high (>>10 million dollars), then this cost was judged to be unreasonable.

3. If there are clear positive effects from using a particular technological enhancement, and it is used in the industry elsewhere, then implementation of such an enhancement was judged to be reasonable.

If a particular technological enhancement was recommended by the JRP, then it was judged to be reasonable and “cost reasonableness“ was not evaluated further.

The following four enhancements were evaluated for mitigating potential effects relating to the key attributes:

1. Noise Abatement (MDCT enhancement),
2. Plume Abatement (MDCT enhancement),
3. Intake Enhancement (OTC and MDCT enhancement), and
4. Outfall Enhancement (OTC and MDCT enhancement)
5. Use of larger trucks (MDCT enhancement).

A brief description of selected and considered enhancements is provided below. Selected enhancements were determined to be both technically feasible and have reasonable costs. Additional details can be found in Appendix G under the Cost Worksheet.

6.3.2.1 Noise Abatement

Once Through Cooling

Noise for OTC is primarily from the water flow and the noise level would not increase over the background value at receptors on- or off- the site. Therefore, no modification is needed to enhance the baseline OTC option.

Mechanical Draft Cooling Towers

For the MDCT option, large industrial fans are used to move all of the air required to achieve the design heat transfer; this is the major source of noise generated during operation. The noise abatement technologies that could be used to reduce the noise
level include silencers, screens and encapsulation (See Appendix I for further details). Specific abatement technology will be selected at the detailed design phase.

The attributes affected by Noise Abatement include:

- Noise,
- Worker Health and Safety, and
- Cost.

Updated scores for the enhanced option are included in the Attribute Evaluation Sheets (Appendix G), and summarized in Section 6.3.2.5.

6.3.2.2 Plume Abatement

**Once Through Cooling**

The OTC system does not produce a visible plume and therefore no technical enhancement to the baseline OTC option is warranted.

**Mechanical Draft Cooling Towers**

The visible plume generated by the MDCT option could be mitigated by using several technologies, such as:

- Parallel Path Wet-Dry with Water-to-Air Heat Exchangers,
- Parallel Path Wet-Dry with Air-to-Air Heat Exchangers, and
- Series Path Wet-Dry (SPWD).

These technologies involve heating of the steam and removal of the liquid fraction from emission to air. They would require additional energy which may result in the reduction of the density, dimensions and frequency of the visual plume. However, the technologies would not remove incidences of the visual plume occurring altogether.

The MDCT structure with plume abatement is taller than the unabated MDCT. It also has a larger footprint and each tower is separated by a greater distance (140 m between each tower block) than MDCT without plume abatement. Further details on plume abatement technology can be found in Appendix I.

The attributes affected by Plume Abatement include:

- Water Consumption,
- Local Climate Change,
- Visual Effect,
- Technical Performance, and
- Cost

Updated scores for the enhanced option are included in the Attribute Evaluation Sheets (Appendix G), and summarized in Section 6.3.2.5.

6.3.2.3 Intake Enhancement
Once Through Cooling

A number of potential design enhancements have been identified [44]. The improved porous veneer structure may include the following design considerations:

- The porous veneer intake is made of concrete modules. The removal of the concrete vanes in each module will increase the porous area reducing the available space for Zebra Mussel growth (biofouling mitigation);

- Installation of a finer screen (compared to DNGS) made of Zebra Mussel deterrent material would reduce maintenance requirements. The deterrent material is a copper-nickel alloy which would minimize Zebra Mussel attachment.

- An increase in porosity would reduce the approach velocity from about 12.2 cm/s to 6 cm/s, thus reducing impingement and entrainment.

These design enhancements will result in further reduction of impingement (see Appendix I for details). It is anticipated that entrainment of larvae would be less due to the reduction in approach velocity. Larval fish, as small as 3.8 mm, can obtain burst speeds of 6 cm/s.

Furthermore, OPG agreed to undertake additional fish, larvae and egg surveys, including a sampling program in deeper water. The results of this program would be used to place the intake in an area with low concentrations of sensitive species, such as Round Whitefish. This should also result in further reduction in entrainment, although the reduction cannot be estimated quantitatively on the basis of currently available information.

For example, it is expected that moving the intake location to deeper water would reduce both impingement and entrainment. At a depth of approximately 12 m, the entrainment of Round Whitefish eggs and larvae would be further reduced by avoiding depths that have higher concentrations of eggs and young larvae. In addition, at 12 m depth, it is still unlikely that Deepwater Sculpin would be encountered given that they are a demersal species found in deeper water.

Updated scores for the enhanced option are included in the Attribute Evaluation Sheets (Appendix G), and summarized in Section 6.3.2.5.

Mechanical Draft Cooling Towers

For the MDCT option, enhancement involves installation of four separate water intake pipes at a water depth of 10 m to draw makeup water from Lake Ontario. The enhanced option will employ wedge wire screens with 10 mm slot openings with the application of a permanent metal coating capable of resisting Zebra Mussels. The screens will be equipped with an airburst system to prevent biofouling.

The use of wedgewire screens will further reduce both fish impingement and entrainment.

The attributes affected by intake enhancements include:

- Fish Impingement,
- Fish Entrainment,
- Aquatic Habitat, and
- Cost.

Updated scores for the enhanced option are included in the Attribute Evaluation Sheets (Appendix G), and summarized in Section 6.3.2.5.

6.3.2.4 Outfall Enhancement

**Once Through Cooling**

Thermal discharge to the lake has been identified as a key attribute due to its size. It is assumed that the plume dimensions would be similar to the baseline. Several design enhancement options have been considered to reduce the size of the area affected by the thermal discharge.

However, as part of the DNGS Refurbishment and Continued Operation Project Environmental Assessment, it was concluded that the current diffuser design is performing well and as a result there is no potential for adverse effects [47]. This has been demonstrated as follows:

- The screening level benchmark for thermal exposure of Round Whitefish eggs and larvae at DNGS was established as 5°C, which is the temperature threshold at which potential effects may occur.
- The temperature in all monitoring locations in the vicinity of diffuser was less than the 5°C level during the critical time of egg/embryo development and larval survival, with one exception. The temperature in one location reached a maximum value of 6.47°C. This exceeds the 5°C threshold over short periods of time and beyond the typical depths of 5 m to 10 m at which Round Whitefish eggs have historically been found. At most locations temperatures were below 3°C until mid-March.
- By the time the temperatures reached 5°C in mid April, the larvae moved inshore to feed and were not impacted.

In particular, it was found that 75% of the time the maximum temperature increase within the mixing zone is 1.5°C and that the temperature increases at the edge of the mixing zone are generally less than 1°C. The area contained within the 1°C contour is approximately 0.7 km² and the area within 1.5°C is only 0.1 km².

Therefore it is concluded that enhancement to the DNNP outfall design is not required.

**Mechanical Draft Cooling Towers**

No enhancements are necessary for the MDCT option.

6.3.2.5 Use of Larger Trucks

**Once Through Cooling**

The OTC system does not produce additional excavated materials requiring disposal and therefore no technical enhancement to the baseline OTC option is warranted.

**Mechanical Draft Cooling Towers**
It was assumed that a “conventional truck” with a capacity of 10 m$^3$ would be used for the majority of off-site transfers relating to additional excavation requirements for MDCT (see Section 6.1.2.9).

It is feasible that larger trucks could be used, at least partially, to reduce the number of off-site trips. There are several types of transport vehicles that could be used for transportation and disposal of excavated material off-site. These include:

- **Tandem Dump Truck**: These vehicles typically have a payload capacity of between 9 and 11 m$^3$. They are designed for use on public roads and highways and have an average speed of up to 80 km/h.

- **Superdump Truck**: A Superdump is a straight dump truck equipped with a liftable, load-bearing axle. Trailing behind the rear tandem, the trailing axle stretches the outer "bridge" measurement—the distance between the first and last axles—to the maximum overall length allowed. This increases the gross weight allowed. A typical super dump can hold 26 tons of load per trip, equivalent to payload capacity of 12 to 14 m$^3$. These trucks can be operated at highway speeds.

- **Tractor and Semi-Trailer or Articulated Hauler**: A tractor-trailer combination wherein the trailer itself contains the hydraulic hoist. A key disadvantage is that they are very unstable when raised in the dumping position limiting their use in many applications where the dumping location is uneven. An articulated hauler is distinct from a semi-trailer truck in that the power unit is a permanent fixture rather than a separable vehicle. With typical payload of 20 m$^3$, tractor trailers and articulated haulers have larger capacity but lower manoeuvrability. The top speed is limited at 55–60 km/h.

Thus the potential number of vehicle-trips could potentially be reduced by a factor of 2. Note that use of larger trucks will be constrained by the road network in the vicinity of potential location of the disposal facility and the type of on-site operations. Nevertheless, it is feasible and will reduce the number of trips. However, any advantages will be partially negated by increases in noise levels and emissions per trip. Use of heavier trucks will also result in detriments in terms of road maintenance requirements.

Therefore use of larger vehicles for haulage of excavated material will not impact selection of BATEA.

### 6.3.2.6 Other Considered Enhancements

- **Relocating Intake and Discharge to a Deeper Location (OTC)**

  OPG has committed to the completion of the Round Whitefish Action Plan in which baseline population studies will be conducted [48]. Depending on the outcome of these studies, it may be decided to locate the intake and discharge at a depth of between 10m and 20m.

  This is a technically feasible enhancement. The incremental capital cost was estimated by OPG to not exceed $70M, depending on the tunnel construction method.
Cost reasonableness of this potential enhancement can be determined following implementation of the Round Whitefish Action Plan.

- **Live Fish Return System (OTC)**
  The system was considered in a supporting study [24]; the estimated capital and annual operational costs are $2M and $550K, respectively. Taking into account that a significant proportion of returned fish will be represented by invasive species, OPG made a judgement that these costs are not reasonable, given highly uncertain benefits.

- **Acoustic System Deterrent System (OTC)**
  The system was considered in a supporting study [24]; the estimated capital cost is $7M, excluding the cost of the electrical supply lines. Taking into account that the efficiency of this system is species specific, it was determined that this enhancement would not reduce impingement across all species and there would be no reduction in entrainment. On this basis it was judged that the costs of implementing and operating an acoustic fish deterrent system are not reasonable.

- **Porous Dyke System (OTC)**
  The system was considered in a supporting study [24]; it was judged that it was not technically feasible as it is designed for a shoreline-type intake.

- **Wedgewire Intake Screen with an Air-Burst Cleaning System (OTC)**
  The system was considered; the capital cost for the given size of the OTC intake screen was estimated to be approximately $220M [24]. Given high cost and lack of operational experience with large wedgewire screens at nuclear power this enhancement was not judged to have a reasonable cost.

- **Relocation of the Main Access Road (MDCT)**
  The relocation of the Holt Road could allow for additional onsite disposal, reducing the quantity of waste soil material which would have to be transported on-site. Access along the east of the site is already included as part of the construction for New Build, however this road will be used for movement of construction traffic and must be kept separate from normal site entrance. Relocation of the Holt Road is being undertaken but close to the existing location with a small impact footprint. Relocation of the access road to the west of the site would require a completely new crossing of the Highway 401 and CN Rail necessitating a larger impact footprint along the Highway 401. This would result in additional costs and environmental impacts and is not considered to be a reasonable option.

- **Relocation of Cooling Towers (MDCT).**
  Placement of cooling towers on the north side of the rail line may reduce soil disposal costs and allow for the Bank Swallow habitat to be partially preserved. This would likely require some negotiations with CN Rail to allow access to their land for construction, and would increase the base power requirements for the
site due to the longer distances required to pump water. The transmission easement passes straight through this area and rerouting this line to accommodate the cooling towers would also have a significant environmental impact. Also, this area has been identified as potentially restorable following construction – the footprint of land that can be restored would be significantly impacted if the cooling towers were located here. Movement of the towers to the north side would mean relocation of the construction facilities and laydown area, so there would still be significant impact to the environment since the overall area of land use would be unchanged. Another factor is the number of units constructed – with four units the footprint of the MDCT is larger than the space available to the north of the railway, and the proximity of the Highway 401 means that no additional land could be purchased. East and north of the railway, where additional land could potentially be purchased, the land slopes and forms the drainage catchment – any construction on this area could significantly impact the local terrestrial and aquatic environment.

Given additional power requirements required to pump water over long distances and substantial practical difficulties in implementing this option, it is deemed neither feasible nor economical at the Darlington site.

6.3.3 Evaluation of DNNP Condenser Cooling Options with Enhancements

Both options were re-evaluated against all attributes taking into account the enhancements described in Section 6.3.2. Assessment of option performance for the affected attributes has been revised to include appropriate changes to the facts and assumptions. The scores for the enhanced options reflect the impact of the described enhancements where applicable. The attribute scores have been summarized for the base (Stage 1) and enhanced (Stage 2) cooling options in Table 22.

6.3.3.1 Risks to Public Health and Safety

Facts

Once Through Cooling

• No change in the limiting risk for Public Health and Safety.

Mechanical Draft Cooling Tower

• No change in the limiting risk for Public Health and Safety.
• Reduced noise levels due to noise abatement.

Assumptions

Once Through Cooling

• No change.

Mechanical Draft Cooling Tower

• No change.

Score
Once Through Cooling
- No change.
- A score of 5 is assigned to this attribute.

Mechanical Draft Cooling Tower
- No change.
- A score of 4 is assigned to this attribute.

6.3.3.2 Risks to Worker Health and Safety

Facts
Once Through Cooling
- No change in the limiting risk for Worker Health and Safety.

Mechanical Draft Cooling Tower
- No change in the limiting risk for Worker Health and Safety.
- Reduced noise levels due to noise abatement.
- Reduced on-site fogging and icing events due to plume abatement.

Assumptions
Once Through Cooling
- No change.

Mechanical Draft Cooling Tower
- No change.

Score
Once Through Cooling
- No change.
- A score of 5 is assigned to this attribute.

Mechanical Draft Cooling Tower
- No change.
- A score of 4 is assigned to this attribute.

6.3.3.3 Water Quality/Emission to Water

Facts
Once Through Cooling
- No change.

Assumptions
Once Through Cooling
Intake enhancement includes the use of a copper-nickel alloy screen. There is a strong evidentiary basis supporting the use of such screens and demonstrating that resulting copper concentrations in lake water are negligible.

**Mechanical Draft Cooling Tower**

Intake enhancement includes the use of a copper-nickel alloy wedge wire screen. There is a strong evidentiary basis supporting the use of such screens and demonstrating that resulting copper concentrations in lake water are negligible.

**Score**

**Once Through Cooling**

- No change.
- A score of 4 is assigned to this attribute.

**Mechanical Draft Cooling Tower**

- No change.
- A score of 3 is assigned to this attribute.

### 6.3.3.4 Air Quality/Emission to Air

**Facts**

**Once Through Cooling**

- No change.

**Mechanical Draft Cooling Tower**

- No change.

**Assumptions**

**Once Through Cooling**

- No change.

**Mechanical Draft Cooling Tower**

- No change.

**Score**

**Once Through Cooling**

- No change.
- A score of 4 is assigned to this attribute.

**Mechanical Draft Cooling Tower**

- No change.
- A score of 3 is assigned to this attribute.
6.3.3.5 Noise Level

Facts

Once Through Cooling
- No change.
- No adverse effects to mitigate.

Mechanical Draft Cooling Tower
- The noise abatement technologies which will be used to reduce noise levels include silencers, screens and encapsulation.

Assumptions

Once Through Cooling
- No change.

Mechanical Draft Cooling Tower
- Noise levels from the MDCT can be reduced by 30%, which is consistent with best industry practice.

Score

Once Through Cooling
- No change.
- A score of 5 is assigned to this attribute.

Mechanical Draft Cooling Tower
- No increase over background levels with noise abatement for off-site noise receptor locations.
- A score of 5 is assigned to this attribute.

6.3.3.6 Water Consumption

Facts

Once Through Cooling
- No change.

Mechanical Draft Cooling Tower
- See assumptions.

Assumptions

Once Through Cooling
- No change.

Mechanical Draft Cooling Tower
- 20% water consumption reduction from the baseline from use of plume abatement.
- Rate of water being lost to evaporation would be 3.6 m³/s.

**Score**

*Once Through Cooling*
- No change.
- A score of 5 is assigned to this attribute.

*Mechanical Draft Cooling Tower*
- The rate of water being lost to evaporation would be 3.6 m³/s due to operation of MDCTs with plume abatement technology.
- A score of 2 is assigned to this attribute.

6.3.3.7 Local Climate Change

**Facts**

*Once Through Cooling*
- No change.
- No adverse effects to mitigate.

*Mechanical Draft Cooling Tower*
- See assumptions.

**Assumptions**

*Once Through Cooling*
- No change.

*Mechanical Draft Cooling Tower*
- Reduced on-site fogging and icing events due to plume abatement.

**Score**

*Once Through Cooling*
- No change.
- A score of 5 is assigned to this attribute.

*Mechanical Draft Cooling Tower*
- Fogging and icing events cannot be fully mitigated.
- A score of 4 is assigned to this attribute.

6.3.3.8 Visual Effects

**Facts**
Once Through Cooling

- No change.

Mechanical Draft Cooling Tower

- MDCT will produce a visible vapour plume which could be mitigated by using several technologies, which are supported by evidence from industrial applications. Visual plume frequency would be reduced, as determined by modelling predictions which are listed below.
  - Plume modelling predicted that the worst case vapour plume dimensions taking into account abatement will be reduced by 66%, as follows:
    - Length - 3,500 m
    - Height - 350 m
    - Radius – 170 m
  - The frequency of the plume will be reduced by 70%.
  - The density of the plume will be reduced by 50%.

Assumptions

Once Through Cooling

- No change.

Mechanical Draft Cooling Tower

- The addition of plume abatement technology would increase the overall size of the structure. Each of the four linear MDCT banks with plume abatement will measure 28 m tall by 37 m wide by 393 m long.

Score

Once Through Cooling

- No change.

- A score of 4 is assigned to this attribute.

Mechanical Draft Cooling Tower

- Reduction in plume frequency due to implementation of plume abatement technology. However, effect cannot be fully mitigated. Furthermore height of the towers will increase compared to the non-abated option.

- A score of 2 is assigned to this attribute.

6.3.3.9 Excavated Materials

Facts

Once Through Cooling

---

10 A four unit station with MDCT may impose development constraints on the site.
No change.
No enhancements can be implemented to significantly reduce excavation.

**Mechanical Draft Cooling Tower**
No change.
No enhancements can be implemented to significantly reduce excavation.

**Assumptions**

**Once Through Cooling**
No change.

**Mechanical Draft Cooling Tower**

MDCT with plume abatement will likely require more space and excavation than MDCT without plume abatement.

**Score**

**Once Through Cooling**
No change.
A score of 5 is assigned to this attribute.

**Mechanical Draft Cooling Tower**
No change.
A score of 1 is assigned to this attribute.

6.3.3.10 Fish Impingement

**Facts**

**Once Through Cooling**

Installation of a finer screen (compared to DNGS) made of mussel deterrent material would reduce maintenance requirements. The deterrent material is copper-nickel alloy which would minimize mussel attachment.

Increase in screen porosity would reduce approach velocity from about 12.2 cm/s to 6 cm/s, thus reducing impingement. The sustained and burst swimming capabilities of juvenile and adult fish commonly impinged at the existing DNGS are well above this velocity.

No behavioural deterrents are included in the enhanced design as they would have to be species-specific and there is no firm evidence on their efficiency.

Due to intake enhancement, the estimated reduction in impingement rate will increase from 80% to over 90% compared to baseline.

The dominant fish species in the vicinity of DNGS that may be impinged or entrained generally have Lake Ontario wide abundance. In 2009, the population estimate for alewife was 134 million yearling-and-older fish, translating into an estimated biomass of 5,298,000 kg. In the same year, the
rainbow smelt population was estimated to be 311 million yearling-and-older fish, translating into a biomass of 1,714,000kg. The abundance of rainbow smelt remains at low levels since the early 2000s even though there was a modest increase in the population of yearling-and older rainbow smelt. An exception is Round Whitefish whose population is more concentrated along the north shore of Lake Ontario (i.e., not lake-wide distributed).

**Mechanical Draft Cooling Tower**

- Installation of a wedge wire screen would further reduce impingement as supported by evidence from nuclear and non-nuclear plants.
- Due to intake enhancement, the estimated reduction in impingement rate will increase from over 90% to over 95% compared to baseline.
- The dominant fish species in the vicinity of DNGS that may be impinged or entrained generally have Lake Ontario wide abundance. In 2009, the population estimate for alewife was 134 million yearling-and-older fish, translating into an estimated biomass of 5,298,000 kg. In the same year, the rainbow smelt population was estimated to be 311 million yearling-and-older fish, translating into a biomass of 1,714,000kg. The abundance of rainbow smelt remains at low levels since the early 2000s even though there was a modest increase in the population of yearling-and older rainbow smelt. An exception is Round Whitefish whose population is more concentrated along the north shore of Lake Ontario (i.e., not lake-wide distributed).

**Assumptions**

**Once Through Cooling**

- OPG plans to carry out additional fish, larvae and egg surveys, including a sampling program in deeper waters. The results of this program will be used to place the intake in an area with low concentration of sensitive species, such as Round Whitefish. Based on historic sampling data from the existing DNGS, it is expected that the intake can be placed at a location such that entrainment of eggs and earlier smaller post-hatch larvae for sensitive species such as Round Whitefish can be minimized. Round Whitefish eggs and larvae are typically found at depths of less than 12 m. At depths of 12 m, it is still unlikely that deepwater Sculpin would be encountered as they are a demersal species (i.e., a species living or found in the deepest part of a body of water).
- Placement of the intake into such a location would result in further reduction of fish impingement. This should also result in further reduction in entrainment, although the reduction cannot be estimated quantitatively on the basis of currently available information.

**Mechanical Draft Cooling Tower**

- No change.

**Score**

**Once Through Cooling**
• >90% reduction in fish impingement as compared to an OTC shoreline water intake system with no fish protection.
• A score of 3 is assigned to this attribute.

Mechanical Draft Cooling Tower

• >95% reduction in fish impingement as compared to an OTC shoreline water intake system with no fish protection.
• A score of 4 is assigned to this attribute.

6.3.3.11 Fish Entrainment

Facts

Once Through Cooling

• Increase in screen porosity would reduce approach velocity from about 12.2 cm/s to 6 cm/s, thus reducing impingement. The sustained and burst swimming capabilities of juvenile and adult fish commonly impinged at the existing DNGS are well above this velocity.
• The dominant fish species in the vicinity of DNGS that may be impinged or entrained generally have Lake Ontario wide abundance.
• Due to intake enhancement, the estimated reduction in entrainment rate will increase from 60% to >60% compared to baseline.

Mechanical Draft Cooling Tower

• The dominant fish species in the vicinity of DNGS that may be impinged or entrained generally have Lake Ontario wide abundance.
• Due to intake enhancement, the estimated reduction in entrainment rate will increase from over 90% to >95% compared to baseline.

Assumptions

Once Through Cooling

• It is anticipated that entrainment of larvae would be less due to reduction in approach velocity. Larval fish as small as 3.8 mm can attain burst speeds of 6 cm/s.
• OPG plans to carry out additional fish, larvae and egg surveys, including a sampling program in deeper waters. The results of this program will be used to place the intake in an area with low concentration of sensitive species, such as Round Whitefish. Based on historic sampling data from the existing DNGS, it is expected that the intake can be placed at a location such that entrainment of eggs and earlier smaller post-hatch larvae for sensitive species such as Round Whitefish can be minimized. Round Whitefish eggs and larvae are typically found at depths of less than 12 m. At depths of 12 m, it is still unlikely that deepwater Sculpin would be encountered as they are a demersal species (i.e., a species living or found in the deepest part of a body of water).
Placement of the intake into such a location would result in further reduction of fish impingement. This should also result in further reduction in entrainment, although the reduction cannot be estimated quantitatively on the basis of currently available information.

**Mechanical Draft Cooling Tower**
- No change.

**Score**

**Once Through Cooling**
- >60% reduction in fish entrainment as compared to an OTC shoreline water intake system with no fish protection.
- A score of 1 is assigned to this attribute.

**Mechanical Draft Cooling Tower**
- >95% reduction in fish impingement as compared to an OTC shoreline water intake system with no fish protection.
- A score of 4 is assigned to this attribute.

6.3.3.12 Thermal Discharge to Lake

**Facts**

**Once Through Cooling**
- No change.
- Design is comparable to the existing DNGS diffuser design which has been found to be performing well. No discharge enhancement is required to mitigate thermal impacts.

**Mechanical Draft Cooling Tower**
- No change.
- Suggested design represents best practice for discharges for power plant with Cooling Towers.

**Assumptions**

**Once Through Cooling**
- No change.

**Mechanical Draft Cooling Tower**
- No change.

**Score**

**Once Through Cooling**
- No change.
- A score of 1 is assigned to this attribute.
6.3.3.13 Aquatic Habitat

**Facts**

*Once Through Cooling*
- The enhanced intake structure requires 10,436 m$^2$ (1.4 ha) of aquatic habitat
- No change to discharge structure.

*Mechanical Draft Cooling Tower*
- No change.

**Assumptions**

*Once Through Cooling*
- No change.

*Mechanical Draft Cooling Tower*
- No change.

**Score**

*Once Through Cooling*
- A total of 10,487 m$^2$ (1.5 ha) of aquatic habitat is required.
- A score of 4 was assigned to this option.

*Mechanical Draft Cooling Tower*
- No change.
- A score of 1 was assigned to this option.

6.3.3.14 Terrestrial Habitat

**Facts**

*Once Through Cooling*
- No change in loss of bank swallow habitat.

*Mechanical Draft Cooling Tower*
- No change in loss of bank swallow habitat.

**Assumptions**

*Once Through Cooling*
- No change.

*Mechanical Draft Cooling Tower*
• Reduction in salt deposition due to plume abatement technology.

Score

Once Through Cooling

• No change.
• A score of 5 was assigned to this option.

Mechanical Draft Cooling Tower

• No change.
• A score of 1 was assigned to this option.

6.3.3.15 Technical Performance

Facts

Once Through Cooling & Mechanical Draft Cooling Tower

• Installation of a finer screen (compared to DNGS) made of zebra mussel deterrent material would reduce maintenance requirements. The deterrent material is copper-nickel alloy which would minimize zebra mussel attachment.

Mechanical Draft Cooling Tower

• Plume abatement for cooling towers is mature and has been widely used with a good track record (non-nuclear fossil power plants), but there is little experience with the technology in the nuclear industry.

Assumptions

Once Through Cooling & Mechanical Draft Cooling Tower

• The porous veneer intake is made of concrete modules. The removal of the concrete vanes in each module will increase the porous area, reducing the available space for zebra mussel growth (biofouling mitigation). This will improve maintenance and operation of the station.

Score

Once Through Cooling

• No change.
• A score of 5 was assigned to this option.

Mechanical Draft Cooling Tower

• Lack of plume abatement technology track record in the nuclear industry.
• A score of 4 was assigned to this option.

6.3.3.16 Cost

Facts

Once Through Cooling
- Capital Costs include:
  - Additional porous veneer intake modules required
  - Addition of a copper-nickel alloy intake screen
- Operation and Maintenance Costs include:
  - Reduced maintenance (savings) from inclusion of the copper-nickel alloy intake screen (zebra/quagga mussel mitigation)

**Mechanical Draft Cooling Tower**
- Capital Costs include:
  - Inclusion of plume abatement technology in MDCT design
  - Additional pumps and fans required (higher number of cooling tower cells)
  - Inclusion of noise abatement in MDCT design
  - Addition of copper-nickel alloy wedge wire intake screens
- Operation and Maintenance Costs include:
  - Additional cooling tower cells to inspect during bi-annual inspections and maintenance
  - Additional cooling tower cells (and complexity) to refurbish during mid-life reconstruction.
  - Increase in lost generation from additional condenser cooling water pumps and cooling tower fans.

**Assumptions**

**Once Through Cooling**
- No change.

**Mechanical Draft Cooling Tower**
- No change.

**Costs**

**Once Through Cooling**
- NPV = $543.2M
- TAC = $38.7M

**Mechanical Draft Cooling Tower**
- NPV = $1,412.0M
- TAC = $100.6M
<table>
<thead>
<tr>
<th>Attribute Group</th>
<th>Attribute</th>
<th>Base Scores (Stage 1)</th>
<th>Enhanced Scores (Stage 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>OTC</td>
<td>MDCT</td>
</tr>
<tr>
<td>1. Health and Safety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.1 Risks to Public Health and Safety</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1.2 Risks to Worker Health and Safety</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>2. Physical Environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.1 Water Quality/Emission to Water</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2.2 Air Quality/Emission to Air</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2.3 Noise Level</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2.4 Water Consumption</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2.5 Local Climate Change</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2.6 Visual Effects</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2.7 Excavated Materials</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>3. Habitat and Ecosystem</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1 Fish Impingement</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3.2 Fish Entrainment</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3.3 Thermal Discharge to Lake</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3.4 Aquatic Habitat</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3.5 Terrestrial Habitat</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>4. Technical Performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.1 Technical Performance</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>5. Cost</td>
<td>5.1 Cost (in $, millions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TAC</td>
<td>38.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NPV</td>
<td>538.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>80.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,123.9</td>
<td></td>
</tr>
</tbody>
</table>
6.4 Adaptability to Future Changes

A number of potential changes may occur over the period of operation of the plant that would impact functioning of the condenser cooling system. These changes may relate to climate change, introduction of new species into the lake or modifications in regulatory requirements.

6.4.1 Potential Changes

6.4.1.1 Climate Changes

In recent decades there has been an ever expanding body of research on climate change. While climate is constantly undergoing change, the term has come to mean a climate that is impacted by pollution and other anthropogenic sources, leading to changes in the climate system that are not derived from natural causes. Today, many scientists equate climate change with a warming climate, a climate that is warming faster than natural causes would allow for, and faster than has been historically observed (known as ‘global warming’).

Global Climate Models (GCM’s) attempt to simulate the climate at timescales beyond what conventional weather models produce. These models use a vast array of observations that are taken from around the world, and can accurately simulate the weather at scales down to less than 1 km. However, climate is driven by factors relating to timescales that range from months to decades. Modellers make assumptions on the factors that drive climate change. Greenhouse gases are known to have a warming effect, and this is built into the GCM’s (Section 4.1 (51)). Potential climate changes that may have adverse impacts on the two cooling options are presented below.

Change in Total Annual Precipitation

The Canadian Centre for Climate 2nd generation Global Circulation Model (CCC GCM2) was used to determine results for Canada. The models predict an increase in the amount of precipitation for extreme events (Section 4.1.1.2 (51)) but declines can be seen for lighter events. No work has been done yet to determine the frequency of extreme precipitation on a regional basis.

Change in Atmospheric Temperature

A GCM study looked at 20 year return values of selected parameters and found that the 20 year return value for maximum atmospheric temperature increased by approximately 6°C over southern Ontario. Winter temperatures in the vicinity of Darlington are predicted to rise by 2°C by 2040 and by as much as 5°C in 2100. Similar temperature changes are expected to occur during the summer months (Section 4.1.2.2 (51)). Results of extreme value analyses indicated that there is a low probability for extreme temperatures at 10 m above ground level at the site to exceed a maximum of 42.3°C and a minimum of -33°C during the next 200 years (Section 7.0 (51)).

Change in Wind Speeds
Global climate models are unable to simulate the small-scale weather phenomena that drive peak wind events in the mid-latitudes, such as Ontario. GCMs do predict increased transport of moisture from the equator poleward. Increased moisture together with increased temperature implies more frequent and more intense convection. It is therefore reasonable to assume that in southern Ontario, the frequency and intensity of thunderstorms would increase in a warming world. Since the strongest thunderstorms can produce straight-line wind gusts of well over 100 km/h, and tornadoes are associated with the strongest supercells, it can be inferred that extreme wind events during spring, summer, and fall would be more frequent in the Darlington region in a warming world (Section 4.1.3 (51)).

**Changes in Lake Ontario Water Level and Temperature**

Water levels in Lake Ontario have been controlled and regulated since 1960. While there are naturally occurring fluctuations in precipitation and evaporation, the control of water levels reduces the range and occurrences of extreme lake levels. Results from the International Lake Ontario – St. Lawrence River Study stated that the water level of 75.6 m would be exceeded at a frequency of once every 100 years. A maximum lake level of 76.6 m is predicted, which is close to the maximum found in historic data and greater than the 100 year recurrence level (Section 7.2.9 (52)). Based on data provided in a Canadian Centre GCM, by 2090, it is predicted that the maximum surface temperature for Lake Ontario will be 27.5°C (increase of 6.5°C from 1975 data). The mean bottom temperature is predicted to be 7°C by 2090 (increase of 3°C from 1975 data).

Minimum water level in Lake Ontario is regulated, as stated above. Given this, the depth of the intakes according to conceptual designs for both technologies, and that precipitation is expected to stay at the same level, reduction of water levels below intake is not considered to be feasible.

6.4.1.2 Changes in Aquatic Populations in Lake Ontario

Increases in Lake Ontario water temperatures and/or introduction of invasive species could result in the increase of Algal and Mussel growth and the alteration of fish communities. Increase of populations could lead to changes in cooling efficiency, in an increase in maintenance/cleaning requirements for the OTC system and in an increase in impingement and entrainment of invasive species.

6.4.1.3 Changes in Regulatory Requirements

New regulations may come into force in future with tighter restrictions on fish impingement and entrainment or enforcing specific mitigation systems.

The existing regulations could be revised with lower limits on contaminant concentrations.

New regulations may also be enacted to limit the occurrence of fog/icing or visual impact resulting from the cooling towers.
6.4.2 Adaptability of the Cooling Options

The two cooling options could be modified to adapt to the potential future environmental changes discussed above with the implementation of mitigation measures. The mitigation measures could be categorized as follows:

- Design with margin: both cooling options could be designed with sufficient margin, which will ensure the options to have certain level of flexibility to deal with potential changes that can be anticipated at this time.

- Modification of some components for each cooling option: once the issue discussed above arises, some components of the cooling system could be modified correspondingly to cope with the potential changes. The modification could include:
  - Modifying the intake structure (e.g. adding fish handling and return system, installation of behavioural systems such as light, sound, and bubble barriers, and installing new screen on the existing system)
  - Modifying the discharge structure
  - Upgrading the cooling towers with replacement of cooling fans, pumps, spray system and fill.

In addition, given that some of unforeseen beyond design changes will occur infrequently, the impact could be further mitigated with the operational changes such as de-rating. Under those circumstances, the units could be temporarily de-rated.

Table 23 summarizes the impact of potential changes on two cooling options and potential to adapt the two technologies. The extreme, low likelihood scenarios are not included in Table 23. Examples of these scenarios are that the regulatory or environmental changes are such that the cooling system cannot be modified to address them and there is insufficient design margin in the original system. This may occur, for example, if a blanket ban were to be introduced on the OTC or, if due to increased frequency and strength of beyond design high wind events, cooling towers were to become vulnerable to tornados or straight winds in southern Ontario.

While these are very low likelihood scenarios, it is recognized that there is some uncertainty as to what the future changes may be, resulting in potential limits on adaptability for both technologies. This situation isn’t unique to the DNNP project. For these scenarios, the proposed cooling system would have to be entirely rebuilt, incurring capital costs associated with the respective option. There could also be significant economic impact resulting from loss of electricity generation.

6.4.3 Costs for Various Mitigations

The cost (NPV) for implementing different mitigation measures was estimated at the conceptual level (order of magnitude) and summarized in Table 24. The costing was based on the cost estimate for four units with the enhanced design features as discussed in Section 6.3.3.16.

Note that the cost was not estimated for rebuilding the cooling system which is only warranted for the extreme, low likelihood scenario. The capital cost to rebuild the
cooling system would be very high and comparable to initial capitals costs provided in Section 6.3.3.16.

6.4.4 **Summary**

The potential climate changes that could adversely affect the cooling systems are increases in environmental temperatures and wind speeds. MDCT would be affected more than OTC by increases in environmental temperatures as the predicted increase in atmospheric temperatures is greater than predicted increase in lake bottom temperatures. However increase in lake temperatures would lead to changes in lake species populations, which could adversely affect OTC. As the MDCT are above ground, they are more susceptible to effects from increased wind speeds. Negative effects from MDCT on local weather and plume visibility may also be increased by changes in climate. Most of the potential effects can be mitigated by design and to some extent by engineered enhancements post construction, however this would incur additional costs.
Table 23: Potential Future Changes, Impacts on Two Cooling Options and Mitigation Measures

<table>
<thead>
<tr>
<th>Potential Change</th>
<th>Once-Through Cooling</th>
<th>Mechanical Draft Cooling Towers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme Precipitation and other Flood Hazards</td>
<td>Extreme precipitation may cause flood hazard to operation of electrical equipment and pumps. Flood defences and drainage systems could be adapted to cope with changes in this hazard.</td>
<td>Extreme precipitation may cause flood hazard to operation of electrical equipment and pumps. Flood defences and drainage systems could be adapted to cope with changes in this hazard.</td>
</tr>
<tr>
<td>Atmospheric Temperature</td>
<td>Not Applicable – potential changes will not affect the design.</td>
<td>Increases in atmospheric temperature would increase the incidence of power reduction (i.e., station electrical output de-rating) because of reduced cooling capacity. The MDCT can be designed to cope with the predicted temperature rise. However if the changes exceed predicted estimates, the performance of cooling towers will deteriorate. It may be feasible to upgrade cooling tower components to adapt to such changes. In particular this may involve replacement of cooling fans, pumps, spray system and fill. Temperature changes may also impact plume visibility, density, extension and frequency of fogging and icing. It is unlikely that these effects could be mitigated by adapting existing designs once the facilities are in place. Rebuilding the cooling tower is required for the extreme events.</td>
</tr>
<tr>
<td>Wind Speed</td>
<td>Not Applicable – potential changes typically only affect above ground structures.</td>
<td>Increases in the frequency of thunderstorms, tornados, downbursts and hurricanes which could adversely affect above ground structures. MDCT can be designed to cope with the predicted weather phenomena for a given frequency requirement with a certain margin. However in the event of increase in high wind event frequency and magnitude exceeds design, there is relatively little design modifications that can be implemented to improve wind resistance of the existing cooling tower structures. Rebuilding of the cooling tower is required for the extreme events.</td>
</tr>
<tr>
<td>Lake Water Level Drop</td>
<td>The OTC intake is well below the controlled lake water level; hence the potential changes will have no effect.</td>
<td>The MDCT intake is well below the controlled lake water level; hence the potential changes will have no effect.</td>
</tr>
<tr>
<td>Lake Temperature</td>
<td>Increase in temperature at the bottom of the lake would increase the incidence of power reduction (i.e., station electrical output de-rating) because of reduced cooling</td>
<td>Not Applicable – potential changes will not affect the design.</td>
</tr>
<tr>
<td>Potential Change</td>
<td>Once-Through Cooling</td>
<td>Mechanical Draft Cooling Towers</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td></td>
<td>capacity. It would also increase the thermal plume area. The increase in ambient lake temperature may also enhance the maximum plume temperatures resulting in a potential thermal effect on larval growth. There are also indirect effects (see Aquatic Populations below). The OTC can be designed to cope with the predicted temperature rise. If predicted values were to be exceeded, the intake structure could be extended into deeper water. Also, it may be feasible to adjust the flow rates. Rebuilding the cooling system would be required if modification were not possible.</td>
<td></td>
</tr>
<tr>
<td>Aquatic Populations</td>
<td>Increases in Lake Ontario water temperatures and/or introduction of invasive species could result in the increase of Algal and Zebra Mussel growth and the alteration of fish communities. Increase of populations could lead to a loss of cooling efficiency for the OTC system and increase in impingement and entrainment. However, the OTC can be designed to cope with the potential changes.</td>
<td>Limited impact on the intake due to potential introduction of new species.</td>
</tr>
</tbody>
</table>
| New Regulations | New regulations may come into force with tighter restrictions. While these cannot be anticipated, the following components can be modified post construction:  
- Intake screens  
- Intake structure  
- Pumps and pump structures  
- Diffuser | New regulations may come into force with tighter restrictions. While these cannot be anticipated, the following components can be modified post construction:  
- Intake screen  
- Pumps and pump structures  
- Cooling tower components including fans, pumps, spray systems and fills  
- Diffuser |
### Table 24: Estimated Order-of-Magnitude Costs for Additional Mitigation Measures

<table>
<thead>
<tr>
<th>Potential changes</th>
<th>OTC Mitigation measures required</th>
<th>Cost (M$)</th>
<th>MDCT Mitigation measures required</th>
<th>Cost (M$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Climate change</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extreme Precipitation and other Flood Hazards</td>
<td>Flood defences and drainage systems with appropriate contingency</td>
<td>&lt;1</td>
<td>Flood defences and drainage systems with appropriate contingency</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Atmospheric Temperature Increase</td>
<td>None</td>
<td>0</td>
<td>• Upgrade cooling tower components with replacement of cooling fans, pumps, spray system and fill</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• De-rating (assuming 4% loss of electricity for four units over 60 years)</td>
<td>860.4</td>
</tr>
<tr>
<td>Increase in frequency and magnitude of high winds</td>
<td>None</td>
<td>0</td>
<td>Depends on the nature of environmental changes</td>
<td>Unknown</td>
</tr>
<tr>
<td>Lake Water Level Drop</td>
<td>None</td>
<td>0</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>Lake Temperature Increase</td>
<td>Upgrade pumps and pump structures to increase flows.</td>
<td>18.1</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>De-rating (assuming 1% electricity loss for four units over 60 years)</td>
<td>272.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquatic Populations (Increase of Algal and Mussel growth and the alteration of fish communities)</td>
<td>Introduce additional impingement/entrainment mitigation measures</td>
<td>42</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>New Regulations Impacting Intake and Discharge Structures</td>
<td>Modification of following components post construction:</td>
<td>220</td>
<td>Modification of following components post construction:</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>• Intake screens and air-burst system</td>
<td>18.1</td>
<td>• Intake screen</td>
<td>28.8</td>
</tr>
<tr>
<td></td>
<td>• Pumps and pump structures</td>
<td>70</td>
<td>• Pumps and pump structures</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>• Intake/discharge structure including additional excavation and tunnelling</td>
<td></td>
<td>• Upgrade cooling tower components with replacement of cooling fans, pumps, spray system and fill</td>
<td>3.4</td>
</tr>
</tbody>
</table>
7.0 **STEP 8 - INITIAL SELECTION OF THE BATEA FOR DNNP CONDENSER COOLING**

The initial selection of the BATEA was made on the basis of the initial evaluation of the enhanced options [49,45]. This selection, BATEA methodology, as well as facts and assumptions supporting the selection were then presented to stakeholders in a series of workshops described in Section 8.0 (Step 9).

Subsequently a number of revisions were made to the assessment to address stakeholder inputs. These changes are also summarized in Section 8.0 and have been incorporated in the option evaluation described above.

The final selection of BATEA for Condenser Cooling System for the DNNP is presented in Section 9.0 (Step 10).
8.0 **STEP 9 –STAKEHOLDER CONSULTATION**

Following the initial selection of the BATEA, OPG conducted a stakeholder consultation program regarding the DNNP Condenser Cooling Water Option Assessment Initial Selection with the public and stakeholders.

The purpose was to provide the public and stakeholders with information regarding the assessment and the results so that they may be informed and made aware of OPG's plans. It was also to provide stakeholders and the public with an opportunity to participate in the assessment by reviewing and confirming the factual basis of the evaluation and confirming the accuracy of assumptions used in the evaluation of attributes.

To achieve these objectives, OPG implemented a variety of information sharing and consultation activities. These included:

- providing information on the condenser cooling option assessment to the general public through a community newsletter distributed to 96,000 homes and businesses;
- the publication of a public summary in plain language;
- a dedicated page on the OPG DNNP EA website; and
- presentations to seven community committees and municipal councils.

OPG also sought feedback from informed stakeholders through a series of six roundtable meetings to which thirty different stakeholder groups were invited. A separate meeting was held with First Nations.

OPG received feedback on the assessment overall, the facts and assumptions for each attribute, the study methodology and initial selection. No issues or concerns were raised regarding the use of a multi-attribute analysis or the range of attributes used for the assessment. Comments and feedback was provided on all attributes and some additional attributes were suggested for inclusion. Generally, clarification was sought with respect to the technology options selected and their physical characteristics; the facts and assumptions used in the assessment; and the rationale and justification for scoring.

A few questioned the need for the assessment given OPG's operating experience with once-through lake water cooling systems and the site location. Municipal leaders and officials sought to ensure their preferences for once through lake water cooling were fully reflected in the assessment.

While many were comfortable with the initial selection of once through cooling, some concerns were raised regarding the transparency of the decision logic. Transparency in the final decision logic for the condenser cooling system is seen as extremely important.

AMEC and OPG responded to all questions and comments brought forward during the stakeholder program as they were raised, in a few instances follow up information was provided. In general the information provided on the assessment, and the opportunity to input to the assessment was appreciated by those involved.
Further details are provided in the stakeholder consultation report [45].

A number of changes were made to the assessment and report to address feedback received from the stakeholders. The most significant of these changes are summarized below:

1. Attributes “Excavated Materials”, “Aquatic Habitat” and “Terrestrial Habitat” were recalibrated so that the scores were clear and consistent and accounted only for impacts directly related to condenser cooling options. The scores for each design or technological enhancement were adjusted accordingly. The Stakeholder Involvement report provides information on specific concerns with the scoring schemes for these attributes [45]:

   - Section 3.5 of the Stakeholder Involvement Report: “The Participants raised some important considerations respecting the evaluation of the attributes, especially the rationale for attributes that appeared to account for the same effect. It was also stressed that it must be consistent in measuring the effect of the technology options and not the facility they support. For example, it was not clearly communicated how much of the excavation was associated with only the condenser cooling technology”.

   - Excavated Materials – Section 4.2.4 of the Stakeholder Involvement Report: “The total volume of excavated materials should not be used as the baseline as it under-estimates the effects; the scoring needs to reflect the difference in effects of the options”

   - Aquatic Habitat - Section 4.2.2 of the Stakeholder Involvement Report: “Clarity is required regarding the lake infill assumptions, including whether any is actually required for the project and why different lake infill assumptions are used for this one attribute; and the basis for the scoring calibration for this attribute should be made clear given the difference in the amount of lake infill required.”

   - Community Interest Groups Roundtable Meeting: April 16, 2012: “For a number of attributes (… Aquatic Habitat, Terrestrial Habitat) the scoring was seen to be problematic (the basis for scoring was not clear; the basis for the calibration was not clear”

The resulting changes in calibration for these attributes are documented in Appendix K.

2. “Global Warming Adaptability” and “Public Perception” attributes were removed from the list of evaluated attributes. These attributes were evaluated on a purely qualitative basis and there were overlaps between “Public Perception” and other attributes leading to potential double counting. “Space” attribute was removed to avoid overlap with Excavated Materials attribute. The information relating to these issues is documented in Section 6.4 and in the appendices (See Appendix G, and Appendix L).

3. A new section on sensitivities to different types of parameter uncertainties was added to summarize information presented in the Appendices and to document information related to uncertainties that was collated during Stakeholder workshops (see Section 10.0).
4. Additional clarification was provided to present the approach for selecting the BATEA, including an additional explanation for why simple summation of numerically weighted scores for the two technologies is not used in the assessment (see Section 2.1).

More information on the comments received from the stakeholders and responses is provided in Appendix K.
9.0 **STEP 10 - FINAL SELECTION OF THE BATEA FOR DNPP CONDENSER COOLING**

The best condenser cooling water option was selected using a logical, systematic, and transparent method based on the results of the option evaluation described in Section 6.0.

In accordance with the Option Assessment Methodology (Section 4.0), there were three possible scenarios for selecting the best option:

- If one of the two options were to perform better across all attributes, it would be selected as the BATEA.
- If there is no substantive difference in performance against non-financial attributes between the two options then cost will be the deciding factor.
- If one option were to perform better against certain attributes but not others then the BATEA will be selected on the basis of attribute importance, the differences in attribute performance for each cooling technology and cost.

Scores for the OTC and MDCT options against the key attributes are presented in Table 25. It can be seen that the BATEA selection falls under the third scenario.

**Table 25: Key Attribute Evaluation Summary (enhanced)**

<table>
<thead>
<tr>
<th>Key Attribute</th>
<th>OTC Score</th>
<th>Basis of OTC Score</th>
<th>MDCT Score</th>
<th>Basis of MDCT Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise</td>
<td>5</td>
<td>Operation does not result in any additional noise.</td>
<td>5</td>
<td>Does not result in increase over background noise levels off-site.</td>
</tr>
<tr>
<td>Local Climate Change</td>
<td>5</td>
<td>No adverse effects.</td>
<td>4</td>
<td>Occasional icing and fogging.</td>
</tr>
<tr>
<td>Visual Effects</td>
<td>4</td>
<td>OTC has no adverse effect</td>
<td>2</td>
<td>Frequent occurrence of plume up to 350m high, particularly in winter.</td>
</tr>
<tr>
<td>Fish Impingement</td>
<td>3</td>
<td>OTC has the estimated reduction in impingement rate of over 90% compared to baseline.</td>
<td>4</td>
<td>MDCT has the estimated reduction in impingement rate of over 95% compared to baseline.</td>
</tr>
<tr>
<td>Fish Entrainment</td>
<td>1</td>
<td>OTC has the estimated reduction in entrainment rate of over 60% compared to baseline.</td>
<td>4</td>
<td>MDCT has the estimate reduction in entrainment rate of over 90% compared to baseline.</td>
</tr>
<tr>
<td>Thermal Discharge</td>
<td>1</td>
<td>OTC results in thermal plume with a footprint equal to EA estimates.</td>
<td>4</td>
<td>MDCT results in thermal plume with a footprint which is 1% of the OTC.</td>
</tr>
<tr>
<td>Excavated Materials</td>
<td>5</td>
<td>OTC does not result in any additional requirement for off-site soil management.</td>
<td>1</td>
<td>MDCT would require some 2.6Mm$^3$ of soil to be moved off-site. Primary impact is due to transportation, which is limited in time to 2-3 years during construction.</td>
</tr>
</tbody>
</table>
Terrestrial Habitat  |  5 | OTC results in no additional loss of Bank Swallow habitat. There is some potential for the quality of the habitat to be impacted during construction. | 1 | MDCT results in a complete loss of the Bank Swallow habitat. 

Cost (NPV), M$ | 543 | Capital costs include: intake and discharge structures, tunnelling, excavation, implementation of JRP recommendations and tax shield credits. 

Operation and Maintenance costs include cleaning of the intake and discharge structures, water usage and net power generation loss due to condenser cooling water pumps. | 1,412 | Capital costs include: cooling towers, intake and discharge structures, excavation, tunnelling, lake bottom/shoreline procurement, implementation of JRP recommendations and tax shield credits. 

Operation and Maintenance costs include bi-annual inspections and maintenance of the cooling towers, water usage, chemicals, major component replacement for mid-life reconstruction of cooling towers, net power loss generation due to CCW pups, cooling tower fan loads and thermal efficiency losses.

*Notes: scores are for the OTC and the MDCT options respectively after enhancements.*

From the evaluation of the key attributes, the following were judged to be significant differentiators between the two options:

- **Visual Effect**
  
  OTC - No visual impact. 
  
  MDCT – Visual plume impact extending up to 3.5 km off site and occurring 46% of the time in winter as well as 3-15% of the time during other seasons.

- **Local Climate Change**
  
  OTC - No risk of occasional fogging and icing off-site. 
  
  MDCT – Occasional off-site icing and fogging.

- **Terrestrial Habitat**
  
  OTC - Bank Swallow habitat will be preserved. 
  
  MDCT – Bank Swallow habitat will be removed.

- **Excavated Materials**
  
  OTC - Minimal excavation; no increase in off-site soil management is required over the site preparation period 
  
  MDCT – Additional excavation, resulting in significant increase in off-site traffic

It can be seen that for the MDCT option, the above impacts are only partially mitigated with design enhancements. The residual differences in option performance for these attributes are significant.

The following key attributes for which the MDCT design performs better were recognized: Fish Impingement, Fish Entrainment and Thermal Discharge to the Lake. However, after intake enhancement, the difference in performance between the two
options for these aspects is minimal. These factors do not compensate for the better environmental performance of the OTC system for the following reasons:

- **Fish Impingement**
  
  There would be an additional reduction in fish impingement due to the proposed design enhancements for the DNNP OTC system. It is estimated that impingement would be reduced by over 90% compared to the baseline. This would be comparable to the performance of a MDCT intake.

- **Fish Entrainment**
  
  The dominant fish species whose eggs and larvae could be entrained are represented throughout Lake Ontario. The quantity of potential entrainment for these species would only be a small fraction of their overall population. The exception is Round Whitefish whose population is more concentrated along the north shore of Lake Ontario. Entrainment of Whitefish eggs and larvae would likely be reduced further as described below [44].

  Entrainment of Round Whitefish and other species would be further reduced by:

  - Reduction of the intake approach velocity to 6 cm/s (larval fish as small as 3.8 mm can attain avoidance burst speeds of 6 cm/s), and
  - Placement of the intake in a location with low concentration of Round Whitefish eggs and larvae (Round Whitefish eggs and larvae are typically found at depths of less than 12 m. At these depths, it is still unlikely that deepwater Sculpin would be encountered as they are a demersal species).

  While habitat compensation has not been credited in this assessment, OPG has committed to develop and implement fish habitat compensation plan [48]. Furthermore, data from the existing DNGS suggests entrainment losses are less consequential than those from impingement [44].

- **Thermal Discharge**
  
  There is evidence from the existing DNGS that the current diffuser design is performing well and that thermal discharge does not result in adverse effect on aquatic species (see Section 6.3.2.4).

Therefore OTC has an advantageous environmental performance against the most significant factors. Furthermore, while it is recognized that both cooling technologies are acceptable as neither option would result in unacceptable environmental consequences that exceed regulatory limits, the OTC option is considerably less expensive. The OTC design with an enhanced intake is estimated to cost $543M while the MDCT design with plume abatement is nearly triple the cost at $1,412M.

Option performance for the non-key attributes further supports selection of the OTC as the preferred option. This is because the OTC option does not involve use of chemicals, consumes less water and has smaller aquatic habitat footprint. The OTC option also has slight Technical Performance advantage as there is little experience with plume abatement in the nuclear industry.
The following additional considerations either provide further support for selecting the OTC as the preferred option or have no impact on selection:

- As confirmed in Section 6.0, both options can be implemented in such a manner that public and worker health and safety are maintained.

- Although space utilization remains dependent on the reactor technology selected and efforts to optimize site layout, use of the MDCT in combination with the lake infill to the 2m depth mark, will likely constrain the total number of units that could fit onto the site. Conceptual layouts indicating potential problem for some of the considered technologies are illustrated in OPG’s response to JRP’s request for Undertaking 29 [50]. The MDCT option, considered in this response, did not include plume abatement and was estimated to require 8 ha above and beyond the 2m lake infill. Use of plume abatement further increases the footprint of this cooling technology.

- Both technologies could be impacted by future environmental changes. The OTC is more susceptible to changes in the aquatic environment and ambient water temperature while the MDCT technology would be impacted by increases in air temperature as well as frequency and intensity of extreme weather events. Both technologies could be designed with sufficient margins to cope with foreseeable changes. It is feasible that environmental changes will exceed design margins. Depending on the nature of these changes and unknown future regulatory requirements, both options could be adapted following plant construction (See Section 6.4).

- The OTC option was strongly favoured by local stakeholders (See Section 8.0).

The systematic assessment documented in this report concludes that OTC is the BATEA for the DNNP. Section 10 provides sensitivity analysis to evaluate robustness of this finding.
10.0 UNCERTAINTY AND SENSITIVITY ANALYSIS

Sensitivity analysis is essential when utilizing the multi-attribute assessment approach to test the robustness of BATEA selection in the light of assessment uncertainties. It allows one to evaluate the potential impact of each category of uncertainties and to take into account the impact of different stakeholders’ views and values on the assessment.

Assumptions that might have a significant impact on the conclusions have to be made explicit and be supported, including the reasons for the degree of confidence expressed in those assumptions. As stated in Section 2.0, for conceptual decisions, numerical sensitivity analysis should not take precedence over providing robust justification of assumptions and more qualitative arguments that influence the conclusions [7].

In the current study there are five main areas of uncertainty:

1. Detailed design uncertainty, including selection of reactor technology and design of condenser cooling options, including potential enhancements.
2. Selection of evaluation attributes.
3. Evaluation of option scoring performance against attributes.
4. Assessing trade-offs and parameter importance among conflicting objectives, including selection of the Key Attributes and the BATEA selection logic.
5. Potential environmental or regulatory changes.

10.1 Option design uncertainty

There are three types of design uncertainty: selection of the reactor technology, selection of feasible cooling options and selection of cooling option enhancements.

Selection of the condenser cooling option is largely independent of the reactor technology itself, but it may be impacted by plant capacity and the associated heat rejection rate requirement. Selection of the two conceptual cooling options has been conducted outside of the current study as described in Section 5.2. For this reason the resulting uncertainty is not evaluated further. The impact of plant capacity and selection of potential enhancements for each of the two options are discussed below.

Uncertainty in Plant Capacity

The effect of reducing plant capacity was analyzed by evaluating attribute performance for heat rejection rate requirement of 4418 MWt, which is half the baseline heat rejection rate.

Table 26 contains information on the resulting scores, taking design enhancements into account. It should be noted that the number of attributes for which the OTC option performs better did not change. For the MDCT option the scores for two attributes were impacted by the reduction in heat rejection rate (Air Quality/Emissions to Air and Water Consumption). Further details are provided in Appendix G. It can be
seen that the factors, driving identification of the OTC system as the BATEA would not be changed if the number of units were to be reduced. Namely:

- No visual impact,
- No noise impact,
- No risk of occasional fogging and icing off-site,
- Negligible site footprint – approximately 80% of Bank Swallow habitat could be undisturbed,
- Minimal excavation; no increase in off-site soil management is required over the site preparation period, and
- Lower lifetime costs.

Therefore selection of OTC system as the BATEA is not sensitive to a reduction in the size of the plant from four to two units.
Table 26: Sensitivity of Attribute Scores to Heat Rejection (enhanced)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>OTC score</th>
<th>MDCT score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 Units</td>
<td>2 Units</td>
</tr>
<tr>
<td>Risks to Public Health and Safety</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Risks to Worker Health and Safety</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Water Quality and Emissions</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Air Quality and Emissions</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Noise</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Water Consumption</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Local Climate Change</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Visual Effects</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Excavated Materials</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Aquatic Habitat</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Terrestrial Habitat</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Thermal Discharge to Lake</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fish Impingement</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Fish Entrainment</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Technical Performance</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cost (in $, millions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAC</td>
<td>38.7</td>
<td>28.8</td>
</tr>
<tr>
<td>NPV</td>
<td>543.2</td>
<td>404.2</td>
</tr>
</tbody>
</table>
Uncertainty in Selecting Design Enhancements

This is an important area of potential uncertainty. The study considered a wide range of potential enhancements to improve performance of the two options against the key attributes. In the absence of detailed design, judgements had to be made to determine design enhancements which could mitigate negative impacts at a reasonable cost. Selection of alternative enhancements would have resulted in different performance of the enhanced options against the key environmental attributes and cost.

An evaluation of the potential impact of design enhancements on selecting the BATEA for condenser cooling was conducted by qualitatively assessing the sensitivity of environmental performance and cost to a selection of enhancements (see Table 27).

Table 27: Sensitivity to Selection of Enhancements

<table>
<thead>
<tr>
<th>Design Enhancement</th>
<th>Variability in environmental performance</th>
<th>Variability in cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise abatement (MDCT)</td>
<td>Low. Abatement took account of the best practice.</td>
<td>Low. Estimated cost of noise abatement of $14.2M represents 1% of the overall cost for MDCT.</td>
</tr>
<tr>
<td>Plume Abatement (MDCT)</td>
<td>Medium. A wide range of plume abatement options could be implemented. Performance of the two “extremes” was evaluated in the current report, providing an understanding of the variability.</td>
<td>High. The incremental cost for the MDCT option with visual plume abatement is $309.2M. This represents 22% of the overall cost for MDCT.</td>
</tr>
<tr>
<td>Intake Enhancement (MDCT)</td>
<td>Low. Performance of intake without enhancement is considered satisfactory.</td>
<td>Low. Estimated cost of wedgewire screen and airburst system of $4.8M represents less than 1% of the overall cost for MDCT.</td>
</tr>
<tr>
<td>Intake Enhancement (OTC)</td>
<td>Low. Performance of intake without enhancement is considered satisfactory.</td>
<td>Low. Estimated cost of providing improved porous veneer vane design and the use of the copper-nickel alloy screen of $7.6M represents 1.4% of the overall costs of OTC. Note that provision of wedgewire screen for the OTC intake was ruled out as not achievable on the</td>
</tr>
</tbody>
</table>

11 Includes capital costs, maintenance and major component replacement costs, and loss generation costs
<table>
<thead>
<tr>
<th>Design Enhancement</th>
<th>Variability in environmental performance</th>
<th>Variability in cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outfall Enhancement (MDCT)</td>
<td>Low. Performance of intake without enhancement is considered satisfactory.</td>
<td>Low. Although not evaluated, typical costs for relocating or modifying the outfall are likely to be less than 1% of the overall cost of MDCT.</td>
</tr>
<tr>
<td>Outfall Enhancement (OTC)</td>
<td>Low. Performance of intake without enhancement is considered satisfactory.</td>
<td>Low. Although not evaluated, typical costs for relocating or modifying outfall are likely to be less than 1% of the overall cost of OTC.</td>
</tr>
</tbody>
</table>

It can be seen that only the selection of plume abatement technology for MDCT has the potential to impact the environmental performance and cost of this option in a meaningful manner. The two bounding plume abatement designs (no abatement and maximum abatement) have been evaluated in the report. Having evaluated relative performance of these bounding designs on plume visibility, local climate change and cost, it can be concluded that while affecting the underlying reasons for BATEA selection, plume abatement design does not change selection of the best cooling option. This is because even with maximum abatement, there will be an estimated 46% occurrence of visual plume in winter, which also has the potential to be associated with fogging and icing conditions.

Inclusion of additional abatement features that enhance the performance of non-key attributes has a low impact on BATEA selection.

### 10.2 Uncertainty in Selection of Evaluation Attributes

A comprehensive set of evaluation criteria was considered in the current assessment. International experience in evaluating cooling options and stakeholder priorities were taken into account in selecting the list of assessment attributes (see Sections 0 and 5.3). A number of additional attributes were considered and not included, largely as not having the potential to impact BATEA selection (See Appendix G). Stakeholders identified several additional attributes for inclusion in the assessment (See Appendix K). Only Energy Efficiency and Tritium Concentration in Water are potential differentiators between the two options. However, inclusion of these two issues as separate attributes would benefit the OTC option, which is the selected option. Therefore their inclusion would not impact which option is selection as BATEA.
10.3 Uncertainty in Evaluation of Options’ Performance

Uncertainties in the key data supporting the attribute evaluation are identified in Appendix G. The most important assumptions and uncertainties in attribute scores are also presented in Section 6.0.

For the two considered options, the impact of these uncertainties can be best evaluated by analyzing whether:

- the performance of the selected option may have been overestimated and
- the performance of the option that was not selected may have been underestimated

Sensitivity of BATEA to uncertainties in attribute scores can then be evaluated by analyzing the impact of taking the upper performance bounds for the MDCT and the lower performance bounds for the OTC option and analyzing the impact on BATEA selection. The resulting scores are presented in Table 28.

Table 28: Sensitivity of Attribute Scores to Evaluation Uncertainties (enhanced)*

<table>
<thead>
<tr>
<th>Once Through Cooling Performs Better</th>
<th>Mechanical Draft Cooling Tower Performs Better</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risks to Public Health and Safety (5/4)</td>
<td>Fish Impingement (3/4)</td>
</tr>
<tr>
<td>Risks to Worker Health and Safety (5/4)</td>
<td>Fish Entrainment (2/4)</td>
</tr>
<tr>
<td>Water Quality and Emissions (4/3)</td>
<td>Thermal Discharge to Lake (1/4)</td>
</tr>
<tr>
<td>Air Quality and Emissions (4/4)*</td>
<td></td>
</tr>
<tr>
<td><strong>Noise (5/5)</strong></td>
<td></td>
</tr>
<tr>
<td>Water Consumption (4/2)*</td>
<td></td>
</tr>
<tr>
<td><strong>Local Climate Change (5/4)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Visual Effects (4/2)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Excavated Materials (5/1)</strong></td>
<td></td>
</tr>
<tr>
<td>Aquatic Habitat (4/1)</td>
<td></td>
</tr>
<tr>
<td><strong>Terrestrial Habitat (4/1)</strong></td>
<td></td>
</tr>
<tr>
<td>Technical Performance (5/4)</td>
<td></td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Note: scores in brackets are for the OTC and the MDCT options respectively after enhancements. Attributes with modified scores due to uncertainty in evaluated parameters are identified with an asterisk.

It can be seen that option performance has not changed for most of the attributes. Minor changes in scoring for Terrestrial Habitat, Air Quality and Emissions and Water Consumption have no impact on option selection as the OTC would still perform better against these attributes even taking uncertainty into account.

For costs AACE Class 4 concept study and AACE Class 5 feasibility study estimates have been used. This combined estimate is considered to have an accuracy of -30% to +70% which in this case is sufficient to differentiate between the two cooling technologies. Assuming the lower bound of the combined estimate accuracy for MDCT
and the higher bound of the combined estimate accuracy for OTC, it can be seen that OTC is still judged to be the more cost efficient of the two options.

More significant is uncertainty in option performance for the following attributes:

- **Terrestrial Habitat.**
  
The score for this attribute is based on preservation of habitat for Bank Swallows. Although there is high confidence in preservation of habitat for the OTC option, there is uncertainty in potential impact on Bank Swallows during the construction of a nuclear power plant even if the habitat isn’t removed. These changes may be due to construction noise or potential impact on geotechnical stability and erosion of the bank.

- **Fish Impingement and Entrainment.**
  
  Uncertainty in these attributes is associated with uncertainty in Fish Spawning and Habitat Data. Although OPG is planning to conduct a survey of fish habitat at depths of 16 to 20 m to address a JRP recommendation, this is not going to impact the BATEA finding. The current assessment was conducted assuming an intake location at 10 m depth, since the data are available. This led to a conservative estimate of fish impingement and entrainment, thus any potential for placement of the intake in areas with lower concentrations of fish, eggs and larvae would not change the conclusion that the OTC condenser cooling system is the BATEA for the DNNP.

- **Thermal Discharge to Lake**
  
  Uncertainty in the impact of thermal discharge on populations of fish for the OTC option is low due to sufficient data being available from operation of the DNGS discharge.

Although uncertainties in option evaluation may impact performance against individual attributes, the underlying reasons for selecting OTC as the BATEA have low sensitivity to parameter uncertainty. The overall environmental performance of the OTC option is still preferable due to lack of plume and lack of local fogging and icing. Uncertainties exist in OTC impacts on fish, but the evaluation was based on conservative estimates, hence these uncertainties do not affect option selection. The cost of the OTC option is estimated to be lower than the MDCT, even accounting for uncertainty.

### 10.4 Uncertainties in Attribute Importance

Attribute importance uncertainty may have an impact on selecting the Key Attributes and on relative comparison (“trade-off”) between advantages and disadvantages of each option.

The three attributes for which the MDCT option performs better have been selected as Key Attributes, thus maximizing their significance in the selection of BATEA. The actual impact on populations of fish in Lake Ontario of the OTC option is predicted to be small. In order for a different BATEA selection to be made, the importance of all the other environmental attributes and costs would have to be neglected altogether.
10.5 Uncertainties Due to Potential Changes in the Environment or Regulatory Changes

Potential effects and adaptability of both technologies to climate change, to other environmental changes and to enactment of new regulations are described in Section 6. Although difficult to predict, performances of both technologies might be impacted by such changes, and both technologies can be adapted to a certain extent.

Of particular note is the Ontario Endangered Species Act, which identifies a list of species under threat and which is frequently updated. The potential effect on terrestrial habitat has already been identified as a Significant Attribute, one of the factors which contributed to selecting OTC as BATEA. While the list has been updated with new species, and in all likelihood will be updated further before and after construction of DNNP, this would not affect the rationale for selecting BATEA as OTC does not impact terrestrial habitat.
11.0 CONCLUSIONS

This study determined the BATEA for the condenser cooling system for the DNNP.

The following two options were evaluated based on previous analysis and recommendations of the Joint Review Panel:

- Once Through Cooling, and
- Mechanical Draft Cooling Towers.

The assessment was conducted for two sets of conceptual designs: baseline and enhanced. The latter included a number of cost-effective enhancements developed to mitigate potential environmental impacts relating to key attributes.

Both options are acceptable as neither of the options would result in environmental consequences exceeding regulatory limits. It was found that the OTC option performs better for six key and seven non-key attributes. The MDCT option performs better for three key attributes. The OTC design with enhancements was found to be considerably less expensive as compared to the MDCT design with enhancements.

After intake enhancement, the difference in performance between the two options for the three attributes for which MDCT option performs better is minimal and does not compensate for the better environmental performance of the OTC system. On this basis, OTC is identified as the BATEA for the DNNP. The analysis of sensitivities of this selection to a range of option evaluation uncertainties demonstrated robustness of the BATEA selection. Furthermore, this selection is consistent with the approach accepted at most operating and planned nuclear power plants as the best available technology for locations adjacent to a large water body with a large heat sink capacity.

The selected BATEA is recommended for consideration by OPG as the basis for the decision on condenser cooling system for the DNNP. OPG will use this information to make the final decision on condenser cooling technology in accordance with their mandate, corporate values and interests.
12.0 REFERENCES


[18] Dominion Nuclear, "North Anna Early Site Permit Application (Chapters 1 and 2)," September 2006.


[22] Enercon Services, Inc, "Engineering Feasibility And Costs Of Conversion Of Indian Point Units 2 And 3 To A Closed-Loop Condenser Cooling Water Configuration," February 2010.

[23] OPG, "Use of plant parameters envelope to encompass the reactor designs being considered for the Darlington site," N-REP-01200-10000 R03, November 2010.


http://www.mto.gov.on.ca/english/safety/orsar/orsar08/people.shtml


[29] Ontario Ministry of the Environment (MOE), "Summary of Standards and Guidelines to Support Ontario Regulation 419: Air Pollution – Local Air Quality; Standards Development Branch,"
PIBS#6569e, February 2008.


[58] Sciencelab. Sodium Hypochlorite. [Online].
http://www.sciencelab.com/msds.php?msdsId=9925001


http://www.ee.iitb.ac.in/~nanoe/msds/sulphuric%20acid.pdf


Appendix A: Overview of BATEA Equivalent Methodology in Other Jurisdictions

A.1 BEST PRACTICABLE ENVIRONMENTAL OPTION METHOD (UK)

In UK, the concept equivalent to BATEA is Best Practicable Means (BPM) or Best Practicable Environmental Option (BPEO).

The regulatory authorities in the UK have produced a series of guidelines over the last 100 years or so to help direct decisions for minimising environmental impacts. The first set of guidelines was published in 1874 as part of the Alkali Act, which was brought in to reduce air pollution in urban areas. This Act set out the concept of BPM, which helped to identify appropriate pollution reduction technologies for industry by balancing costs against environmental benefits. The BPM concept has been the basis for environmental pollution control ever since, although it has been updated and extended in scope. The concept of the ‘Best Practicable Environmental Option’ (BPEO) can be considered to be an extension of the BPM approach.

The term ‘BPEO’ was originally introduced by the Royal Commission on Environmental Pollution (RCEP) in 1976, also in the context of the control of atmospheric pollution [2]. Its basis is more explicitly to involve consideration of environmental aspects in the decision making process than might be done using the BPM approach alone. Since 1976, the BPEO approach has been applied more widely than to atmospheric pollution issues to cover many other potentially polluting practices, including the management of radioactive materials.

In 1986, a comprehensive review of systems of radioactive waste management was undertaken by the Department of the Environment using what was considered, at that time, to be a state-of-the-art approach to applying the principles of BPEO [51].

The definition of BPEO by RCEP is as follows:

“A BPEO is the outcome of a systematic consultative and decision-making procedure which emphasises the protection and conservation of the environment across land, air and water. The BPEO procedure establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well in the short term” [52].

The RCEP also provided a set of basic of principles for the application of the BPEO approach. These included, as the first three steps:

- Defining objectives in terms that do not prejudge the means by which the objective is to be achieved,
- Generating options, alternative options should be sought ‘diligently and imaginatively’, and
- Evaluating the options using a combination of quantitative methods and qualitative evaluation.

The approach has progressively evolved to become more sophisticated and has been extended for more general application. As a rule, wider ranges of options and attributes are now routinely considered; nevertheless, the level of detail to which options and attributes are addressed should reflect the overall context within which
the appraisal is carried out. Under the 1990 Environmental Protection Act, a BPEO is simply defined as:

"... the option which provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as the short term."

Following the 1990 EPA, the BPEO approach was formally introduced into regulations controlling industrial processes as part of Integrated Pollution Control (IPC). This requires operators to demonstrate that the measures they take to reduce pollution represent the Best Available Techniques Not Entailing Excessive Cost (BATNEEC), having regard to the BPEO for those processes. In particular, by having regard to the BPEO, the identification of the ‘best’ technique was intended to account for the possibility of releases to a range of different media from a given source or process, as well as the possible existence of other sources of pollution in the vicinity.

Processes that may lead to releases of radioactivity are controlled under a different regulatory framework to IPC. The methodology developed for IPC BPEO studies can, nonetheless, be extended and adapted for use with environmental assessments involving radioactive discharges. This is supported by the Environment Agency of England and Wales, which have issued a guidance document on the methodology which states that:

"it can be applied flexibly and imaginatively as appropriate to particular circumstances" [10].

Although the RCEP has provided a set of basic principles for the application of the BPEO approach and the Environment Agency has produced its guidelines for IPC BPEO studies, there are, in fact, no prescribed ‘rules’ for designing and implementing a BPEO study. There is, however, a growing body of precedent to demonstrate how the approach can be applied in different contexts. This illustrates that the concept itself is best treated as a framework, within which information on possible solutions to the problem (‘options’) and the measures on which they should be judged (‘attributes’) are brought together.

The primary concepts involved in a BPEO assessment can, essentially, be explained by considering the words of the acronym in reverse order.

- Option: Alternative ways of achieving the desired result have to be considered.
- Environmental: Environmental (and safety) issues have to be considered at an early stage in the decision-making process.
- Practicable: Options have to be in accordance with current technical knowledge and should not have disproportionately adverse financial or social implications.
- Best: The final option after screening for environmental and practicable considerations.

If rigorously and comprehensively applied, a BPEO study provides a framework for making environmentally responsible, efficient and cost-effective decisions in a transparent and auditable manner. However, it is important to recognize that there are some limitations associated with the BPEO methodology and that these limitations can affect the chosen ‘best’ option.
The BPEO methodology has to rely, to some extent, on personal or expert judgment to compare and contrast issues such as practicability and potential environmental impacts. Different stakeholders may have a variety of perspectives on what is most important to them and could define different attributes or assign different weightings to them. As such, the BPEO process should not, by itself, be used as the decision making process but rather as one contribution to decision making. The BPEO choice tends to be robust against different stakeholder perspectives and is quite often not selected for other reasons, such as public perception, planning issues and procurement complexity and justified to the regulators on that basis.

Furthermore, defining the practicability and potential environmental impacts for various options needs to be done with consideration of the available technologies and costs. Since technologies tend to improve with development, it is likely that the chosen ‘best’ option could change over time as a result. Sometimes it is not possible to identify a single ‘best’ option on the basis of the information available with which to compare the alternatives and that other considerations may be required to narrow the choice to a single preferred option.

A.2 BEST AVAILABLE TECHNIQUES TO INDUSTRIAL SYSTEMS (EUROPEAN COMMISSION)


BAT is defined as a technology, method or procedure and the result of an integrated approach to reduce the environmental impact of industrial cooling systems, maintaining the balance between both the direct and indirect impacts. Reduction measures should be considered maintaining at minimum the efficiency of the cooling system or with a loss of efficiency, which is negligible, compared with the positive effects on the environmental impact.

It is stated that the firstly BAT approach means that attention must be paid to the overall energy efficiency before measures are taken to optimize the cooling system.

After optimization of the overall energy efficiency of the industrial or manufacturing process a given amount and level of non-recoverable heat remains and a first selection for a cooling configuration to dissipate this heat can be made balancing:

- Cooling requirements of the process,
- Site limitations (including local legislation), and
- Environmental requirements.

An assessment of alternative cooling methods is conducted against the following environmental criteria:

- Energy consumption,
- Impingement and entrainment,
- Consumption of water,
- Emissions of heat into the surface water,
- Emissions of substances into surface water,
- Use of biocide,
- Emission to air,
- Noise,
- Risk aspects, and
- Residues (waste) from cooling systems operation.

It is stated that "OTC systems are commonly applied to large capacity installations in locations where sufficient cooling water and receiving surface water are available. If a reliable water source is not available, recirculating systems (cooling towers) are used."

For each cooling technology a number of specific BAT requirements are prescribed.
Appendix B: Description of the two cooling options subject to BATEA assessment

B.1 ONCE THROUGH COOLING OPTION

The DNNP OTC water system prior to implementation of any enhancements is based on the DNGS OTC water system.

B.1.1 System Description

The purpose of the OTC system is to provide continuous supply of lake water to cool the unit steam condensers under all operating conditions, transient conditions and during steam dumping into the condenser.

This system also dilutes the station effluent to a level which meets the Ministry of Environment requirements. The system draws water from the bottom of Lake Ontario through a tunnel (under the lake bottom) to a common Forebay for all units.

An identical system is provided for each unit. Each system supplies cooling water to the unit’s main steam condenser.

The system comprises of six travelling water screens, three 33 1/3% duty pumps (and additional standby pumps), pump isolating valves, condenser inlet and outlet isolating valves, connecting piping, a discharge duct common to four units and a common control gate which regulates the water surface elevation at the discharge structure.

A schematic of the Circulating Water System at DNGS is shown in Figure B-1.

The DNGS Forebay also supplies lake water for the following systems:

- Low Pressure Service Water,
- Emergency Service Water System (& Fire Water System), and
- Water Treatment Plant.

However, it should be noted that the reservoir for the Emergency Service Water System (& Fire Water System) for the DNNP will be separate.

B.1.2 Sub-System Descriptions

The various subsystems of the OTC system are described below:

1. The Intake Tunnel would be excavated by either drilling/blasting or by machine boring methods. The vertical section of the tunnel is 9.5 m in diameter, while the horizontal portion of the tunnel is 7.5 m diameter. Located at a water depth of 10 m, the Intake Tunnel is about 900 m long. The inside of the tunnel is covered in 250 mm of concrete.
2. An Intake Structure at the entrance to the tunnel (at the bottom of the lake) provides the optimum flow pattern over the whole intake surface while minimizing frazil ice formation and fish entrapment/impingement.

3. The Forebay would run the complete length of the station and is nominally 15 m wide at the Intake Tunnel end tapering to 4.5 m wide at the other end. The depth of the Forebay varies from 30 m to 10 m. Retaining walls form one side at the pump houses while the other side is sloped to direct fish away from the pump house intakes.

4. At the entrance to the Pumphouse, CW Travelling screens remove debris from the water entering the system.

5. Each unit has three 33 1/3% duty CW pumps (and additional standby pumps), each with a capacity of 10.5 m³/s.

6. An in-line, backwashing debris filter is installed upstream of each condenser water box inlet. The debris is discarded to the CCW outlet line.

7. Outlet piping from the condensers connects to the common Discharge Duct. The CW discharge duct is of reinforced concrete, running below grade and carries the CW water discharged from the condensers, the service water discharged from equipment and the roof drainage from each unit.
8. The station cooling water is discharged through a set of mixing diffusers at a 10 m depth in the lake and mixes with the surrounding water to a temperature which is acceptable to the Ministry of Environment.

9. During winter months, to prevent frazil ice formation and the risk of Forebay icing, a portion of the warm CW discharge flow can be diverted to the CW intake tunnel exit at the Forebay.

B.2 MECHANICAL DRAFT COOLING TOWER OPTION

The MDCT system is based on the description within the MPR report [2].

B.2.1 System Description

The purpose of this system is to provide a continuous supply of cooling water to cool the unit steam condensers under all operating conditions, transient conditions and during steam dumping into the condenser. This type of recirculation water system accomplishes cooling by providing intimate mixing of water and air, which results in cooling primarily by evaporation. A small portion of the water being cooled is allowed to evaporate into a moving air stream to provide significant cooling to the rest of that water stream.

MDCT use large fans to move all of the air required to achieve the design heat transfer. This recirculation system uses untreated lake water as the cooling medium for the condensers. Untreated lake water is also used to provide make-up for evaporation and blowdown losses. Recirculating pumps are used to provide flow to the condenser. To prevent the recirculating water from biofouling, scaling or corroding the wet surfaces in the cooling system, chemicals are injected.

Blowdown is used to control recirculating water quality by reducing lake water contaminants concentrated in the process. The blowdown water is treated and cooled (with lake water) prior to discharge back to the lake.

To provide the required cooling, individual cooling towers would be assembled into a bank of cooling towers 37 m wide by 316 m long by 16 m tall for each nuclear reactor. Conceptual designs to date have not stated if the individual banks of cooling towers would be unitized, or have interconnection capability.

The bank of cooling towers must be placed so as to maximize performance. This alignment is based on prevailing winds and relative location of adjacent cooling tower banks. A schematic of a cooling tower circulating water chemical conditioning system is shown in Figure B2.

B.2.2 Sub-system descriptions

The various subsystems of the MDCT system are described below.

Makeup water would be drawn from Lake Ontario using four separate water intake pipes located at a water depth of 10 m. The intake would be sized for the maximum makeup water flow and an inlet velocity of 0.122 m/s to minimize fish impingement concerns. The four makeup water intake pipes would be connected to a pump house near the lake shore. Six (five plus one spare) makeup water pumps would supply...
makeup water to the cooling towers and makeup (quench) water to the blowdown discharge piping when necessary via high density polyethylene (HDPE) piping.

To prevent the recirculating water from biofouling, scaling or corroding the wet surfaces in the cooling system, the following chemicals are injected:

- Sodium Hypochlorite (12% wt) – biocide,
- Sulphuric Acid (93% wt) - pH control, and
- Antiscalant.

Blowdown water must be treated prior to discharge to the lake. A clarification process removes suspended solids in the wastewater by injecting coagulants (ferric chloride) with flocculants (usually a long chain polymer) into a large upflow tank. The suspended solids precipitate out and the sludge that is produced by the falling particles requires on-site water removal before becoming a transportable solid. The onsite site water removal treatment includes decanting and belt filtration.

The MDCT system option does not preclude the need to draw water from Lake Ontario for:

- Low Pressure Service Water,
- Emergency Service Water System (& Fire Water System), and
- Water Treatment Plant.

However, it should be noted that the reservoir for the Emergency Service Water System (& Fire Water System) for DNNP will be separate.
Figure B-2: Schematic of a Cooling Tower Circulating Water Chemical Conditioning System (Adapted from [2]).
Appendix C: Linkage Between JRP Recommendations and Attributes Selected

Table C-1 shows how those JRP recommendations which are related to condenser cooling technology are addressed in this report with appropriate attributes. The shaded areas are those JRP recommendations which are not related to the BATEA assessment.
<table>
<thead>
<tr>
<th>REC #</th>
<th>Responsible / Phase</th>
<th>Recommendation</th>
<th>BATEA? (Y/N)</th>
<th>Attributes Related to Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Canadian Nuclear Safety Commission will determine whether this environmental assessment is applicable to the reactor technology selected by the Government of Ontario for the Project. Nevertheless, if the selected reactor technology is fundamentally different from the specific reactor technologies bounded by the plant parameter envelope, the Panel recommends that a new environmental assessment be conducted.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>CNSC - PRIOR TO SITE PREPARATION</td>
<td>The Panel recommends that prior to site preparation, the Canadian Nuclear Safety Commission require OPG to conduct a comprehensive soils characterization program. In particular, the potentially impacted soils in the areas OPG identifies as the spoils disposal area, cement plant area and asphalt storage area must be sampled to identify the nature and extent of potential contamination.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that the Canadian Nuclear Safety Commission require that as part of the Application for a License to Construct a reactor, OPG must undertake a formal quantitative cost-benefit analysis for cooling tower and Once Through condenser cooling water systems, applying the principle of best available technology economically achievable. This analysis must take into account the fact that lake infill should not go beyond the 2 m depth contour and should include cooling tower plume abatement technology.</td>
<td>Y</td>
<td>A Condenser Cooling Water Option Assessment study (this work) will be conducted to identify the best available technology considering both environmental performance and cost. Specifically, lake infill restriction and the cooling tower plume abatement technology are considered during the detailed assessment.</td>
</tr>
<tr>
<td>REC #</td>
<td>Responsible / Phase</td>
<td>Recommendation</td>
<td>BATEA? (Y/N)</td>
<td>Attributes Related to Recommendation</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
<td>----------------</td>
<td>-------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>4</td>
<td>CNSC - OVER THE LIFE OF THE PROJECT</td>
<td>The Panel recommends that the Canadian Nuclear Safety Commission exercise regulatory oversight to ensure that OPG complies with all municipal and provincial requirements and standards over the life of the Project. This is of particular importance because the conclusions of the Panel are based on the assumption that OPG will follow applicable laws and regulations at all jurisdictional levels.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>CNSC - DURING SITE PREPARATION</td>
<td>To avoid any unnecessary environmental damage to the bluff at Raby Head and fish habitat, the Panel recommends that no bluff removal or lake infill occur during the site preparation stage, unless a reactor technology has been selected and there is certainty that the Project will proceed.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>CNSC - PRIOR TO SITE PREPARATION</td>
<td>The Panel recommends that prior to site preparation, the Canadian Nuclear Safety Commission require OPG to update its preliminary decommissioning plan for site preparation in accordance with the requirements of Canadian Standards Association Standard N294-09. The OPG preliminary decommissioning plan for site preparation must incorporate the rehabilitation of the site to reflect the existing biodiversity in the event that the Project does not proceed beyond the site preparation phase. OPG shall prepare a detailed preliminary decommissioning plan once a reactor technology is chosen, to be updated as required by the Canadian Nuclear Safety Commission.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>REC #</td>
<td>Responsible / Phase</td>
<td>Recommendation</td>
<td>BATEA? (Y/N)</td>
<td>Attributes Related to Recommendation</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>CNSC - PRIOR TO SITE PREPARATION</td>
<td>The Panel recommends that prior to site preparation, the Canadian Nuclear Safety Commission require that OPG establish a decommissioning financial guarantee to be reviewed as required by the Canadian Nuclear Safety Commission. Regarding the decommissioning financial guarantee for the site preparation stage, the Panel recommends that this financial guarantee contain sufficient funds for the rehabilitation of the site in the event the Project does not proceed beyond the site preparation stage.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>CNSC - PRIOR TO SITE PREPARATION</td>
<td>The Panel recommends that prior to site preparation, the Canadian Nuclear Safety Commission require OPG to develop a follow-up and adaptive management program for air contaminants such as Acrolein, NO2, SO2, SPM, PM2.5 and PM10, to the satisfaction of the Canadian Nuclear Safety Commission, Health Canada and Environment Canada. Additionally, the Canadian Nuclear Safety Commission must require OPG to develop an action plan acceptable to Health Canada for days when there are air quality or smog alerts.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>CNSC - PRIOR TO SITE PREPARATION</td>
<td>The Panel recommends that the Canadian Nuclear Safety Commission, in collaboration with Health Canada, require OPG to develop and implement a detailed acoustic assessment for all scenarios evaluated. The predictions must be shared with potentially affected members of the public. The OPG Nuisance Effects Management Plan must include noise monitoring, a noise complaint response mechanism and best practices for activities that may occur outside of municipal noise curfew hours to reduce annoyance that the public may experience.</td>
<td>Y</td>
<td>Attribute “Noise Level” has been identified.</td>
</tr>
<tr>
<td>REC #</td>
<td>Responsible / Phase</td>
<td>Recommendation</td>
<td>BATEA? (Y/N)</td>
<td>Attributes Related to Recommendation</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------</td>
<td>--------------------------------------</td>
</tr>
</tbody>
</table>
| 10    | CNSC - PRIOR TO SITE PREPARATION    | The Panel recommends that the Canadian Nuclear Safety Commission require OPG to undertake a detailed site geotechnical investigation prior to commencing site preparation activities. The geologic elements of this investigation should include, but not be limited to:  
  - collecting site-wide information on soil physical properties;  
  - determining the mechanical and dynamic properties of overburden material across the site;  
  - mapping of geological structures to improve the understanding of the site geological structure model;  
  - confirming the lack of karstic features in the local bedrock at the site; and  
  - confirming the conclusions reached concerning the liquefaction potential in underlying granular materials. | N           |                                      |
<p>| 11    | CNSC - OVER THE LIFE OF THE PROJECT | The Panel recommends that the Canadian Nuclear Safety Commission require OPG to develop and implement a follow-up program for soil quality during all stages of the Project.                                                                 | N           |                                      |
| 12    | CNSC - PRIOR TO SITE PREPARATION    | The Panel recommends that before in-water works are initiated, the Canadian Nuclear Safety Commission require OPG to collect water and sediment quality data for any future embayment area that may be formed as a consequence of shoreline modifications in the vicinity of the outlet of Darlington Creek. This data should serve as the reference information for the proponent’s post-construction commitment to conduct water and sediment quality monitoring of the embayment area. | Y           | Attribute “Water quality / Emissions to Water” has been identified. |</p>
<table>
<thead>
<tr>
<th>REC #</th>
<th>Responsible / Phase</th>
<th>Recommendation</th>
<th>BATEA? (Y/N)</th>
<th>Attributes Related to Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>CNSC - PRIOR TO SITE PREPARATION</td>
<td>The Panel recommends that the Canadian Nuclear Safety Commission require OPG to collect and assess water quality data for a comprehensive number of shoreline and off-shore locations in the site study area prior to commencing in-water works. This data should be used to establish a reference for follow-up monitoring.</td>
<td>Y</td>
<td>Attribute &quot;Water Quality / Emissions to Water&quot; has been identified.</td>
</tr>
<tr>
<td>14</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that following the selection of a reactor technology for the Project, the Canadian Nuclear Safety Commission require OPG to conduct a detailed assessment of predicted effluent releases from the Project. The assessment should include but not be limited to effluent quantity, concentration, points of release and a description of effluent treatment, including demonstration that the chosen option has been designed to achieve best available treatment technology and techniques economically achievable. The Canadian Nuclear Safety Commission shall also require OPG to conduct a risk assessment on the proposed residual releases to determine whether additional mitigation measures may be necessary.</td>
<td>Y</td>
<td>The following attributes have been identified:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Risks to Public Health and Safety</td>
<td></td>
<td>• Water Quality / Emissions to Water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Thermal Discharge to Lake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>CNSC - DURING OPERATION</td>
<td>The Panel recommends that following the start of operation of the reactors, the Canadian Nuclear Safety Commission require OPG to conduct monitoring of ambient water and sediment quality in the receiving waters to ensure that effects from effluent discharges are consistent with predictions made in the environmental impact statement and with those made during the detailed design phase.</td>
<td>Y</td>
<td>Attribute &quot;Water quality / Emissions to Water&quot; has been identified.</td>
</tr>
<tr>
<td>REC #</td>
<td>Responsible / Phase</td>
<td>Recommendation</td>
<td>BATEA? (Y/N)</td>
<td>Attributes Related to Recommendation</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>16</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that prior to the start of construction, the Canadian Nuclear Safety Commission require the proponent to establish toxicity testing criteria and provide the test methodology and test frequency that will be used to confirm that stormwater discharges from the new nuclear site comply with requirements in the <em>Fisheries Act</em>.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that the Canadian Nuclear Safety Commission require OPG to provide an assessment of the ingress and transport of contaminants in groundwater on-site during successive phases of the Project as part of the Application for a License to Construct. This assessment shall include consideration of the impact of wet and dry deposition of all contaminants of potential concern and radiological constituents, especially tritium, in gaseous emissions on groundwater quality. OPG shall conduct enhanced groundwater and contaminant transport modelling for the assessment and expand the modelling to cover the effects of future dewatering and expansion activities at the St. Mary's Cement quarry on the Project.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>CNSC - DURING OPERATION</td>
<td>The Panel recommends that based on the groundwater and contaminant transport modelling results, the Canadian Nuclear Safety Commission require OPG to expand the Radiological Environmental Monitoring Program. This program shall include relevant residential and private groundwater well quality data in the local study area that are not captured by the current program, especially where the modelling results identify potential critical groups based on current or future potential use of groundwater.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>REC #</td>
<td>Responsible / Phase</td>
<td>Recommendation</td>
<td>BATEA? (Y/N)</td>
<td>Attributes Related to Recommendation</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------</td>
<td>----------------</td>
<td>-------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>19</td>
<td>CNSC - DURING SITE PREPARATION</td>
<td>The Panel recommends that the Canadian Nuclear Safety Commission require OPG to expand the scope of the groundwater monitoring program to monitor transitions in groundwater flows that may arise as a consequence of grade changes during the site preparation and construction phases of the Project. The design of the grade changes should guide the determination of the required monitoring locations, frequency of monitoring and the required duration of the program for the period of transition to stable conditions following the completion of construction and the initial period of operation.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>CNSC - PRIOR TO SITE PREPARATION</td>
<td>The Panel recommends that the Canadian Nuclear Safety Commission require OPG to perform a thorough evaluation of site layout opportunities before site preparation activities begin, in order to minimize the overall effects on the terrestrial and aquatic environments and maximize the opportunity for quality terrestrial habitat rehabilitation.</td>
<td>Y</td>
<td>Attributes “Terrestrial Habitat” and “Aquatic Habitat” have been identified. Attribute “Excavated Materials” is also related to this issue.</td>
</tr>
<tr>
<td>21</td>
<td>CNSC - DURING SITE PREPARATION</td>
<td>The Panel recommends that the Canadian Nuclear Safety Commission require OPG to compensate for the loss of ponds, like-for-like, preferably in the site study area. The Panel also recommends that the Canadian Nuclear Safety Commission require OPG to use best management practices to prevent or minimize the potential runoff of sediment and other contaminants into wildlife habitat associated with Coot’s Pond during site preparation and construction phases.</td>
<td>Y</td>
<td>Attributes “Terrestrial Habitat” and “Aquatic Habitat” have been identified.</td>
</tr>
<tr>
<td>REC #</td>
<td>Responsible / Phase</td>
<td>Recommendation</td>
<td>BATEA? (Y/N)</td>
<td>Attributes Related to Recommendation</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
<td>----------------</td>
<td>--------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>22</td>
<td>CNSC - PRIOR TO SITE PREPARATION</td>
<td>The Panel recommends that the Canadian Nuclear Safety Commission require OPG to develop a follow-up program for insects, amphibians and reptiles, and mammal species and communities to ensure that proposed mitigation measures are effective.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>ENVIRONMENT CANADA – DURING OPERATION</td>
<td>The Panel recommends that Environment Canada collaborate with OPG to develop and implement a follow-up program to confirm the effectiveness of OPG's proposed mitigation measures for bird communities should natural draft cooling towers be chosen for the condenser cooling system.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>ENVIRONMENT CANADA – DURING SITE PREPARATION</td>
<td>The Panel recommends that during the site preparation stage, Environment Canada shall ensure that OPG not undertake habitat destruction or disruption between the period of May 1 and July 31 of any year to minimize effects to breeding migratory birds.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>CNSC - PRIOR TO SITE PREPARATION</td>
<td>Nuclear Safety Commission requires OPG to conduct more sampling to confirm the presence of Least Bittern before site preparation activities begin. The Panel recommends that the Canadian Nuclear Safety Commission require OPG to develop and implement a management plan for the species at risk that are known to occur on-site. The plan should consider the resilience of some of the species and the possibility of off-site compensation.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that the Canadian Nuclear Safety Commission require OPG to develop a comprehensive assessment of hazardous substance releases and the required management practices for hazardous chemicals on-site, in accordance with the Canadian Environmental Protection Act, once a reactor technology has been chosen.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>REC #</td>
<td>Responsible / Phase</td>
<td>Recommendation</td>
<td>BATEA? (Y/N)</td>
<td>Attributes Related to Recommendation</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
<td>----------------</td>
<td>--------------</td>
<td>-------------------------------------</td>
</tr>
</tbody>
</table>
| 27    | CNSC - PRIOR TO CONSTRUCTION | The Panel recommends that prior to any destruction of the Bank Swallow habitat, the Canadian Nuclear Safety Commission require OPG to implement all of its proposed Bank Swallow mitigation options, including:  
- the acquisition of off-site nesting habitat;  
- the construction of artificial Bank Swallow nest habitat with the capacity to maintain a population which is at least equal to the number of breeding pairs currently supported by the bluff and as close to the original bluff site as possible; and  
- the implementation of an adaptive management approach in the Bank Swallow mitigation plan, with the inclusion of a threshold of loss to be established in consultation with all stakeholders before any habitat destruction takes place. | Y | Attribute “Terrestrial Habitat” has been identified.  
Attribute "Cost" is also identified. |
| 28    | FISHERIES & OCEANS CANADA – OVER THE LIFE OF THE PROJECT | The Panel recommends that Fisheries and Oceans Canada require OPG to continue conducting adult fish community surveys in the site study area and reference locations on an ongoing basis. These surveys shall be used to confirm that the results of 2009 gillnetting and 1998 shoreline electrofishing reported by OPG, and the additional data collected in 2010 and 2011, are representative of existing conditions, taking into account natural year-to-year variability.  
Specific attention should be paid to baseline gillnetting monitoring in spring to verify the findings on fish spatial distribution and relatively high native fish species abundance in the embayment area, such as white sucker and Round Whitefish. The shoreline electrofishing habitat use study is needed to establish the contemporary baseline for later use to test for effects of lake infill armouring, if employed, and the effectiveness of mitigation. | N |  |
<table>
<thead>
<tr>
<th>REC #</th>
<th>Responsible / Phase</th>
<th>Recommendation</th>
<th>BATEA? (Y/N)</th>
<th>Attributes Related to Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>FISHERIES &amp; OCEANS CANADA – OVER THE LIFE OF THE PROJECT</td>
<td>The Panel recommends that Fisheries and Oceans Canada require OPG to continue the research element of the proposed Round Whitefish Action Plan for the specific purpose of better defining the baseline condition, including the population structure, genome and geographic distribution of the Round Whitefish population as a basis from which to develop testable predictions of effects, including cumulative effects.</td>
<td>N</td>
<td></td>
</tr>
</tbody>
</table>
| 30    | FISHERIES & OCEANS CANADA – PRIOR TO CONSTRUCTION | In the event that a Once Through condenser cooling system is chosen for the Project, the Panel recommends that prior to the construction of in-water structures, Fisheries and Oceans Canada require OPG to conduct:  
  • additional impingement sampling at the existing Darlington Nuclear Generating Station to verify the 2007 results and deal with inter-year fish abundance variability and sample design inadequacies; and  
  • additional entrainment sampling at the existing Darlington Nuclear Generating Station to better establish the current conditions. The program should be designed to guard against a detection limit bias by including in the analysis of entrainment losses those fish species whose larvae and eggs are captured in larval tow surveys for the seasonal period of the year in which they occur. A statistical optimization analysis will be needed to determine if there is a cost-effective entrainment survey design for Round Whitefish larvae. | Y | Attributes “Fish Impingement” and “Fish Entrainment” have been identified. |
<p>| 31    | FISHERIES &amp; OCEANS CANADA –DURING CONSTRUCTION | Irrespective of the condenser cooling system chosen for the Project, the Panel recommends that Fisheries and Oceans Canada not permit OPG to infill beyond the 2 m depth contour in Lake Ontario. | Y | Attribute “Excavated Materials” has been identified. |</p>
<table>
<thead>
<tr>
<th>REC #</th>
<th>Responsible / Phase</th>
<th>Recommendation</th>
<th>BATEA? (Y/N)</th>
<th>Attributes Related to Recommendation</th>
</tr>
</thead>
</table>
| 32    | FISHERIES & OCEANS CANADA – PRIOR TO CONSTRUCTION | In the event that a Once Through condenser cooling system is chosen for the Project, the Panel recommends that Fisheries and Oceans Canada require OPG to mitigate the risk of adverse effects from operation, including impingement, entrainment and thermal excursions and plumes, by locating the system intake and diffuser structures in water beyond the nearshore habitat zone. Furthermore, OPG must evaluate other mitigative technologies for the system intake, such as live fish return systems and acoustic deterrents. | Y | The following attributes have been identified:  
- Fish impingement,  
- Fish entrainment, and  
- Thermal discharge to lake |
| 33    | FISHERIES & OCEANS CANADA – OVER THE LIFE OF THE PROJECT | The Panel recommends that Fisheries and Oceans Canada require OPG to conduct an impingement and entrainment follow-up program at the existing Darlington Nuclear Generating Station and the Project site to confirm the prediction of adverse effects, including cumulative effects, and the effectiveness of mitigation. For future entrainment sampling for Round Whitefish, a statistical probability analysis will be needed to determine if unbiased and precise sample results can be produced. | N | |
| 34    | ENVIRONMENT CANADA – PRIOR TO CONSTRUCTION | In the event that a Once Through condenser cooling system is chosen for the Project, the Panel recommends that prior to construction, Environment Canada ensure that enhanced resolution thermal plume modelling is conducted by OPG, taking into account possible future climate change effects. Fisheries and Oceans Canada shall ensure that the results of the modelling are incorporated into the design of the outfall diffuser and the evaluation of alternative locations for the placement of the intake and the diffuser of the proposed condenser cooling water system. | Y | Attribute “Thermal Discharge to Lake” has been identified. |

Understanding the recommendations:

- **Impingement and Entrainment**: The recommendations focus on mitigating the risks associated with impingement (physical impact) and entrainment (suction effect) of fish, especially near the system intake and diffuser structures.

- **Thermal Discharge**: The recommendations emphasize the importance of managing thermal plume discharge to minimize adverse effects on aquatic life.

- **Follow-up Programs**: The Panel suggests implementing follow-up programs to validate model predictions and assess the effectiveness of mitigation strategies.
<table>
<thead>
<tr>
<th>REC #</th>
<th>Responsible / Phase</th>
<th>Recommendation</th>
<th>BATEA? (Y/N)</th>
<th>Attributes Related to Recommendation</th>
</tr>
</thead>
</table>
| 35    | CNSC - PRIOR TO CONSTRUCTION  | In the event that a Once Through condenser cooling system is chosen for the Project, the Panel recommends that prior to operation, the Canadian Nuclear Safety Commission require OPG to include the following in the surface water risk assessment:  
  • the surface combined thermal and contaminant plume; and  
  • the physical displacement effect of altered lake currents as a hazardous pulse exposure to fish species whose larvae passively drift through the area, such as lake herring, lake whitefish, emerald shiner and yellow perch.  
If the risk assessment result predicts a potential hazard then the Canadian Nuclear Safety Commission shall convene a follow-up monitoring scoping workshop with Environment Canada, Fisheries and Oceans Canada and any other relevant authorities to develop an action plan. | Y          | Attributes “Thermal Discharge to Lake”, “Aquatic Habitat”, and “Water Quality / Emissions to Water” have been identified. |
<p>| 36    | CNSC - DURING OPERATION       | In the event that a Once Through condenser cooling system is chosen for the Project the Panel recommends that during operation, the Canadian Nuclear Safety Commission require OPG to undertake adult fish monitoring of large-bodied and small-bodied fish to confirm the effectiveness of mitigation measures and verify the predictions of no adverse thermal and physical diffuser jet effects. | Y          | Attributes “Aquatic Habitat” and “Thermal Discharge to Lake” have been identified.                                       |</p>
<table>
<thead>
<tr>
<th>REC #</th>
<th>Responsible / Phase</th>
<th>Recommendation</th>
<th>BATEA? (Y/N)</th>
<th>Attributes Related to Recommendation</th>
</tr>
</thead>
</table>
| 37    | CNSC - PRIOR TO CONSTRUCTION | In the event that a Once Through condenser cooling system is chosen for the Project, the Panel recommends that prior to construction, the Canadian Nuclear Safety Commission require OPG to determine the total area of permanent aquatic effects from the following, to properly scale mitigation and scope follow-up monitoring:  
• the thermal plume + 2°C above ambient temperature;  
• the mixing zone and surface plume contaminants;  
• physical displacements from altered lake currents; and  
• infill and construction losses and modifications. | Y            | The following attributes have been identified:  
• Thermal Discharge to Lake  
• Water Quality/Emission to Water  
• Aquatic Habitat |
| 38    | CNSC - PRIOR TO SITE PREPARATION  | The Panel recommends that the Canadian Nuclear Safety Commission require that the geotechnical and seismic hazard elements of the detailed site geotechnical investigation to be performed by OPG include, but not be limited to:  
Prior to site preparation:  
• demonstration that there are no undesirable subsurface conditions at the Project site. The overall site liquefaction potential shall be assessed with the site investigation data; and  
• confirmation of the absence of paleoseismologic features at the site and, if present, further assessment to reduce the overall uncertainty in the seismic hazard assessment during the design of the Project must be conducted.  
During site preparation and/or prior to construction:  
• verification and confirmation of the absence of surface faulting in the overburden and bedrock at the site. | N            |                                                                                                                                             |
<table>
<thead>
<tr>
<th>REC #</th>
<th>Responsible / Phase</th>
<th>Recommendation</th>
<th>BATEA? (Y/N)</th>
<th>Attributes Related to Recommendation</th>
</tr>
</thead>
</table>
| 38 (cont.) | CNSC - PRIOR TO SITE PREPARATION (continued) | Prior to construction:  
- verification of the stability of the cut slopes and dyke slopes under both static and dynamic loads with site/Project-specific data during the design of the cut slopes and dykes or before their construction;  
- assessment of potential liquefaction of the northeast waste stockpile by using the data obtained from the pile itself upon completion of site preparation;  
- measurement of the shear strength of the overburden materials and the dynamic properties of both overburden and sedimentary rocks to confirm the site conditions and to perform soil-structure interaction analysis if necessary;  
- assessment of the potential settlement in the quaternary deposits due to the groundwater drawdown caused by future St. Mary's Cement quarry activities; and  
Prior to operations:  
- assessment of the effect of the potential settlement on buried infrastructures in the deposits during the design of these infrastructure development and implementation of a monitoring program for the Phase 4 St. Mary's Cement blasting operations to confirm that the maximum peak ground velocity at the boundary between the Darlington and St. Mary’s Cement properties is below the proposed limit of three millimetres per second (mm/s). | N | |
<table>
<thead>
<tr>
<th>REC #</th>
<th>Responsible / Phase</th>
<th>Recommendation</th>
<th>BATEA? (Y/N)</th>
<th>Attributes Related to Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that prior to construction, the Canadian Nuclear Safety Commission require OPG to prepare a contingency plan for the construction, operation and decommissioning Project stages to account for uncertainties associated with flooding and other extreme weather hazards. OPG shall conduct localized climate change modelling to confirm its conclusion of a low impact of climate change. A margin/bound of changes to key parameters, such as intensity of extreme weather events, needs to be established to the satisfaction of the Canadian Nuclear Safety Commission. These parameters can be incorporated into hydrological designs leading up to an application to construct a reactor, as well as measures for flood protection. OPG must also conduct a drought analysis and incorporate any additional required mitigation/design modifications, to the satisfaction of the Canadian Nuclear Safety Commission, as part of a Licence to Construct a reactor.</td>
<td>Y</td>
<td>Attribute “Technical Performance” has been identified.</td>
</tr>
<tr>
<td>40</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that prior to construction, the Canadian Nuclear Safety Commission require OPG to: • establish an adaptive management program for algal hazard to the Project cooling water system intake that includes the setup of thresholds for further actions; and • factor the algal hazard assessment into a more detailed biological evaluation of moving the intake and diffuser deeper offshore as part of the detailed siting studies and the cost-benefit analysis of the cooling system.</td>
<td>Y</td>
<td>Attributes “Technical Performance” and “Cost” have been identified.</td>
</tr>
<tr>
<td>REC #</td>
<td>Responsible / Phase</td>
<td>Recommendation</td>
<td>BATEA? (Y/N)</td>
<td>Attributes Related to Recommendation</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>41</td>
<td>CNSC - PRIOR TO SITE PREPARATION</td>
<td>The Panel recommends that prior to site preparation, the Canadian Nuclear Safety Commission coordinate discussions with OPG and key stakeholders on the effects of the Project on housing supply and demand, community recreational facilities and programs, services and infrastructure as well as additional measures to help deal with the pressures on these community assets.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>ONTARIO POWER GENERATION – OVER THE LIFE OF THE PROJECT</td>
<td>The Panel recommends that on an ongoing basis, OPG pursue its strategy to ensure that Aboriginal students can benefit from the permanent job opportunities that will be available during the lifetime of the Project. In this regard, OPG should collaborate with various secondary and post-secondary education institutions as well as Aboriginal groups to ensure that such programs would be successful.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>CNSC - OVER THE LIFE OF THE PROJECT</td>
<td>The Panel recommends that the Canadian Nuclear Safety Commission engage appropriate stakeholders, including OPG, Emergency Management Ontario, municipal governments and the Government of Ontario to develop a policy for land use around nuclear generating stations.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>GOVERNMENT OF ONTARIO – OVER THE LIFE OF THE PROJECT</td>
<td>The Panel recommends that the Government of Ontario take appropriate measures to prevent sensitive and residential development within three kilometers of the site boundary.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>MUNICIPALITY OF CLARINGTON – OVER THE LIFE OF THE PROJECT</td>
<td>The Panel recommends that the Municipality of Clarington prevent, for the lifetime of the nuclear facility, the establishment of sensitive public facilities such as school, hospitals and residences for vulnerable clienteles within the three kilometer zone around the site boundary.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>REC #</td>
<td>Responsible / Phase</td>
<td>Recommendation</td>
<td>BATEA? (Y/N)</td>
<td>Attributes Related to Recommendation</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>46</td>
<td>GOVERNMENT OF ONTARIO – OVER THE LIFE OF THE PROJECT</td>
<td>Given that a severe accident may have consequences beyond the three and 10-kilometre zones evaluated by OPG, the Panel recommends that the Government of Ontario, on an ongoing basis, review the emergency planning zones and the emergency preparedness and response measures, as defined in the Provincial Nuclear Emergency Response Plan (PNERP), to protect human health and safety.</td>
<td>N</td>
<td></td>
</tr>
</tbody>
</table>
| 47    | CNSC - PRIOR TO SITE PREPARATION                       | The Panel recommends that prior to site preparation, the Canadian Nuclear Safety Commission ensure the OPG Traffic Management Plan addresses the following:  
  • contingency plans to address the possibility that the assumed road improvements do not occur;  
  • consideration of the effect of truck traffic associated with excavated material disposal on traffic operations and safety;  
  • further analysis of queuing potential onto Highway 401; and  
  • consideration of a wider range of mitigation measures, such as transportation-demand management, transit service provisions and geometric improvements at the Highway 401/Waverley Road interchange. | N            |                                       |
<p>| 48    | CNSC - PRIOR TO SITE PREPARATION                       | In consideration of public safety, the Panel recommends that prior to site preparation, the Canadian Nuclear Safety Commission coordinate a committee of federal, provincial and municipal transport authorities to review the need for road development and modifications. | N            |                                       |</p>
<table>
<thead>
<tr>
<th>REC #</th>
<th>Responsible / Phase</th>
<th>Recommendation</th>
<th>BATEA? (Y/N)</th>
<th>Attributes Related to Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>49</td>
<td>TRANSPORT CANADA – PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that prior to construction, Transport Canada ensure that OPG undertake additional quantitative analysis, including collision frequencies and rail crossing exposure indices, and monitor the potential effects and need for mitigation associated with the Project.</td>
<td>N</td>
<td></td>
</tr>
</tbody>
</table>
| 50    | TRANSPORT CANADA – PRIOR TO CONSTRUCTION | The Panel recommends that prior to construction, Transport Canada require OPG to conduct a risk assessment, jointly with Canadian National Railway, that includes:  
- an assessment of the risks associated with a derailment or other rail incident that could affect the Project;  
- an analysis of the risks associated with a security threat, such as a bomb being placed on a train running on the tracks that bisect the Project;  
- a comparative evaluation of the effectiveness of various mitigation measures or combination of measures (e.g., blast wall, retaining wall, recessed tracks, berm and railway speed restrictions within the vicinity of the site);  
- a determination of the design criteria necessary to ensure the effectiveness of these measures (e.g., the appropriate height, strength, material and design of a blast wall); and  
- a critical analysis to confirm that these measures, when properly designed and implemented, would be sufficient to provide protection to the Project site in the event of a derailment at full speed or other adverse event. | Y | The recommendation is not directly related to the selection of condenser cooling technology. However, attribute “Excavated Materials” accounts for the need to ensure that the cooling facilities are sufficiently remote from the railway. |
<table>
<thead>
<tr>
<th>REC #</th>
<th>Responsible / Phase</th>
<th>Recommendation</th>
<th>BATEA? (Y/N)</th>
<th>Attributes Related to Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>TRANSPORT CANADA – PRIOR TO CONSTRUCTION</td>
<td>In the event that a Once Through condenser cooling system is chosen for the Project, the Panel recommends that prior to construction, Transport Canada work with OPG to develop a follow-up program to verify the accuracy of the prediction of no significant adverse effects to boating safety from the establishment of an increased prohibitive zone. OPG must also develop an adaptive management program, if required, to mitigate potential effects to small watercraft.</td>
<td>Y</td>
<td>Attribute &quot;Risks to Public Health and Safety&quot; has been identified.</td>
</tr>
<tr>
<td>52</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that prior to construction, the Canadian Nuclear Safety Commission require OPG to make provisions for on-site storage of all used fuel for the duration of the Project, in the event that a suitable off-site solution for the long-term management for used fuel waste is not found.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that prior to construction, the Canadian Nuclear Safety Commission require OPG to make provisions for on-site storage of all of low and intermediate-level radioactive waste for the duration of the Project, in the event that a suitable off-site solution for the long-term management for this waste is not approved.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>CNSC - DURING OPERATION</td>
<td>The Panel recommends that during operation, the Canadian Nuclear Safety Commission require OPG to implement measures to manage releases from the Project to avoid tritium in drinking water levels exceeding a running annual average of 20 Becquerels per litre at drinking water supply plants in the regional study area.</td>
<td>Y</td>
<td>Attribute &quot;Water Quality / Emissions to Water&quot; has been identified.</td>
</tr>
<tr>
<td>REC #</td>
<td>Responsible / Phase</td>
<td>Recommendation</td>
<td>BATEA? (Y/N)</td>
<td>Attributes Related to Recommendation</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
<td>----------------</td>
<td>--------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>55</td>
<td>HEALTH CANADA/CNSC – OVER THE LIFE OF THE PROJECT</td>
<td>The Panel recommends that Health Canada and the Canadian Nuclear Safety Commission continue to participate in international studies seeking to identify long-term health effects of low-level radiation exposures, and to identify if there is a need for revision of limits specified in the Radiation Protection Regulations.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>CNSC - OVER THE LIFE OF THE PROJECT</td>
<td>The Panel recommends that over the life of the Project, the Canadian Nuclear Safety Commission require OPG to conduct ambient air monitoring in the local study area on an ongoing basis to ensure that air quality remains at levels that are not likely to cause adverse effects to human health.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that prior to construction, the Canadian Nuclear Safety Commission require OPG to undertake an assessment of the off-site effects of a severe accident. The assessment should determine if the off-site health and environmental effects considered in this environmental assessment bound the effects that could arise in the case of the selected reactor technology.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that prior to construction, the Canadian Nuclear Safety Commission confirm that dose acceptance criteria specified in RD-337 at the reactor site boundary—in the cases of design basis accidents for the Project’s selected reactor technology—will be met.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>MUNICIPALITY OF CLARINGTON – OVER THE LIFE OF THE PROJECT</td>
<td>The Panel recommends that the Municipality of Clarington manage development in the vicinity of the Project site to ensure that there is no deterioration in the capacity to evacuate members of the public for the protection of human health and safety.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>REC #</td>
<td>Responsible / Phase</td>
<td>Recommendation</td>
<td>BATEA? (Y/N)</td>
<td>Attributes Related to Recommendation</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>60</td>
<td>GOVERNMENT OF CANADA – PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that prior to construction, the Government of Canada review the adequacy of the provisions for nuclear liability insurance. This review must include information from OPG and the Region of Durham regarding the likely economic effects of a severe accident at the Darlington Nuclear site where there is a requirement for relocation, restriction of use and remediation of a sector of the regional study area.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>CNSC - DURING OPERATION</td>
<td>The Panel recommends that during operation, the Canadian Nuclear Safety Commission require OPG to monitor aquatic habitat and biota for potential cumulative effects from the thermal loading and contaminant plume of the discharge structures of the existing Darlington Nuclear Generating Station and the Project.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>ENVIRONMENT CANADA – PRIOR TO SITE PREPARATION</td>
<td>The Panel recommends that prior to site preparation, Environment Canada evaluate the need for additional air quality monitoring stations in the local study area to monitor cumulative effects on air quality.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>CNSC - PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that prior to construction, the Canadian Nuclear Safety Commission require OPG to evaluate the cumulative effect of a common-cause severe accident involving all of the nuclear reactors in the site study area to determine if further emergency planning measures are required.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>THE CANADIAN ENVIRONMENTAL ASSESSMENT AGENCY – GENERAL</td>
<td>The Panel recommends that the Canadian Environmental Assessment Agency revise the Canadian Environmental Assessment Agency Cumulative Effects Practitioner’s Guide to specifically include a consideration of accident and malfunction scenarios.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>REC #</td>
<td>Responsible / Phase</td>
<td>Recommendation</td>
<td>BATEA? (Y/N)</td>
<td>Attributes Related to Recommendation</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>--------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>65</td>
<td>GOVERNMENT OF CANADA – OVER THE LIFE OF THE PROJECT</td>
<td>The Panel recommends that the Government of Canada make it a priority to invest in developing solutions for long-term management of used nuclear fuel, including storage, disposal, re-processing and re-use.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>GOVERNMENT OF CANADA – PRIOR TO CONSTRUCTION</td>
<td>The Panel recommends that the Government of Canada update the <em>Nuclear Liability and Compensation Act</em> or its equivalent to reflect the consequences of a nuclear accident. The revisions must address damage from any ionizing radiation and from any initiating event and should be aligned with the polluter pays principle. The revised <em>Nuclear Liability and Compensation Act</em>, or its equivalent, must be in force before the Project can proceed to the construction phase.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>GOVERNMENT OF CANADA – OVER THE LIFE OF THE PROJECT</td>
<td>The Panel recommends that the Government of Canada provide clear and practical direction on the application of sustainability assessment in environmental assessments for future nuclear projects.</td>
<td>N</td>
<td></td>
</tr>
</tbody>
</table>
Appendix D: The Rationale for Exclusion of Some Aspects

There are some other aspects which have been considered as candidate attributes at the early stage of the attribute selection process. However, they are excluded from the final attribute list. The rationale for excluding these aspects for consideration is summarized in Table D-1 below.
<table>
<thead>
<tr>
<th>Candidate attributes</th>
<th>Rationale for exclusion from the final attribute list</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global climate change</td>
<td>The potential for the two condenser cooling options to cause global climate change has not been assessed. Although there may be potential emissions of greenhouse gases associated with the need to replace loss in energy generation associated with MDCT compared to OTC, it is not known what type of electricity generation will be used. Therefore the potential impact on global warming cannot be evaluated. The effect of global climate change on the operation of the condenser cooling has been considered under technology adaptation.</td>
</tr>
<tr>
<td>Power consumption and reduced production of electricity</td>
<td>Power consumption requirements may differ depending on the condenser cooling system technology employed. Environmental impact may result from the need to compensate for reduced electricity generation for the cooling tower option by increasing output from other energy sources, such as fossil fuel power plants. This attribute will not form part of the formal BATEA assessment under a separate attribute. The financial impacts of lost generation will be addressed in the attribute “Cost”.</td>
</tr>
<tr>
<td>Nuclear safety</td>
<td>The two options subject to assessment are both widely used and are accepted industry technologies. Both options would comply with all relevant codes and regulations.</td>
</tr>
<tr>
<td>Water withdrawal</td>
<td>The major impact of water withdrawal is impingement and entrainment which have been covered under attributes “Impingement” and “Entrainment”, respectively. The associated cost due to water withdrawal ($/m³ withdrawal) will be included in the attribute “Cost”.</td>
</tr>
<tr>
<td>Solid waste</td>
<td>Solid waste streams generated as a result of implementing the two options include excavated material, biomass resulting from impingement/entrainment and decommissioning wastes. The most significant aspect is disposal of excavated material. This has been covered by the attribute “Excavated Materials”. Effects of impingement/entrainment are already addressed by a separate attribute. Waste generated as a result of decommissioning is not a potential differentiator between</td>
</tr>
<tr>
<td>Candidate attributes</td>
<td>Rationale for exclusion from the final attribute list</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>O&amp;M complexity and reliability</td>
<td>This attribute has been covered by the attribute “Technical Performance” and also the attribute “Cost”.</td>
</tr>
<tr>
<td>Operational availability</td>
<td>This attribute has been covered by attribute “technical performance” and also the attribute “Cost”.</td>
</tr>
<tr>
<td>Security</td>
<td>The two options subject to assessment are both widely used and are accepted industry technologies. There are no significant nuclear security implications.</td>
</tr>
<tr>
<td>Installation and implementation time</td>
<td>This aspect has no environmental impact and therefore is not considered as an independent attribute.</td>
</tr>
<tr>
<td>Viable suppliers</td>
<td>This attribute has no environmental impacts and therefore is not included.</td>
</tr>
<tr>
<td>Traffic</td>
<td>This attribute is addressed by the “Public Safety” and “Excavated Materials” attributes.</td>
</tr>
<tr>
<td>Archaeological impact</td>
<td>There are no environmental impacts associated with this attribute. There are two Euro-Canadian archaeological sites, which might have potential heritage value and interest. Mitigation measures of the two affected archaeological sites would include advanced excavation before construction-related activites could occur. All procedures set by Ministry of Culture’s draft Standards and Guidelines for Consultant Archaeologists would be carried out. With the implementation of this mitigation measure, there would be no residual adverse effects on Euro-Canadian archaeological resources.</td>
</tr>
<tr>
<td>Extreme weather condition</td>
<td>Safety implications of extreme weather conditions are not considered because the two options subject to assessment are both widely used and are accepted industry technologies. There are no nuclear safety implications. The impact of extreme weather conditions on operability is considered under the “Technical Performance” attribute and within “other factors for consideration”.</td>
</tr>
<tr>
<td>Radioactivity and Tritium Concentrations in</td>
<td>Radioactivity and Tritium concentrations are not considered because radionuclide</td>
</tr>
<tr>
<td>Candidate attributes</td>
<td>Rationale for exclusion from the final attribute list</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>the Environment</td>
<td>released are associated with vendor-specific reactor technologies and not the choice of CCW option.</td>
</tr>
<tr>
<td>Space Requirement</td>
<td>This attribute is addressed by the “Excavated Materials” and “Aquatic Habitat” attributes.</td>
</tr>
<tr>
<td>Agricultural Land</td>
<td>The use of agricultural land owned by OPG for DNNP has not been considered since this land will be utilized regardless of the chosen cooling option. This is not a potential differentiator between the two options.</td>
</tr>
</tbody>
</table>
Appendix E: Attributes Used in Other Reference Studies

A summary of the factors considered in the condenser cooling system selection studies that were reviewed in the current report are presented in Table E-1.
<table>
<thead>
<tr>
<th>Attribute Group/Attribute</th>
<th>Study using similar attribute</th>
<th>Description of attribute in Reference Study</th>
<th>Governing Regulations or Methodology Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Health and Safety</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Risks to public health and safety</td>
<td>Hinkley Point</td>
<td>Water quality (including effluents containing radioactivity or toxic chemicals)</td>
<td>UK Environment Agency multi-attribute analysis</td>
</tr>
<tr>
<td></td>
<td>Nine Mile Point</td>
<td>Water quality (including effluents containing radioactivity or toxic chemicals)</td>
<td>BTA approach under US Clean Water Act Section 316(b); Numerous US NRC regulatory guides</td>
</tr>
<tr>
<td></td>
<td>North Anna</td>
<td>Human health impacts (exposure to thermophilic micro-organisms)</td>
<td>Best Available Technology Assessment as part of US NRC Early Site Permit application</td>
</tr>
<tr>
<td></td>
<td>PNGS</td>
<td>Public safety requirements</td>
<td>BTA approach under US Clean Water Act Section 316(b); Sections 32 and 35 of the Canadian Fisheries Act</td>
</tr>
<tr>
<td>1.2 Risks to worker health and safety</td>
<td>North Anna</td>
<td>Radiation Dose</td>
<td>Best Available Technology Assessment as part of US NRC Early Site Permit application</td>
</tr>
<tr>
<td><strong>2. Physical environment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Water quality/emission to water (concentration of waterborne contaminants)</td>
<td>Oak Creek-Elm Road</td>
<td>Water quality</td>
<td>BTA approach under US Clean Water Act Section 316(b)</td>
</tr>
<tr>
<td></td>
<td>Nine Mile Point</td>
<td>Chemical effects of biocides</td>
<td>BTA approach under US Clean Water Act Section 316(b); Numerous US NRC regulatory guides</td>
</tr>
<tr>
<td></td>
<td>Oldbury</td>
<td>Surface water and flooding</td>
<td>EU BAT</td>
</tr>
<tr>
<td>Attribute Group/Attribute</td>
<td>Study using similar attribute</td>
<td>Description of attribute in Reference Study</td>
<td>Governing Regulations or Methodology Basis</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------</td>
<td>---------------------------------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>2.2 Air quality/emission to air (concentration of airborne contaminants)</td>
<td>Oak Creek-Elm Road</td>
<td>Air quality</td>
<td>BTA approach under US Clean Water Act Section 316(b)</td>
</tr>
<tr>
<td></td>
<td>Oldbury</td>
<td>Air quality and dust</td>
<td>EU BAT</td>
</tr>
<tr>
<td></td>
<td>North Anna</td>
<td>Atmospheric effects</td>
<td>Best Available Technology Assessment as part of US NRC Early Site Permit application</td>
</tr>
<tr>
<td>2.3 Noise level (noise levels at receptor locations)</td>
<td>Hinkley Point</td>
<td>Noise</td>
<td>UK Environment Agency multi-attribute analysis</td>
</tr>
<tr>
<td></td>
<td>Oldbury</td>
<td>Noise and vibration</td>
<td>EU BAT</td>
</tr>
<tr>
<td></td>
<td>PNGS</td>
<td>Noise</td>
<td>BTA approach under US Clean Water Act Section 316(b); Sections 32 and 35 of the Canadian Fisheries Act</td>
</tr>
<tr>
<td></td>
<td>Nine Mile Point</td>
<td>Noise</td>
<td>BTA approach under US Clean Water Act Section 316(b); Numerous US NRC regulatory guides</td>
</tr>
<tr>
<td></td>
<td>North Anna</td>
<td>Noise levels</td>
<td>Best Available Technology Assessment as part of US NRC Early Site Permit application</td>
</tr>
<tr>
<td></td>
<td>Indian Point</td>
<td>Noise</td>
<td>BTA approach triggered by pollutant discharge limit reapplication</td>
</tr>
<tr>
<td>2.4 Water consumption (consumption rate)</td>
<td>Nine Mile Point</td>
<td>Water consumption</td>
<td>BTA approach under US Clean Water Act Section 316(b); Numerous US NRC regulatory guides</td>
</tr>
<tr>
<td></td>
<td>Indian Point</td>
<td>Reduced intake flow</td>
<td>BTA approach triggered by pollutant</td>
</tr>
<tr>
<td>Attribute Group / Attribute</td>
<td>Study using similar attribute</td>
<td>Description of attribute in Reference Study</td>
<td>Governing Regulations or Methodology Basis</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------</td>
<td>---------------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>discharge limit reapplication</td>
<td>North Anna</td>
<td>Water use</td>
<td>Best Available Technology Assessment as part of US NRC Early Site Permit application</td>
</tr>
<tr>
<td>Cooling tower plume impacts (Reference study includes icing, fog, additional precipitation and salt deposition. Note salt deposition does not apply as DNNP will be on a freshwater lake.)</td>
<td>Nine Mile Point</td>
<td></td>
<td>BTA approach under US Clean Water Act Section 316(b); Numerous US NRC regulatory guides</td>
</tr>
<tr>
<td></td>
<td>Indian Point</td>
<td>Cooling tower plume</td>
<td>BTA approach triggered by pollutant discharge limit reapplication</td>
</tr>
<tr>
<td>Visual impact</td>
<td>Hinkley Point</td>
<td>Visual impact</td>
<td>UK Environment Agency multi-attribute analysis</td>
</tr>
<tr>
<td>Landscape and visual amenity</td>
<td>Oldbury</td>
<td></td>
<td>EU BAT</td>
</tr>
<tr>
<td>Visual impact</td>
<td>PNGS</td>
<td></td>
<td>BTA approach under US Clean Water Act Section 316(b); Sections 32 and 35 of the Canadian Fisheries Act</td>
</tr>
<tr>
<td>Waste Generation, including radioactive waste and sediment waste</td>
<td>Hinkley Point</td>
<td></td>
<td>UK Environment Agency multi-attribute analysis</td>
</tr>
<tr>
<td>Soils removal; Construction activities</td>
<td>Indian Point</td>
<td></td>
<td>BTA approach triggered by pollutant discharge limit reapplication</td>
</tr>
<tr>
<td>Attribute Group/Attribute</td>
<td>Study using similar attribute</td>
<td>Description of attribute in Reference Study</td>
<td>Governing Regulations or Methodology Basis</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------</td>
<td>---------------------------------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>North Anna</td>
<td>Terrain considerations</td>
<td>Best Available Technology Assessment as part of US NRC Early Site Permit application</td>
<td></td>
</tr>
<tr>
<td>Oldbury</td>
<td>Geology, hydrogeology and soils</td>
<td>EU BAT</td>
<td></td>
</tr>
</tbody>
</table>

### 3. Habitat and ecosystems

3.1 Fish impingement (impingement reduction rate/quantity of fish mortality)

<table>
<thead>
<tr>
<th>Study using similar attribute</th>
<th>Description of attribute in Reference Study</th>
<th>Governing Regulations or Methodology Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinkley Point</td>
<td>Fish impingement and entrainment</td>
<td>UK Environment Agency multi-attribute analysis</td>
</tr>
<tr>
<td>PNGS</td>
<td>Fish impingement mortality and entrainment</td>
<td>BTA approach under US Clean Water Act Section 316(b); Sections 32 and 35 of the Canadian Fisheries Act</td>
</tr>
<tr>
<td>Nine Mile Point</td>
<td>Fish impingement mortality and entrainment</td>
<td>BTA approach under US Clean Water Act Section 316(b); Numerous US NRC regulatory guides</td>
</tr>
<tr>
<td>Oak Creek-Elm Road</td>
<td>Fish impingement mortality and entrainment</td>
<td>BTA approach under US Clean Water Act Section 316(b)</td>
</tr>
<tr>
<td>North Anna</td>
<td>Regulatory restrictions</td>
<td>Best Available Technology Assessment as part of US NRC Early Site Permit application</td>
</tr>
<tr>
<td>Indian Point</td>
<td>Fish impingement mortality and entrainment</td>
<td>BTA approach triggered by pollutant discharge limit reapplication</td>
</tr>
<tr>
<td>Attribute Group/Attribute</td>
<td>Study using similar attribute</td>
<td>Description of attribute in Reference Study</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>3.2 Fish entrainment</td>
<td>See attribute 3.1</td>
<td>See attribute 3.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3 Thermal discharge to lake</td>
<td>Hinkley Point</td>
<td>Thermal plume impacts</td>
</tr>
<tr>
<td></td>
<td>North Anna</td>
<td>Thermal and physical effects</td>
</tr>
<tr>
<td></td>
<td>Oak Creek-Elm Road</td>
<td>Thermal plume impacts (documented in studies done leading up to the Elm Road Reference Study)</td>
</tr>
<tr>
<td>3.4 Aquatic habitat (area of aquatic habitat)</td>
<td>Oldbury</td>
<td>Aquatic biota impacts/Ecology and nature conservation</td>
</tr>
<tr>
<td></td>
<td>Nine Mile Point</td>
<td>Physical changes (For example, blockage to movement and migration,)</td>
</tr>
<tr>
<td></td>
<td>Nine Mile Point</td>
<td>Radiation Dose to non-human biota</td>
</tr>
</tbody>
</table>
### OTHER REFERENCE STUDIES

<table>
<thead>
<tr>
<th>Attribute Group/Attribute</th>
<th>Study using similar attribute</th>
<th>Description of attribute in Reference Study</th>
<th>Governing Regulations or Methodology Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5 Terrestrial habitat (area of terrestrial habitat)</td>
<td>Nine Mile Point</td>
<td>Cooling tower plume impacts (Reference study includes icing, fog, additional precipitation and salt deposition. Note salt deposition does not apply as DNNP will be on a freshwater lake.)</td>
<td>BTA approach under US Clean Water Act Section 316(b); Numerous US NRC regulatory guides</td>
</tr>
<tr>
<td></td>
<td>Nine Mile Point</td>
<td>Radiation Dose</td>
<td>BTA approach under US Clean Water Act Section 316(b); Numerous US NRC regulatory guides</td>
</tr>
<tr>
<td></td>
<td>Oldbury</td>
<td>Ecology and nature conservation</td>
<td>EU BAT</td>
</tr>
</tbody>
</table>

#### 4. Technical performance

**4.1 Technical performance (maturity, reliability and operating experience)**

<table>
<thead>
<tr>
<th>Study using similar attribute</th>
<th>Description of attribute in Reference Study</th>
<th>Governing Regulations or Methodology Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinkley Point</td>
<td>Operating experience</td>
<td>UK Environment Agency multi-attribute analysis</td>
</tr>
<tr>
<td>Hinkley Point</td>
<td>Energy Efficiency</td>
<td>UK Environment Agency multi-attribute analysis</td>
</tr>
<tr>
<td>Hinkley Point</td>
<td>Thermal capacity and efficiency (This attribute was used in the reference study to evaluate whether the receiving and source water body was able to manage heat removed from the reactor and provide adequate cooling without excessive heating in marine environment.)</td>
<td>UK Environment Agency multi-attribute analysis</td>
</tr>
<tr>
<td>Attribute Group/Attribute</td>
<td>Study using similar attribute</td>
<td>Description of attribute in Reference Study</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>PNGS</td>
<td>Pumping consideration</td>
<td>BTA approach under US Clean Water Act Section 316(b); Sections 32 and 35 of the Canadian Fisheries Act</td>
</tr>
<tr>
<td>Oak Creek-Elm Road</td>
<td>Technical performance</td>
<td>BTA approach under US Clean Water Act Section 316(b)</td>
</tr>
<tr>
<td>Oak Creek-Elm Road</td>
<td>Ease of operation and maintenance (Including capital costs, operation and maintenance costs, energy penalty, and administrative costs. Cost-benefit analysis to demonstrate prohibitively high costs for closed-cycle cooling system.)</td>
<td>BTA approach under US Clean Water Act Section 316(b)</td>
</tr>
<tr>
<td>Indian Point</td>
<td>Parasitic losses attributable to new components</td>
<td>BTA approach triggered by pollutant discharge limit reapplication</td>
</tr>
<tr>
<td>Indian Point</td>
<td>Technical/engineering feasibility (including decommissioning)</td>
<td>BTA approach triggered by pollutant discharge limit reapplication</td>
</tr>
<tr>
<td>North Anna</td>
<td>Operating and maintenance experience</td>
<td>Best Available Technology Assessment as part of US NRC Early Site Permit application</td>
</tr>
<tr>
<td>North Anna</td>
<td>General efficiency penalty</td>
<td>Best Available Technology Assessment as part of US NRC Early Site Permit application</td>
</tr>
<tr>
<td>North Anna</td>
<td>Regulatory restrictions</td>
<td>Best Available Technology Assessment as part of US NRC Early Site Permit application</td>
</tr>
</tbody>
</table>

5. Cost
<table>
<thead>
<tr>
<th>Attribute Group/ Attribute</th>
<th>Study using similar attribute</th>
<th>Description of attribute in Reference Study</th>
<th>Governing Regulations or Methodology Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Cost (TAC/NPV)</td>
<td>PNGS</td>
<td>Replacement power during construction phase</td>
<td>BTA approach under US Clean Water Act Section 316(b); Sections 32 and 35 of the Canadian Fisheries Act</td>
</tr>
<tr>
<td></td>
<td>PNGS</td>
<td>Loss of salable power</td>
<td>BTA approach under US Clean Water Act Section 316(b); Sections 32 and 35 of the Canadian Fisheries Act</td>
</tr>
<tr>
<td></td>
<td>PNGS</td>
<td>Annual maintenance costs</td>
<td>BTA approach under US Clean Water Act Section 316(b); Sections 32 and 35 of the Canadian Fisheries Act</td>
</tr>
<tr>
<td></td>
<td>North Anna</td>
<td>Capital costs</td>
<td>Best Available Technology Assessment as part of US NRC Early Site Permit application</td>
</tr>
<tr>
<td></td>
<td>North Anna</td>
<td>Operating costs</td>
<td>Best Available Technology Assessment as part of US NRC Early Site Permit application</td>
</tr>
<tr>
<td></td>
<td>Indian Point</td>
<td>Estimated cost</td>
<td>BTA approach triggered by pollutant discharge limit reapplication</td>
</tr>
<tr>
<td></td>
<td>Indian Point</td>
<td>Operational and maintenance costs</td>
<td>BTA approach triggered by pollutant discharge limit reapplication</td>
</tr>
<tr>
<td></td>
<td>Indian Point</td>
<td>Costs due to new condenser operating parameters</td>
<td>BTA approach triggered by pollutant discharge limit reapplication</td>
</tr>
<tr>
<td></td>
<td>Indian Point</td>
<td>Economic and Power Losses</td>
<td>BTA approach triggered by pollutant discharge limit reapplication</td>
</tr>
<tr>
<td></td>
<td>Indian Point</td>
<td>Parasitic losses attributable to new components</td>
<td>BTA approach triggered by pollutant discharge limit reapplication</td>
</tr>
<tr>
<td>Attribute Group/Attribute</td>
<td>Study using similar attribute</td>
<td>Description of attribute in Reference Study</td>
<td>Governing Regulations or Methodology Basis</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------</td>
<td>---------------------------------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>Indian Point</td>
<td>Water treatment costs</td>
<td>BTA approach triggered by pollutant discharge limit reapplication</td>
<td></td>
</tr>
</tbody>
</table>
Appendix F: PNGS Fish Barrier Study, Canada, 2009

**Background**

A study [53] was conducted for the Pickering nuclear site, about 40 km east of Toronto. This site consists of Pickering Nuclear Generating Stations (PNGS) A and B, for a total of 8 reactors in an east-west orientation along the shore of Lake Ontario. The plant utilizes an OTC water system with an intake canal, two circulation water intake structures and a sediment suction system. The option study was performed to assess various methods for reducing fish impingement and entrainment at PNGS A and B [53].

**Methodology Overview**

A cost/benefit assessment methodology was employed in this study. Several flow reduction and intake technology alternatives were studied, some of which were discounted at an early stage due to issues like practicality of installation at the given site or performance standard; the remainder were studied in greater detail and used to determine cost estimates [53].

**Standards/guidelines used for option selection**

- Section 32 of the Canadian Fisheries Act prohibits the destruction of fish by any means other than fishing, unless it is authorized by the Department of Fisheries and Oceans (DFO). Section 35 of the Fisheries Act prohibits any work or undertaking that results in the harmful alteration, disruption, or destruction of fish habitat, unless it is authorized by the DFO [53].

- In recent years the US Environmental Protection Agency (US EPA) has based various regulations to reduce impingement and entrainment on Section 316(b) of the Clean Water Act. These regulations established performance standards for existing generation stations requiring them to reduce impingement by 80 to 95 percent and reduce entrainment by 60 to 90 percent relative to the calculation baseline (assuming no controls in place). US EPA is developing new regulations related to impingement and entrainment in light of the litigation [53].

**Attributes studied**

The key attributes studied were reduction of fish impingement mortality and entrainment at PNGS.

Secondary attributes studied included worker and public safety, visual and noise impact, commercial/recreational navigation impacts, pumping considerations, replacement power during construction phase, loss of salvable power, and annual maintenance costs [17].

**Major Lessons Learned**

1. Based on a third-party review comment, the study was revised to explain that traveling screens and modular inclined screens would return the weight of impinged fish to the lake, where it may be consumed by the predator species, salmon. Thus, estimates of total indirect fishery impacts for traveling screens...
and modular inclined screens do not include direct biomass lost; they only include foregone production.

2. The revised study also explains that all entrained eggs and larvae are assumed to be destroyed and that the predator species is assumed not to consume the destroyed eggs and larvae discharged from the facility. If the predator species were assumed to consume the destroyed eggs and larvae under baseline conditions, the alternatives that reduce entrainment would have lower benefits, and the alternatives that do not reduce entrainment would have the same benefits. Assuming no consumption of destroyed eggs and larvae is thus conservative in that it overstates benefits.

3. The highest effectiveness estimates were used to make the benefit estimates conservative as there is significant uncertainty regarding the effectiveness of technological alternatives.

**Results**

The cost benefit analysis indicated that the most feasible fish protection alternatives would all have larger costs than expected benefits. The report suggests that Cisco restoration combined with a barrier net is the most cost effective integrated solution [53].
Appendix G: Attribute Evaluation Sheets

This appendix presents information on ranking systems, attribute scores, uncertainties and supporting information for each of the considered attributes in the format of standardized worksheets. If performance of one or both of the considered options was impacted by the proposed abatement technology, then the revised scores and supporting information is also included.
1. Health and Safety

1.1 Risk to Public Health and Safety

<table>
<thead>
<tr>
<th>Attribute Scoring Criteria</th>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>Potential risk &gt;12</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Potential risk in the range of 11 to 12</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Potential risk in the range of 9 to 10</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Potential risk in the range of 7 to 8</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Potential risk in the range of 5 to 6</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Potential risk ≤4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency of Events</th>
<th>Likelihood</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10^4 per year</td>
<td>Almost Impossible</td>
<td>1</td>
</tr>
<tr>
<td>between 10^3 and 10^4 per year</td>
<td>Unlikely</td>
<td>2</td>
</tr>
<tr>
<td>&gt;10^3 per year</td>
<td>Possible</td>
<td>3</td>
</tr>
<tr>
<td>&gt;10^2 per year</td>
<td>Probable</td>
<td>4</td>
</tr>
<tr>
<td>&gt;10^1 per year</td>
<td>Likely</td>
<td>5</td>
</tr>
<tr>
<td>&gt;0.5 per year</td>
<td>Very Likely</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Severity</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil (No risk of injury or exposure to hazardous substance)</td>
<td>1</td>
</tr>
<tr>
<td>Negligible (Public exposed to accident consequences, no medical attention)</td>
<td>2</td>
</tr>
<tr>
<td>Minor (Public exposed to accident consequences, requiring minor medical attention, e.g. minor abrasions, bruising etc.)</td>
<td>3</td>
</tr>
<tr>
<td>Moderate (Non-life threatening physical or chemical injuries e.g. person went to the hospital was treated in the emergency room but was not admitted.)</td>
<td>4</td>
</tr>
<tr>
<td>Serious (Critical physical or chemical injuries, e.g. person was admitted to a hospital)</td>
<td>5</td>
</tr>
<tr>
<td>Catastrophic (Fatality, e.g. person killed immediately or within 30 days of the accident)</td>
<td>6</td>
</tr>
</tbody>
</table>
First Pass Evaluation – No Abatement

Summary of Evaluation:

A number of potential public health and safety risks have been identified. These hazards include:

- Air emissions and related health issues from inhalation of cooling option treatment chemicals,
- Chemical spills, resulting in public exposure to hazardous substances,
- Traffic accidents involving the public and chemical deliveries resulting in a fatality,
- Noise in excess of background level resulting in hearing loss to the public,
- Shipping/boating accidents involving the public and service cooling systems,
- Fire/explosion of the cooling systems resulting in injuries to the public, and
- Structure collapse resulting in injuries to the public.

It was determined that both cooling options have little to no risk involved for noise, boating, shipping, fire/explosion and structure collapse.

Once Through Cooling

No plausible accident scenarios affecting the public were identified for the OTC system. Therefore a score of 5 was assigned to this option.

Mechanical Draft Cooling Towers

A traffic accident involving a member of the public and a truck containing chemicals required for cooling tower operation was identified as the limiting hazard for the cooling tower option. This hazard was assigned as an “almost impossible” event (frequency score of 1) with a potential fatality (severity value of 6) resulting in the overall score of 4 for the Public Health and Safety.

Generic OPEX research and searches through Powersearch (the OPG Database) found no significant accidents resulting in injuries to the public with respect to the operation of cooling towers.

Below are the public safety risk values for both cooling options.
### Once Through Cooling

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Likelihood</th>
<th>Severity</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Emissions</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Chemical Spill</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Traffic Accident</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Noise</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Boating</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Shipping</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fire/Explosion</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Structure Collapse</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

### Mechanical Draft Cooling Tower

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Likelihood</th>
<th>Severity</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Emissions</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Chemical Spill</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Traffic Accident</td>
<td>1</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Noise</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Boating</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Shipping</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fire/Explosion</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Structure Collapse</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

### CURRENT SCORING:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four Units</td>
<td>Two Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>5</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>4</td>
</tr>
</tbody>
</table>

### SUPPORTING INFORMATION:

**Air Emissions**

There are a variety of disinfecting chemicals used to reduce biological induced fouling and corrosion in cooling tower systems. The common biocides used include: chlorine and bromine based chemicals, organic biocides, algaecides, fungicides, etc. These biocides are injected to kill aquatic life entrained or growing in the circulating water flow.
### Once Through Cooling

The OTC system at the existing Darlington Nuclear Generating Station (DNGS) does not use biocide and the DNPP OTC system would also not have biocides injected (Section 4.1.6 [2]). Since the OTC system does not release any emissions or utilize biocides, this hazard does not exist.

**Likelihood: 1**  
**Severity: 1**

### Mechanical Draft Cooling Tower

MDCT continuously require biocides to properly maintain equipment. The following is a list of chemicals used that may be released into the air (Section 3.11 [2]):

- Chlorine-based chemical biocide called sodium hypochlorite (bleach)
  - Used in low concentrations to disinfect recirculation water
- Sulphuric acid
  - pH control
- Polymaleic anhydride with a dispersant polymer
  - Antiscalant

There is the risk of disease spread by cooling tower drift and windage from an untreated tower; potentially causing Legionnaires’ disease in near-by residences. However the implementation of a cooling tower for DNPP would be designed to reduce any biocide impact and regulatory standards of maintenance would be followed. See the attribute Air Quality for more detail on air emissions.

It is not specifically known how the chemicals will degrade within the system. Water treatment chemicals are usually mixed in the appropriate concentrations so they are fully consumed within the system. It is reasonable to consider that the majority of the treatment chemicals are consumed within the system and not released in any measurable quantity to the atmosphere (Section 4.3.3.2 [54]).

Cooling towers would utilize a number of different chemicals, which would be consumed throughout the system. Proper maintenance and treatment would be conducted, decreasing the likelihood of causing Legionnaires’ disease to an unlikely event. However, the severity of Legionnaires’ disease is considered moderate, since medical attention would be required.

An OPEX search identified that there have been no incidents of the public contracting Legionnaires’ disease and similar respiratory illnesses from an under maintained power plant and therefore the likelihood is negligible.

**Likelihood: 1**  
**Severity: 4**

### Chemical Spills

#### Once Through Cooling

The OTC system would not use any kind of chemical treatment (biocides); therefore there would be no additional amount of chemicals than those already stored on-site (see discussion for MDCT). The likelihood of a chemical spill for OTC is considered impossible with no severity.

**Likelihood: 1**  
**Severity: 1**
Mechanical Draft Cooling Tower

Quantity

A variety of chemicals are continuously used to maintain cooling towers during the operational phase. These chemicals and their daily amounts include (Section 3.11 [2]):

- Disinfectant – Sodium Hypochlorite – 92 kg/h (83 L/h)
- pH Control – Sulphuric Acid – 596 kg/h (324 L/h)
- Antiscalant – Polymaleic anhydride with a dispersant polymer – 62 kg/h (54 L/h)
- Blowdown Treatment
  - Coagulant – Iron (III) Chloride and polymers – 208.2 kg/h (114 L/h)
  - Sodium Bisulphite – 138 kg/h (93 L/h)

In total, the cooling towers would require about 16,032 L/day for chemical treatments, equating to 224,448 L/biweekly; assuming biweekly deliveries.

DNGS has a number of different chemicals stored on-site for various plant systems; it is reasonable to expect that the same chemicals and relative quantities would be present at DNNP. The chemicals and their weekly storage amounts include [55]:

- Aqueous Ammonia – 8 totes x 1,000 L
- Hydrogen Peroxide – 8 totes x 1,000 L
- Morpholine – 8 totes x 1,000 L
- Hydrazine – 8 totes x 1,000 L
- Sulphuric Acid – 36,240 L
- Caustic Soda – 46,335 L
- Sodium Hypochlorite – 2 tanks x 20,000L

The total volume of chemicals stored on-site for basic biweekly operation is 154,575 L. If cooling towers were implemented at DNNP, there would be less than 279,023 L of chemicals stored on-site; about a 180% increase from OTC.

Spill Frequency

An extensive OPEX search was completed of OPG's Station Condition Records (SCR) for a reporting period of 15 years at the Darlington site. Findings showed that there was only one reported chemical spill that required very minor medical attention of a worker. Since there was no record of a spill affecting the public, the likelihood of this event is considered “almost impossible.”

Likelihood: 1

Severity

While the above chemicals exhibit various levels of toxicity, the site chemical (not including cooling tower treatment chemicals) of major concern is hydrazine. It was classified as Group 2B – Possibly carcinogenic to humans (Section 3.4.3 [56]) by the International Agency for Research on Cancer (IARC) [57]. The chemicals unique to the cooling towers can be compared to those that will be located on-site.

The antiscalant and coagulant are disregarded as a risk, because they are not classified by the IARC. Sodium hypochlorite [58] and sodium bisulphite [59] are classified as Group 3 – Not classifiable as to its carcinogenicity to humans, which is less severe than hydrazine and not considered to be an additional
risk. Sulphuric acid [60] is classified as Group 1 – Carcinogenic to humans and does pose a risk to site workers. However, sulphuric acid is already used at DNGS and it is assumed it will be used at DNNP, independent of the cooling option.

All chemical releases would occur on-site, and would not affect the public. An OPEX search concluded that there have been no on-site spills where airborne concentrations would affect the public. There also has been no reported incident of a major cooling tower chemical released leading to an exceedance of regulatory drinking water standard concentrations.

**Severity: 1**

**Containers**

It is expected that the use of appropriate approved chemical containers (totes, tanks, etc.) would minimize the chances of a chemical spill. All current DNGS containers must be built to CAN/CGSB-43.146-2002 (Canadian General Standards Board) standards. Containers built to this standard must be able to pass a drop test; from a height of approximately 1 m, the container must not lose its contents. Because metal cages surround the containers, punctures from forklifts and the consequent accidental release is not considered a credible accident. It is anticipated that DNNP would also use totes, or similarly robust containers thus minimizing the possibility of a chemical spill (Section 3.4.3 [56]).

**Traffic Accidents**

**Off-site Soil Management**

It is assumed that a "conventional truck" with a capacity of 10 Mm$^3$ will be used for off-site transfers. The reactor block baseline would require 3.81 Mm$^3$ of off-site material to be managed, therefore about 381,000 truck loads.

The OTC would not require any addition off-site soil management; therefore no off site trucking is required for the implementation of the OTC system. Since the MDCT system would require 2.62 Mm$^3$ of soil transfer, when compared to the baseline, it would require an additional 262,000 truck loads, for a total of about 643,000 truck loads.

The construction risks associated with off-site soil management were not quantified for public health and safety since the DNNP would be a construction zone if either cooling option was chosen. It was not seen as a potential differentiator between the two options as construction would take place over a relatively short period of time compared to operation and because health and safety risks associated with this type of conventional construction for large industrial projects are generally accepted by the public.

**Chemical Transportation**

**Once Through Cooling**

The OTC system does not require the use of vehicles to transport materials e.g. chemicals on or off-site. Therefore this hazard does not exist.

**Likelihood: 1**

**Severity: 1**

**Mechanical Draft Cooling Tower**

MDCT would require a 73% increase in the amount of chemical that would have to be stored on-site. This would increase the number of truck deliveries and hence the possibility of a fatal accident with a member of public. Statistically the number of persons killed in motor vehicle collisions per 100 million km travelled is 0.51 [26]. There is a requirement of 112,224 L of cooling tower chemicals in a week; 5.84E06 L/year [55]. Given that a basic truck travels 50 km with a 34,000 L [61] delivers to Darlington every week. This means that:
Number of trips per year = \((5.84 \times 10^6 \text{ L/year}) / (34,000 \text{ L}) = 1.72 \times 10^2 \text{ trips/year}\)

Kilometres per year = \((1.72 \times 10^2 \text{ trips/year}) \times (50 \text{ km}) = 8.58 \times 10^3 \text{ km/year}\)

Number of persons killed = \((0.51 / 1.0 \times 10^8 \text{ km}) \times (8.58 \times 10^3 \text{ km/year}) = 4.38 \times 10^{-5} \text{ people/year}\)

Therefore this gives an “almost impossible” likelihood of a fatal accident occurring. Note that an OPEX search also gave no results for a traffic accident involving members of the public and a delivery truck set for the Darlington site.

**Noise**

Long-term exposure to elevated equipment noise level is a health concern for the public, especially for St. Mary’s Cement Group which boarders OPG’s boundaries. Since St. Mary’s workers are considered part of the public, they may be affects by excess noise from the operation of the condenser cooling option.

**Once Through Cooling**

The OTC system does not require any additional equipment than what is standard for a cooling system (CCW pumps). The noise levels from OTC would not affect the general public and in turn, St. Mary’s workers.

**Mechanical Draft Cooling Tower**

MDCT towers require the use of additional equipment in the form of industrial fans. Modelling of the incremental noise level from background was completed in the physical environmental attribute “Noise Levels”. When the MDCT was modelled as a stationary and non-stationary source during full power operation, there was an exceedance of 3.3 dBa over established regulatory backgrounds at night for a one hour time frame [54]. This exceedance was located only at the South Service Road and is considered to not be harmful for any time frame (i.e. the noise would only just be overheard from background levels). Therefore, St. Mary’s workers would not be affected.

**Boating**

**Once Through Cooling**

It is unlikely that the public safety of recreational boating will be adversely impacted by the OTC option as the flowrates associated with the OTC option are very small and water is drawn from at least 10 m depth.

**Mechanical Draft Cooling Tower**

No impacts from MDCT are expected for recreational boating. Flow rates are also very low.
### Shipping

Designated shipping routes are located offshore in the middle of Lake Ontario (Section 5.1.5 [43]). The main hazard is with a ship grounding accident that could damage and/or block the water intake or discharge channels—e.g., via spillage of loads or waterborne debris. The principal source of this hazard will be visits of large vessels to the St. Marys Cement Plant wharf. This is because the general navigation routes for commercial shipping in Lake Ontario are offshore, towards the middle of the lake approximately 24 km from the shoreline at Darlington [55].

However, the Transportation Safety Board of Canada has not identified any issues with respect to safety in this area [55]. Similarly, any work at the DNNP site and related shipping activities near the shore will have little, if any, impact on the commercial shipping traffic (Section 5.1.5 [43]).

**Severity: 1**

#### Once Through Cooling

In order for the ship that suffers an accident, to veer off course, damage water intake structure, and to have an impact on the ability to cool DNNP, it has to sink right over the top of the water intake and the configuration of the vessel must be such that it can block the entire intake. The resulting water intake capacity would have to be reduced to less than the minimum 3% capacity requirement needed for cooling the station in a shut down state using the Emergency Service Water. This is not considered to be credible. Therefore a nuclear accident resulting from such an event is considered to be an incredible event [55].

**Likelihood: 1**

#### Mechanical Draft Cooling Tower

In the event of a ship suffering an accident and blocking water intake, sufficient water can still be provided by recirculation to supply Emergency Service Water. Therefore a nuclear accident resulting from such an event is considered to be an incredible event [55].

**Likelihood: 1**

### Fire and Explosion

#### Once Through Cooling and Mechanical Draft Cooling Tower

Both cooling options are not major sources of fire/explosions at nuclear power plants during operation. Therefore, the likelihood of a cooling option being the main source of a fire or explosion is almost impossible with no severity for the general public (Section 3.5.4.3 [56]). Should such an event occur, the flames will be rapidly extinguished with the suppression system and/or by the emergency response team and no significant spread in flames or smoke is anticipated. The general public has limited access to the site and therefore could only be affected through the atmospheric pathway.

**Likelihood: 1**

### Structure Collapse

#### Once Through Cooling and Mechanical Draft Cooling Tower

This evaluation is essentially an assessment of the cooling option's operational phase; for which no structure collapse for a modern design has been identified for either cooling option as a potential risk.

**Likelihood: 1**

**Severity: 1**
**UNCERTAINTY:**

The frequency of spills is based on current data available in the OPG Darlington SCR database. Other operating facilities may have a different frequency for such risks however, it is expected that similar policies and procedures for the operation of Darlington would apply to the DNNP and therefore the same frequency would be expected.

Overall uncertainty associated with public health and safety is low.

---

**SECOND PASS EVALUATION - ABATEMENT**

For noise with the application of mitigation for MDCT, including silencers, screens or a combination of both, it is expected that there would be minimal criteria exceedance for any off-site receptors. Therefore, no adverse risks from noise are anticipated for the public upon abatement.

No additional mitigation beyond the standard safety regulations/practices are required for the assessment the other risk factors.
### 1.2 Risk to Worker Health and Safety

<table>
<thead>
<tr>
<th>Attribute Scoring Criteria</th>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>Potential risk &gt;20</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Potential risk in the range of 18 to 20</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Potential risk in the range of 15 to 17</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Potential risk in the range of 12 to 14</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Potential risk in the range of 9 to 11</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Potential risk ≤8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency of Events</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10^{-4} per year</td>
<td>Almost Impossible</td>
</tr>
<tr>
<td>between 10^{-3} and 10^{-4} per year</td>
<td>Unlikely</td>
</tr>
<tr>
<td>&gt;10^{-3} per year</td>
<td>Possible</td>
</tr>
<tr>
<td>&gt;10^{-2} per year</td>
<td>Probable</td>
</tr>
<tr>
<td>&gt;10^{-1} per year</td>
<td>Likely</td>
</tr>
<tr>
<td>&gt;0.5 per year</td>
<td>Very Likely</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil (no risk of injury)</td>
</tr>
<tr>
<td>Negligible (No medical attention)</td>
</tr>
<tr>
<td>Minor (Some injury including medical attention)</td>
</tr>
<tr>
<td>Moderate (Lost time injury &lt;40 days, Critical injuries less serious in nature (e.g. broken bone))</td>
</tr>
<tr>
<td>Serious (Lost time injury &gt;40 days, Critical injuries more serious in nature, e.g. amputations)</td>
</tr>
<tr>
<td>Catastrophic (Fatality)</td>
</tr>
</tbody>
</table>
### Severity

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>nil</th>
<th>Negligible</th>
<th>Minor</th>
<th>Moderate</th>
<th>Serious</th>
<th>Catastrophic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost Impossible</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Unlikely</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Possible</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>12</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Probable</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td>16</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Likely</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Very Likely</td>
<td>6</td>
<td>12</td>
<td>18</td>
<td>24</td>
<td>30</td>
<td>36</td>
</tr>
</tbody>
</table>

### Summary of Evaluation:

A number of worker health and safety risks have been identified. These hazards include:

- Chemical spills, resulting in worker exposure to hazardous substances,
- Shipping/boating accidents of workers involved in servicing cooling systems,
- Noise in excess of acceptable levels resulting in hearing damage,
- Icy conditions due to operation of the cooling systems leading to injuries due to slippage,
- Fire/explosion of the cooling systems resulting in worker injuries,
- Structure collapse resulting in worker injuries, and
- Other accidents associated with physical injuries due to maintenance (e.g. falls).

It was determined that both cooling options have little to no risk involved for shipping, fire/explosion and structure collapse.

**Once Through Cooling**

No plausible accident scenarios were identified for the Once Through cooling system. This is supported by OPEX searches. Therefore a score of 5 was assigned to this option.

**Mechanical Draft Cooling Towers**

Chemical spills were identified as the limiting hazard. This hazard was assigned as a likely event (frequency score of 5) with negligible severity (value of 2) resulting in the overall score of 4 for the Worker Health and Safety.

Below are the worker safety risk values for both cooling options.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Likelihood</th>
<th>Severity</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Spill</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Noise</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Icy Conditions</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Fire/Explosion</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Scenario</td>
<td>Likelihood</td>
<td>Severity</td>
<td>Risk</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------</td>
<td>----------</td>
<td>------</td>
</tr>
<tr>
<td>Chemical Spill</td>
<td>5</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Noise</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Icy Conditions</td>
<td>3</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Fire/Explosion</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Structure Collapse</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Other Accidents</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

**Mechanical Draft Cooling Tower**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Likelihood</th>
<th>Severity</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Spill</td>
<td>5</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Noise</td>
<td>3</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Icy Conditions</td>
<td>3</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Fire/Explosion</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Structure Collapse</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Other Accidents</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

**CURRENT SCORING:**

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>5</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>4</td>
</tr>
</tbody>
</table>

**SUPPORTING INFORMATION:**

This evaluation is an assessment of the cooling option's operational phase only. The construction phase is conventional and standard to any construction site and does not influence the decision between the cooling options.

**Chemical spills**

**Once Through Cooling**

The OTC system would not use any kind of chemical treatment (biocides), therefore there would be no additional amount of chemicals than those already stored on-site (see discussion for Mechanical Draft Cooling Towers).

**Likelihood: 1**  
**Severity: 1**

**Mechanical Draft Cooling Tower**

**Quantity**

A variety of chemicals are continuously used to maintain cooling towers during the operational phase. These chemicals and their daily amounts include (Section 3.11 [2]):

- **Disinfectant** – Sodium Hypochlorite – 92 kg/h (83 L/h)
- **pH Control** – Sulphuric Acid – 596 kg/h (324 L/h)
- **Antiscalant** – Polymaleic anhydride with a dispersant polymer – 62 kg/h (54 L/h)
- **Blowdown Treatment**
Coagulant – Iron (III) Chloride and polymers – 208.2 kg/h (114 L/h)
Sodium Bisulphite – 138 kg/h (93 L/h)

In total, the cooling towers would require about 16,032 L/day for chemical treatments, equating to 224,448 L/biweekly; assuming biweekly deliveries.

DNPS has a number of different chemicals stored on-site for various plant systems; it is reasonable to assume that the same chemicals quantities would be present at DNPP. The chemicals and their assumed weekly storage amounts include [55]:

- Aqueous Ammonia – 8 totes x 1,000 L
- Hydrogen Peroxide – 8 totes x 1,000 L
- Morpholine – 8 totes x 1,000 L
- Hydrazine – 8 totes x 1,000 L
- Sulphuric Acid – 36,240 L
- Caustic Soda – 46,335 L
- Sodium Hypochlorite – 2 tanks x 20,000L

This adds up to a total of 154,575 L of chemicals stored on-site for basic biweekly operation. If cooling towers were implemented at DNPP, there would about 279,023 L chemicals stored biweekly on-site; about a 180% increase from OTC. It is assumed that the increase in transportation, handling, and storage of these treatment chemicals around the DNPP site would be considered in layout planning.

**Spill Frequency**

An extensive OPEX search was completed in OPG’s Station Condition Records (SCR) for a reporting period of 15 years at the Darlington site. Findings showed that there was only one reported chemical spill that required very minor medical attention of a worker [62].

Therefore the frequency of chemical spills that may affect a worker are as follows:

- Chemical Spill Frequency = (1 occurrence) / (15 years) = 0.07 occurrences/year

It is assumed that the frequency is equivalent for all types of chemical storage.

The above frequency is considered when there is the standard 154,575 L/biweekly of chemicals located on-site. If cooling towers were implemented, there would be an additional 224,448 L/biweekly of treatment chemicals; introducing additional risk. The frequency of spills determined for the standard site can be altered to represent the incremental frequency for cooling tower chemicals:

- Cooling Tower Chemical Spill Frequency = 
  
$$
(0.07 \text{ occurrences/year}) \times (224,448 \text{ L/biweekly}) / (154,575 \text{ L/biweekly}) = 0.10 \text{ occurrences/year}
$$

Therefore, the likelihood of a cooling tower treatment chemical spilling and affecting a worker is “likely”.

**Likelihood: 5**

**Severity**

While the listed chemicals exhibit various levels of toxicity, the site chemical (not including cooling tower treatment chemicals) of major concern is hydrazine. It was classified as Group 2B – Possibly carcinogenic to humans (Section 3.4.3 [56]) by the International Agency for Research on Cancer (IARC) [57]. The chemicals unique to the cooling towers can be compared to those that will be located on-site.
The antiscalant and coagulant are disregarded as a risk, because they are not classified by the IARC. Sodium hypochlorite [58] and sodium bisulphite [59] are classified as Group 3 – Not classifiable as to its carcinogenicity to humans, which is less severe than hydrazine and not considered to be an additional risk. Sulphuric acid [60] is classified as Group 1 – Carcinogenic to humans and does pose a risk to site workers. However, sulphuric acid is already used at DNGS and it is assumed it will be used at DNNP, independent of the cooling option. Therefore, workers would already have experience with carcinogenic substances and the implantation of cooling towers would promote additional WHMIS training. Since workers would always use necessary personal protection equipment (PPE) when handling all chemicals on-site, the increase of sulphuric acid is not considered additional severity.

If a major chemical spill were to occur, workers involved in the cleanup would be exposed to higher concentrations of chemicals in the atmosphere. These workers would wear appropriate personal protective equipment such as respirators, gloves and goggles while located within the vicinity of the spill. Workers not involved in the cleanup activities would not remain in the area (Section 3.5.3.2 [56]). Those immediately exposed would retreat to a safe distance and receive appropriate medical attention.

The OPEX search showed that there has been only one recorded chemical spill that affected a site worker. The worker had concentrated nitric acid spilled onto their coveralls; the affected area was doused with water and the technician was asked to visit the station nurse, although there was no apparent injury [62]. Since it was clear that no medical attention was required the severity of this incident is considered negligible.

**Severity: 2**

**Containers**

It is expected that the use of appropriate approved chemical containers (totes, tanks, etc.) would minimize the chances of a chemical spill. All current DNGS containers must be built to CAN/CGB-43.146-2002 (Canadian General Standards Board) standards. Containers built to this standard must be able to pass a drop test; from a height of approximately 1 m the container must not lose its contents. Metal cages surround the containers, lowering the chances of forklift punctures and the consequent accidental release. An OPEX search in OPG’s SCR found that no accidental release from a forklift puncture resulting in worker injury was recorded for Darlington during a 15 year period.

It is anticipated that DNNP would also use totes, or similarly robust containers thus reducing the possibility of a chemical spill (Section 3.4.3 [56]).

**Addition Issues**

An OPEX search identified that there have been no incidents of worker contracting Legionnaires’ disease or similar respiratory illness from an under maintained power plant and therefore the likelihood is negligible.

**Noise**

**Once Through Cooling**

OTC system does not require any additional equipment than what is standard for a cooling system (CCW pumps); all noise levels above background are very low. Therefore, it is assumed that noise would not affect worker health. All appropriate personal protection equipment (PPE), including ear protection, will be used when working in the plant. This potential health concern will have very low severity and no likelihood.

**Likelihood: 1**

**Severity: 1**
Mechanical Draft Cooling Tower

MDCT towers require the use of addition equipment in the form of industrial fans; noise levels above background are moderately high. The model analysis completed in the physical environmental attribute Noise Levels described that noise levels on-site could be \( \geq 80 \text{ dBA} \) (Figure G.1-8 [54]). This is a concern for workers who would complete maintenance on the cooling towers or are situated around the cooling system. However, all workers would have adequate ear protection when completing work in the plant. The major concern is long time exposure to the high onsite noise levels in areas that do not require PPE (i.e. parking lots). An operating experience search was completed to see if any other nuclear plants with cooling towers have this issue; no dilemma was found. It is uncertain of the exact location of DNNP’s parking lots, and it is expected that these noise level would not cause any serious damage. Therefore this issue is possible with only negligible severity.

| Likelihood: 3 |
| Severity: 2 |

Icy Conditions

Once Through Cooling

OTC system does not produce a moisture/water vapour plume. This cooling option would not produce any additional amount of ice onsite. Therefore, this potential health concern will have no severity and no likelihood.

| Likelihood: 1 |
| Severity: 1 |

Mechanical Draft Cooling Tower

MDCT will produce a plume of excess moisture, which can often lead to excess icing on-site, leading to slipping hazards for workers. A model analysis was completed in the physical environmental attribute Local Climate Change described that because the prevailing winds (particularly in the winter) are from the north-west quadrant, icing conditions are predicted to occur only south-east of the cooling towers, and for only about 1-2 hours per year (Section 6.3.2 [54]). It is assumed that if the cooling tower plume does cause excess ice onsite, appropriate salting would occur. However, it is possible that a slip would occur due to excess ice, but the severity would only be minor.

| Likelihood: 3 |
| Severity: 3 |

Fire and Explosion

Once Through Cooling and Mechanical Draft Cooling Tower

Based on operating experience searches, neither cooling option is a major source of fire/explosions at nuclear power plants during operation. Therefore, the likelihood of a cooling option being the main source of a fire or explosion is almost impossible. Should such event occur, the flames will be rapidly extinguished with the suppression system and /or by the emergency response team and no significant spread in flames or smoke is anticipated. Workers near to the fire would be exposed to the smoke or heat resulting from the event. However, due to the rapid extinguishing of the flames, only minor injury is expected. Appropriate fire training will be given to personnel, and station emergency response plans and protocols will be put in place. (Section 3.5.4.3 [56]).

| Likelihood: 1 |
| Severity: 2 |
**Structure Collapse**

*Once Through Cooling and Mechanical Draft Cooling Tower*

This evaluation is an assessment of the cooling option’s operational phase; for which no structure collapse for a modern design has been identified for either cooling option.

| Likelihood: 1 |
| Severity: 1 |

**Other Accidents**

*Once Through Cooling*

No other hazards resulting physical injuries have been identified for the OTC option.

| Severity: 1 |

*Mechanical Draft Cooling Tower*

The main hazard is associated with working at heights and potential falls during maintenance of the cooling towers. All appropriate personal protection equipment will be worn at all times; and when maintaining the cooling towers, all fall protection procedures will be carried out. If an accident were to occur, it is likely that the severity would only be minor.

| Severity: 3 |

**Other Supporting Information:**

Several operating experience searches were completed for both cooling options on potential worker injuries that may occur; including a search through Powersearch OPEX OPG Database. There have been no recordings of any injuries directly related to a cooling option.

| Likelihood: 1 |

**UNCERTAINTY:**

Due to extensive experience in operation of both cooling options and operating experience data indicating no worker injuries resulting from operation of cooling systems, the uncertainty level is assessed to be small. The expectation is that required safety levels will be built into design and operational procedures and that safety record of the cooling systems for the new plant will be at least as good as that of other OPG-operated cooling systems.

---

**SECOND PASS EVALUATION - ABATEMENT**

There is no additional mitigation beyond the standard safety regulations required for this attribute.

It should be noted that with the implementation of noise abatement, noise levels on-site could be reduced by 10-15 dBA. However, the severity and likelihood of this hazard would remain the same.

Furthermore implementation of the plume abatement technology would reduce the on-site icing and therefore provide additional mitigation for worker slippage hazard.
2. Physical Environment

2.1 Water Quality/Emission to Water

<table>
<thead>
<tr>
<th>ATTRIBUTE SCORING CRITERIA</th>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>Significant and widespread change to water quality (exceeding substance-specific concentration limits)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Moderate and widespread changes to water quality</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Moderate and localized changes to water quality</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Marginal and localized changes to water quality</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>No discernible change to water quality</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Improved water quality</td>
</tr>
</tbody>
</table>

FIRST PASS EVALUATION — NO ABATEMENT

SUMMARY OF EVALUATION:

This attribute does not include effects from thermal plumes. Based on the current operating experience at DNGS, the operation of OTC technology itself has no adverse effects on water quality. For example, the concentration of total residual chlorine (TRC) in cooling water, which is used for biofouling control of other systems, does not exceed the Provincial Water Quality Objectives (PWQO) of 2 µg/L [38]. This cooling option is therefore given a score of 4.

Compared with the OTC option, the cooling tower technology has the following specific characteristics which could have adverse effects on water quality:

- Concentration of contaminants: Water within the cooling tower system is re-circulated and the water bled off from the system would contain contaminants. With the operation of a “four cycle” system, the concentrations intake water contaminants would be four times those in the original lake water due to the recycling and evaporation. In contrast, the OTC system is non-contact and the water quality in the cooling water discharge flow would be essentially identical to the intake water with the assumption of no chlorination of the cooling water system.

  It should be clarified that operations at existing OPG nuclear facilities do not use chlorination as a means of zebra mussels control of the CCW as it is not practical (e.g., volume of water). This would be the same case for a DNNP OTC system. Chlorination is however, used to control zebra mussels in the station service water systems which, although they share the CCW discharge, are not considered to be a facet of the OTC design within this scope.

- More chemical additives to the cooling system: For the cooling tower system, chemicals would be added to maintain appropriate water quality within the circulated cooling water system, e.g., biocides, anti-scaling agents, pH control and blowdown treatment.

Any discharges to the environment, no matter what option selected, would meet regulatory requirements (e.g., Municipal/Industrial Strategy for Abatement and Environmental Compliance Approval (ECA) process). For this purpose, appropriate water treatment is needed, specifically for the cooling tower option. However, it is expected that the contaminant concentrations as a result of the Cooling Tower operation would be higher than that from the OTC option. Therefore the cooling tower option is assigned a score of 3.

It should be noted that radiological aspects are not included in this attribute. Radionuclide releases are
reactor specific and for that reason were not included in the assessment. Total quantity of radioactivity released does not depend on the condenser cooling system. While environmental concentrations of radionuclide may be affected by the choice of condenser cooling option, doses have been estimated to be significantly below the limit for both options.

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Water quality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td></td>
<td>Two Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>No discernible change</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>Marginal changes</td>
</tr>
</tbody>
</table>

**CURRENT SCORING:**

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>4</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>3</td>
</tr>
</tbody>
</table>

**SUPPORTING INFORMATION:**

**Four Units**

**Once Through Cooling Option**

1. Construction of the new intake and diffuser for the OTC option is expected to cause some localized re-suspension of fine lake sediments and may result in a visible turbidity plume. There is only a thin veneer of fine sediments (less than 5 mm) in the area (Section 5.1.3.2 [38]). Any resulting turbidity plume is expected to be short in duration and contain suspended sediment concentrations that are less than those typically observed during storm events (bluff erosion, Darlington Creek, etc). It is anticipated that these effects would be temporary in nature and not warrant consideration assuming that Good Industry Management Practices are employed during construction. This also applies to the construction of the coffer dam and lake infill (Section 5.1.3.1 [38]).

Openings for ports of the cooling water discharge diffuser (90 ports at 10 m depth) would be excavated in the lake floor. This would be done from a barge mounted operation. A drilling technique such as reverse circulation drilling would be used to drill the holes. Cuttings and used drill water would be managed to minimize deleterious effects to the environment (Section 3.2.2.1 [63]).

2. The water quality in the cooling water discharge flow would be essentially identical to the intake water, with the assumption of no chlorination. Changes to the water quality in the OTC water discharge could occur, as a result of discharges into the cooling water flow from other systems; such as treated effluent from the Radioactive Liquid Waste Management System and Inactive Drainage System. However, the assessment of the cooling options is done independently of the operation of the rest of the plant and therefore contaminants arising from operation of the reactors are not evaluated in this study. Any discharges to the environment would meet regulatory water quality requirements (Section 5.1.3.2 [38]).

3. Since the expected flow rate of any of the other system flows is less than 1% of the cooling water flow, they would be immediately diluted by a factor of at least 100 before being discharged to the
lake (with all units in operation). The initial dilution in the lake provided by the diffuser (13.6 at edge of turbulent mixing zone) would provide additional reduction in the contaminant concentrations. At the edge of the turbulent mixing zone, an overall dilution factor of at least 1,300 would be applied to any of the parameters (Section 5.1.3.2 [38]).

4. All discharges to the environment would meet regulatory requirements (i.e., MISA and ECA).

**Mechanical Draft Cooling Tower**

1. The discharge structure for the cooling tower option would be a single port with a nozzle orientated at an upward 45° angle above horizontal and located 1 m above the bottom. There are three main concerns with respect to cooling tower water quality discharge:
   a) Water is recirculated within the cooling tower system and some of the water is bled off from the system, which is replaced with fresh make-up water from Lake Ontario. The bleed-off water would contain contaminant concentrations of four times those in the original lake water due to the recycling and evaporation.
   b) Cooling water discharge may be affected due to the addition of chemicals for cooling tower maintenance. The most common cooling tower treatment chemicals are as follows (Section 3.6 [2]):
      - Disinfectant
        - Sodium Hypochlorite
      - pH Control
        - Sulphuric Acid
      - Antiscalants or scale inhibitors
        - Polymaleic anhydride with a dispersant polymer
      - Blowdown Treatment
        - Coagulant (FeCl₃)
        - Polymers
        - Sodium Bisulphite

      It is not known at this time which specific chemicals would be used for the cooling tower process. The greater part of the process chemicals will be consumed within the system, but trace amounts of residual chemicals would be neutralized before blowdown. This discharge to the environment would meet regulatory water quality requirements.

   c) Similar to the OTC water system, water quality of the cooling tower system could be affected as a result of discharges into the cooling water flow from other systems, such as (treated) effluent from the Radioactive Liquid Waste Management System, Inactive Drainage System and Service Water System and/or conventional liquid waste (associated with the Management of Conventional Waste project work and activity). However, the assessment of the cooling options is done independently of the operation of the rest of the plant and therefore contaminants arising from operation of the reactors are not evaluated in this study. Any discharges to the environment would meet regulatory water quality requirements (Section 5.1.3.2 [38]).

2. The construction of the intake and discharge is expected to cause some localized re-suspension of fine lake sediments and may result in a visible turbidity plume.

3. It was predicted that a lake dilution factor of 300 would result in a net concentration increase of 1% relative to background for a concentrating factor of 4 due to the cooling tower system (Section 4.3.3.
The near field “plume” with a dilution factor of less than 300 is typically expected to extend 3 km from the outfall (east or west during average conditions) measured parallel/perpendicular to the shore, and have an approximate width of 200 m. The concentrations at any of the far-field locations are expected to be lower based on the actual long-term dilution factors (Section 5.1.3.2 [38]).

The estimated plume concentration for cooling tower option is illustrated in Figure G-1 (Figure 4.6.6-1 [38])

**Figure G-1: Estimated Plume Concentration for Cooling Tower Option**

Since all the dilution factors for the drinking water intakes and surface water quality monitoring locations in the Local and Regional Study Areas which were defined in the EA [38] (where various lake current types are taken into account) are greater than 300, changes in concentrations at these locations would not differ measurably from the background conditions due to concentration in the cooling tower system.

**Two Units**

It is assumed that the quantity of the contaminants discharged to the lake water for the case of two unit design would be 50% of that for four units. It is expected that effects on water quality would be less than that estimated for four units.

**Water Contamination Resulting from Releases to Air**

Substances in air could enter the cooling system through dry deposition and precipitation. Airborne substances usually consist of clay and dirt particles. They could also include gases such as hydrogen sulphide, which forms insoluble precipitates with many metal ions. The possibility of airborne contaminants entering the cooling system would be affected by many factors such as physical/chemical properties of the contaminants and local meteorological conditions. It is expected that effects on the
surface water of airborne contaminants is negligible compared with additives for water treatment or leakage or spills of process chemicals, which directly enter the system at measurable amounts.

**UNCERTAINTY:**

There is extensive operating experience from similar facilities and sophisticated analysis that has been carried out for DNNP. Since the dispersion model is conservative, there is low uncertainty with respect to the water quality.

<table>
<thead>
<tr>
<th>SECOND PASS EVALUATION - ABATEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is no mitigation required for this attribute.</td>
</tr>
</tbody>
</table>
2.2 Air Quality/Emission to Air

<table>
<thead>
<tr>
<th>ATTRIBUTE SCORING CRITERIA</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The concentrations of airborne contaminants continuously exceed MOE Air Quality Criteria at multiple points of impingement</td>
</tr>
<tr>
<td>1</td>
<td>The concentrations of airborne contaminants at point of impingement increase by over 20% above baseline concentration over extended periods of time</td>
</tr>
<tr>
<td>2</td>
<td>The concentrations of airborne contaminants at point of impingement increase by 10% to 20% (inclusive) above the baseline concentration over extended periods of time</td>
</tr>
<tr>
<td>3</td>
<td>The concentrations of airborne contaminants at point of impingement increase by 5% to 10% (inclusive) above the baseline concentration over extended periods of time</td>
</tr>
<tr>
<td>4</td>
<td>There is no discernible increase of airborne contaminants (increase at point of impingement by &lt;5% above the baseline concentration) over extended periods of time</td>
</tr>
<tr>
<td>5</td>
<td>Improved air quality</td>
</tr>
</tbody>
</table>

**FIRST PASS EVALUATION — NO ABATEMENT**

**SUMMARY OF EVALUATION:**

Emissions from the cooling tower systems may contain airborne contaminants and, in particular, particulate matter. It has been analytically demonstrated [54] that the 24-hour maximum concentrations (including SPM, PM10 and PM2.5) at residential receptors during the operational phase are below the 24-hour AAQC. The only exception was for one location where there the incremental increases of SPM and PM10. However, the increase was not considered to be potentially measurable [54].

Cooling towers also require the use of various chemicals to help maintain the equipment and water quality. The chemicals would typically be added in appropriate concentrations such that they would be fully consumed within the system, and are not release into the air in any measurable quantity. These chemicals would typically include:

- Sodium hypochlorite (disinfect recirculation water)
- Sulphuric acid (pH control)
- Polymaleic anhydride with a dispersant polymer (scale inhibitor)

Once Through cooling does not emit any airborne contaminants or use any biocides.

Emission concentrations for SPM, PM10 and PM2.5 were determined from computer modelling for the overall DNNP site [54]. This analysis was completed again for the overall DNNP site, but with the inclusion of cooling towers; all emission concentrations for residential receptors were below the Ambient Air Quality Criteria. The percentage increment between concentrations at residential receptors and the background environment were established for 24-hour and annual periods; these values for the operation of four units are:
It is reasonable to assume that the situation with two units would have about half the amount of emissions that the four units. Plume abatement may even reduce these emission rates.

Though the OTC does not emit any contaminants, it does not improve air quality either; this option was given a score of 4. The airborne contaminant SPM for the Mechanical Draft Cooling Tower has an average concentration of 5% to 10% above the baseline concentration, over an extended period of time. This option was scored as a 3 for four units.

It should be noted that radiological aspects are not included in this attribute. Radionuclide releases are reactor specific and for that reason were not included in the assessment. Total quantity of radioactivity released does not depend on the condenser cooling system. While environmental concentrations of radionuclide may be affected by the choice of condenser cooling option, doses have been estimated to be significantly below the limit for both options.

**CURRENT SCORING:**

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>4</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>3</td>
</tr>
</tbody>
</table>

**SUPPORTING INFORMATION:**

**Assessment Criteria**

Currently, there are no Federal or Provincial criteria for assessing the effects related to the operation of cooling towers. However, emissions from cooling systems may contain airborne contaminants and, in particular, particulate matter. Air quality criteria are defined by both the Ontario Ministry of the Environment and Environment Canada. The air quality criteria applicable to the activities associated with this Project (including operational releases) are provided in Table G-1 (Section 3.1 [54]).

**Table G-1: Ambient Air Quality Criteria**

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended Particulate Matter (SPM)</td>
<td>120 µg/m3 (24-hour average)</td>
</tr>
<tr>
<td></td>
<td>60 µg/m3 (annual average - desirable)</td>
</tr>
<tr>
<td></td>
<td>70 µg/m3 (annual average - acceptable)</td>
</tr>
<tr>
<td>Particulate Matter &lt;10 µg (PM10)</td>
<td>50 µg/m3 (24-hour average)</td>
</tr>
</tbody>
</table>
| Particulate Matter <2.5 µg (PM2.5)    | 30 µg/m3 (24-hour average – 98th percentile over 3 years)
Once Through Cooling

Once Through cooling does not emit any kind of airborne contaminants, as it does not produce a plume or use any sort of biocide. Therefore, this cooling option is not analyzed further.

However, emissions from the DNNP site as a whole (no cooling tower present) can be found in Appendix A. These values are modeled for the operational phase of DNNP at resident receptors around the Darlington site. Incremental percentage differences between the measured emission rates and background levels were also determined.

Mechanical Draft Cooling Tower

Potential Releases to Air

Operating MDCT typically have two types of air emissions:

- Evaporation: Small percentages of the water evaporates from the cooling towers, which cools the circulating water and heats the air
- Drift: Drift emissions are water droplets containing dissolved and suspended solids.

Drift emissions and, to a smaller extent, evaporative emissions may also include water treatment chemicals. This can include anti-fouling agents, biocides, anti-corrosives, and anti-scalants (Section 4.3.3.2 [54]).

To reduce biological induced fouling and corrosion caused by water based cooling systems, a disinfecting chemical (i.e., a biocide) is often injected. There are a number of different biocides commonly used, including: chlorine and bromine based chemicals, organic biocides, algaecides, fungicides, etc. However, these biocides often kill aquatic life (e.g., algae, bacteria) entrained or growing in the circulating water flow. It would be expected that entrained biota would suffer a near 100% mortality rate on a percentage basis in cooling towers, since it would be subject to biocidic disinfection and heat and mechanical stresses (Section 4.1.6 [2]).

Mechanical draft cooling towers require continuous use of biocides and typically use the chlorine-based chemical biocide, sodium hypochlorite (commonly known as bleach) in low concentrations to disinfect the recirculation water. The biocidic effect of sodium hypochlorite can be neutralized prior to discharge by the injection of a strong reducing agent, such as sulphuric acid, or periodically discharging the cooling tower only when water quality (i.e., chlorine residual) is within the allowable plant discharge limits. Scale and corrosion is controlled with polymaleic anhydride with a dispersant polymer (Section 4.3.3.2 [54], Section 3.6 [2]). There are additional chemical which are used for blowdown treatment, but are not considered for this attribute; see the evaluation for Water Quality.

It has not been determined what chemicals will be utilized for the treatment of circulated cooling water as the design has not been finalized. Table G-2 lists the potential chemicals that might be used in the cooling system and their effluent concentrations.
Table G-2: Chemical Usage for Circulating Water Chemical Conditioning (Section 3.11 [2])

<table>
<thead>
<tr>
<th>Function</th>
<th>Chemical</th>
<th>Injection Concentration (ppm as 100%)</th>
<th>Annual Average Mass Injection (kg/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disinfectant</td>
<td>Sodium Hypochlorite (12% wt) - (continuous)</td>
<td>0.5</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Sodium Hypochlorite (12% wt) - (shock)</td>
<td>5</td>
<td>23</td>
</tr>
<tr>
<td>pH Control</td>
<td>Sulphuric Acid (93% wt)</td>
<td>280</td>
<td>596</td>
</tr>
<tr>
<td>Scale Inhibitor</td>
<td>Polymaleic anhydride (PMA) (18% wt) with Dispersant polymer (HSP2) (12% wt)</td>
<td>30</td>
<td>62</td>
</tr>
</tbody>
</table>

It is not known at this time which specific chemicals would be used for the cooling tower process. The greater part of the process chemicals would be consumed within the system, but trace amounts of residual chemicals would be released into the atmosphere. All trace amounts would not be released in any measurable quantity and would be below AAQC regulation (Section 4.3.3.2 [54]).

Cooling tower circulating water will also contain solids which are associated with evaporation. AP-42 from the U.S. EPA provides an emission rate for particulate PM10 only. This emission is associated with MDCT drifts, where the liquid water droplets are carried with the exhaust air from the cooling tower. Using the U.S. EPA emission calculation (solids concentration in solution drift release rate), the PM10 emission rate is estimated to be approximately 3.8 g/s (Section 4.3.3.2 [54]). Considering the size and immediate surrounding area of DNNP, this rate is below the baseline given in Table G-1.

Receptors

For the purpose of Reference [54], the predicted concentrations of air parameters have been assessed at nearby residential receptor locations. Figure G-2 and Table G-3 shows the location of the specific receptors in relation to the site and immediate surrounding area (Section 5.4 [54]).

Figure G-2: Receptor Locations (Section 5.4 [54])
Particulates from Cooling Tower Operation

An analysis was undertaken to examine the potential effects of particulate emissions from Mechanical Draft Cooling Towers for DNNP. PM10 emission rates were calculated from the U.S. EPA AP-42 methodology based on a Total Dissolved Solid concentration in the source water of 277 ppm and four cycles of concentration (1.7 g/s). PM2.5 particulates were assumed to equal to PM10 emissions and SPM rates were also assumed to be equal to PM10 emissions with additional contribution from the Total Suspended Solid Concentration in the source water of 11.4 ppm (1.8 g/s) (Section 6.2.5 [54]).

AERMOD, the U.S. EPA air dispersion modeling system, was able to model cooling tower emissions as volume sources. When compared to the overall DNNP site emission (see Appendix A), the inclusion of MDCT in the maximum predicted 24-hour and annual SPM, PM10 and PM2.5 concentrations did increase emissions but did not yield any additional exceedances of the AAQCs (Ambient Air Quality Criteria – Table G-1). The model results were presented as ranged percentage increases from the overall DNNP site assessment. Table G-4 lists the ranges and median percentage increments.

Table G-4: Predicted Emission Rates - Ranged Percentage Increase from Overall DNNP – No Cooling Towers (Section 6.2.5 [54])

<table>
<thead>
<tr>
<th>Emission</th>
<th>Minimum Increment (%)</th>
<th>Median Increment (%)</th>
<th>Maximum Increment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24-Hour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPM</td>
<td>0</td>
<td>0.65</td>
<td>1.30</td>
</tr>
<tr>
<td>PM10</td>
<td>0</td>
<td>2.55</td>
<td>5.10</td>
</tr>
<tr>
<td>PM2.5</td>
<td>0.60</td>
<td>5.1</td>
<td>9.60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPM</td>
<td>0.30</td>
<td>0.95</td>
<td>1.60</td>
</tr>
<tr>
<td>PM10</td>
<td>0.40</td>
<td>0.95</td>
<td>1.50</td>
</tr>
<tr>
<td>PM2.5</td>
<td>0.70</td>
<td>2.15</td>
<td>3.60</td>
</tr>
</tbody>
</table>

To determine the emission rates for cooling towers at each receptor, the emission rate for the overall DNNP site (no cooling tower – Addendum A) would be multiplied by the median of each range.
Table G-5 shows the incremental percentage difference between the maximum predicted 24-hour and annual SPM, PM10 and PM2.5 concentrations for the whole DNNP site with cooling towers and background levels. These values were modelled for the same residential receptor stated in Table G-3.

**Table G-5: Predicted Maximum 24-Hour and Annual Maximum Percentage Increase of Particulates Over Background – Overall DNNP Site with Cooling Towers during Operational Phase [54]**

<table>
<thead>
<tr>
<th>Emission</th>
<th>Maximum Increment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24-Hour</td>
</tr>
<tr>
<td>SPM</td>
<td>9.90</td>
</tr>
<tr>
<td>PM10</td>
<td>5.51</td>
</tr>
<tr>
<td>PM2.5</td>
<td>1.52</td>
</tr>
</tbody>
</table>

These values are based on the bounding case of four units; it is reasonable to assume that two units would have about half the amount of emissions that of the four units. It can also be assumed that with the presence of plume abatement these values may decrease.

**Cumulative Effects**

There is the potential for emissions from the MDCT plume to act cumulatively (overlap in type, space and time) with the effects of other projects and activities around the DNNP site. There will be emissions to the air from the planned Durham-York Energy form Waste (EFW) Facility (Section ES.8 [1]), but there is little potential for overlap with the MDCT plume emissions due to predominant wind directions. Emissions from both plants will be lower than regulatory criteria.

Air concentration during the site preparation period is expected to exceed AAQC regulations very infrequently, since an extensive dust mitigation program will be applied to the DNNP site [54]. From this information, cumulative effects with other nearby facilities are expected to be minimal since it would occur over a short time period in relation to the life time of the plant.

It is expect that there would be no residual environmental impacts due to the cumulative effects between DNNP and other facilities in the immediate future. There is uncertainty that this expectation would remain valid, since the construction of potential future facilities in the region is undetermined. However, all facilities would have to be licensed and operate in accordance with regulatory requirements.

**UNCERTAINTY:**

The uncertainty for air dispersion modeling is generally affected by the quality of the input (emission data and meteorology) and the capabilities of the program. Accounting for uncertainty in emission estimation, the maximum emission scenarios were used to estimate the potential effect of the cooling options in operation. When comparing against regulatory criteria, the maximum predicted concentration for each time frame (24-hour and annual) over a five year period was used. All of these factors were included to reduce the potential of underestimating a potential effect (Section 6.2.11 [54]).

The following are the ranges of incremental particulate emissions for the overall DNNP site with a cooling tower during the operation of four units.

The increment values for the cooling towers can be seen in Table G-6. Values from the primary assessment, where the DNNP site has no cooling towers, [54] were multiplied by the percentage factors presented in Table G-4. See Addendum A for initial modeling values.
Table G-6: Predicted Emission Concentration Increments for Cooling Towers \[54\]

<table>
<thead>
<tr>
<th>Emission</th>
<th>Minimum Increment (%)</th>
<th>Average Increment (%)</th>
<th>Maximum Increment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>24-Hour</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPM</td>
<td>4.72</td>
<td>6.20</td>
<td>9.90</td>
</tr>
<tr>
<td>PM10</td>
<td>0.292</td>
<td>2.44</td>
<td>5.51</td>
</tr>
<tr>
<td>PM2.5</td>
<td>0.60</td>
<td>0.358</td>
<td>1.52</td>
</tr>
<tr>
<td><strong>Annual</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPM</td>
<td>4.84</td>
<td>6.95</td>
<td>10.1</td>
</tr>
<tr>
<td>PM10</td>
<td>1.05</td>
<td>1.82</td>
<td>3.24</td>
</tr>
<tr>
<td>PM2.5</td>
<td>0.70</td>
<td>2.15</td>
<td>3.60</td>
</tr>
</tbody>
</table>

From Table G-6, the average increments of SPM for the cooling towers remain within the 5-10% of the background emission concentrations, and all other are lower than 5%. However, when maximum increments are considered, they do rise above 10% of the background. The scoring for the minimum and maximum increments can be seen in Table G-7.

Table G-7: Sensitivity Scoring for Cooling Towers

<table>
<thead>
<tr>
<th>Reactor Option</th>
<th>Score</th>
<th>Worst Case Minimum Increment</th>
<th>Predicted</th>
<th>Optimal Case Maximum Increment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four Units</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Two Units</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

**SECOND PASS EVALUATION - ABATEMENT**

**SUMMARY OF EVALUATION:**
The first pass evaluation shows low amounts of particulates being released to the air, so that no additional mitigation is required.

**SUPPORTING INFORMATION:**

**Mitigation**

**Once Through Cooling System**

The OTC system has no plume and does not utilize treatment chemicals; therefore there are no particulate emissions. No mitigation is required for OTC systems.

**Mechanical Draft Cooling Tower**

Most air constituent concentrations due to the DNNP Project are not expected to exceed AAQC (Table G-1). Therefore no additional mitigation is recommended for the cooling towers related air quality effects (Section 6.5 \[54\]).
ADDENDUM A

Overall DNNP Site Evaluation – No Cooling Towers

Table G-8, Table G-9 and Table G-10 provide the maximum predicted 24-hour average and annual average SPM, PM10 and PM2.5 concentrations for the operational scenario for the nearest residential locations. Note that the criteria values can be found in Table G-1 and predicted values include upwind background. The background values are for comparative purposes and are equal to values for the future no-build scenario. Predicted concentrations from the operational phase that exceed 10% of the associated background concentration are considered a potentially measurable effect.

Values which are in bold are considered potentially measurable effects; the assessment criterion is 10% of the 24-hour background concentration. Values noted in italics are values that exceed the AAQC (Section 6.2.2 – 6.2.4 [54]).

Table G-8: Predicted 24-Hour and Annual SPM Concentrations at the Nearest Residential Receptors During Operational Phase – Overall DNNP Site (Section 6.2.2 [54])

<table>
<thead>
<tr>
<th>Receptor ID</th>
<th>24-Hour</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Background</td>
<td>Operation</td>
<td>Increment (%)</td>
<td>Background</td>
<td>Operation</td>
</tr>
<tr>
<td>R15</td>
<td>88.4</td>
<td>93.2</td>
<td>5.43</td>
<td>23.7</td>
<td>25.7</td>
</tr>
<tr>
<td>R16</td>
<td>96.0</td>
<td>101.3</td>
<td>5.52</td>
<td>38.1</td>
<td>40.5</td>
</tr>
<tr>
<td>R17</td>
<td>82.0</td>
<td>86.5</td>
<td>5.49</td>
<td>26.2</td>
<td>28.1</td>
</tr>
<tr>
<td>R18</td>
<td>65.5</td>
<td>71.9</td>
<td>9.77</td>
<td>24.0</td>
<td>25.4</td>
</tr>
<tr>
<td>R19</td>
<td>103.6</td>
<td>110.6</td>
<td>6.76</td>
<td>30.4</td>
<td>32.4</td>
</tr>
<tr>
<td>R20</td>
<td>180.2</td>
<td><strong>192.4</strong></td>
<td>6.77</td>
<td>57.4</td>
<td>61.6</td>
</tr>
<tr>
<td>R21</td>
<td>45.9</td>
<td>48.5</td>
<td>5.66</td>
<td>15.8</td>
<td>17.0</td>
</tr>
<tr>
<td>R22</td>
<td>66.9</td>
<td>71.1</td>
<td>6.28</td>
<td>18.1</td>
<td>19.9</td>
</tr>
<tr>
<td>R23</td>
<td>52.6</td>
<td>55.1</td>
<td>4.75</td>
<td>20.7</td>
<td>21.7</td>
</tr>
<tr>
<td>R24</td>
<td>75.8</td>
<td>80.8</td>
<td>6.60</td>
<td>21.1</td>
<td>22.5</td>
</tr>
<tr>
<td>R25</td>
<td>69.9</td>
<td>73.2</td>
<td>4.72</td>
<td>24.3</td>
<td>25.5</td>
</tr>
<tr>
<td>Average</td>
<td>84.2</td>
<td>89.5</td>
<td>6.16</td>
<td>27.3</td>
<td>29.1</td>
</tr>
</tbody>
</table>

With the exception of R20, the 24-hour maximum predicted SPM concentrations at residential receptors during the operational phase are below the 24-hour AAQC of 120 µg/m³. The frequency analysis, illustrating the percentage of 24-hour periods where the AAQC is exceeded for R20 is less than 1% (6.2.2 [54]).
Table G-9: Predicted 24-Hour and Annual PM10 Concentrations at the Nearest Residential Receptors During Operational Phase – Overall DNNP Site (Section 6.2.3 [54])

<table>
<thead>
<tr>
<th>Receptor ID</th>
<th>24-Hour</th>
<th>Annual</th>
<th>24-Hour</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Background</td>
<td>Operation</td>
<td>Increment (%)</td>
<td>Background</td>
</tr>
<tr>
<td>R15</td>
<td>38.6</td>
<td>39.4</td>
<td>2.07</td>
<td>16.57</td>
</tr>
<tr>
<td>R16</td>
<td>40.1</td>
<td>40.9</td>
<td>2.00</td>
<td>18.75</td>
</tr>
<tr>
<td>R17</td>
<td>39.2</td>
<td>40.7</td>
<td>3.83</td>
<td>17.07</td>
</tr>
<tr>
<td>R18</td>
<td>36.3</td>
<td>37.4</td>
<td>3.03</td>
<td>16.74</td>
</tr>
<tr>
<td>R19</td>
<td>44.0</td>
<td>45.1</td>
<td>2.50</td>
<td>17.76</td>
</tr>
<tr>
<td>R20</td>
<td>52.5</td>
<td>54.3</td>
<td>3.43</td>
<td>21.96</td>
</tr>
<tr>
<td>R21</td>
<td>34.2</td>
<td>34.3</td>
<td>0.292</td>
<td>15.40</td>
</tr>
<tr>
<td>R22</td>
<td>38.2</td>
<td>40.2</td>
<td>5.24</td>
<td>15.98</td>
</tr>
<tr>
<td>R23</td>
<td>34.6</td>
<td>34.9</td>
<td>0.867</td>
<td>16.17</td>
</tr>
<tr>
<td>R24</td>
<td>37.7</td>
<td>38.6</td>
<td>2.39</td>
<td>16.24</td>
</tr>
<tr>
<td>R25</td>
<td>38.2</td>
<td>38.4</td>
<td>0.524</td>
<td>16.79</td>
</tr>
<tr>
<td>Average</td>
<td>39.4</td>
<td>40.4</td>
<td>2.38</td>
<td>17.2</td>
</tr>
</tbody>
</table>

The PM_{10} concentration at R20 was predicted to slightly exceed the criterion value. The frequency of R20 exceeding the 24-hour PM_{10} AAQC (50 µg/m³) during the operational phase is less than 1% (Section 6.2.3 [54]).

Table G-10: Predicted 24-Hour and Annual PM2.5 Concentrations at the Nearest Residential Receptors During Operational Phase – Overall DNNP Site (Section 6.2.4 [54])

<table>
<thead>
<tr>
<th>Receptor ID</th>
<th>24-Hour</th>
<th>Annual</th>
<th>24-Hour</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Background</td>
<td>Operation</td>
<td>Increment (%)</td>
<td>Background</td>
</tr>
<tr>
<td>R15</td>
<td>20.5</td>
<td>20.6</td>
<td>0.488</td>
<td>7.6</td>
</tr>
<tr>
<td>R16</td>
<td>21.0</td>
<td>21.1</td>
<td>0.476</td>
<td>7.7</td>
</tr>
<tr>
<td>R17</td>
<td>23.0</td>
<td>23.0</td>
<td>0</td>
<td>7.7</td>
</tr>
<tr>
<td>R18</td>
<td>21.5</td>
<td>21.5</td>
<td>0</td>
<td>7.6</td>
</tr>
<tr>
<td>R19</td>
<td>21.9</td>
<td>22.0</td>
<td>0.457</td>
<td>7.7</td>
</tr>
<tr>
<td>R20</td>
<td>26.0</td>
<td>26.0</td>
<td>0</td>
<td>7.9</td>
</tr>
<tr>
<td>R21</td>
<td>22.1</td>
<td>22.1</td>
<td>0</td>
<td>7.5</td>
</tr>
<tr>
<td>R22</td>
<td>21.6</td>
<td>21.9</td>
<td>1.39</td>
<td>7.7</td>
</tr>
<tr>
<td>R23</td>
<td>22.0</td>
<td>22.1</td>
<td>0.454</td>
<td>7.6</td>
</tr>
<tr>
<td>R24</td>
<td>20.5</td>
<td>20.6</td>
<td>0.488</td>
<td>7.6</td>
</tr>
<tr>
<td>R25</td>
<td>23.8</td>
<td>23.8</td>
<td>0</td>
<td>7.6</td>
</tr>
<tr>
<td>Average</td>
<td>22.2</td>
<td>22.2</td>
<td>0.341</td>
<td>7.7</td>
</tr>
</tbody>
</table>

No exceedances of the criteria or measurable changes in PM_{2.5} concentrations are predicted at any of the residential receptors during the operational phase.
### 2.3 Noise Level

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The incremental sound level at off-site receptor locations (over background level) is more than 16dBA</td>
</tr>
<tr>
<td>1</td>
<td>The incremental sound level at off-site receptor locations (over background level) is in the range of 10 to 16 dBA (inclusive)</td>
</tr>
<tr>
<td>2</td>
<td>The incremental sound level at off-site receptor locations (over background level) is in the range of 5 to 10 dBA (inclusive)</td>
</tr>
<tr>
<td>3</td>
<td>The incremental sound level at off-site receptor locations (over background level) is in the range of 3 to 5 dBA (inclusive)</td>
</tr>
<tr>
<td>4</td>
<td>The incremental sound level at off-site receptor locations (over background level) is in the range of 0 to 3 dBA (inclusive)</td>
</tr>
<tr>
<td>5</td>
<td>There is no increase of sound level over the background value at receptor locations off-site</td>
</tr>
</tbody>
</table>

Note: The noise level of up to 3 dBA (over background level) is deemed hardly perceptible and 3 – 5 dBA noticeable; 5 – 10 dBA represents a definite noise problem and 10 – 16 dBA a serious noise problem.

### First Pass Evaluation – No Abatement

**SUMMARY OF EVALUATION:**

Once Through cooling does not require any additional equipment than what is standard for a cooling system; therefore noise levels would not increase over the background value at receptors on or off the site. Therefore, Once Through Cooling is not further assessed in this evaluation and is scored a 5.

Mechanical draft cooling towers require the additional cooling system equipment in the form of industrial fans. Modelling of the incremental noise level from background during different development phases for DNNP was completed in Reference [54]. There was no exceedance of the established criteria at any of the receptor points during the operational phase when the cooling towers were considered to be a stationary source.

Another evaluation was completed where cooling towers are considered both a stationary and non-stationary source. During Full Operation the resident receptor that measured the largest exceedance over established regulated background levels is located at the South Service Road; each exceedance occurred during the night. For a maximum one hour time frame, the sound level for Full Operation was at 3.3 dBA [54].

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Noise Level Above Background – Stationary sources Full Operation 2026*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>Less than background</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>Less than background at all off-site receptor locations</td>
</tr>
</tbody>
</table>

*Operations include operation of all reactors and associated cooling towers, boilers, and emergency and diesel generators.
**Cooling options**

<table>
<thead>
<tr>
<th></th>
<th>Noise Level Above Background Stationary and non-stationary sources**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four Units</td>
<td></td>
</tr>
<tr>
<td>Two Units</td>
<td></td>
</tr>
<tr>
<td><strong>Full Operation 2026</strong></td>
<td></td>
</tr>
<tr>
<td>Once Through</td>
<td>Less than background</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>3.3 dBA</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CURRENT SCORING:**

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four Units</td>
<td></td>
</tr>
<tr>
<td>Two Units</td>
<td></td>
</tr>
<tr>
<td><strong>Full Operation 2026</strong></td>
<td></td>
</tr>
<tr>
<td>Once Through</td>
<td>5</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>3</td>
</tr>
</tbody>
</table>

**SUPPORTING INFORMATION:**

**Noise Criteria**

Noise impact is generally assessed in terms of exceedance above stated sound level criteria or increase in sound levels above the existing background sound environment. The following describes what noise criteria are used for cooling tower systems noise assessment (Section 3.2 [54]):

- The Ontario Ministry of the Environment (MOE) publication NPC-205 provides sound level limits for stationary sources in urban areas (Table 1) as energy equivalent sound level, $L_{eq}$, in dBA.

The land-use planning section of the guidance document Health Canada provides a discussion of the relative severity of noise impacts as summarized in Table G-11. This table is used to compare the noise impact from cooling tower systems (on-site stationary sources). This assessment states that the criterion is to be applied to off-site receptor locations. To be in noise level exceedance, noise from on-site sources associated with the Project will be above the criteria levels (background levels).

**Table G-11: Minimum Sound Level Limits by Time of Day – Stationary Sources (Section 3.2 [54])**

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Class 1 Area</th>
<th>Class 2 Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>07:00 - 19:00</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>19:00 - 23:00</td>
<td>47</td>
<td>45</td>
</tr>
<tr>
<td>23:00 - 07:00</td>
<td>45</td>
<td>45</td>
</tr>
</tbody>
</table>

$L_{eq}$ – energy equivalent sound level

Note: the limit at a receptor for steady noise from a stationary source is the higher of either the one-hour $L_{eq}$ resulting from existing volumes of road traffic and any industry which is not under investigation for noise excess, or the appropriate level in Table G-11.
Note: A “Class 1 Area” is considered to be an acoustical environment typical of a major population centre, where the background sound level is dominated by the urban hum.

Note: A “Class 2 Area” is considered to be the following:

- An acoustical environment where low background sound level, normally occurring between 23:00 and 7:00 hours in Class 1 Areas, will typically be realized as early as 19:00 hours/
- Absence of an urban hum between 19:00 and 23:00.
- Evening background sound levels defined by natural environment and infrequent human activity, and
- No clear audible sound from stationary sources other than from those under assessment.

Scoring for this attribute is based on the operation of each cooling option and the potential noise level that would rise above the levels set in Table G-11. The incremental increases above the criteria are summarized in Table G-12, which is in accordance with provincial and federal guidance; however, the scoring scheme is based on Table G-12 but contains smaller ranges (Section 3.2 [54]).

**Table G-12: Applying Recommended Sound Level Limits to Residential Land Use Developments**

<table>
<thead>
<tr>
<th>Excess Above Recommended Sound Level Limits (dBA)</th>
<th>Change in Subjective Loudness</th>
<th>Magnitude of the Noise Problem</th>
<th>Noise Control Measures (or action to be taken)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Excess</td>
<td>-</td>
<td>No expected noise problem</td>
<td>None</td>
</tr>
<tr>
<td>1 to 5 dB inclusive</td>
<td>Noticeably louder</td>
<td>Slight noise problem</td>
<td>Optional</td>
</tr>
<tr>
<td>6 to 10 dB inclusive</td>
<td>Almost twice as loud</td>
<td>Definite noise problem</td>
<td>Recommended</td>
</tr>
<tr>
<td>11 to 15 dB inclusive</td>
<td>Almost three times louder</td>
<td>Serious noise problem</td>
<td>Strongly recommended</td>
</tr>
<tr>
<td>16 dB and over</td>
<td>Almost four times louder</td>
<td>Very serious noise problem</td>
<td>Strongly recommended (may be mandatory)</td>
</tr>
</tbody>
</table>

Note that high noise levels from the Condenser Cooling Water system (e.g. pumps) is considered to be part of the plant as a whole. This evaluation is determining the incremental difference between noise levels for each specific cooling option.

**Once Through Cooling**

Once Through cooling does not require any additional equipment than what is standard for a cooling system; therefore, noise levels above background specifically from this option are very low. Because of this, no evaluation was completed on this cooling option and it is assumed that any noise during the construction phase would be part of the overall new build.

**Mechanical Draft Cooling Tower**

Operating Cooling Systems – Potential Sources of Noise

Mechanical draft cooling towers require the use of addition equipment in the form of industrial fans. For bounding assessment purposes, the noises from the fans for the Mechanical Draft Cooling Towers were evaluated (Section 4.3.3.2 [54]). It should be noted that because of the exclusion zone requirements, the location of the MDCT and reactor block cannot be altered. See the attribute Excavated Materials for more information on location details.

**Receptors**

For the purpose of Reference [54], the predicted noise levels have been assessed at nearby residential receptor locations.

Figure G-3 shows the location of the specific receptors in relation to the site and immediate surrounding.
area (Section 5.4 [64]). Table G-13 lists the location of each receptor.

**Figure G-3: Receptor Locations (Section 5.4 [54])**
**Table G-13: Off-Site Receptor Locations**

<table>
<thead>
<tr>
<th>Receptor ID</th>
<th>Receptor Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Dr. Ross Tilley Public School</td>
</tr>
<tr>
<td>R2</td>
<td>Holy Family Catholic Elementary</td>
</tr>
<tr>
<td>R3</td>
<td>Bowmanville Sports Field</td>
</tr>
<tr>
<td>R4</td>
<td>Upper Soccer Fields</td>
</tr>
<tr>
<td>R5</td>
<td>Lower Soccer Fields</td>
</tr>
<tr>
<td>R6</td>
<td>OPG Baseball Diamond</td>
</tr>
<tr>
<td>R7</td>
<td>Oshawa General Racing Pigeon Club</td>
</tr>
<tr>
<td>R8</td>
<td>Darlington Provincial Park</td>
</tr>
<tr>
<td>R9</td>
<td>Port Darlington Marina</td>
</tr>
<tr>
<td>R10</td>
<td>Oshawa Second Marsh / MacLaughlin Bay</td>
</tr>
<tr>
<td>R11</td>
<td>Bowmanville Trail at Spry Avenue in Bowmanville</td>
</tr>
<tr>
<td>R12</td>
<td>Waterfront Trail Entrance West off Solina Road</td>
</tr>
<tr>
<td>R13</td>
<td>Waterfront Trail Entrance Northeast off South Service Road at unopened road allowance (Maple Grove Road)</td>
</tr>
<tr>
<td>R14</td>
<td>Durham Regional Police Fleet / Property Bureau on Courtice Court south of Baseline Road</td>
</tr>
<tr>
<td>R15</td>
<td>Nearest Existing Resident (West) on Solina Road</td>
</tr>
<tr>
<td>R16</td>
<td>Nearest Existing Resident (East) on Waverly Road</td>
</tr>
<tr>
<td>R17</td>
<td>Nearest Existing Resident (Northeast) on Maple Grove Road</td>
</tr>
<tr>
<td>R18</td>
<td>Nearest Existing Resident (North) on Holt Road</td>
</tr>
<tr>
<td>R19</td>
<td>Nearest Existing Resident (Northwest) on Rundle Road</td>
</tr>
<tr>
<td>R20</td>
<td>Nearest Existing Resident (East) on South Service Road</td>
</tr>
<tr>
<td>R21</td>
<td>Nearest Existing Resident (East) on Green Road north of 401</td>
</tr>
<tr>
<td>R22</td>
<td>Nearest Existing Resident (East) at base of Waverly Road</td>
</tr>
<tr>
<td>R23</td>
<td>Almec Farms Limited on Holt Road North of Baseline Road</td>
</tr>
<tr>
<td>R24</td>
<td>Nearest Future Resident (Courtice)</td>
</tr>
<tr>
<td>R25</td>
<td>Nearest Future Resident (Bowmanville)</td>
</tr>
</tbody>
</table>

**Cadna-A Modelling**

Cadna-A was utilized in noise modelling to predict the impact of the bounding scenarios on the receptor locations. The Cadna-A program is a powerful predictive modelling tool, it utilizes a standardized method of calculation which allows for noise from various source types to be predicted at receptor locations. The model calculates the reduction in sound level due to the distance between the source(s) and receptor(s), and accounts for any intervening obstructions to noise propagation.

Cadna-A predicts noise from traffic using information such as hourly vehicle traffic counts, percentage rate for vehicles larger than 2.8 tonnes, vehicle speed limit, and road surface type. While Ontario has defined approaches to assess noise due to traffic, the objective of this study was to determine an incremental change between baseline sound levels and sound levels due to the Project. Provided the approach to estimating traffic noise levels is consistent in both the baseline model runs and the model runs estimating the effects of the Project, this comparison can be conducted (Section 5.3 [54]).
Modelling Results – Stationary Sources

Construction Phase

A search was conducted to evaluation possible significant sources of noise during the construction phases of each cooling option (Site Preparation and Construction and Construction and Operation). It was determined that these noise levels would not exceed anything more than expected for a standard construction site. Since the construction of DNNP occurs over a short time period in relation to the lifetime of the plant, the construction phases are not considered to be a major concern. This period is when the cooling options are regarded as stationary and a combination of stationary/non-stationary sources.

Four Units

The following section describes the effect of the stationary sources on the off-site receptor locations for the maximum daytime and night-time impact scenarios. Stationary sources were assessed on a maximum one-hour impact scenario, per NPC-205. The maximum noise impact occurs when the receptor experiences minimal background traffic noise (modelled using the lowest hourly traffic volume for daytime and night-time hours) compared to the maximum hour of noise output from the site. According to NPC-205, the criterion that applies at a point of reception is the higher of the minimum hourly background noise or the minimum criterion value of 50 dBA for daytime hours and 45 dBA for night-time hours.

For full operation, there were no exceedances of the established criteria at any of the receptor points. As such, the activities related to the Project are considered to be in compliance with the regulatory criteria in NPC-205 and no mitigation to the stationary sources was required to meet this criterion. The stationary sources associated with the operations scenarios include the reactor building(s), cooling towers, boilers and generators (Section 6.4.1 [54]).

See Figure G-4 and Table G-14 for the predicted impacts of stationary sources (Section G.1 [54]).
Note that this figure is a scenario for a noise model only and is not a representation of the potential DNNP layout. It is also assumed that individual cooling towers would be assembled into four linear rows; one for each unit (Appendix I - Section 1.2 [2]). This would be two linear rows if two units were utilized.
Table G-14: One-Hour Equivalent Sound Level Due to Stationary Sources: 2026-Full Operation with Cooling Towers (Table G.1-2 [54])

<table>
<thead>
<tr>
<th>Receptor ID</th>
<th>Applicable Criteria Minimum One-Hour Sound Level (dBA)</th>
<th>Future Build One-Hour Sound Level (dBA)</th>
<th>Maximum Project-Related Incremental Increase (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day</td>
<td>Night</td>
<td>Day</td>
</tr>
<tr>
<td>R1</td>
<td>50.4</td>
<td>45.0</td>
<td>NI</td>
</tr>
<tr>
<td>R2</td>
<td>50.0</td>
<td>45.0</td>
<td>NI</td>
</tr>
<tr>
<td>R3</td>
<td>62.5</td>
<td>56.0</td>
<td>57.4</td>
</tr>
<tr>
<td>R4</td>
<td>59.0</td>
<td>52.5</td>
<td>48.0</td>
</tr>
<tr>
<td>R5</td>
<td>54.6</td>
<td>49.2</td>
<td>NI</td>
</tr>
<tr>
<td>R6</td>
<td>59.5</td>
<td>59.5</td>
<td>51.3</td>
</tr>
<tr>
<td>R7</td>
<td>56.3</td>
<td>48.5</td>
<td>NI</td>
</tr>
<tr>
<td>R8</td>
<td>60.7</td>
<td>53.7</td>
<td>NI</td>
</tr>
<tr>
<td>R9</td>
<td>50.9</td>
<td>45.0</td>
<td>NI</td>
</tr>
<tr>
<td>R10</td>
<td>50.0</td>
<td>45.0</td>
<td>NI</td>
</tr>
<tr>
<td>R11</td>
<td>53.3</td>
<td>45.7</td>
<td>NI</td>
</tr>
<tr>
<td>R12</td>
<td>53.7</td>
<td>49.2</td>
<td>NI</td>
</tr>
<tr>
<td>R13</td>
<td>67.7</td>
<td>61.1</td>
<td>51.7</td>
</tr>
<tr>
<td>R14</td>
<td>62.8</td>
<td>55.8</td>
<td>NI</td>
</tr>
<tr>
<td>R15</td>
<td>52.6</td>
<td>48.5</td>
<td>NI</td>
</tr>
<tr>
<td>R16</td>
<td>61.3</td>
<td>54.2</td>
<td>NI</td>
</tr>
<tr>
<td>R17</td>
<td>60.0</td>
<td>53.6</td>
<td>51.9</td>
</tr>
<tr>
<td>R18</td>
<td>58.8</td>
<td>50.9</td>
<td>50.2</td>
</tr>
<tr>
<td>R19</td>
<td>63.5</td>
<td>56.6</td>
<td>30.8</td>
</tr>
<tr>
<td>R20</td>
<td>68.0</td>
<td>61.7</td>
<td>53.7</td>
</tr>
<tr>
<td>R21</td>
<td>55.6</td>
<td>49.3</td>
<td>48.3</td>
</tr>
<tr>
<td>R22</td>
<td>50.0</td>
<td>45.4</td>
<td>43.1</td>
</tr>
<tr>
<td>R23</td>
<td>56.0</td>
<td>48.2</td>
<td>49.4</td>
</tr>
<tr>
<td>R24</td>
<td>58.5</td>
<td>50.6</td>
<td>NI</td>
</tr>
<tr>
<td>R25</td>
<td>62.2</td>
<td>51.0</td>
<td>47.5</td>
</tr>
</tbody>
</table>

Note: The applicable criteria are the higher of the predicted Future Baseline (background) sound levels and the MOE Stationary Source Criteria. NI stands for No Impact. Operations include the operation of all reactors and associated cooling towers, boilers and emergency and diesel generators.
Modelling Results – Combined Stationary and Non-Stationary Sources

Four Units

Noise modelling including the existing DNGS and St Mary’s Cement sites and all expected sources of noise associated with the Project (i.e., not just stationary sources) were performed for daytime and night-time hours in order to provide a more comprehensive representation of the noise environment at off-site receptor locations. The maximum one-hour impact during the daytime and night-time was predicted at each receptor location, as well as the average daytime and night-time sound levels. For these model runs, daytime hours were assumed to be 07:00 to 23:00 (16 hrs) and night-time hours were assumed to be 23:00 to 07:00 (8 hrs). In general, the maximum off-site impacts occurred during the one-hour timeframes, as these included the traffic associated with shift changes occurring within the hour assessed. These one-hour peaks associated with the shift changes were less pronounced when considered over the full daytime or night-time period (Section 6.4.2 [54]). See Table G-15 for a summary of the sound level effects for stationary and non-stationary sources.

Full Operation

The only receptor point affected during Scenario 4 (Full Operation) is R20, which experiences a night-time maximum one-hour increase in sound level of 3.3 dB. When considered over the average daytime and night-time periods, there are no increases of greater than 3 dB associated with this scenario. This one-hour increase is largely due to the traffic associated with the changing of shifts, which has conservatively been assumed to take place in a one-hour period and this period is unlikely to line up with the hour in which background traffic levels are at a minimum (3 am to 4 am) (Section 6.4.2 [54]).

Table G-15: Summary of Sound Level Effects for Stationary and Non-Stationary Sources in Maximum One-Hour Timeframe – Cooling Towers (Table 6.4-1 [54])

<table>
<thead>
<tr>
<th>Receptor ID</th>
<th>Future Baseline Minimum One-Hour Sound Level (dBA)</th>
<th>Future Build Maximum One-Hour Sound Level (dBA)</th>
<th>Maximum Project-Related Increment Increase (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day</td>
<td>Night</td>
<td>Day</td>
</tr>
<tr>
<td>Full Operation 2026</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R20</td>
<td>68.0</td>
<td>61.7</td>
<td>69.1</td>
</tr>
</tbody>
</table>

Note: Future Build modelling includes the baseline traffic sources with project-related sources operating concurrently, resulting in an incremental increase.

Two Units

No data was presented for two units; therefore, it is assumed that all noise levels would be equal or less than that of four units.

UNCERTAINTY:

There are several sources of uncertainty inherent in the predicted sound levels at the receptor locations. The uncertainties reside in the following:

- Estimation of equipment and other Project-related source sound levels (i.e. traffic); and
- Calculation of sound propagation to receptor points.

In short, there is uncertainty in the calculation of the sound levels applied in the modelling, and in the modelling itself. Uncertainty in the measurement of a source of sound may be minimized through application of rigorous measurement methodology, as the reproducibility of the result is increased. Many
of the sound levels applied to sources in this assessment however were based on calculations (i.e., for construction equipment; Cadna-A calculated sound levels for the roads based on estimated traffic volume and speed), and measurement of many sources operating simultaneously (i.e., existing DNGS and St. Mary’s Cement operations). These methods are considered to have higher uncertainty than sound levels determined through measurement under reproducible conditions.

The uncertainty due to the calculation of the propagation of sound is described in the ISO Standard on which the modelling software used in the assessment is based. According to this Standard, the uncertainty in the prediction method is within ±3 dB for distances up to 1,000 m, where the mean height of source and receptor is between 0 m and 5 m (Section 6.4.4 [54]).

This uncertainty can be utilized to obtain best/worst case scenarios for the off-site receptors. If we apply the worst case scenario of +3 dB for the operation of stationary sources (values located in Table G-14), then receptors R21 and R22 would be about 2 dBA over the background limits during the night. When the +3 dB is applied for the operation of stationary and non-stationary sources in Table G-15, the maximum potential exceedance for receptor R20 is 6.3 dBA during the night.

If we apply the best case scenario of -3 dB for the operation of stationary sources (values located in Table G-14), then all receptors would not surpass the background limits for any time. When the -3 dB is applied for the operation of stationary and non-stationary sources in Table G-15, the minimum potential exceedance for receptor R20 is 0.3 dBA during the night.

The scoring for predicted, worst and best case estimates can be seen in Table G-16; this incorporates the operation of both stationary and non-stationary sources.

<table>
<thead>
<tr>
<th># Units</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Worst Case</td>
</tr>
<tr>
<td>4 Units</td>
<td>2</td>
</tr>
<tr>
<td>2 Units</td>
<td>2</td>
</tr>
</tbody>
</table>

### SECOND PASS EVALUATION - ABATEMENT

**SUMMARY OF EVALUATION:**

With the application of mitigation, including silencers, screens or a combination of both, it is expected that there would be minimal criteria exceedance for any off-site receptors. It is yet to be determined what specific abatement technology would be utilized, though the use of screens will often reduce noise levels by 10-15 dBA; this requires further engineering design.

Based upon the evaluation completed in the First Pass and Reference [54], it is expected that with mitigation the Full Operation of stationary and non-stationary sources would improve the cooling tower score to a 5; compared to a 3 for no abatement.

No mitigation is required for OTC systems.
ABATED SCORING:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>5</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>5</td>
</tr>
</tbody>
</table>

SUPPORTING INFORMATION:

Noise Abatement

Noise effects on residential receptors are largely related to background traffic, and to a lesser extent, the influence of St. Mary’s Cement. A moderate noise effect was noted at the closest residence west of the DN Site. The predicted noise increase for the balance of the residential receptors is expected to be negligible during all phases of the Project. It has been stated that no additional mitigation is recommended for Project related noise effects; however, abatement options will still be evaluated [54].

Noise abatement is necessary if acoustic demands are made which cannot be met by using low noise equipment alone. The silencers used for this have influence on the design of cooling towers, component selection and operation of the cooling tower.

The fitting of noise reduction measures can substantially impact the operating parameters of a cooling tower and are likely to reduce cooling capacity. All aspects of the design must be considered and designed as a system, accounting simultaneously for sound and cooling performance.

Silencers

Duct silencers can be used to reduce the noise level only at the air-inlet and air-discharge openings. Their use may be necessary for severe noise level reduction.

The duct silencers usually contain baffles, with mineral wool packing and parallel air passages. The attenuation increases with the length and thickness of the baffles and decreases with the distance between them.

Noise attenuation by baffles is generally given as insertion attenuation for band sound levels (expressed usually in octave band levels). This means that the same arrangement of baffles may lead to different results for attenuation when the band levels of noise sources are different, even when the overall levels have the same magnitude.

Hence it is necessary to know the partial band sound power levels for the cooling tower openings when determining effective noise reduction measures.

It should be noted that the use of silencers can result in an additional pressure drop which has a substantial effect on the operating point of the fan. The supplementary pressure loss can require a significant increase in drive power and/or numbers of fan blades in order to maintain cooling performance (Section 6.2 [65]).

Screening

The use of screens can reduce the noise pressure level in the vicinity of a cooling tower. An insertion attenuation of 10 - 15 dBA can be achieved. The characteristic length is defined as the path difference from noise source to observer, with and without the screen. The noise reduction depends on the frequency and path difference. At low frequencies only minor reductions in noise level can be achieved.
Furthermore, the noise reduction effect is dependent on weather conditions.

The effect of the screen increases as the distance to the cooling tower decreases and the margin by which the screen periphery is at a higher level than the noise source. Generally the screens are used for reducing the noise which is propagated by air inlet openings and cooling tower walls. To minimize the additional pressure drop, the distance to the cooling tower should not be less than the height of the cooling tower inlet area. The side facing the cooling tower can be coated with sound absorbing material to further reduce the noise level.

The reductions in noise level which can be achieved with series cooling tower arrangements vary, even with the same geometric conditions. The reason for this is the broad spread of spectra of the noise propagated from the air inlet. It must be stated clearly that the use of screens does not reduce the noise power levels of a noise source.

When it comes to the sizing and location of such sound barrier walls, it is recommended to closely cooperate with the suppliers of the cooling tower and sound barrier wall and an acoustical engineer to ensure that the acoustical requirements are met. Sound barrier walls can provide an effective solution to a problem where sound radiation is only critical in certain directions, since they offer the possibility to "partially" encapsulate (Section 6.3 [65]).

**Encapsulation**

To further improve the acoustical performance of cooling tower with sound attenuation, encapsulation may be considered. By encapsulation, any noise radiation from the cooling tower shell can be reduced. Such a measure is only justified if the noise radiated from the shell has a dominating influence on the total noise radiated. For this reason encapsulation is only sensible if the air, water and mechanical (motor) noise of the tower are already attenuated.

Encapsulating is often applied with smaller equipment in an indoor location. In such a case only the intake and discharge areas radiate noise to the surroundings. The noise emitted from the shell will stay inside the enclosure. The prediction of this noise not only depends on the noise coming from the shell but also the type of enclosure, as the noise will be reflected from the surrounding walls. Due to reflections, the internal noise can increase but usually the noise inside a machine room is of less concern (worker protective measures may be required). For the external noise radiation it is recommended to specify partial sound power levels for the air intake and discharge areas.

When an indoor location of the cooling tower cannot be considered, it is possible to reduce the shell emissions by acoustical encapsulation. For such encapsulation to be effective it is necessary to use insulation material with a high mass. Heat insulation material is not suitable for this purpose. With properly selected insulation material it is possible to acoustically match an indoor installation. When applying the encapsulation it must however be assured that access to the cooling tower maintenance points is maintained, i.e. the encapsulation must not obstruct any access doors.

Encapsulation is acoustically feasible but generally requires a significant investment. It is recommended to closely cooperate with the supplier of both cooling tower and encapsulation and an acoustical engineer to ensure that the acoustical requirements are met.

Sound barrier walls are also a means of acoustical encapsulation. Such walls are built in the vicinity of the cooling tower either in the sound critical direction or as a total enclosure. Due to the distance between sound barrier wall and cooling tower the access to maintenance points is assured (Section 6.4 [65]).

There is also the possibility of encapsulation in the form of depth landscaping, where equipment (pumps etc.) would "sink" into the soil, which would act as a sound barrier. However, there is concern over the increase in excavation and the limitation of space; this abatement option would need additional engineering design.
Initial Screening

A specific noise abatement technology has yet to be determined, since it requires further engineering design. Any inclusion of noise abatement would not yield a change in the physical size or configuration of the Mechanical Draft Cooling Towers. An initial screening of the noise abatement options shows that silencers or a silencer/screening combination would yield the highest results in lowering the cooling tower noise levels.
## 2.4 Water Consumption

### Attribute Scoring Criteria

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>1</td>
<td>Water consumption rate is ≥4.5 m³/s</td>
</tr>
<tr>
<td>2</td>
<td>Water consumption rate is ≥3 but &lt;4.5 m³/s</td>
</tr>
<tr>
<td>3</td>
<td>Water consumption rate is ≥1.5 but &lt;3 m³/s</td>
</tr>
<tr>
<td>4</td>
<td>Water consumption rate is &gt;0 but &lt;1.5 m³/s</td>
</tr>
<tr>
<td>5</td>
<td>No water consumption rate due to evaporation</td>
</tr>
</tbody>
</table>

### First Pass Evaluation — No Abatement

#### Summary of Evaluation:

For Once Through Cooling, it is expected that the net consumption of water due to evaporation is negligible; receiving a score of 5.

Cooling tower operation would have a consumption rate of 4.5 m³/s; giving cooling towers with four units a score of 1. Two units would have a rate of 2.25 m³/s and receive a score of 3. It should be noted that this consumption rates are negligible compared to the Lake Ontario inflow rate.

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Water Consumption rate (m³/s)</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
<td>Two Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>negligible</td>
<td>negligible</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>4.5</td>
<td>2.25</td>
</tr>
</tbody>
</table>

#### Current Scoring:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>5</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>1</td>
</tr>
</tbody>
</table>

### Supporting Information:

Water consumption is defined as the quantity of water lost due to evaporation and drift (i.e. not returned to the water body).

In Ontario, water taking is regulated by Ontario’s Water Taking Regulation (O. Reg. 387/04) [66]. Anyone who requires more than 50,000 litres of water a day from water resources such as lakes, rivers, streams or groundwater sources, must obtain a Permit to Take Water (PTTW) from the MOE. These permits help to ensure the conservation, protection, management and sustainable use of Ontario’s water.
When a PTTW is issued, it comes with terms and conditions that the permit holder must follow strictly when actually conducting water taking activities. However there is no specific regulation, guideline or standard limiting water consumption although there is a government fee associated with water consumption, which is $3.71 CAD/1000 m$^3$ [66].

**Four Units**

**Once Through Cooling Option**

Net consumption of water associated with OTC, if any, would be from the evaporation process. For the DNNP, if the OTC is adopted, cooling water flowing through condensers will be discharged to Lake Ontario through diffusers which are 10 to 20 m under the lake surface (Section 3.4 [37]). The discharged cooling water would quickly be mixed with lake water. The maximum expected temperature increase at the surface is minimal, at the edge of the turbulent mixing zone is $<0.7 ^\circ C$, and at the centreline of the jet of the turbulent mixing zone is $<1.3 ^\circ C$ [38]. Therefore, it is expected that the additional evaporation due to the release of discharge cooling water, which is beyond the normal evaporation of lake water to air, is minimal. As such, the net consumption of water due to the evaporation process is scored as negligible.

**Mechanical Draft Cooling Tower**

For cooling towers, the net consumption of water will be due to evaporation and drift. Also, a portion of circulated cooling water (water blowdown) will be discharged back to the lake after appropriate treatment, which will reduce the net water consumption. It has been determined by the CNSC that the water vapour present in the cooling tower plume discharge should not be considered to return to Lake Ontario.

The EA evaluated that the cooling tower flow withdrawal from Lake Ontario would be approximately 6 m$^3$/s, while operating on a “four cycle” system (cycle refers to the cycles of concentration, a measure of cooling tower operation efficiency, which is equal to the tower water (system) concentration divided by makeup water concentration. Increasing the number of cycles reduced the rate of withdrawal but increases the concentration of contaminants in the blowdown (discharge) water). The rate at which water would be lost to evaporation would be 4.5 m$^3$/s. The remaining 1.5 m$^3$/s will “bleed-off” from the cooling tower and return to Lake Ontario (Section 4.2.1 [38]).

**Two Units**

It was assumed that water consumption for the case of two units will be 50% of that for four units [23]. On this basis, the water consumption due to evaporation and /or drift would be negligible for OTC and 2.25 m$^3$/s for the MDCT option.

**UNCERTAINTY:**

Once Through Cooling has limited uncertainty due to the potential increase in evaporation of water from the lake due to the presence of a thermal plume. However, it is assumed that the net evaporation due to this effect is negligible.

For the cooling tower option, the evaporation rate is related to the local meteorological conditions and the design and operational conditions of the cooling tower. For example, the employment of plume abatement technology will not only reduce the visual effect associated with the plume generated by cooling tower but also reduce the water consumption due to evaporation [67].

However, given the high Lake Ontario inflow rate ($\sim$7,000 m$^3$/s), the effect of the uncertainty associated with the impact of water consumption on performance of the options is judged to be small.
SECOND PASS EVALUATION - ABATEMENT

SUMMARY OF EVALUATION:

For Once Through Cooling, it is expected that abatement is not required and the net consumption of water due to evaporation is still negligible; receiving a score of 5.

Mechanical draft cooling towers with plume abatement would have a 20% reduction in the baseline consumption (non-abated cooling towers). Therefore, the abated cooling tower would have a consumption rate of <3.6 m$^3$/s; giving cooling towers with four units a score of 2. Two Units would have a rate of <1.8 m$^3$/s and receives a score of 3.

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Water Consumption rate(m$^3$/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td></td>
<td>Two Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>negligible</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>&lt;3.6</td>
</tr>
<tr>
<td></td>
<td>&lt;1.8</td>
</tr>
</tbody>
</table>

ABATED SCORING:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>5</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>2</td>
</tr>
</tbody>
</table>

SUPPORTING INFORMATION:

Once Through Cooling Option

Since the net consumption of water due to evaporation process is negligible for OTC, it is not considered for abatement.

Mechanical Draft Cooling Tower

Wet/dry MDCT with plume abatement, also referred to as a Hybrid towers, are a common form of plume abatement cooling tower. For the purpose of this report, these are referred to as MDCT with plume abatement (Enclosure 1 - Section 1.2 [2]).

The MDCT with plume abatement uses the normal evaporation process but also involves dry heat transfer to the atmosphere. Not only would this decrease the frequency of a vapour plume, but water consumption would be expected to be 10-30% less than non-abated towers (Appendix B [2]). An average value of 20% water consumption reduction from the baseline (non-abated cooling towers) is assumed for this attribute; giving a consumption rate of <3.6 m$^3$/s for four units. It is assumed that this number is halved for two units; <1.8 m$^3$/s.

For more information on plume abatement, see the attribute “Visual Effects”.

UNCERTAINTY:

With plume abatement, there is still high uncertainty with respect to the evaporation rates of each cooling option. However, given the high Lake Ontario inflow rate (~7,000 m$^3$/s), the effect of the uncertainty associated with the impact of water consumption on performance of the options is judged to be small.
2.5 Local Climate Change

**Attribute Scoring Criteria**

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Any technology-induced presence of icing on Highway 401</td>
</tr>
</tbody>
</table>
| 1     | • Either >30 days of additional off-site fogging or  
        • >24 hours of off-site icing (no icing on Highway 401) |
| 2     | • ≥20 but <30 days of additional off-site fogging or  
        • ≥16 but <24 hours of off-site icing (no icing on Highway 401) |
| 3     | • ≥10 but <20 days of additional off-site fogging or  
        • ≥8 but <16 hours off-site icing (no icing on Highway 401) |
| 4     | • >0 but <10 days of additional off-site fogging or  
        • >0 but <8 hours of off-site icing (no icing on Highway 401) |
| 5     | No adverse effect |

Note: If an option obtains different scores for fogging and icing impact then the lower of the two scores will be used.

**First Pass Evaluation — No Abatement**

**Summary of Evaluation:**

OTC would not experience any fogging or icing since this system does not produce a vapour plume or have any releases to atmosphere other than evaporation. Therefore, Once Through Cooling has no adverse effects on local climate; receiving a score of 5.

The cooling tower analysis showed that regardless of configuration of the MDCT, fogging effects would be infrequent, no large icing effects would occur, and water deposition was minimal. There would be less than one additional day (≤20 hours) for off-site fogging and only an additional 2 hours of icing per year [54]. It is predicted that the extent of fogging and icing for two units are half of that for four units. These effects result in a score of 4 for both four units and two units.

**Fogging Summary**

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Fogging on Site Property (h/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td></td>
<td>Two Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Negligible</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

**Icing Summary**

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Icing on Site Property (h/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td></td>
<td>Two Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Negligible</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>
CURRENT SCORING:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score Four Units</th>
<th>Score Two Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Once Through</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

SUPPORTING INFORMATION:

Assessment Criteria

Currently, there are no Federal or Provincial criteria for assessing effects related to cooling tower operation. However, the U.S. Nuclear Regulatory Commission (NRC) has a 1999 document “Standard Review for Environmental Reviews for Nuclear Power Plants” which provides instructions for the type of information to be included in applications related to nuclear power plants. This document also identifies limited criteria which can be used to assess environmental effects. The only specific guidelines provided in this document to assess cooling tower effects are related to the effects of fogging and icing (Section 3.1 [54]).

Fog or Ice – use an order of magnitude approach as follows:
- Fogging or icing of vegetation on the order of a few hours per year is generally not severe;
- Fogging or icing on the order of tens of hours per year may cause detectable damage to vegetation;
- Fogging or icing occurring for hundreds of hours per year could be severe enough to suggest the need for design changes.

Bounding Cases

Since the OTC system does not produce a vapour plume or have any releases to atmosphere other than evaporation, it is not considered in this assessment.

Mechanical draft cooling towers operate by forcing air through circulating water using large fans, and are often installed in series; as in the case for the DNNP (Section 5.2 [54]). There is one main cooling tower configuration for the assessment of four units; individual cooling towers would be assembled into four linear rows, each 37 m wide, 316 m long and 16 m tall (Appendix I - Section 1.2 [2]). It is assumed that for two units, the cooling tower dimensions would be the same, but are assembled into two linear rows.

Description of Model – SACTI

The Seasonal Annual Cooling Tower Impacts (SACTI) model is a mathematical model for the prediction of the seasonal/annual physical impacts of cooling tower plumes, drift, fog, icing and shadowing. This model was developed specifically for use in Environmental Impact Statements for nuclear and fossil-fuelled electric generating stations in the US and has been field validated (Section 5.0 [54]).

Fogging

For fogging to occur, the visible plume must touch the ground. This requires high wind speeds and low dew point depression. Figure G-5 demonstrates the number of hours that fogging could occur for a linear cooling tower configuration. The MDCT may cause on-site fogging to occur up to 20 hours per year, and fogging on Highway 401 could occur up to approximately 10 hours per year; as seen in Figure G-5.

On average (1953-2001), fog resulting in a visibility of <1km would occur approximately 26 days per year.
(624 hours) around the DNNP site. The meteorological conditions that may result in fogging due to MDCT operation, would be similar to the conditions which cause fogging along the north shore of Lake Ontario (Section E 3.1 [54]). Therefore, the addition of 20 hours of on-site fogging and 10 hours on Highway 401 does not significantly add to the overall frequency of fogging, but only coincide with normal fog conditions.

Fogging due to MDCT should not be a cause for any additional safety concerns along Highway 401, the extension of Highway 407, South Service Road, any on-site roads, or St. Mary's Cement. Safety protocols already in place for the natural effects of fogging.

This analysis was completed under the bounding scenario of four units, it is reasonable to assume that the extent of fogging is halved for two units. The number of hours for fogging between two and four units is considered to be equal, since this is dependent on weather conditions.

**Figure G-5: Predicted Annual Hours of Fogging for Mechanical Draft Cooling Towers – Linear Configuration (Section E.3.1 [54])**

Note that this figure is a fogging model result for Mechanical Draft Cooling Towers only and is not a representation of the potential layout for DNNP.

Icing

Icing is predicted to occur during a fogging condition when the temperature is below 0°C. Because the prevailing winds (particularly in the winter) are from the north-west quadrant, icing conditions are predicted to occur only south-east of the cooling towers, and for only about 1-2 hours per year. No icing of Hwy. 401 is predicted. See Figure G-6 for the number of hours which icing will occur. This analysis was completed under the bounding scenario of four units, it is reasonable to assume that the extent of icing is halved for two units. The number of hours for icing between two and four units is considered to be equal, since this is dependent on weather conditions.

On average (1953-2001), there is about 20 hour of freezing rain per year along the north shore of Lake Ontario.
Ontario. An addition of 1 to 2 hours per year of icing, most of which would occur over the DNNP site and Lake Ontario (see Figure G-6), is not considered to add to the overall natural icing that occurs (Section 6.3.2 [54]). Icing due to MDCT should not be a cause for any additional safety concerns along Highway 401, the predicted extension for Highway 407, South Service Road, or any on-site roads. Safety protocols are in place for the natural effects of icing.

There could be potential impacts resulting from prevailing winds blowing water vapour towards the St. Mary’s Cement site. Since it has been noted that icing due to the MDCT plume is not expected to significantly add to the hours that occur naturally and remain mostly on-site (Figure G-6), icing loads on structures and transmission lines are not considered to be significant. The MDCT icing should not be a cause for any additional safety concerns for the St. Mary’s process, docking operation and on-site workers; since there are already safety protocols for natural icing.

Nine Mile Point Nuclear Station also predicted a relatively low number of hours of icing around the site (See Uncertainty). However, the site’s parking lot had to be re-configured due to frequent icy condition.

It should be noted that a search was conducted to determine if icing was a major concern for various nuclear stations, but no issues were found.

**Figure G-6: Predicted Annual Hours of Icing for Mechanical Draft Cooling Towers – Linear Configuration (Section E.3.2 [54])**

Note that this figure is an icing model result for Mechanical Draft Cooling Towers only and is not a representation of the potential lay out for DNNP.

**UNCERTAINTY:**

Inherent uncertainty exists in the climate change modelling. In order to evaluate the uncertainty, three other nuclear sites were examined to compare the expected number of icing hours. Two plants expected icing to occur over 35 hours a year, but one plant had also modelled a low number of hours of icy conditions. Therefore it is reasonable to assume that the number of icing hours around Darlington may have been under-predicted when compared to predictions at other nuclear sites.

See Addendum A for description for each of the three sites, including modelling results.
SECOND PASS EVALUATION - ABATEMENT

The cooling tower analysis showed that regardless of the configuration of the towers, fogging and icing effects on Hwy. 401 would be infrequent. However, it is reasonable to assume that the total hours for fogging and icing will decrease due to plume abatement. See Visual Effects evaluation for more detail.

ADDENDUM A

Salem Generating Station

The Salem Generating Station is located in Lower Alloways Creek Township, New Jersey and owned by Public Service Enterprise Group (PSEG) Nuclear LLC. The facility wanted to build a new intake structure and had to choose between Mechanical or Natural draft cooling towers. Decisions were based on an Environmental Impact Statement. The Environmental Assessment used the Seasonal and Annual Cooling Tower Impacts (SACTI) model for the MDCT scenario to assess fogging/icing potential. In order to complete a preliminary assessment for potential fogging and icing impacts, a previous SACTI study on MDCT conducted by PSEG (for Linden Generating Station) was examined. The Linden study was conducted using northeastern New Jersey (Newark Airport) meteorological conditions. It evaluated the same tower design as assumed for the Salem closed-cycle MDCT retrofit option and therefore is useful to provide an “order of magnitude” assessment for the Salem/Hope Creek site.

The towers were modelled as approximately 15 m above grade and the plumes from these towers were expected to have a greater probability of causing significant fogging/icing near the tower based on the results of Salem study. The assessment stated that there were no critical offsite public highways, bridges or other infrastructure in the area that would appear to be near enough to be adversely impacted by the Mechanical Draft Cooling Tower plume icing.

The maximum distance at which at least one hour per year of icing was predicted was approximately 1200 m southwest of the towers. For onsite impacts, the greatest number of hours of predicted impacts occurred within 200 m of the cooling towers. Onsite icing impacts were predicted at 35.6 hour/year. The predominant directions for icing impacts were stated to be south and west of the towers, due to the previously mentioned adverse meteorological conditions commonly associated with easterly component winds which promote long plumes and plume touchdown. Note that impacts from the MDCT installed for Salem would be expected to be more severe than those impacts modelled for the Linden Generation Station because of the greater heat and moisture release (Section 3.A.2.c [68]).

As a general comparison to DNNP the number of icing hours is 6% of that predicted for the Salem Station.

Indian Point Energy Centre

Indian Point Energy Centre Unit No. 3 is located in Buchanan, NY. It sits on the east bank of the Hudson River and is owned and operated by Entergy Nuclear Northeast.

Indian Point compared a NDCT to a mechanical closed-cycle cooling tower system in an environmental assessment. The EA determined that the operation of MDCT would produce a moderate frequency of occurrence of icing but this would cause negligible problems. The model calculations were based on the hourly on-site meteorological data for the full year period October 1973 through September 1974 recorded by means of the 400-foot meteorological tower.

Icing conditions were modelled for wet linear configuration MDCT operation. Predictions indicated that icing would not occur in November; however, 20 hours of icing were predicted for December, 20 hours
for January, 30 hours for February, 10 hours for March and 3 hours for April. The annual icing occurrence was determined to be 83 hours (Section 6.1.3 [69]).

As a general comparison to DNPP the number of icing hours is 2% of that predicted for Indian Point.

**Nine Mile Point Nuclear Station**

Nine Mile Point Nuclear Station (NMPNS) is located in Scriba, northeast of Oswego NY on the shore of Lake Ontario. The 900 acre site is also occupied by the Fitzpatrick Nuclear Generating Station and operated by Constellation Energy Group.

An assessment of Nine Mile Point Unit 3 Nuclear Power plant (NMP3NPP) completed a comparison of MDCT and NDCT. For NMP3NPP, the impacts from fogging and icing were modelled using the Electric Power Research Institute’s Seasonal/Annual Cooling Tower Impact (SACTI) prediction code.

Icing was predicted to occur for a maximum of 0.2 hours during the winter season in the south-southwest direction. Icing was not predicted to occur during the spring, summer or fall seasons. Annually, the icing would occur for a maximum of 0.61 hours in all directions. Icing was most likely to occur on-site and would occur off-site for less than 1 hour per year. This represents a very small percentage of the total hours per year (0.01%). No icing was predicted to occur at the closest road or agricultural area (Section 5.3.3.1.3 [70]).

As a general comparison to DNPP the number of icing hours is equivalent to Nine Mile Point.
### 2.6 Visual Effect

#### Attribute Scoring Criteria

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>1</td>
<td>Negative changes to the visual aesthetics observed &gt;10 km from the site</td>
</tr>
<tr>
<td>2</td>
<td>Negative changes to the visual aesthetics observed 3 to 10 km from the site</td>
</tr>
<tr>
<td>3</td>
<td>Negative change to the visual aesthetics observed in the vicinity of the site (&lt;3 km)</td>
</tr>
<tr>
<td>4</td>
<td>No discernible reduction in visual aesthetics</td>
</tr>
<tr>
<td>5</td>
<td>Improvement of visual aesthetics</td>
</tr>
</tbody>
</table>

Note: The distance range used here (<3 km, 3 to 10 km and >10 km) is consistent with the distances used for the assessment in the EA [33].

#### First Pass Evaluation – No Abatement

**Summary of Evaluation:**

The OTC system does not produce a plume and therefore is not a concern for this evaluation. However, it does not improve the visual aesthetics of the DN site and is therefore given a score of 4.

Reference [33] completed an evaluation of the potential visual plume created by MDCT. It was determined that the worst case vapour plume would have a length of 10,000 m with a height of 1000 m and a radius of 500 m. It was determined that the plume would be seen over 10 km away from the DN site property; therefore, the cooling tower option was given a score of 1.

It is expected that the visual effects modelled for cooling towers with four units (visibility of vapour plume) would also apply to two units to an equal or lesser extent.

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Visual effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>No discernible reduction in visual aesthetics</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>Changes to the visual aesthetics can be observed over 10 km from the site and cannot be fully mitigated.</td>
</tr>
</tbody>
</table>

#### Current Scoring:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
<td>Two Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
SUPPORTING INFORMATION:

Once Through Cooling

Four Units / Two Units

OTC has no obvious vapour plume as the result of station operation. Therefore it is not assessed in this evaluation.

Mechanical Draft Cooling Tower

Four Units

The considered layout for MDCT is that the individual towers would be assembled into four linear rows [71]. However, the bounding scenario for the visual effects assessment was established to be four circular MDCT. These were selected because they have the greatest plume dimensions and/or visible plume characteristics (Section 3.0 [33]). It is assumed that these configurations are equivalent for the context of plume assessment.

The MDCT plume itself would have the appearance of a white cloud. The cooling tower structures would be visible when heading west on Highway 401. The MDCT would also be visible with the new extension of Highway 407 and the plume would be visible from the lake. The MDCT and the associated plume would not cause more of a visual distraction than an ordinary industrial site.

Modelling

The landscape and visual setting was assessed using an established assessment methodology and professional judgement. Views and vistas identified in Reference [33] were compared to the expected views and vistas after the construction of the cooling towers. A computer simulated image of the project was superimposed onto photographs that were taken during site reconnaissance. In establishing the baseline, the characteristics and locations of views likely to be affected were identified. For the effects assessment, a determination is made of what, if any, view changes will be discernible in the Local and Regional Study Areas prior to mitigation, and whether there will be a permanent effect on the visual setting (views and viewsheds).

The cooling tower will be located on the south-eastern portion of the OPG property. Four different vapour plume scenarios for the cooling towers were established to reflect general seasonal changes, summer and winter temperature differences and visual bounding conditions (Section 3.2.1.2 [33]).

The atmospheric modelling created height, length and radii data for the plume based on compass directions. A cumulative vapour plume was developed based on the atmospheric data. For the purposes of this modelling, four scenarios were derived from the atmospheric data. These include (Section 3.2.1.2 [33]):

1. 50th Percentile - Median
   a. Foliage
   b. No-Foliage
2. Worst Case Scenario – theoretical bounding condition
   a. Foliage
   b. No-Foliage

Table G-17 identifies plume dimensions based on the median and worst case scenarios. Although data for four vapour plume scenarios is provided, modelling was completed for the 'worst case' plume scenario in 'no foliage' condition because it is the theoretical bounding condition for the project from a visual perspective (Section 3.2.1.2 [33]).
Table G-17: Mechanical Draft Cooling Tower Vapour Plume Scenarios (Section 3.2.1.2 [33])

<table>
<thead>
<tr>
<th>Plume Dimension</th>
<th>50th Percentile*</th>
<th>Bounding Condition/Worst Case for Vapour Plume**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Foliage</td>
<td>Foliage</td>
</tr>
<tr>
<td>Height (m)</td>
<td>840</td>
<td>430</td>
</tr>
<tr>
<td>Length (m)</td>
<td>3,500</td>
<td>700</td>
</tr>
<tr>
<td>Radius (m)</td>
<td>305</td>
<td>125</td>
</tr>
</tbody>
</table>

*Median

**Theoretical worst case scenario

The frequency of the plume for the four seasons is displayed in Table G-18.

Table G-18: Visible Plume Frequency - Mechanical Draft Cooling Tower Comparison (Presentation Page 4 [71])

<table>
<thead>
<tr>
<th>Cooling tower technology</th>
<th>Winter %</th>
<th>Spring %</th>
<th>Summer %</th>
<th>Fall %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unabated</td>
<td>99</td>
<td>93</td>
<td>66</td>
<td>93</td>
</tr>
</tbody>
</table>

Visual Assessment Analysis

Visual assessment locations have been assessed depending on the sensitivity of the view, distance from the DN site, degree of obstruction, extent of visibility and duration of view.

The views have been organized into four categories that are used in the Assessment of Environmental Effects for modeling and effects assessment. These four assessment categories include (Section 4.3 [33]):

1. Views from potentially sensitive locations within 3 km of the DN site.
2. Views from key locations in the Local and Regional Study Areas; located greater than 10 km from the DN site.
3. Views from key transportation corridors (i.e., Highway 401, Highway 35/115, and planned Highway 407) in the Local and Regional Study Areas; located at various distances to the DN site from within close proximity of DN site to 10 km from the DN site.
4. Views from Lake Ontario and the Lake Ontario waterfront; located over 10 km from the DN site.

Items 3 and 4 above are not significant when compared to 1 and 2 as per the scoring scheme. These categories were not considered in the scoring of this attribute.

The views for the worst case scenarios for MDCT without plume abatement are illustrated in Figure G-7 to Figure G-10. Note that these diagrams were completed by a professional engineering company representing what a plume might look like; actual visual effect depends on specific weather conditions.
Figure G-7: Views from Potentially Sensitive Locations in Bowmanville - Within 3 km of the DN Site Property (Figure 4.3-7 [33])

Figure G-8: Views from Key Transport Corridors in the Local and Regional Study Areas – 4.5 km away from DN site Property (Figure 4.3-12 [33])
Based on the modelling completed, it is clear that the vapour plume created by the MDCT will be visible at large distances. The tower structures were rarely visible from various locations but the vapour plume was visible regardless of the presence of foliage.

Two Units
It is expected that the visual effects modelled for the case of cooling towers with four units (visibility of
vapour plume) applies to two units to an equal or lesser extent.

**UNCERTAINTY:**

There is a low level of uncertainty for this attribute since the worst case scenario vapour plume was modelled for the purpose of the visual analysis. There is also extensive operating experience for cooling towers in colder climates. However, it is anticipated that the plume characteristics will change through the year based on atmospheric conditions which will create variability in the plume appearance (Section 4.3.4 [33]). Therefore the predicted score was based on the worst case values presented in Table G-17. Table G-19 presents the predictions for worst and optimal cases for MDCT.

<table>
<thead>
<tr>
<th>Table G-19: Uncertainty Scoring for Mechanical Draft Cooling Tower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
</tr>
<tr>
<td>Worst Case</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

**SECOND PASS EVALUATION - ABATEMENT**

**SUMMARY OF EVALUATION:**

OTC does not produce a plume, therefore no mitigation is required. The Second Pass score is equivalent to the First Pass.

With the inclusion of plume abatement, the frequency, dimension and density of the plume generated by the cooling towers can all be reduced. When plume abatement is utilized, the frequency of a visible plume in the summer reduces from 66% to 3% and 93% to 15% in the fall. The visible plume would only be minimally observed over 10 km away from the DN site, therefore the plume abated cooling tower would be given a score of 2; compared to the score of 1 for no abatement.

**ABATED SCORING:**

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>4</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>2</td>
</tr>
</tbody>
</table>

**SUPPORTING INFORMATION:**

Wet/dry MDCT with plume abatement, also referred to as a Hybrid tower, are a common form of plume abatement for cooling towers. For the purpose of this evaluation, these are referred to as MDCT with plume abatement. The MDCT with plume abatement scenario consists of the construction and operation of four linear MDCT with plume abatement and four reactor units (Section 1.2 [71]).

The atmospheric modeling that was completed in the first pass, was also used for abated cooling towers; creating height, length and radii data. Again, the cumulative vapour plume was developed based on the atmospheric data. Table G-20 identifies plume dimensions based on the median and worst case scenario for both abated and unabated MDCT. Note that 'Foliage' refers to summer and "No Foliage" to winter.
**Table G-20: Mechanical Draft Cooling Tower Vapour Plume Scenarios (Enclosure 2, Table 3 [71])**

<table>
<thead>
<tr>
<th>Plume Dimension</th>
<th>50&lt;sup&gt;th&lt;/sup&gt; Percentile*</th>
<th>Bounding Condition/Worse Case for Vapour Plume**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Foliage</td>
<td>Foliage</td>
</tr>
<tr>
<td><strong>Mechanical Draft Cooling Tower</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (m)</td>
<td>840</td>
<td>430</td>
</tr>
<tr>
<td>Length (m)</td>
<td>3,500</td>
<td>700</td>
</tr>
<tr>
<td>Radius (m)</td>
<td>305</td>
<td>125</td>
</tr>
<tr>
<td><strong>Mechanical Draft Cooling Tower with Plume Abatement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (m)</td>
<td>300</td>
<td>-</td>
</tr>
<tr>
<td>Length (m)</td>
<td>1,200</td>
<td>-</td>
</tr>
<tr>
<td>Radius (m)</td>
<td>100</td>
<td>-</td>
</tr>
</tbody>
</table>

*Median  
**Theoretical worst case scenario  

With the employment of the plume abatement technology, the frequency, dimension and density of the plume generated by cooling tower can all be reduced. For example, plume density can be reduced by 50% and the dimension can be reduced by 66%. As shown in Table G-21 below, the frequency of the plume generated by cooling tower with the plume abatement is in the range of 3% in summer to 46% in winter, corresponding to the frequency range of 66% to 99% when the abatement technology is not used. The frequency of the plume is reduced by over 70% compared with that generated by cooling tower without plume abatement [71].

**Table G-21: Visible Plume Frequency - Mechanical Draft Cooling Tower Comparison (Presentation Page 4 [71])**

<table>
<thead>
<tr>
<th>Cooling tower technology</th>
<th>Winter %</th>
<th>Spring %</th>
<th>Summer %</th>
<th>Fall %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without plume abatement</td>
<td>99</td>
<td>93</td>
<td>66</td>
<td>93</td>
</tr>
<tr>
<td>With plume abatement</td>
<td>46</td>
<td>11</td>
<td>3</td>
<td>15</td>
</tr>
</tbody>
</table>

The frequency of plume visibility could be further reduced if the operation of the cooling tower can be optimized.  
The addition of plume abatement also alters the dimensions for the cooling towers. As seen in Table G-22, when plume abatement is included, the height of the cooling towers rises by 75%; the length also increases by >24%.  

---

AMEC NSS Limited  
D0077/RP/001 R00  
Page 255 of 378
Table G-22: Mechanical Draft Cooling Tower Dimension [71]

<table>
<thead>
<tr>
<th>Cooling tower technology</th>
<th>Height (m)</th>
<th>Width (m)</th>
<th>Length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without plume abatement</td>
<td>16</td>
<td>37</td>
<td>316</td>
</tr>
<tr>
<td>With plume abatement</td>
<td>28</td>
<td>37</td>
<td>393</td>
</tr>
</tbody>
</table>

**Mechanical Draft Cooling Towers with Plume Abatement**

The visual effects of the presence of the MDCT and the potential vapour plume generated which has taken into account the plume abatement technology have been investigated based on the modelling results of the view at the following locations (Table 3.1-2 [71]):

- Three potentially sensitive locations within close proximity of the DN site: located within 3 km of the DN site
- One key location in the Local and Regional Study Areas: located greater than 10 km from the DN site
- Five locations at key transportation corridors (i.e., Highway 401, Highway 35/115, and planned Highway 407) in the Local and Regional Study Areas: located at various distances to the DN site from within close proximity of DN site to 10 km from the DN site.
- Two locations at Lake Ontario and the Lake Ontario waterfront: located over 10 km from the DN site.

The views for the worst case scenarios for MDCT with plume abatement are illustrated in Figure G-11 to Figure G-14. Note that these diagrams were completed by a professional engineering company representing what a plume might look like; actual visual effect depends on specific weather conditions.
Figure G-11: Views from Potentially Sensitive Locations in Bowmanville - Within 3 km of the DN Site Property (Figure 3.1-1 [71])

Figure G-12: Views from Key Transport Corridors in the Local and Regional Study Areas – 4.5 km away from DN Site Property (Figure 3.1-6 [71])
Figure G-13: Views from Key Locations in the Local and Regional Study Areas – Greater than 10 km Away from DN Site Property (Figure 3.1-4 [71])

The study concluded that the visual character throughout the Local and Regional Study Areas will be altered to varying degrees as a result of the development of the MDCT with plume abatement. The topography along with the presence of natural environmental features and existing structures may obstruct the view of the MDCT with plume abatement structures from some of the receptor locations. The vapour plume associated with the MDCT with plume abatement will however remain visually

Figure G-14: Views from Lake Ontario and Lake Ontario Waterfront – Location is over 10 km from DN Site Property (Figure 3.1-11 [71])
prominent. Visibility of the vapour plume as a result of the MDCT with plume abatement would therefore be considered to have a measurable change on the quality of views and vistas, in particular from Lake Ontario. In-design mitigation can be implemented to minimize the visual effects, but given the scale and the distance of the vapour plumes associated with the MDCT with plume abatement, mitigation measures will not completely eliminate the visual effects (Section 3.1.3 [71]).

Despite this, the MDCT with plume abatement structures and plume must be considered in the context of the surrounding setting and its current and future industrial uses (i.e., the St. Marys Cement facility to the east, and proposed energy from waste facility to the west). The frequency of the predicted plume visibility associated with the MDCT with plume abatement should also be considered. For the MDCT with plume abatement, the frequency of a visible plume is reduced in comparison to the unabated MDCT. In the winter months, because of the lower temperatures and relative humidity in the area, the plume could potentially be visible approximately 50% of the time. However, in the summer months the plume visibility drops to generally less than 3% of the time and in the spring and fall, the frequency of plume visibility is approximately 10-15% (Section 2.1.1.2 [71]). The frequency can be further reduced by optimizing the operation of the cooling towers. However, the tower structures will remain visible at all times from some of the receptor locations such as the 401 and Lake Ontario.

Types of Plume Abatement

The frequency of plume visibility can be reduced if the operation of the cooling tower can be optimized. Evaporative cooling systems often emit a visible plume. Even though a cooling tower plume contains mostly pure water and hardly any pollutants, it is often seen as a nuisance. Below is a list of several abatement technologies to eliminate the visible plume from an evaporative cooling tower [72]. However, it is not determined yet what specific technology will be utilized.

Parallel Path Wet-Dry (PPWD) with Water-to-Air Heat Exchangers

For this abatement technology, the plenum of the tower is extended upward to leave room for the fin tube and heating coils to be installed vertically along the sides of the tower. Hot water from the process goes into the heating coils first then into the wet section. Sometimes the water flow going to the heating coils is a fraction of the overall water flow rate; air dampers are often installed in front of the heating coils. In the summer mode of operation, the air dampers are closed so most of the cooling air goes through the wet section, but due to damper leakage some air bypasses the wet section resulting in additional energy usage. In the no-plume mode of operation, the air dampers are open and some cooling air goes through the wet section while some cooling air goes in parallel through the dry section. The air coming from the wet section is warm and saturated with moisture, while the air going through the dry section is hot and dry. When both flows of air mix in the plenum, the overall relative humidity of the exhaust air is less and the plume remains invisible.

PPWD is a good technology, particularly adapted to large field erected towers; however, it is usually expensive. The water-to-air heat exchangers are typically metallic fin tube bundles consisting of 10-12 fins per inch and designed in accordance with standard API 661. This technology requires higher than usual plenum heights for the water-to-air heat exchanger installation. The resultant high structural loads, due to additional weight and a higher center of gravity, become critical under seismic and wind load requirements. Baffles can be installed in the tower plenum to enhance the mixing between the hot dry air and the saturated air and provide level 2 plume abatement. A vacuum system is also added to remove the non-condensable gases trapped at the top of the tube bundles while at the same time providing a siphon that lowers considerably the operational pumping head.

Parallel Path Wet-Dry with Air-to-Air Heat Exchangers

Another PPWD technology uses air-to-air heat exchangers made of patented plastic packs in the tower plenum designed to de-saturate the leaving air by sensible heat transfer with ambient air.
Series Path Wet-Dry (SPWD)

Another way to abate the plume, more typically utilized in packaged cooling towers, is by heating the exhaust air with heating coils in the plenum above the drift eliminators or over the fan. The amount of heat required to heat the exhaust air enough to abate the plume is much greater in the case of a PPWD system. Typically very hot water or preferably steam is used to heat the air and the heating coils have only one or two rows of tubes. In addition, the added static pressure incurred year-round from the fin coil makes the application of this technology in induced draft cooling towers often impractical, and adds to the overall fan energy.

Dual Coil Closed Circuit Cooling Tower

The dual coil closed circuit cooling tower is based on a new fin coil technology that has been developed to provide water conservation and plume abatement for factory assembled and field erected cooling towers. In contrast to the PPWD and SPWD arrangements, the dual coil closed circuit cooling tower is comprised of two separate spiral fin coils and two independent spray water systems. The fin coils serve a dual purpose of providing both sensible and latent heat transfer, depending on the ambient conditions.

Although fin coils have been used extensively for dry cooling, there have also been limited applications in evaporative closed circuit cooling equipment to improve winter operation dry capacity and limited free cooling. Typical fin coils, utilized in these coolers, are comprised of round tube coils with spiral fins spaced at 4-5 fins per inch. These coils tend to be constructed of spiral fins on round tubes with welded return bends. However, the cost of the dry cooling capacity for these round tube fin coils is a large increase in the air-side pressure drop which in turn negatively impacts the tower thermal capability in the design summertime evaporative cooling mode.

The new spiral fin coil technology utilizes elliptical tubes with an extended surface fin tension wound around the tube. The elliptical tube design allows for closer tube spacing, resulting in greater surface area per plan area than round tube coil designs and without the air side pressure drop increase. Because of this, the thermal capacity is greatly increased compared to bare tube elliptical coils. The elliptical spiral fin technology increases heat transfer and reduced air side pressure drop as compared to round tube fin coils. This reduced air-side pressure drop allows for less fan energy with increases in heat transfer efficiency. The dual coil closed circuit cooling tower offers a combination of sensible and evaporative heat transfer to significantly reduce any plume that may occur with evaporative cooling equipment.

During the coldest times of the year, when the potential for visible plume is greatest, the dual coil closed circuit cooling tower operates 100% dry, completely eliminating the plume and using no water. This new arrangement can operate with the entire unit spray system on, or one half of the spray system on and half dry, or in completely dry operation. When the dual coil tower operates with one coil wet and the other dry, the visibility of the plume is reduced. The process fluid to be cooled flows in series from the first coil to the second. The dry coil is the first coil, with the warmest process fluid. Warm dry air then exits into the fan plenum from the first dry coil while warm moist air exits from the second wet coil.

If necessary, air mixers can be installed in the plenum section to provide more thorough mixing of the hot saturated air and the hot dry air before discharging to the atmosphere to completely eliminate the visible plume for most or all conditions. Under severe cold weather conditions, the dual coil closed circuit cooling tower can be operated in 100% dry mode, again completely eliminating the plume under the most difficult conditions.

For these applications, both water savings and plume abatement can be achieved without adding to the tower height or fan power requirements. The change to a closed system must be anticipated in the design stage since a heat exchanger is no longer needed and piping will change. In addition, substituting a closed circuit cooler instead of an open cooling tower allows for smaller evaporative water inventory and less water treatment chemical requirements in the warmer seasons, while allowing for no water or water treatment chemicals at all during cold months.
Initial Assessment

An initial screening of the plume abatement options gave preference to Parallel Path Wet-Dry with Water-to-Air Heat Exchangers, as they are expected to help reduce the frequency of a visual plume while being the most cost effective.

UNCERTAINTY

There is higher uncertainty for Mechanical Draft Cooling Towers with abatement, since the abatement technology is not readily used in the nuclear industry. See the attribute Technical Performance for more discussion. Furthermore, the visibility of the tower structure at off-site locations such as the 401 may change as a result of the final cooling tower design (dimensions) and site layout/configuration.
### 2.7 Excavated Material

<table>
<thead>
<tr>
<th>ATTRIBUTE SCORING CRITERIA</th>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Exceeds the estimated volume of 2.6 Mm(^3) of additional excavated materials which requires off-site management</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.7 Mm(^3) to 2.6 Mm(^3) (inclusive) of additional excavated materials which requires off-site management</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.87 Mm(^3) to 1.7 Mm(^3) (inclusive) of additional excavated materials which requires off-site management</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Less than 0.87 Mm(^3) of additional excavated materials which requires off-site management</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>No additional excavated materials requiring off-site management (all being used for 2 m lake infill and on-site storage)</td>
</tr>
</tbody>
</table>

#### FIRST PASS EVALUATION – NO ABATEMENT

**SUMMARY OF EVALUATION:**

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Additional Off-Site Soil Management (Mm(^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>0</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>2.62</td>
</tr>
</tbody>
</table>

**CURRENT SCORING:**

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>5</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>1</td>
</tr>
</tbody>
</table>

**SUPPORTING INFORMATION:**

**Site Layouts for Consideration**

The latest DNPP site layout drawings are contained in the OPG submission to the JRP in response to Undertaking 29 [50] and the MPR report [2].
Background

The amount of off-site soil disposal is dependent on the amount of excavation required for the reactor block and cooling technology. Reactor block excavation would be disposed in various on-site soil disposal locations; any additional excavation for the cooling technology would be placed in any remaining on-site soil disposal areas. Once the on-site locations are exhausted, soil would be transported off-site.

In total, there would be 71 ha of space available for DNNP, which would primarily occupy the eastern one-third of the overall DNGS site, (note that 1 ha = 10,000 m$^2$). The amount of available usable space is broken down as follows [1]:

- 17.2 ha north of the CN railway line,
- 7.7 ha south of the rail line but north of the access road, and
- 46.1 ha south of the access road (including the portion of the lake infill east of the protected area). This area will support the reactor block and all supporting facilities.

The space requirement for the cooling options does impact land use by making space unavailable for other OPG uses; such as, support facilities, offices or lay down areas. Note that all excavation quantities used are Bank or bench Cubic Meters (bcm); defined as the net quantity before excavation or in-situ quantity.

Reactor Block Baseline

The reactor block would require a total excavation of 8.77 Mm$^3$ regardless of the chosen cooling technology. The first on-site location of disposal is a North-East soil stockpile, which would hold 4.50 Mm$^3$. Soil can also be deposited into a lake infill that would extend to a 2 m depth contour; this would be consistent with the JRP recommendations. The reactor block would only require a partial 2 m lake infill, located just west of Maple Grove Road, which would be constructed to accommodate different reactor types and condenser cooling systems; this is independent to the chosen cooling option [23]. This partial 2 m lake infill would hold 0.457 Mm$^3$, providing 12.2 ha of space; see Figure G-15 for layout and Section 5.2.4 for details.

The remaining 3.81 Mm$^3$ of excavated material would require off-site soil management (storage or selling). This assessment is an evaluation of the amount of additional excavation that requires off-site transfer. It would be ensured that an appropriate off-site location will be found and that all Clarington by-laws are observed; this includes the of dumping fill, removing fill or altering grades within the Municipality of Clarington, under by-law No. 2008-114 as amended by By-law 2012-022 [73,74].

Assessment

Four Units

The following are excavation quantities (in Mm$^3$) that were calculated for this project:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Excavation Required</th>
<th>Disposal</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 m Lake Infill</td>
<td>NE Soil Stockpile</td>
</tr>
<tr>
<td>Reactor Block</td>
<td>8.77</td>
<td>0.457</td>
<td>4.50</td>
</tr>
<tr>
<td>OTC</td>
<td>Negligible</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MDCT</td>
<td>2.89</td>
<td>0.268</td>
<td>0</td>
</tr>
</tbody>
</table>
Once Through Cooling

The OTC would have a negligible amount of space, allowing all reactor supporting facilities to fit on-site with ease. OTC would require excavation for a 2 km intake channel with a 10 m diameter intake, yielding about 157,000 m$^3$ of material. This material from the intake channel would consist of rock that would be used elsewhere on-site (i.e. crushed stone). Also, this excavation is in an order of magnitude that is smaller than the excavation amount for the reactor block; therefore the quantity of excavation is considered negligible. Since OTC would require no additional off-site soil management, this cooling option is give a score of 5.

Mechanical Draft Cooling Tower

An optimized MDCT would require 30 ha of space; however, due to tower alignment, the use of a full 2 m lake infill would be necessary. This full lake infill would extend beyond Maple Grove Road, providing an additional 7.2 ha of space for a total space amount of 19.4 ha. The tower cannot be place in the space north of the access road (7.7 ha) for a number of reasons:
• It would be too close to the CN rail line to be used for industrial purposed (safety issue),
• The grade is too steep, and
• The shape/location of the area surrounding the proposed MDCT position would not be very useful for other building needs.

Note that the current proposed placement of the MDCT and site facilities requires more than the allotted 2 m infill as set by the JRP. This would require customized engineering work in order to meet the lake infill criterion. In addition, some of the supporting facilities would need to be moved off-site, potentially increasing costs and associated risks.

The MDCT would require 2.89 Mm$^3$ of excavation; including the reactor block this give a total excavation of 11.7 Mm$^3$. The area west of Maple Grove Road for the full 2 m lake infill would allow an additional 0.268 Mm$^3$ for disposal; giving a total of 0.725 Mm$^3$ of infill disposal area. The remaining 2.62 Mm$^3$ of material would be transferred off-site. Since this additional 2.62 Mm$^3$ of excavated materials which requires off-site management is an incremental difference from the reactor block is; therefore, a score of 1 is assigned to MDCT.

2 Units

To not limit the future use of the site, it is assumed the excavation for four units would be done regardless. The scoring for the 2 units is the same as for 4 units.

Off-Site Soil Management

It is assumed that a “conventional truck” with a capacity of 10 Mm$^3$ will be used for off-site transfers. The reactor block baseline would require 3.81 Mm$^3$ of off-site material to be managed, therefore about 381,000 truck loads.

The OTC would not require any addition off-site soil management; therefore no trucks are required for the implementation of the OTC system. Since the MDCT system would require 2.62 Mm$^3$ of soil transfer, when compared to the baseline, it would require an addition 262,000 truck loads, for a total of about 643,000 trucks.

The location and route for the soil disposal has not yet been identified, but it is assumed that the trucks will have a 25 km radius from DNNP for disposal travel. This 50 km return trip would cause nuisance effects for neighbours and road ways. These nuisance effects include (Section 6.0 [43]):

• Green house gas emissions for the excavation and disposal of the soil,
• Impacts on the degradation of road and infrastructure used for the off-site disposal of the soil,
• Redesign of access roads and possible road repairs,
• Increase in the amount of dust in the surrounding DNNP area during excavation,
• Noise and traffic issues for the public for the off-site disposal of the soil, and
• Impacts on the local wildlife with the increase of road activity

However, excavation and off-site soil management would only occur during the site preparation period; two to three years, which is a relative short time span in relation to the plant life. Excavation and off-site transfer would not have any adverse long-term effects to the surrounding land and wildlife.

There was consideration of using the CN rail line for off-site soil transfer, but the train would block entrance to St. Marys Cement and spur construction is not economically achievable.

Concerns about the public safety implications of having an increase of truck traffic is discuss in Public Health and Safety attribute.
**UNCERTAINTY:**
Moderate, site layouts, quantity of material to be excavated and space may vary as a result of reactor and cooling technology selection.

**Sensitivity Analysis #1 – Excavation Values**
The original Darlington topography was done prior to DNGS construction. The latest two updates to the topography included:
- A 2001 topography update done by Northway Photomap for Hydro 1 Networks.
- A 2007 topography update done by Northway Photomap in the area around the DWMF.
The updates were done using photographs taken from a plane flying overhead. A datum point is used at a landmark on the ground and the topography is generated throughout the rest of the map. The method is accurate within a few feet.
As the excavation numbers are so large (millions of cubic m), any uncertainty in the method would have minimal impact on the excavation values and no impact on the scoring.

**SECOND PASS EVALUATION - ABATEMENT**

**MITIGATION**
There is no direct mitigation that has been examined for reducing the excavation of both cooling options.
However, the amount of materials to be excavation for MDCT may be impacted by the choice of plume abatement technology (see the Visual Effects attribute); since the footprint of MDCT with plume abatement may be larger additional excavation would be required. Since the major mitigation change is related to height, it is expected that the abated towers would continue fit within the 30 ha of space available. However, this may depend on the final configuration and design of the towers and the chosen reactor technology. If the footprint is larger for abated towers, the excavation would increase proportionally, causing uncertainty in this attribute which may require additional engineering optimization for site layout.
3. Habitat and Ecosystems

3.1 Fish Impingement

<table>
<thead>
<tr>
<th>ATTRIBUTE SCORING CRITERIA</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Reduction &lt;80% for impingement compared to a once through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>1</td>
<td>Reduction ≥80% but &lt;85% for impingement compared to a once through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>2</td>
<td>Reduction ≥85% but &lt;90% for impingement compared to a once through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>3</td>
<td>Reduction ≥95% but &lt;95% for impingement compared to a once through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>4</td>
<td>Reduction ≥95% for impingement compared to a once through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td>5</td>
<td>No impingement</td>
</tr>
</tbody>
</table>

FIRST PASS EVALUATION – NO ABATEMENT

SUMMARY OF EVALUATION:
The OTC option intake structure is an update from the baseline condition at DNGS, which includes a porous veneer intake structure to reduce fish impingement by 80% as compared with an OTC shoreline intake without fish protection. This quantity of fish not impinged (14,360 kg per annum), gives the Once Through Cooling option a score of 1. An unmitigated MDCT will often achieve fish impingement reductions >90% (>16,155 kg per annum of fish not impinged); this gives the MDCT option a score of 3.

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Fish Impingement Reduction (biomass not impinged– kg per annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>80% (14,360)</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>&gt;90% (&gt;16,155)</td>
</tr>
</tbody>
</table>

CURRENT SCORING:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>1</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>3</td>
</tr>
</tbody>
</table>
**SUPPORTING INFORMATION:**

Section 32 of the Canadian *Fisheries Act* states that “no person shall destroy fish by any means other than fishing except as authorized by the Minister or under regulations made by the Governor in Council under this act.” There are no provisions in this Act for proposed technologies to meet specific goals in impingement reduction. However, legislation existing in the US may be used as guidance for Canada. Recently, the CNSC gave the PNGS a target to reduce fish impingement by 80% (resulting in the installation of a barrier net and implementation of an effectiveness study in 2010) and this was based on guidance of the US EPA 316b Phase II legislation for existing facilities (Section 1.0 [24]).

US EPA Clean Water Act, Section 316b Phase I legislation for cooling water intakes for “new” facilities recommends using cooling towers (Track I) or best technology available (BTA as equivalence-Track II) to minimize adverse effects due to impingement. Requirements for US EPA 316b Phase I, Track I include reducing the intake flow, at a minimum, to a level commensurate with that which can be attained by a closed-cycle recirculating cooling water system. Requirements for Track II include: demonstrating that the alternative technologies employed will reduce the level of adverse environmental impact from the cooling water intake structure to a comparable level to that which would be achieved with Track I; and 2) demonstrating that the technologies employed will reduce impingement mortality to 90% or greater of the reduction that would be achieved through Track I (Section 1.0 [24]).

**DNPP Impingement Reduction Baseline – Once Through Cooling**

Fish impingement reductions at DNPP were established by scaling DNGS baseline impingement performance by the increased flow rate. The fish impingement performance that DNGS would achieve, if it had a Once Through shoreline intake system without any fish protection, was established using data from neighbouring nuclear power plants. This is presented in the DNGS section below.

**PNGS**

The CNSC requested that OPG reduce fish impingement at their Pickering Nuclear Facility with a target of 80%. The 80% target was based on guidelines set out in the US EPA 316b Phase II Rule for existing facilities. It was estimated that PNGS achieved approximately 80% reduction in impinging fish biomass in 2010 (4,617 kg per annum) compared to the baseline data in 2003/04 (18,214 kg per annum) when no fish protection measures were in place (based on impingement sampling). Furthermore, the Fish Diversion System Barrier Net, which was installed in 2010, was found to range from 75% (spring season) to 100% (fall season) effective based on intensive hydroacoustic and gillnetting assessments. On average, the barrier net at PNGS was at least 80% effective in reducing fish impingement based on both the hydroacoustic and gillnetting assessments (Section 2.1.1.1 [24]).

**DNGS**

The DNGS impingement can be established by comparison with other power plants on the Great Lakes [24]. The comparison is particularly relevant with PNGS since impingement measurements were conducted at both PNGS and DNGS during the same year (2010-11). PNGS is located on Lake Ontario approximately 35 km west of DNGS and there is an accepted impingement reduction baseline for PNGS based on pre- and post- fish protection measures.

A total of 304,593 fish per annum were impinged at PNGS compared to the slightly lower count of 274,931 fish per annum at DNGS in 2010-11; note that PNGS had the FDS Barrier Net in place during this time. However, in terms of biomass, impingement losses at DNGS are approximately half that of PNGS (2362 kg/year vs. 4617 kg/year, respectively). At DNGS, 13 species and 2 groups identified to family level were impinged. At PNGS, 41 species were impinged, as well as 5 groups identified to family level. It must be noted that the electrical output of DNGS (3512 MW) is also 12% higher than PNGS (3100 MW). Based on the PNGS and other power plant comparisons, it is evident that the performance of the off-shore DNGS porous veneer intake structure is effective in reducing impingement.

The intake structure at DNGS includes a unique porous veneer intake structure which has been
specifically designed to reduce fish impingement and the intake structure has been placed offshore at a 10 m depth. The porous veneer cap is made of 184 structurally independent precast reinforced concrete modules and a reinforced concrete center piece. 124 porous veneer modules consist of concrete vanes separated by a 14 cm wide space and each is flush with the lake bottom. A stainless steel 15 cm x 15 cm screen overlay is placed over each porous module.

Based on recent annualized estimates of impingement at DNGS (2010-11 data) and comparisons to annualized estimates at other Great Lakes facilities, in particular PNGS (2010 data), the impingement reduction at DNGS (i.e. its baseline) is estimated at 80% effective compared to a shoreline installation. In terms of fish impingement biomass lost, this relates to approximately 2,362 kg per annum of fish impinged (9,448 kg/year of fish not impinged) compared to an extrapolated estimate of 11,810 kg\textsuperscript{12} per annum, with a shoreline surface intake installation and no fish protection (Section 2.1.1.1 [24]).

**DNNP**

The baseline condition at DNNP includes a unique porous veneer intake structure which has been specifically designed to reduce fish impingement and the intake structure has been placed offshore at a 10 m depth. The porous veneer cap is made of 242 structurally independent precast reinforced concrete modules and a reinforced concrete center piece. 182 porous veneer modules consist of concrete vanes separated by a 14 cm wide space and each is flush with the lake bottom. A stainless steel 15 cm x 15 cm screen overlay is placed over each porous module (Section 4.1.1.1 [38]). The intake rate would be 228 m\textsuperscript{3}/s [23] and this design is expected to achieve a mean water intake velocity (as permitted at DNGS) of 12.2 cm/s (Section 4.1.1.1 [38]). See the Aquatic Habitat evaluation for more details.

Considering that the DNNP intake is potentially larger by 52%, to accommodate the additional flow (DNGS = 150 m\textsuperscript{3}/s and DNNP = 228 m\textsuperscript{3}/s) (Section 1.0 [44]) while still maintaining an average approach velocity of 12.2 cm/s [24], the scaled DNGS impingement baseline for the DNNP is as follows:

\[
2362 \text{ kg impinged (DNGS)} \times \frac{228}{150} = 3590 \text{ kg per annum impinged at DNNP, which is an 80% reduction from a shoreline intake with no fish protection systems (Section 1.0 [44]). Based on extrapolated calculations presented for DNGS, DNNP would have approximately 14,360 kg per annum of fish not impinged compared to an estimate of about 17,950 kg per annum for a shoreline Once Through system with no fish protection.}
\]

**Impingement Reduction Baseline – Mechanical Draft Cooling Towers**

**DNNP**

Based on US EPA 316b Phase I literature, cooling tower performance achieves a >90% reduction in impingement from conditions with no fish protection or mitigation in place (Section 2.3.1.2 [24]). Since the cooling towers would have the same approach velocity as OTC (12.2 cm/s) [38], there would be >16,155 kg per annum of fish not impinged (<1,795 kg per annum impinged).

The intake structure for cooling tower makeup water would use four separate water intake pipes located at a water depth of 10 m (similar to DNGS) [2]. Impingement losses at 10 m depth will be considerably lower than those occurring under baseline conditions for OTC at DNNP [24].

---

\textsuperscript{12} This value is derived as follows. If the DNGS veneer is 80% effective and 2,362 kg per annum of fish is impinged, then it is only impinging 20% of the biomass that would be impinged if the intake were a shoreline installation with no fish protection in place. Thus, 100% of this biomass (i.e., shoreline installation and no fish protection) would be estimated at 11,810 kg per annum.
Assessment Results:

Four Units

The OTC impingement reduction is 80% (14,360 kg per annum of fish not impinged).
The MDCT impingement reduction is >90% (>16,155 kg per annum of fish not impinged)

Two Units

The intake structure will be sized for the maximum number of units to be built on-site. Thus, the intake structure for two units will be sized for four units. Although the intake tunnel would be constructed for four units the intake structure could differ. It is possible that the complete intake structure for 4 units would be built or two separate intake structures sized for 2 units each. For the latter, the intake structure would be sealed until the final 2 units are constructed. The impingement percentage reduction will be equal for both 4 and 2 units, but the biomass of fish impinged for two units is expected to be half of that for four units.

The OTC impingement reduction is 80% (7,180 kg per annum of fish not impinged).
The MDCT impingement reduction is >90% (>8,077 kg per annum of fish not impinged).

UNCERTAINTY:

This set of data is considered to be bounding.
SECOND PASS EVALUATION - ABATEMENT

SUMMARY OF EVALUATION:
MDCT mitigation includes the placement of wedgewire screens around the intake structure; this is expected to have a fish impingement reduction of >95% (>17,050 kg per annum of fish not impinged). The OTC has several mitigation measures which include finer intake screens, screens made of copper alloy and decreased approach velocity. When utilizing these abatement measures, fish impingement reduction is increased to >90% (>16,155 kg per annum of fish not impinged) [44]. These mitigation measures alter the scoring for the cooling towers to a 4, and the OTC option to a 3.

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Fish Impingement Reduction (biomass not impinged– kg per annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>&gt;90% (&gt;16,155)</td>
</tr>
<tr>
<td>Mechanical tower</td>
<td>&gt;95% (&gt;17,050)</td>
</tr>
</tbody>
</table>

ABATED SCORING:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>3</td>
</tr>
<tr>
<td>Mechanical tower</td>
<td>4</td>
</tr>
</tbody>
</table>

SUPPORTING INFORMATION:
OPG has made commitments on optimizing the intake structure at DNNP for further reducing impingement.

Mechanical Draft Cooling Tower Impingement Reduction

The US EPA316b Phase I Rule for new facilities indicates that fish protection in addition to a cooling tower may be expected if species at risk or of concern are in the vicinity of the intake structure. Round Whitefish are a species of special concern for the Lake Ontario Management Unit of MNR. Since Round Whitefish are found in the vicinity of DNGS at the proposed 10 m depth for the cooling tower intake, wedgewire screens have been considered as a design enhancement and are included as part of the intake structure (as opposed to a conventional velocity cap). There is OPEX for wedgewire screens for low CCW flows (e.g. 17.5 m³/s at Unit 3 at the J.H. Campbell Plant in Lake Michigan). The addition of a wedgewire screen will also reduce the risk of impingement of species of concern such as American eel which was impinged at DNGS in 2011 (Section 2.3.1.1 [24]).

With a 2 mm wedgewire screen, impingement reduction is >95% (<900 kg per annum of fish impinged, and >17,050 kg per annum of fish not impinged) for MDCT (Section 2.3.1.2 [24]).

Once Through Cooling Impingement Reduction

In order to determine the impingement reduction for the OTC system, the DNNP baseline was first established in the first pass evaluation. The reference design was further enhanced and further reductions from the baseline were considered.
**DNNP Once Through Cooling Intake**

Based on the review of options presented in Evaluation of Performance Improvements to the DNNP Intake Design [44], the best option for OTC is to improve the porous veneer structure. This may include the following design considerations (Section 2.0 [44]):

- Removal of concrete vanes to increase the porous area of modules and reduce the available area for zebra mussel growth (biofouling mitigation);
- Use of a finer screen than the baseline DNNP made of zebra mussel deterrent material. The following mesh screen option is being considered:
  - 10 cm opening (square) with cross members of 2.5 cm thickness (width);
- Reduction in average approach velocity from 12.2 cm/s [38] to 6 cm/s.

**Evidence to Support Improved Design**

**Screens**

**Screen Size**

The present baseline condition for the DNNP is 14 cm spaced slots along the length of each porous module (approximately 5.5 m). Earlier laboratory studies have illustrated that fish avoidance response varies not only with spacing (5 to 30 cm) but also the diameter of the material (i.e., cross members) used (Patrick 1981). Smaller spacing will result in an improved performance in reducing fish passage. Consequently, a reduced size opening from 14 cm to 10 cm should result in some improved performance. In addition, thickness of the cross member is also a variable in eliciting a fish avoidance response.

For the DNNP, the proposed intake design consideration should include a coarse mesh with a 10 cm opening and cross-members of 2.5 cm thickness. Based on the 10 cm screen designs, the porosity of the porous module is 45%. The number of porous modules required to achieve a mean intake velocity of 6 cm/s is 276. The total intake structure will occupy approximately 10,500 m², which represents an increase of 79% over the existing intake structure in DNGS (Section 2.11 [44]).

**Screen Material and Biofouling**

Biofouling by zebra mussels can be prevented or reduced by having the screen made of copper alloys. The proposed screen for the DNNP considers a copper-nickel alloy to minimize zebra mussel attachment. There are two examples where this alloy has proven effective in reducing biofouling.

1. In July 1993, intake screens at Unit 3 at the J.H. Campbell Plant located on Lake Michigan were removed and retrofitted with a copper-alloy based screen called Z-Alloy. Zebra mussel biofouling (up to 7 cm thick) had become a problem at the plant. In November 1999, plant operators examined the screens which had never been cleaned since initial installation, and found them to be free of zebra mussels. Only normal light debris was reported. In contrast, the “control” stainless steel structure to which the Z-Alloy screens were attached was heavily colonized by zebra mussels. Furthermore, the Z-Alloy screens were also free of filamentous algae growth compared to stainless steel screens. It was estimated that if all 56 screen sections at Unit 3 were retrofitted with Z-Alloy, the copper discharge concentration would be 0.1 parts per billion (ppb), which is less than one percent of the Michigan Department of Natural Resources ‘safe’ level of 11 ppb.

2. Another example where copper-nickel screens have been installed is at the Oak Creek Power Plant also on Lake Michigan. Twenty-four Z-Alloy screens were installed approximately 2.4 km offshore and in 13.7 m of water. This arrangement was considered to be the largest number of Z-Alloy screens currently used in the U.S. for a single project. Each screen is 10.7 m long, 2.4 m wide and placed 1.5 m off the lake bottom (wedgewire screens). The Z-Alloy screens have been effective in minimizing Zebra Mussel attachment and have reduced annual Zebra Mussel maintenance costs.
Given that lake conditions are similar in Lake Ontario and Lake Michigan, copper-nickel alloy screens should be effective at minimizing Zebra Mussel attachment and algal growth on screens, as well as reducing maintenance costs for the proposed screens at the DNNP (Section 2.11 [44]).

**Flow Reduction**

An approach velocity of less than 15 cm/s is considered best technology available (BTA) in the US EPA proposed draft Rule (USEPA 2011). It should also be noted that EPA may have a provision (in the final Rule due July 2012) that species of concern may not be adequately protected by the intake velocity requirements (i.e., 15 cm/s), and that the owner/operator may also have to employ fish friendly protection measures such as a fish handling and return system. However, no significant impingement of species of concern is expected with a further reduced low average approach velocity of 6 cm/s at the DNNP. The sustained and burst swimming capabilities of juvenile and adult fish commonly impinged at DNGS are well above this velocity. Flow velocity reduction is considered more important than a reduction in screen mesh size. Thus, an impingement reduction of >90% (<1,795 kg impinged) is expected. That is, the difference in total area between the two cases is also not as significant as the reduction in approach velocity. While different fish species have different swimming abilities, smaller fish are generally weaker swimmers and thus a reduction in average approach velocity would translate into more fish being able to overcome or avoid the approach velocities and therefore avoid impingement (Section 2.1.2 [44]).

The estimated reduction in fish impingement would be >90% from a OTC shoreline intake with no fish protection for a 10 cm screen opening and an approach velocity of 6 cm/s. With these abatement measures, there would be >16,155 kg of fish not impinged (<1,795 kg impinged). This is based on a considerably lower approach velocity (from 12 cm/s to 6 cm/s), reduced screen size opening (14 cm to 5 cm) and zebra mussel abatement (Section 2.2.6.3 [24]).

**Assessment Results:**

**Four Units**

The enhanced OTC impingement reduction is >90% (>16,155 kg per annum of fish not impinged).

The enhanced MDCT impingement reduction is >95% (>17,050 kg per annum of fish not impinged).

**Two Units**

The size of the intake structure will be sized for the maximum number of units to be built on-site. Thus, the intake structure for two units will be sized for four units. Although the intake tunnel would be constructed for four units the intake structure could differ. It is possible that the complete intake structure for 4 units would be built or two separate intake structures sized for 2 units each. For the latter the intake structure would be sealed until the final 2 units are constructed. The impingement percentage reduction will be equal for both 4 and 2 units, but the biomass of fish impinged for two units is expected to be half of that for four units.

The enhanced OTC impingement reduction is >90% (>8,077 kg per annum of fish not impinged).

The enhanced MDCT impingement reduction is >95% (>8,525 kg per annum of fish not impinged).

**UNCERTAINTY:**

The above data are considered to be bounding.
### 3.2 Fish Entrainment

<table>
<thead>
<tr>
<th>ATTRIBUTE SCORING CRITERIA</th>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>Reduction of &lt;60% % for entrainment compared to a once through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Reduction of ≥60% but &lt;70% for entrainment compared to a once through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Reduction of ≥70% but &lt;80% for entrainment compared to a once through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Reduction of ≥80% but &lt;90% for entrainment compared to a once through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Reduction of ≥90% for entrainment compared to a once through shoreline intake system without fish protection mitigation</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>No entrainment</td>
</tr>
</tbody>
</table>

### FIRST PASS EVALUATION – NO ABATEMENT

#### SUMMARY OF EVALUATION:

The baseline conditions at DNGS have an entrainment reduction of 60%. Compared to levels expected with a shoreline installation and no fish protection in place, OTC at DNNP would not entrain $1.73 \times 10^7$ eggs + larvae per annum, based on 2006 data [24]. This option is given a score of 1.

Unmitigated MDCT would often achieve fish entrainment reductions >90%, equating to about $>2.60 \times 10^7$ eggs + larvae per annum not entrained, based on 2006 data [24]. The cooling towers are given a score of 4.

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Four Units</th>
<th>Two Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Once Through</td>
<td>60% ($1.73 \times 10^7$)</td>
<td>60% ($8.67 \times 10^6$)</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>&gt;90% ($&gt;2.60 \times 10^7$)</td>
<td>&gt;90% ($&gt;1.30 \times 10^7$)</td>
</tr>
</tbody>
</table>

#### CURRENT SCORING:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>1</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>4</td>
</tr>
</tbody>
</table>

#### SUPPORTING INFORMATION:

Section 32 of the Canadian *Fisheries Act* states that “no person shall destroy fish by any means other than
fishing except as authorized by the Minister or under regulations made by the Governor in Council under this act.” There are no provisions in this Act for proposed technologies to meet specific goals in entrainment reduction. However, legislation existing in the US may be used as guidance for Canada.

US EPA 316b Phase I legislation for “new” facilities recommends using MDCT (Track I) or best technology available (BTA as equivalence - Track II) to minimize adverse effects due to entrainment. Requirements for USEPA 316b Phase I, Track I include reducing the intake flow, at a minimum, to a level commensurate with that which can be attained by a closed-cycle recirculating cooling water system. Requirements for Track II include: demonstrating that the alternative technologies employed will reduce the level of adverse environmental impact from the cooling water intake structure to a comparable level to that which would be achieved with Track I; and 2) demonstrating that the technologies employed will reduce entrainment of all life stages of fish to 90% or greater of the reduction that would be achieved through Track I (Section 1.0 [24]).

**DNPP Entrainment Reduction Baseline – Once Through Cooling**

Fish entrainment reductions at DNPP were established by scaling DNGS baseline entrainment performance by the increased flow rate.

**DNGS**

The intake structure at DNGS includes a unique porous veneer intake which has been specifically designed to reduce fish entrainment and the intake structure has been placed offshore at a 10 m depth. The porous veneer cap is made of 184 structurally independent precast reinforced concrete modules and a reinforced concrete center piece. Each porous veneer module consists of concrete vanes separated by a 14 cm wide space and each is flush with the lake bottom. A stainless steel 15 cm x 15 cm screen overlay is placed over each porous module [24].

The DNGS entrainment reduction baseline was established by a review of available data including entrainment studies conducted at DNGS in 2004 and 2006 as well as larval tow data collected in 1986-88, 1990, 2009 and 2011 (Section 2.1.1.2 [24]).

There is no direct comparison with another power plant because entrainment studies were not conducted in the same year for PNGS as was the case for impingement. Therefore, an emphasis has been placed on the larval depth studies which clearly suggest that fewer larvae are present at deeper depths. The majority of larvae (relative percentage 44%) can be found at approximately the 5 m depth. Approximately 90% of all larvae collected were collected within the 2-10 m depth range. Larval presence decreases after 10 m, with the exception of a small increase at the 15.5 m depth. It should be noted that a few Round Whitefish larvae were found at the 15.5 m depth. Even though these data do not include Round Goby, a recent invasive species, (entrainment data unavailable), the conclusions remain valid (Section 2.1.1.2 [24]).
(Data from years 1986-1988, 1990, 2009 and 2011; note that the sampling data was not completed in full, but it still provides a good representation of the amount of larvae collected at each depth.)

Based on the depth data provided above and best professional judgment, it is estimated that the performance of the DNGS intake porous veneer would be conservatively a minimum of 60% effective in reducing overall entrainment compared to a shoreline installation with no fish protection. In terms of eggs and larvae lost, this amounts to $7.60 \times 10^6$ eggs + larvae per annum, based on 2006 data ($1.14 \times 10^7$ eggs + larvae per annum not entrained), compared to an estimated $1.90 \times 10^7$ eggs + larvae per annum entrained with a shoreline intake installation and no fish protection\(^{13}\) (Section 2.1.1.2 [24]). In terms of age-1 equivalence (the number of age 1 fish that eggs and larvae lost to entrainment would have been expected to produce had they not been entrained) the $7.60 \times 10^6$ eggs + larvae per annum entrained is translated into 11,548 age-1 equivalents (Section 1.0 [44]).

**DNNP**

The baseline condition at DNNP includes a unique porous veneer intake structure which has been specifically designed to reduce fish entrainment and the intake structure has been placed offshore at a 10 m depth. The porous veneer cap is made of 242 structurally independent precast reinforced concrete modules and a reinforced concrete center piece. 182 porous veneer modules consist of concrete vanes separated by a 14 cm wide space and each is flush with the lake bottom. A stainless steel 15 cm x 15 cm screen overlay is placed over each porous module (Section 4.1.1.1 [38]). The intake rate would be 228 m$^3$/s [23] and this design is expected to achieve a mean water intake velocity (as permitted at DNGS) of 12.2 cm/s (Section 4.1.1.1 [38]). See the Aquatic Habitat evaluation for more details.

Considering that the DNNP intake is potentially larger by 52%, to accommodate the additional flow (DNGS = 150 m$^3$/s and DNNP = 228 m$^3$/s) (Section 1.0 [44]) while still maintaining an average approach velocity of 12.2 cm/s [24], the scaled DNGS entrainment baseline for the DNNP is as follows:

---

\(^{13}\) This value is derived as follows. If the DNGS veneer is estimated to be 60% effective, then it is only entraining 40% of eggs + larvae per annum that would be entrained with no fish protection or mitigation in place. Thus, 100% of eggs + larvae per annum (i.e., no fish protection or mitigation in place) would be estimated at $1.900 \times 10^7$ eggs + larvae per annum.
[7.601 x 10⁶ eggs + larvae per annum entrained (DNGS)] x 228/150 = 1.15 x 10⁷ eggs + larvae per annum entrained (DNNP) (60% reduction from a shoreline intake with no fish protection systems) (Section 1.0 [44]).

In terms of age-1 equivalence, this translates into 11,548 age-1 equivalents (DNGS) x 228/150 = 17,553 age-1 equivalents (DNNP) (60% reduction from a shoreline intake with no fish protection systems) (Section 1.0 [44]).

Based on extrapolated calculations presented for DNGS, DNNP would have approximately 1.73 x 10⁷ eggs + larvae per annum not entrained compared to an estimated total of about 2.89 x 10⁷ eggs + larvae per annum.

**DNNP Entrainment Reduction Baseline – Mechanical Draft Cooling Towers**

**DNNP**

The MDCT option requires a combined intake flow rate (intake and makeup for service water) of approximately 6 m³/s [44]; this rate is approximately 2.6% of the OTC DNNP flow. The intake structure for cooling tower makeup water would use four separate water intake pipes located at water depth of 10 m depth (similar to DNGS) [2]. At this depth entrainment will still likely occur but losses will be considerably lower than those occurring under baseline conditions at DNNP due to lower flow.

Based on US EPA 316b Phase I literature, cooling tower performance achieves a >90% reduction in entrainment from conditions with no fish protection or mitigation in place (Section 2.3.1.1 [24]). This entrainment reduction equates to <2.89 x 10⁶ eggs + larvae per annum not entrained, based on 2006 data (>2.600 x 10⁷ eggs + larvae per annum not entrained) and <4,389 age-1 equivalents.

**Assessment Results**

**Four Units**

The OTC entrainment reduction is 60% (1.73 x 10⁷ eggs + larvae per annum not entrained).

The MDCT entrainment reduction is >90% (>2.60 x 10⁷ eggs + larvae per annum not entrained).

**Two Units**

The intake structure will be sized for the maximum number of units to be built on-site. Thus, the intake structure for two units will be sized for four units. Although the intake tunnel would be constructed for four units the intake structure could differ. It is possible that the complete intake structure for 4 units would be built or two separate intake structures sized for 2 units each. For the latter the intake structure would be sealed until the final 2 units are constructed. The entrainment percentage reduction will be equal for both 4 and 2 units, but the number of eggs and larvae entrained for two units is expected to be half of that for four units.

The OTC entrainment reduction is 60% (8.67 x 10⁶ eggs + larvae per annum not entrained).

The MDCT entrainment reduction is >90% (>1.30 x 10⁷ eggs + larvae per annum not entrained).

**UNCERTAINTY:**

The above data are considered to be bounding; however, there is high uncertainty due to limited data on the amount of eggs and larvae entrained. There have been low sample volumes used in earlier entrainment sampling, especially in relation to CCW intake flow (Section 5.0 [44]). There also has been no extensive sampling completed to determine if there would be high amounts of entrainment for near shore species, such as Mysid Shrimp, Sculpin and Round Whitefish. It should be noted that the above entrainment values are approximations only.
SECOND PASS EVALUATION - ABATEMENT

SUMMARY OF EVALUATION:
The Once Through Cooling option has several mitigation measures which include finer intake screens, screens made of copper alloy and decreased approach velocity. However, screen design is not expected to have a significant effect on entrainment reduction, and a reduced flow rate was not evaluated. It is anticipated that entrainment will be reduced to >60% reduction from an OTC shoreline intake (>1.73 x 10⁷ eggs + larvae per annum not entrained) [44]. This however did not change the score for the once through system.

Through mitigation, the MDCT option is expected to have an entrainment reduction of ≥95%. This equates to about ≥2.74 x 10⁷ eggs + larvae per annum not entrained [44][24]; giving this option a score of 4.

<table>
<thead>
<tr>
<th>Cooling Options</th>
<th>Entainment Reduction (# of eggs and larvae not entrained per annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>&gt;60% (&gt;1.73 x 10⁷)</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>≥95% (≥2.74 x 10⁷)</td>
</tr>
</tbody>
</table>

ABATED SCORING:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>1</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>4</td>
</tr>
</tbody>
</table>

SUPPORTING INFORMATION:

Mechanical Draft Cooling Tower Entrainment Reduction

Based on US EPA 316b Phase I literature, MDCT performance achieves a >90% reduction in entrainment from conditions with a shoreline OTC intake with no fish protection or mitigation in place. With the addition of an enhanced 2 mm wedgewire screen overall reduction in entrainment could potentially reach of ≥95% (Section 2.3.1.2 [24]) while keeping the intake rate at 6.0 m³/s (Section 4.2.1 [38]).

This reduction of ≥95% is equal to about 1.444 x 10⁶ eggs + larvae per annum entrained (≥2.74 x 10⁷ eggs + larvae per annum not entrained) and 2,195 age-1 equivalents.

Once Through Cooling Entrainment Reduction

In order to determine the entrainment reduction for the OTC system the DNNP baseline was first established in the first pass evaluation. The reference design was further enhanced and further reductions from the baseline were considered.

DNNP Once Through Cooling Intake

Based on the review of options presented in Evaluation of Performance Improvements to the DNNP Intake Design [44], the best option for OTC is to improve the porous veneer structure. This may include
the following design considerations (Section 2.0 [44]):

- Removal of concrete vanes to increase the porous area of modules and reduce the available area for zebra mussel growth (biofouling mitigation);
- A finer screen than the baseline DNPP screen made of zebra mussel deterrent material. The following mesh screen option is being considered:
  - 10 cm opening (square) with cross members of 2.5 cm thickness (width);
- Reduction in average approach velocity from 12.2 cm/s [38] to 6 cm/s.

Evidence to Support Improved Design

**Screens**

**Screen Size**

The present baseline condition for the DNPP is 14 cm spaced slots along the length of each porous module (approximately 5.5 m). Earlier laboratory studies have illustrated that fish avoidance response varies not only with spacing (5 to 30 cm) but also the diameter of the material (i.e., cross members) used (Patrick 1981). Smaller spacing will result in an improved performance in reducing fish passage. Consequently, a reduced size opening from 14 cm to 10 cm should result in some improved performance. In addition, thickness of the cross member is also a variable in eliciting a fish avoidance response.

For the DNPP, the proposed intake design consideration should include a coarse mesh with 10 cm opening and cross-members of 2.5 cm thickness. Based on the 10 cm screen designs, the porosity of porous module is 45%. The number of porous modules required to achieve a mean intake velocity of 6 cm/s is 276. The total intake structure will occupy approximately 10,500 m$^2$, which represents an increase of 79% from the existing intake structure in DNGS (Section 2.1.1 [44]).

However, this screen mesh design is not expected to have a significant effect on entrainment reduction.

**Screen Material and Biofouling**

Biofouling by zebra mussels can be prevented or reduced by having the screen made of copper alloys. The proposed screen for the DNPP considers a copper-nickel alloy to minimize zebra mussel attachment and algal growth on screens, as well as reduced maintenance costs for the proposed screens at the DNPP (Section 2.11 [44]).

However, this screen material design is not expected to have a significant effect on entrainment reduction.

**Flow Reduction**

Although larval fish entrainment is expected to decrease somewhat for the enhanced DNPP design of 6 cm/s, it has not been evaluated. It is anticipated that entrainment will be reduced to >60% from a Once Through shoreline intake which translates to <1.15 x 10$^7$ eggs + larvae per annum entrained and <17,553 age-1 equivalents (>1.73 x 10$^7$ eggs + larvae per annum not entrained).

A review and analysis of data from 17 studies covering 9 species (n=76 individuals) showed a positive relationship exists between burst speed (i.e., speed attained in short sprints, usually behavioural response to capture prey or avoid predators) and larval fish size. Most of these species evaluated were marine not freshwater species.

In general, some larval fish as small as 3.8 mm can attain burst speeds of 6 cm/s and overcome the proposed DNPP design average approach velocity of 6 cm/s. In contrast, a 15-20 mm larval fish will be able to overcome approach velocity speeds of 15 cm/s or higher for short periods of time. Larval fish characteristics (e.g., size at hatch, swim speeds, etc.) may vastly differ among species but it is concluded that swimming ability is correlated with larval body size. However, it should be noted that temperature is...
also an important variable.

In summary, the proposed reduction in average approach velocity for the DNNP is expected to reduce larval entrainment. However, it should be noted that this reduction in average approach velocity to 6 cm/s is not expected to have an effect on egg entrainment or earlier post-hatch (smaller) larvae of some species.

Although it is evident that the number of entrained larvae will be reduced due to a lower approach velocity, it is conservatively assumed for DNNP that only a small further reduction in entrainment will be realized for these enhancements. Therefore the reduction in entrainment is >60% from baseline (<1.155 x 10^7 eggs + larvae per annum entrained) for the DNNP (Section 3.0 [44]).

**Assessment Results**

**Four Units**

The enhanced OTC system entrainment reduction is >60% (>1.73 x 10^7 eggs + larvae per annum not entrained).

The enhanced MDCT entrainment reduction is ≥95% (≥2.74 x 10^7 eggs + larvae per annum not entrained).

**Two Units**

The intake structure will be sized for the maximum number of units to be built on-site. Thus, the intake structure for two units will be sized for four units. Although the intake tunnel would be constructed for four units the intake structure could differ. It is possible that the complete intake structure for 4 units would be built or two separate intake structures sized for 2 units each. For the latter the intake structure would be sealed until the final 2 units are constructed. The entrainment percentage reduction will be equal for both 4 and 2 units, but the number of eggs and larvae entrained for two units is expected to be half of that for four units.

The enhanced OTC system entrainment reduction is >60% (>8.67 x 10^6 eggs + larvae per annum not entrained).

The enhanced MDCT entrainment reduction is ≥95% (≥1.37 x 10^7 eggs + larvae per annum not entrained).

**UNCERTAINTY:**

The above data are considered to be bounding; however, there is high uncertainty due to the larger intake area at a 10 m depth [44]. It should be noted that the above entrainment values are approximations only.
### 3.3 Thermal Discharge to Lake

#### Attribute Scoring Criteria

<table>
<thead>
<tr>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Exceeds baseline thermal plume/mixing zone from the EA study (&quot;baseline&quot;)</td>
</tr>
<tr>
<td>1</td>
<td>Less than or equal to base line plume / mixing zone</td>
</tr>
<tr>
<td>2</td>
<td>Reduction of &gt; 25% but ≤50% in thermal plume/mixing zone from baseline</td>
</tr>
<tr>
<td>3</td>
<td>Reduction of &gt; 50% but ≤75% in thermal plume/mixing zone from baseline</td>
</tr>
<tr>
<td>4</td>
<td>More than 75% reduction in thermal plume/mixing zone from baseline</td>
</tr>
<tr>
<td>5</td>
<td>No thermal plume/mixing zone</td>
</tr>
</tbody>
</table>

#### First Pass Evaluation – No Abatement

**SUMMARY OF EVALUATION:**

The OTC discharge diffuser has 90 discharge ports that are located between 600 m and 900 m offshore in a southerly direction. These ports are in water from 10 m to 20 m depth. The resulting temperature effects from this design will extend a maximum of 50 m from the diffuser and therefore receives a score of 1.

In contrast, the MDCT have 4 discharge ports resulting in a thermal plume that extends a maximum of 15 m from the diffusers. Taking into account the reduced lateral plume, the mixing zone for the cooling tower option is about 1% of that for the Once Through Cooling option which results in a score of 4 [37].

There is no specific estimate conducted for the case of two units.

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Size of mixing zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four Units</td>
<td></td>
</tr>
<tr>
<td>Once Through</td>
<td>Less than or equal to base line plume / mixing zone</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>About 1% of that for Once Through Cooling option</td>
</tr>
</tbody>
</table>

#### CURRENT SCORING:

<table>
<thead>
<tr>
<th>Cooling Option</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>1</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>4</td>
</tr>
</tbody>
</table>
SUPPORTING INFORMATION:

Four Units

Once Through Cooling Option

The OTC system will absorb heat from the condenser cooling system and, upon discharge to the lake, will result in an increased lake water temperature within the mixing zone.

The effect of thermal discharge can be assessed based on the location and the size of thermal plume or mixing zone. The mixing zone was defined, for the EA purpose, as the area in the plume where the water temperature is within 2ºC of ambient lake temperature. The mixing zone is made up of three zones: the turbulent mixing zone; the transitional zone; and the laminar mixing zone [38].

The boundary of the proposed DNNP Mixing Zone was created based on the bounding DNNP modelled diffuser. The DNNP diffuser has the same basic design as the one used in the Darlington Nuclear Generating Station with one modification for DNNP to make the ports a larger diameter to maintain the same exit velocity. The distance offshore to the first port was set at 600 m, with the diffuser extending 900 m south into the lake at depths from 10 m at the near shore to 20 m at the offshore end (Section 3.4 of [37]). Temperature effects from the thermal discharge are expected to extend a maximum of 50 m from the diffuser (under the modelled average annual case) (Section 5.3.6 [1]). In comparison, the DNGS diffuser is located at a depth of 10 m to 12 m. The reference diffuser location is based on reduced interference with ship movement in the St. Marys Cement wharf to the east. The DNNP diffuser would be oriented perpendicular to the prevailing longshore currents to optimize performance (Section 7.3 of [37]).

Conservatively estimated in accordance with the precautionary principle, the maximum mixing zone for the OTC option is illustrated in Figure G-17 [37]. Note in Figure G-17, the pink area covering an area of 8 ha is the area of potential effect from heat interaction with Round Whitefish spawning areas which is between 6 and 10 m depth. This was identified as the primary area of potential effect, where temperature effects and Round Whitefish spawning habitat has the greatest potential to intersect.

Mechanical Draft Cooling Tower

The size of the mixing zone for the cooling tower option was not estimated in the DNNP EA as it will be bounded by the OTC option. However, it was estimated in the EA (Section 5.1.2.2 [38]) that under average annual conditions the temperature effects are expected to extend a maximum of 15 m from the outfall for the cooling tower option. For comparison, the temperature effects will extend a maximum of 50 m from the diffuser for the OTC option. Also, compared with 90 discharge ports for OTC, the cooling tower has 4 discharge ports; making it much shorter. Therefore, due to a smaller lateral plume extent and a shorted diffuser, the cooling tower mixing zone is about 1% of that for the OTC option. Additional cooling will result from the treatment of cooling tower blowdown.
Figure G-17: Proposed Mixing Zone - Maximum Extent of Exposure within the Mixing Zone [37]

Green Area – 10-13 m Depth Inside Regulated Mixing Zone
Purple Area - <10 m Depth Inside Regulated Mixing Zone

Note that this figure is only an illustration of the potential mixing zones.

**Two Units**

There is no specific estimate conducted for the case of two units regarding the size of mixing zone. However, it is expected that the size of the mixing zone for two units will be less than that for four units for both cooling options. In the absence of estimates for two units, it is conservatively assumed that the thermal plume dimensions will be consistent with the cooling system for four units.

**UNCERTAINTY:**

The above data is considered to be conservative; uncertainties are not expected to impact the scoring of either cooling option.

---

**SECOND PASS EVALUATION - ABATEMENT**

**SUMMARY OF EVALUATION:**

To further minimize the potential effects of the thermal discharge on populations of fish, various thermal discharge enhancement options could be considered. For example, at the detailed design stage it may be feasible to identify a diffuser location that would avoid habitats where spawning, egg development and/or hatching take place. This could be considered for both cooling options.

Thermal plume size might be reduced; however, this would result in higher rates of intake leading to an increase in other potential impacts.

Therefore, although enhancements may be considered at the detailed design stage, for the purposes of BATEA selection it is conservatively assumed that sizes of the thermal plume with enhancement/abatement would not be affected compared to unabated options.

**ABATED SCORING:**

<table>
<thead>
<tr>
<th>Cooling Option</th>
<th>Score Four Units</th>
<th>Score Two Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Once Through</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

**UNCERTAINTY:**

The above data is considered to be conservative; uncertainties are not expected to impact the scoring of either cooling option.
3.4 Aquatic Habitat

<table>
<thead>
<tr>
<th>ATTRIBUTE SCORING CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

FIRST PASS EVALUATION — NO ABATEMENT

SUMMARY OF EVALUATION:

OTC systems would require an intake rate equal to 228 m³/s. Construction would last one to two seasons, which will include tunnelling, blasting and intake/discharge structure installation. 18 000 m² (1.8 ha) [75] of aquatic land would be tunnelled and excavated to install the cooling system’s intake and discharge/diffusers structures and piping. Construction disturbance of aquatic habitat would only be temporary, and a majority of the aquatic habitat would return to an acceptable level of value after completion. The scoring focuses on the operational phase and the additional loss of aquatic habitat from the reactor block, which would utilize 12.2 ha of aquatic habitat for the partial 2 m lake infill.

OTC would only utilize about 0.76 ha [38] of additional aquatic habitat for the intake/discharge areas, resulting in a score of 4.

MDCT construction of intake and discharge structures into Lake Ontario would involve excavation of a trench and installation of piping that could result in temporary disturbance of habitat. Once construction was completed, habitat loss would be restricted to the small areas of the intake/discharge structures and extension of the 2 m lake infill which would equal an additional loss of 7.2 ha [75]; giving cooling towers a score of 1.

This first evaluation is for construction of unabated intake/discharge structures and 2 m lake infill.

CURRENT SCORING:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>4</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>1</td>
</tr>
</tbody>
</table>

SUPPORTING INFORMATION:

Reactor Block Baseline

The 46.1 ha area south of the access road, will support the reactor block and associated facilities. The installation of four unit reactors would require a partial 2 m lake infill. This lake infill would be located just west of Maple Grove Road and would be require 12.2 ha of aquatic habitat; see Section 5.2.4 for
Since this 12.2 ha of aquatic habitat would be utilized regardless of the chosen cooling technology, this attribute will be evaluated on the additional amount of aquatic habitat require for a cooling option. This includes the habitat necessary for intake and discharge structures along with the possible extension of the 2 m lake infill.

**Intake and Discharge Tunnels and Structures for Once Through Lake Water Cooling**

It is assumed that the construction and design of Once Through Cooling water intake and diffuser structures at DNNP would be similar to the existing structures at DNGS. The structures would be appropriately sized to accommodate the required water flow rates at DNNP. The tunnels at DNGS were constructed using typical underground mining techniques involving tunneling (TBM). (Appendix A [75]). Reference [75]’s assessment was completed with Once Through Cooling as the bounding scenario. This scenario would encompass the maximum extent of in-water works that would potentially interact with aquatic habitat and aquatic biota. Some of this work may include (Section 2.2.1 [75]):

- Bridge crossing (box culvert) of the main branch of Darlington Creek for heavy construction equipment access;
- Loss of three on-site ponds;
- Lake infill to the two-m depth contour located along the shoreline in front of DNGS and DNNP sites that would result in a loss of habitat and might alter coastal processes. Note that the lake infill is not accounted for in this attribute but rather in other attributes; see the attribute Excavated Materials.
- A TBM would be used to excavate an area of approximately 1.1 ha. This area would be required to construct the porous veneer OTC CCW intake structure in an area approximately 100 m across, in water that would be at least 10 m deep at a location approximately 850 m offshore;
- The TBM and excavation would be required to install approximately 90 diffuser ports (cumulative area of approximately 0.7 ha) for the once through CCW discharge structure on the discharge tunnel along an alignment extending from approximately 870 m to 1,850 m offshore, in a water depth ranging between 10 m and 20 m.

**Intake Structure**

For an OTC water system, the intake rate would be 228 m$^3$/s [23] and this design is expected to achieve a mean water intake velocity (as permitted at DNGS) of 12.2 cm/s (Section 4.1.1.1 [38]). The current DNGS intake structure is located about 800 m offshore in 10 m deep water where the porous modules are flush with the lake bottom.

The updated DNNP intake design would have a porous veneer cap consisting of 242 structurally independent pre-cast concrete modules, measuring 5.5 m x 5.5 m x 3.0 m high. 182 are porous modules with an area of 5,506 m$^2$, while 60 are non-porous modules with an area of 1,815 m$^2$, the reinforced concrete centre-piece has an area of 272 m$^2$ (Section 4.1.1.1 [38])$^{14}$. Each porous veneer module consists of concrete vanes which are currently spaced at a distance of 14 cm apart. A stainless steel (15 cm x 15 cm) screen overlay is placed over each module (Section 2.1.1 [24]). The intake tunnel is concrete-lined with an inside diameter of 7.5 m (Appendix A [64]), and 800 m long [24].

Table G-23 is a summary of the intake parameters for DNNP and how it would differ from the existing DNGS design. Note a few calculations:

- Area of Modules = number of modules x area of single module

$^{14}$ Note that the number of modules and their respective areas were determined from calculations based on the information present in [38].
- Total Area = area of centre piece + area of non-porous modules + area of porous modules

### Table G-23: Summary of Intake Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Existing DNGS Design [38]</th>
<th>Proposed DNNP Updated Design</th>
<th>Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow (m$^3$/s)</td>
<td>150</td>
<td>228</td>
<td>52</td>
</tr>
<tr>
<td>Number of Non-porous modules</td>
<td>60</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>Number of porous modules</td>
<td>124</td>
<td>182</td>
<td>47</td>
</tr>
<tr>
<td>Module Size – Length (m)</td>
<td>5.5</td>
<td>5.5</td>
<td>0</td>
</tr>
<tr>
<td>Single Module Area (m$^2$)</td>
<td>30.25</td>
<td>30.25</td>
<td>0</td>
</tr>
<tr>
<td>Area of Center Piece (m$^2$)</td>
<td>272</td>
<td>272</td>
<td>0</td>
</tr>
<tr>
<td>Area of Non-porous Modules (m$^2$)</td>
<td>1,815</td>
<td>1,815</td>
<td>0</td>
</tr>
<tr>
<td>Area of Porous Modules (m$^2$)</td>
<td>3,751</td>
<td>5,506</td>
<td>47</td>
</tr>
<tr>
<td>Total Area (m$^2$)</td>
<td>5,838</td>
<td>7,593</td>
<td>30</td>
</tr>
<tr>
<td>Mean Intake Velocity (m/s$^3$)</td>
<td>0.118</td>
<td>0.122</td>
<td>3</td>
</tr>
</tbody>
</table>

*Increase refers to the change against the existing DNGS values*

**Discharge Structure**

The proposed DNNP diffuser would discharge water through 90 single nozzles spaced at 10 m intervals which would alternate in direction with a horizontal angle of 20° from the diffuser axis. The proposed diffuser location is approximately perpendicular to the shoreline to maximize interaction with Lake Ontario’s ambient longshore currents. The lake bed for the predicted location of DNNP’s cooling water outfall has more of a slope compared to the DNGS outfall, averaging a 0.013 m/m downslope. The result is an apparent lake water depth along the 900 m diffuser that varies from about 8 m at the point closest to shore, to 20 m deep at the furthest end offshore. The ports discharge diameters would be 0.85 m, giving a habitat loss of 51 m$^2$ (0.0051 ha), and the inner diameter of the tunnel would be 12.9 m. The near-shore end of the DNGS staged diffuser begins at a distance of about 860 m from the existing shoreline, and extends an additional 900 m into Lake Ontario [38].

See Figure G-18 for the existing locations of the intake, discharge and diffuser tunnels for DNGS and Figure G-19 for the assumed locations of the New Build Intake and Outfall Diffuser.

**Lake Infill**

An extension of the 2m lake infill is not required for OTC. Therefore only the partial lake infill of 12.2 ha for the reactor block is required.

**Total Aquatic Habitat Loss**

The intake structure (modules and concrete center) gives a total aquatic habitat loss of 7,593 m$^2$ (0.76 ha). The discharge structures (90 nozzles with a diameter of 0.85 m) give a total aquatic habitat loss of 51 m$^2$ (0.0051 ha). There would be no extension of the 2 m lake infill. Therefore, there is a total of 7,644 m$^2$ (~0.76 ha) of aquatic habitat loss.

If implementing two units, it is assumed that the amount of land area required would be equivalent or smaller than the land use for four units.
Figure G-18: Existing Locations of Discharge/Diffuser Tunnels [76]
Intake and Discharge Structures for Mechanical Draft Cooling Tower Water Makeup and Service Water

Intake Structure

The MDCT option requires a combined intake flow rate (intake and makeup for service water) of approximately 6 m$^3$/s \[38\]; this rate is approximately 2.6% of the OTC DNNP flow. The make-up water would be drawn from Lake Ontario using four separate water intake pipes located at a water depth of 10 m. Similar to the proposed OTC system, the approach velocity for the cooling towers would be equal to 12.2 cm/s. Each of the four intake pipes would have a diameter of 4.0 m\(^15\) (note that the diameter is a calculation based on data present in Section I.3.2 \[2\]) with a length of 800 m \[24\]. These four pipes openings have a total habitat loss of 50.3 m\(^2\) (0.005 ha).

Although a porous-veneer intake is not anticipated for the cooling tower intake, it would nevertheless include in-design mitigation measures to limit fish losses (Section 2.2.1 \[75\]); see second pass evaluation for more mitigation measures.

\(^{15}\) Although Reference \[2\] indicated that the envisioned cooling tower system for DNNP would have four 1.4 m diameter pipes (Section K.1), four pipes with a diameter of 3.6 m are required for the approach velocity (12.2 cm/s) and intake flow rate (6 m$^3$/s).
Discharge Structure

For MDCT, the discharge would have a flow rate of 1.5 m$^3$. The discharge structure was assumed to be a single port with a 0.77 m diameter nozzle oriented with an upward angle of 45° above horizontal; there would be a habitat loss of 0.47 m$^2$ (0.00005 ha). It would be located 1 m above the bottom and about 900 m offshore in water approximately 12 m deep [38].

Lake Infill

MDCT would require an extension of the 2 m lake infill; see the attribute Excavated Materials for more details. This extension would remove an additional 7.2 ha of aquatic habitat from the reactor block baseline. The full 2 m lake infill would require a total of 19.4 ha of aquatic habitat.

Total Aquatic Habitat Loss

The intake structure (four pipes each with a 4.0 m diameter) gives a total aquatic habitat loss of 50.3 m$^2$ (0.005 ha). The discharge structures (single port with 0.77 m diameter) give a total aquatic habitat loss of 0.47 m$^2$ (0.00005 ha). The extension of the 2 m lake infill would have an additional habitat loss of 72,000 m$^2$ (7.2 ha). Therefore, there is a total of 72,050.77 m$^2$ (7.2 ha) of aquatic habitat loss.

If implementing two units, it is assumed that the amount of land area required would be equivalent or smaller than the land use for four units.

Potential Environmental Interactions

The 1.8 ha (18,000 m$^2$) of land that would undergo tunnelling (completed by a tunnel boring machine) and excavation could result in the loss of a small area of potential fish habitat in the footprints of both the intake and discharge structures (Section 3.1 [75]).

Site Preparation and Construction Phase — Construction of Intake and Discharge Structures

Since the construction of DNPP is a short time period in relation to the life time of the plant (one to two seasons), the construction phases are not considered to be a major concern. The following is included to give an understanding of what may occur during construction for each cooling option.

Once Through Cooling System

Construction of the intake and discharge tunnels for the OTC system is expected to involve tunnelling via TBM through bedrock beneath the lake bed. There is little scope for interaction with the aquatic environment due to the separation of the tunnel from habitat within the lake. However, tunnelling and excavating to open the intake tunnel to the lake and to prepare the lake bed for installation of the porous veneer intake structure could involve incidental fish losses and would replace an area of the lake bed habitat with an artificial structure (Section 3.2.1.3 [75]).

Mechanical Draft Cooling Tower

The intake and discharge structures would be smaller in comparison to the OTC (also with a smaller permanent footprint). The method of construction would consist of tunnelling and/or trenching to place the intake and outfall pipes. Pipes would be placed in trenches and backfilled with a granular material, and armour surface protection. Screens may be used to prevent debris from entering the intake structure. Both the intake and discharge structures for makeup water and service water would be substantially smaller than those required for OTC due to the smaller associated water volumes (Appendix A [75]). This construction could involve a similar total area of temporary disturbance compared to OTC cooling (Section 3.2.1.3 [75]).

Assessment of Likely Effects on the Environment — Construction of Intake and Discharge Structures

Since the construction phases are not judged a major concern, the issue of fish loss during construction...
(i.e. shockwave from blasting) was also not considered. However, an evaluation of the effect for intake/discharge installation on surrounding aquatic habitat was conducted for both cooling options. Mitigation measures will be taken to minimize potential effects.

**Once Through Cooling System**

Construction of the intake and discharge would most definitely interact with the aquatic environment. These interaction would occur from:

- Excavation to connect the intake tunnel to the lake,
- Preparing the lake bed for installation of the porous veneer intake structure, and
- Installation of the diffuser ports along the discharge tunnel.

The intake structure would be situated in approximately 10 m depth, in the zone that was determined in studies conducted for the placement of the DNGS intake to be offshore of the highest concentrations of fish and inshore of the highest concentrations of *Mysis* (freshwater shrimp) (Section 3.3.1.7 [75]).

Siting of the intake and discharge diffuser structures would minimize the interaction with the VEC (Valued Ecosystem Component) indicator species by avoiding shallow warmer water and nearshore spawning areas. Interactions can be summarized as follows (Section 3.3.1.7 [75]):

- **Benthic invertebrates** – localized mortality and permanent loss of habitat within the affected areas. Species and community conservation would not be affected as total area affected is small,
- **Round Goby** – localized mortality and permanent loss of habitat within the affected areas. Conservation of this widespread exotic invasive species as a forage species is not a concern, especially since the total area affected is small,
- **Emerald Shiner** – little interaction is expected as the works avoid the primary nearshore habitat of emerald shiner,
- **Alewife** – localized incidental mortality of small numbers of alewife due to construction. Area of habitat affected is negligible against total available alewife habitat,
- **White sucker** – little interaction is expected as the works avoid the primary nearshore habitat of white sucker,
- **Round Whitefish** – little interaction is expected as the works avoid the primary nearshore spawning areas of Round Whitefish. Incidental mortality of a few individuals could occur with construction. Recent larval fish studies (spring 2009) have indicated the low relative abundance and distribution of Round Whitefish in the vicinity of DNGS,
- **Lake Sturgeon** – little interaction is expected as the works avoid the shallow areas of the nearshore,
- **American Eel** – little interaction is expected as the works avoid the shallow nearshore areas,
- **Lake Trout** – little interaction is expected as the works avoid the primary nearshore spawning areas of lake trout and total area of habitat affected is negligible against available habitat. Incidental mortality of a few individuals could occur with construction, and
- **Salmonid sport fish** – incidental mortality of a few individuals could occur with construction.

Therefore, the area of habitat affected is negligible against total habitat availability for these species.

A small area of habitat would be lost to the intake and discharge structures. As these areas would be located offshore in deeper water, the loss of this habitat is not considered likely to affect any of the VEC indicator species in a meaningful way. Nevertheless, a section 35(2) FA authorization would be required for this and other Project works and activities, and a comprehensive fish habitat compensation plan would offset the loss of habitat and associated productivity.
Lakebed disturbance is limited to the porous veneer intake and individual diffuser ports, which would be permanent structures on the lake bottom. The habitat loss would be restricted to the footprints of these structures, and this is considered the bounding condition for disturbance of lake bottom habitats. Since small areas of lake bottom would be affected, extensive areas of similar habitat are available nearby, any habitat loss would be offset through the fish compensation plan, and the overall effect is considered to be negligible (Section 3.3.1.7 [75]).

Mechanical Draft Cooling Tower

The construction of intake and discharge structures into Lake Ontario for the cooling tower option would involve excavation of a trench and installation of piping that could result in temporary disturbance of habitat. Once construction is complete, habitat loss would be restricted to the small areas of the intake and discharge structures (0.0048 ha). Sedimentation from construction activities is expected to be localized and relatively short term and is not expected to result in mortality of benthic organisms or permanent alteration of nearby lake substrates.

Construction Turbulence

Turbulence is a measurement of the fluctuation in velocity magnitude about a mean value. In general, it is difficult under both laboratory and field conditions to separate the injury resulting from turbulence and shear [77]. During construction phase, increased turbidity would give rise to localized reduction in light penetration, which would in turn impact the ability of primary producers to manufacture food desirable to fish. Sedimentation may smother algae or small animals and may also have adverse impacts on the quality of spawning areas. Any fish present however, would likely avoid areas where there is increased turbidity as visibility would be impaired, thus, affecting their ability to feed (Section 6.0 [78]).

Excessive migration of suspended materials from sediment dredging projects has been identified as having potential to adversely affect fish and fish habitat areas. Negative effects to fish populations can include obstruction of respiratory mechanisms of fish or excessive abrasion of gill tissues. Migration sediments from dredging operations can also negatively affect the substrate of fish habitat and spawning areas by clogging interstitial areas of the spawning substrate, thereby interfering with the normal exchange of water and oxygen which is essential to the survival of fertilized fish eggs and newly hatch fry (Section 6.0 [78]).

However, an evaluation was completed and found little or no mortality of larvae of four fish species when they were exposed to turbulence, in a simulated power plant condenser tube with a shear and pressure from ~2 atm to 0.5 atm [77]. Mitigation for turbulence was assessed in the second pass evaluation.

Operation and Maintenance Phase – Operation of Cooling Systems

The only aquatic habitat loss that is associated with the operation of each cooling system is the exposed portions of each cooling option. The major concern is with impingement and entrainment of various species, which is assessed in different attribute evaluations.

Once Through Cooling System

Intake flow for OTC is equal to 228 m$^3$/s [23]. It is assumed that a lake bottom porous veneer intake structure would be constructed, likely as a scaled up version of the existing intake at DNGS. The DNGS intake design has proven very effective in mitigating fish losses due its offshore location and designed average approach velocity of 12.2 cm/s (Section 2.2.1.1 [24]).

Mechanical Drift Cooling Tower

For the cooling tower option, intake flow is about 6m$^3$/s; due to a small intake diameter as well as placing the intake away from the nearshore environment would be used as possible mitigation strategies. Lake withdrawals would still have entrainment (Section 3.2.2.1 [75]).
UNCERTAINTY:
There is very little uncertainty in respect to the aquatic habitat loss during operation. The final footprint only includes the open modules/ports of the intake and discharge structures. The main uncertainty is with the construction phase; the current approach for OTC is to trench the outfall, however if the outfall was to be tunnelled the area impacts by the diffuser during construction would be smaller.

SECOND PASS EVALUATION - ABATEMENT

SUMMARY OF EVALUATION:
With the implementation of mitigation, lost aquatic habitat can potentially be substituted. These abatement measures include:

- Increase of intake structure area,
- Decreasing turbulence during construction,
- Positioning additional rock over the outfall pipeline, and
- Creating an artificial shoal, leading to additional fish habitat.

Abatement measures to reduce fish impingement/entrainment would lead to a larger OTC intake structure, and an increase in habitat loss. The mitigated structure change would increase OTC aquatic habitat loss to 1.0 ha from 0.76 ha; this gives the same attribute scores as the unabated evaluation. The score for the cooling tower option does not change. This intake enhancement gives 6.2 ha difference for the aquatic habitat loss between OTC and MDCT.

ABATED SCORING:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>4</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>1</td>
</tr>
</tbody>
</table>

SUPPORTING INFORMATION:

Abatement for Intake Structure for Once Through Lake Water Cooling

To reduce fish impingement/entrainment, the intake structure design was enhanced. The ideal enhancement requires a reduction in average approach velocity from 12.2 cm/s to 6 cm/s as well a fine screen made of zebra mussel resistant material. The screen design is to be altered so that the porosity of the porous module is altered to 45%; compared to the 34% porosity for the unabated intake. The design would also require 10 cm square openings with cross members of 2.5 cm thickness (width) to achieve the desired approach velocity. The porous veneer cap would be altered to have 336 structurally independent pre-cast concrete modules, where 276 are porous and 60 are non-porous modules. As a result of the increase of modules, the total surface area of the intake structure increases to 10,436 m² (1.0 ha), altering the total aquatic habitat loss to 10,487 m² (1.0 ha).

If implementing two units, it is assumed that the amount of land area required would be equivalent or smaller than the land use for four units.

Table G-24 is a summary of the enhanced intake parameters for DNNP and its comparison to DNGS.
Table G-24: Summary of Parameters for Abated Intake Structure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Existing DNGS Design [38];</th>
<th>Proposed DNPP Updated Design</th>
<th>Increase* (%)</th>
<th>Proposed DNPP Abated Design – 10 cm opening</th>
<th>Increase/Reduction* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow (m$^3$/s)</td>
<td>150</td>
<td>228</td>
<td>52</td>
<td>228</td>
<td>52</td>
</tr>
<tr>
<td>Number of Non-porous modules</td>
<td>60</td>
<td>60</td>
<td>0</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>Number of porous modules</td>
<td>124</td>
<td>182</td>
<td>47</td>
<td>276</td>
<td>123</td>
</tr>
<tr>
<td>Module Size – Length (m)</td>
<td>5.5</td>
<td>5.5</td>
<td>0</td>
<td>5.5</td>
<td>0</td>
</tr>
<tr>
<td>Single Module Area (m$^2$)</td>
<td>30.25</td>
<td>30.25</td>
<td>0</td>
<td>30.25</td>
<td>0</td>
</tr>
<tr>
<td>Area of Center Piece (m$^2$)</td>
<td>272</td>
<td>272</td>
<td>0</td>
<td>272</td>
<td>0</td>
</tr>
<tr>
<td>Area of Non-porous Modules (m$^2$)</td>
<td>1,815</td>
<td>1,815</td>
<td>0</td>
<td>1,815</td>
<td>0</td>
</tr>
<tr>
<td>Area of Porous Modules (m$^2$)</td>
<td>3,751</td>
<td>5,506</td>
<td>47</td>
<td>8,349</td>
<td>123</td>
</tr>
<tr>
<td>Total Area (m$^2$)</td>
<td>5,838</td>
<td>7,593</td>
<td>30</td>
<td>10,436</td>
<td>79</td>
</tr>
<tr>
<td>Mean Intake Velocity (m/s$^2$)</td>
<td>0.118</td>
<td>0.122</td>
<td>3</td>
<td>0.060</td>
<td>-49</td>
</tr>
<tr>
<td>Porosity</td>
<td>34</td>
<td>34</td>
<td>0</td>
<td>45</td>
<td>32</td>
</tr>
</tbody>
</table>

*Increase refers to the change against the existing DNGS values

**Consideration of Mitigation and Determination of Likely Residual Effects**

The following are in-design mitigation measures that were considered for the construction of the intake and discharge structures (Section 3.4 [75]).

- Siting of the structures in less sensitive habitat offshore of more productive nearshore habitats and spawning areas.
- Underwater construction mitigation methods as per DFO guidance (e.g., seasonal timing restrictions, fish deterrence, bubble curtains and design of charge size, placement and sequencing to minimize incidental mortality) authorization. Since the project also results in Harmful Alteration and Disruption or Destruction of fish habitat, the conditions associated with section 32 authorization under the Fisheries Act would be included within the section 35(2) authorization.
- Fish habitat compensation to offset the loss of direct fish habitat and to satisfy requirements of an authorization under section 35(2) of the Fisheries Act.

**Mitigation for Turbulence During Construction**

Turbidity impacts (elevated levels of turbidity above background) rank low on the list of impacts due to the sub-lethal levels and the ability of adult fish to avoid turbidity plumes. Sedimentation can be a concern where fine sediments are not normally deposited (such as in areas of coral or extensive hard bottom).
Methods to control turbidity during construction include (Section 7.1 [78]):

- Excavated material would be sidecast as close to the trench as possible
- Care would be taken in the side casting of the excavated material to minimize sediments within the water column
- Stockpiles of soil or fill would be kept away from the water and protected by a sediment fence. All other materials, such as construction debris and containers would be kept at least 30 m away from the water
- All sediment fencing would be under regular maintenance, and the areas outside of the sediment fencing would be monitored throughout the work, on a daily basis
- The length of open trench in the lake would be kept to the minimum ahead of pipe laying to minimize the area of lake bed opened for construction
- In-water work would not be performed during storm conditions and during times of high wind, as waves can carry sediments far from the area and cause more harmful effects. In addition, work in the lake would not be performed during these conditions due to safety issues

Compensation Measures

Courtice Water Pollution Control Plant (WPCP) constructed an outfall which is similar to what is desired for DNNP. The design included concrete piping for the outfall and diffuser, which are buried in the lake bed. The pipeline extends 950 m from the shoreline into Lake Ontario, which is optimally located since the effluent is nearby DNGS discharge piping (Section 2.3 [78])

Compensation measures were discussed to improve fish habitat following construction of the outfall. Methods which were proposed to limit wave disruption to the outfall following construction would also serve as fish habitat. These methods include [78]:

- The top portion of the pipeline trench, from the shore out to 2.0 m of water depth, may require armour stone protection. Rock material weighing 1.5 tonnes and not greater than 600 mm thick is proposed to be placed over the excavation and flush with the lake bottom. Although this would not serve as high potential for fish habitat it does offer some protection for near shore spawning. This would improve fish utilization of the nearshore area at this location.
- From depth of water 2 m to 4.5m, rock 300 mm to 450 mm in size and in a 600 mm thick layer can be placed over the backfilled excavation; offering good fish habitat. The size of the rock offers substantial interstitial habitat and would provide an area for fish spawning, nursery and food production that was not previously present.
- Native material should be used to cover the construction area. If only native material is used as cover, the area would not present opportunities for fish habitat. However, to provide additional compensation, an artificial shoal can be constructed.
- Along the diffuser, 50 mm clear stone can be utilized. This material would be side cast along both sides of the length of the diffuser, creating a light crown of fill that can be 400 mm above the original lake bottom and taper to the existing lake bed. This excess diffuser area can also provide additional area for fish habitat.

Artificial Spawning Shoal

An artificial shoal can be constructed in deep waters to provide additional fish habitat. The Toronto Waterfront Aquatic Habitat Restoration Strategy has indicated that shoals can be effective restoration techniques, which increase areas of primary production, increase essential habitats for cool and cold water species, improve forage for aquatic species, and add structural elements to improve off shore habitats. Artificial spawning shoals have been constructed in other areas of Lake Ontario, and have had
successful results. These examples include:

- St Mary’s Cement, and
- Armourstone Shoreline Habitat Constructed along the Shoreline at DNGS (1978-1979)

The ideal shoal would have an angle of 30-45°, a reef height of 1 m, and a width of 3m in order to be the most effective for fish habitat. The shoal must be created as to minimize potential exposure of fish to effluent discharges [78].

**UNCERTAINTY:**

The above data are considered to be conservative; uncertainties are not expected to impact the scoring of either cooling option.
3.5 Terrestrial Habitat

<table>
<thead>
<tr>
<th>ATTRIBUTE SCORING CRITERIA</th>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>&lt;25% of additional habitat of species of concern in the local study area is preserved.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>≥25% but &lt;50% of additional habitat of species of concern in the local study area is preserved.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>≥50% but &lt;75% of additional habitat of species of concern in the local study area is preserved.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>≥75% but &lt;100% of additional habitat of species of concern in the local study area is preserved.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>No additional loss of habitat from the baseline for species of concern in the local study area</td>
</tr>
</tbody>
</table>

**FIRST PASS EVALUATION — NO ABATEMENT**

**SUMMARY OF EVALUATION:**

For the construction of a cooling option, the local terrestrial land area will be affected and various species will experience habitat loss.

The bank swallows are the primary species of concern, since nesting land is lost from site preparation and construction; this species is the main basis behind the scoring for each cooling option.

The cooling tower option requires the clearance and excavation of a larger area, resulting in an increase of terrestrial habitat loss. In particular, due to the need to provide a continuous 2m lake infill along the whole coastline, the bank swallow habitat will have to be removed completely. Therefore the cooling tower option receives a score of 1 for no species protection.

The OTC option would not require additional Bank Swallow habitat, and is equal to the habitat loss set by the baseline; therefore OTC receives a score of 5 for no additional habitat loss.

**Salt Deposition**

Salt deposition rates of 1 - 2 g/m²/month can occur within about 500 m of the MDCT, however little or no natural vegetation is located within this area. The rate drops for the worst case scenario to less than 0.1 g/m²/month at sensitive areas at DN site, including Coot’s Pond and Raby Head Marsh. The latter values are below the 0.1-0.2 g/m²/month guideline criterion which is generally considered to be a level not damaging to plants [79]. These amounts were for four units and it is reasonable to assume that the values would be halved for two units.

**Area: 500 m from tower**

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Salt Deposition (g/m²/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>0</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>1 - 2</td>
</tr>
</tbody>
</table>
### Area: Southwest of Coot’s Pond

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Salt Deposition (g/m²/month)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
<td>Two Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>0.02 – 0.04</td>
<td>0.01 – 0.02</td>
</tr>
</tbody>
</table>

### Area: Raby Head Marsh in St. Mary’s Cement

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Salt Deposition (g/m²/month)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
<td>Two Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>&lt;0.1</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

**Bank Swallow Habitat Loss**

All design scenarios for the MDCT option result in the residual loss of nesting areas for around 1,300 active Bank Swallow burrows (100% of habitat). Mitigation of this effect includes the construction of artificial habitat for Bank Swallows, provision of nesting habitat for related insectivore bird species, integration of interpretive opportunities, acquisition and protection of existing colony areas that are not on the DN property. If these measures were implemented it could result in advances for the species in the long-term [79].

The OTC option would not require additional Bank Swallow habitat, and is equal to the habitat loss set by the baseline.

**CURRENT SCORING:**

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
<td>Two Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**SUPPORTING INFORMATION:**

The goal of this evaluation is to describe the assessment of environmental effects of the installation of cooling options on the local Terrestrial Environment. DNNP will affect a variety of terrestrial valued ecosystem components (VECs) present in the vicinity of the plant. These VECs include:

- Vegetation Communities;
  - Cultural Meadow
  - Cultural Thicket
  - Grass of Parnassus
  - Bur-reed
Sugar Maple
Woodland

- Insects;
  - Monarch butterflies
  - Dragon/damselflies

- Bird Communities;
  - Yellow Warbler
  - Red-eye Vireo
  - Mallard
  - Bufflehead
  - Bank Swallow
  - Long-eared Owl

- Amphibians and Reptiles;
  - Green Frog
  - Midland Painted Turtle

- Mammal Communities and Species;
  - Muskrat
  - Meadow Vole

The cooling option decision will focus only on vegetation affected by salt drifts, bank swallows (representative species) and amphibians/reptiles.

**Salt Deposition Evaluation**

**Salt Drift Criteria**

There are no Federal or Provincial criteria for assessing effects related to cooling tower operation effects. The U.S. Nuclear Regulatory Commission (NRC) has a 1999 document "Standard Review for Environmental Reviews for Nuclear Power Plants" (NUREG 1555, U.S. NRC 1999). This document identifies limited criteria which can be used to assess environmental effects. One of the specific guidelines provided in this document to assess cooling tower effects are related to effects of salt drifts on the terrestrial environment (Section 3.1 [54]).

Drifts are liquid water droplets which are carried with the exhaust air from cooling towers. Water from the drift will contain dissolved and suspended particles (salt) and the solids deposit onto the ground (Section E.2.1 [54]).

Salt Drift Guidelines – use an order of magnitude approach as follows (Section 3.1 [54]), (Section 3.3.3.1 [79]):

- Deposition of salt drift (NaCl) at rate of 1 to 2 kg/ha/mo (0.1 – 0.2 g/m²/mo) is generally not damaging to plants,
- Deposition rates approaching or exceeding 10 kg/ha/mo (1 g/m²/mo) in any month during the growing season could cause leaf damage in many species, and
- Deposition rates of hundreds or thousands of kg/ha/yr could cause damage sufficient to suggest the need for changes of tower-basin salinities or re-evaluation of tower design, depending on the amount of land impacted and the uniqueness of the terrestrial ecosystems expected to be exposed to drift deposition.

MDCT use power driven fan motors to force or draw air through the tower. During operation there is
potential for salt deposition effects on adjacent vegetation communities and species associated with the St. Mary's Cement property. Therefore this interaction is being assessed for effects (Section 3.2.4 [79]).

Description of Model – SACTI

The Seasonal Annual Cooling Tower Impacts (SACTI) model is a mathematical model for the prediction of the seasonal/annual physical impacts of cooling towers. This model has algorithms for MDCT which can be arranged in clusters, also incorporating merging plumes which often occurs with clustered cooling towers. The SACTI modeling predicted the rate of salt deposition from evaluating plume formation (Section 5.2 [54]).

Salt Drift Bounding Cases

Since the OTC system does not produce any sort of vapour plume, salt disposition is not an issue for this option and it is not considered in this assessment.

MDCT operate by forcing air through circulating water using large fans, and are often installed in series; as in the case for the DNNP (Section 5.2 [54]). There is one main cooling tower configuration for the assessment of four units; individual cooling towers would be assembled into four linear rows, each 37 m wide, 316 m long and 16 m tall (Appendix I [2]). It is assumed that for two units, the cooling tower dimensions would be the same, but are assembled into two linear rows.

Modelling Results - Salt Deposition and Damage to Vegetation

Salt deposition from the cooling towers could lead to an effect on vegetation communities and species. It is directly linked to the hardness of Lake Ontario, since naturally occurring minerals/salt in the lake will accumulate within the tower. Drifts will contain these dissolved minerals/salts and will deposit it over the MDCT surrounding area. MDCT use a chemical blowdown to help decrease the amount of salt deposition.

Predictive modeling shows that a very small range of nearby areas (about 500 m from the towers) could receive up to 1 to 2 g/m²/month with the MDCT option. However, little or no natural vegetation or sensitive features will be located within this area. Beyond this range, the sensitive areas on the DN site (the southwest portion of the site and Coot's Pond) would receive 0.02 – 0.04 g/m²/month in a worst case scenario (depending on cooling tower options and configuration), while Raby Head Marsh, in St. Mary's Cement site is expected to receive less than 0.1 g/m²/month (Section 3.3.3.1 [79]). This evaluation is completed under the bounding case of four units in use. It is assumed that with plume abatement in place, these values will be even lower. For two units it is reasonable to assume that these salt deposition rates are about halved.

See Figure G-20 for the predicted annual salt deposition for MDCT assuming four units.
Figure G-20: Predicted Annual Salt Deposition (g/m²/month) – Mechanical Draft – Linear Configuration (Figure E.3.8-1 [54])

Note that this figure is a salt model result for MDCT only for an assumed location of CT placement and is not a representation of the potential lay out for DNNP.

Effects of Construction of Intake and Discharge Channels Structures

Intake and Discharge Tunnels and Structures for Once Through Lake Water Cooling

Tunnels for OTC water at DNNP are to be constructed by tunnelling through bedrock beneath the lake bed (Section 3.2.1.3 [75]). The Once Through cooling water intake and diffuser structures are assumed to be similar to the existing structures at DNGS, and appropriately sized to accommodate the required water flow rates at DNNP. Water from the intake channel will be conveyed to the forebay, which will be excavated into the rock and lined with concrete.

This activity is likely to disturb the near shore area and birds that use that habitat. Therefore this interaction is being assessed for effects (Section 3.2.2 [79]).

Intake and Discharge Structures for Cooling Tower Water Makeup and Service Water

Although the water from MDCT is recirculated, some make-up water is required to replace tower blowdown and other losses (e.g., evaporation), and for plant service water needs. This water will be
drawn from Lake Ontario via intake and discharge pipelines. The open-cut drill-and-blast method is likely to be used to excavate a trench to place the intake or outfall pipe. Pipes will be placed in trenches and backfilled with a granular and armour surface protection. Screens may be used to prevent debris from entering the intake structure. Both the intake and discharge structures for makeup water and service water will be substantially smaller than those required for OTC due to the smaller associated water volumes.

This activity is likely to disturb the near shore area and birds that use that habitat. Therefore this interaction is being assessed for effects (Section 3.2.2 [79]).

**Effects of Construction of Ancillary Facilities**

**Mechanical Draft Cooling Towers**

MDCT are typically short in height. Construction of the towers will involve conventional techniques and materials, primarily steel framing, concrete and masonry, and mechanical and electrical components. These towers will not exceed the height of the generating station buildings and therefore it is not expected that the construction of these elements will have a measurable effect on the numbers of bird strikes on populations or species of conservation concern. Therefore this interaction is not being assessed for effects (Section 3.2.2 [79]).

**Near Shore Birds**

*Potential Effect on VEC – Bank Swallow*

In 2007 there was a shoreline habitat survey along the entire Durham Region shoreline; the results yielded a total of 86 colonies with a sum of 12,759 burrows. Nesting habitat in this area supports approximately 1,000 - 1,300 active Bank Swallow burrows (2007-2009), representing 36% of the colony considered to be within the Bank Swallow Evaluation Area. This represents approximately 10% of the total number of Durham Region shoreline burrows (Section 3.3.3.3 [79]).

The Bank Swallow Evaluation Area extends (for the shoreline area only) from Oshawa Creek to Wilmot Creek. This is a meaningful area for a species which has its breeding habitat more or less confined in this area to the Lake Ontario shoreline area south of the ancient Lake Iroquois shoreline (approximately Taunton Road) (Section 2.2.2 [79]).

Even though the Lake Ontario shoreline along the Bank Swallow Evaluation Area is subject to stochastic events such as slumping, the Bank Swallow Monitoring Program has indicated little variation of active burrows during the breeding season. As such, the Project will eliminate a portion of bluff that supports nesting habitat for approximately 1,000 - 1,300 active burrows annually.

Individual Bank Swallows are known to move occasionally among breeding colonies, but this loss of nesting habitat will not likely be accommodated by other colonies. Suitable nesting substrates such as sand or silty sand at a suitable height and steepness, is relatively scarce along the Lake Ontario shoreline within the Regional Study Area.

The loss of habitat that supports approximately 1,000 - 1,300 active Bank Swallow burrows is an adverse environmental effect and therefore is being advanced for mitigation (Section 3.3.3.3 [79]).

**Evaluation of Cooling Options Based on Bank Swallow Habitat.**

**Reactor Block Baseline**

The 46.1 ha area south of the access road, will support the reactor block and associated facilities. The installation of the reactor block would require a partial 2 m lake infill, which would be required regardless if four or two reactor units are built. The lake infill would be located just west of Maple Grove Road and would be require 12.2 ha of aquatic habitat, independent of the chosen cooling technology; see Section 5.2.4 for details on layout. This partial lake infill would preserve 80-90% of the Bank Swallow nesting habitat [50]; any additional infill would contribute to further loss of Bank Swallow habitat. This attribute
will evaluate the additional amount of Bank Swallow nest habitat that would be lost from the baseline.

**Once Through Cooling**

This option would not have any further impact on the Bank Swallow habitat from the reactor block baseline.

The site layout for the OTC includes sufficient area for a forebay to be located west of Maple Grove Road. The forebay can be accommodated without incrementally impacting bank swallow habitat. This is because the forebay is included in the space allocated to the reactor block.

**Mechanical Draft Cooling**

The cooling tower option requires clearance and excavation of about 30 ha of space, see the Excavated Materials attribute for details. This space requirement would require the extension of the partial infill required by the baseline to a full 2 m lake infill; this full lake infill would not preserve any of the Bank Swallow habitat [50].

Even if the initial number of reactor units is less than four, the MDCT banks would have to be constructed at the lake end of the site. This would leave enough space for the potential construction of additional MDCT to service future reactors at the site.

Therefore, the installation of MDCT would result in a total loss of Bank Swallow habitat.

**Amphibians and Reptiles**

**Potential Effects – Loss of Wildlife Habitat Features**

Three of four ponds onsite will be removed no matter which cooling option will be adopted; the effect of two options on Amphibians and Reptiles will be at the same level.

**Breeding Habitat**

Breeding amphibians are often concentrated in a relatively small area. At the DN site this amphibian breeding occurs at all of the four existing ponds. This assessment is based on implementation of Good Industry Management Practices for stormwater management including sediment control practices, such as the direction of landfill stormwater runoff through settling or pre-treatment pond(s) prior to release to Coot’s Pond. These practices would ensure that good water quality and water delivery will be maintained for Coot’s Pond. Therefore no effects on the population of this measurement indicator at Coot’s Pond are anticipated (Section 3.3.3.4 [79]).

**Key Summer Habitat**

Key summer habitat (primarily cultural meadow, thicket and woodlands) for the species that breed at Coot’s Pond (i.e., Green Frog, American Toad and Northern Leopard Frog) is generally thought to be areas that are located within 300 m of the breeding area. There will be disruption of portions of this habitat for one or two seasons. However, based on existing conditions data the populations are relatively small and sufficient habitat will remain to support these species. A decline due to this effect would not be measurable and habitat will return post-construction. For these reasons no measurable effect is anticipated on summer habitat (Section 3.3.3.4 [79]).

Given proposed changes to amphibian breeding ponds and the relatively low diversity of amphibians (and reptiles) it is unlikely that road mortality by itself will have a measurable ecological effect at the DN site.

Midland Painted Turtles occurred one summer at Treefrog Pond, but the population is centred in Coot’s Pond. For this reason, no effect is anticipated on the presence of this species in Coot’s Pond hence it is not being advanced for mitigation (Section 3.3.3.4 [79]).

**UNCERTAINTY:**

The uncertainty for this attribute is considered moderate and directly related to the DNNP’s final layout.
Once the official layout is determined, the uncertainly in this attribute would be reduced.

There is potential risk to bank swallow habitat for the OTC option. Although the habitat will be preserved, it is possible that some impact will occur due to temporary construction noise or impact from slope terracing and changes in groundwater levels.

The Ontario Endangered Species Act identifies a list of species under threat and which is frequently updated. While the list has been updated with new species, and in all likelihood will be updated further before and after construction of DNNP, it is not expected that addition of other terrestrial species to the list of threatened or potentially threatened species will impact selection of the BATEA, even if these species are present on site as OTC does not impact terrestrial habitat.

**SECOND PASS EVALUATION - ABATEMENT**

**SUMMARY OF EVALUATION:**
Mitigation to optimize the amount of terrestrial habitat preserved is highly dependent on the implementation of an artificial bank swallow habitat. However, since it is not definite how much of the lost habitat the artificial colony would save when building cooling towers, the scoring will not change from the first pass evaluation.

**ABATED SCORING:**

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>5</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>1</td>
</tr>
</tbody>
</table>

**MITIGATION:**

**Salt Deposition**
Based on the evaluation numbers presented in the first pass, the potential for effects related to salt deposition on vegetation does not exceed guideline criterion of 0.1-0.2 g/m²/month; therefore it is not being further advanced for mitigation.

**Amphibian and Reptiles**
For amphibians and reptiles, the removal of three amphibian breeding ponds has no in-design mitigation measures. An additional identified potential mitigation measure is post-development restoration of Cultural Meadow and Cultural Thicket and creation of new fish-free wetland ponds with riparian planting (Table 3.4-1 [79]). However, the overall residual environmental effect of the removal of amphibian breeding ponds is negligible (Table 3.4-3 [79]).

**Consideration of Mitigation and Determination of Likely Residual Effects – Bank Swallow**
For the removal of Bank Swallow Colonies and nesting habitat, are no in-design or technological enhancements that have been identified that can preserve the habitat. However, additional potential mitigation measures were identified as follows (Table 3.4-1 [79]):

- Acquisition of lands containing existing colonies for study and protection
- Provision of artificial Bank Swallow habitat on the DN Site
- Partner to undertake research into declining aerial foragers in Ontario
- Funding of research into declining aerial foragers
• Integration of interpretive opportunities such as interpretive signage and observation decks.

**Detailed Discussion of Bank Swallow Related Mitigation Techniques (Section 3.4.1 [79])**

The following outlines various mitigative approaches commencing with the most important options first. If a colony area is removed, temporal construction constraints will need to be observed due to the requirements of the federal *Migratory Birds Convention Act* and potential conditions of approval. Hence no activity will be permitted from April 01 to September 01 as the colony is active during these months. The Central Lake Ontario Conservation Authority and the Ministry of Natural Resources may also consider themselves stakeholders in this matter through the provincial *Conservation Authorities Act* and the *Lakes and Rivers Improvements Act*, respectively.

The following paragraphs present mitigative approaches.

**Acquisition and Protection of Existing Habitat**

In some ways the protection of habitat is considered a superior approach to the provision of artificial nesting structures. This is because a host of flora and fauna are associated with the bluffs, whereas only Bank Swallows directly benefit from artificial nesting structures.

Historically, and within the Greater Toronto Area many natural shorelines have been hardened and protected from erosion, eliminating or reducing Bank Swallow habitat. This often follows the development of residential dwellings close to cliff tops, attracted by lake vistas. Such development patterns can be seen emerging to the east of the DN site in a few locations.

Acquisition of shoreline properties that include bluffs could protect suitable Bank Swallow nesting shorelines (and appropriate wide tableland buffers) for the long term protection of colony areas. In some cases, such protection would also incorporate vegetation communities of note, important shoreline zones and various species of conservation concern, especially flora. While not replacing nesting habitat directly, the long-term protection of these areas, given the stochastic nature of colony formation, should be considered a viable long term mitigative strategy.

**Artificial Structures for Bank Swallows**

When suitable natural habitat is lacking, Bank Swallows will readily use other types of features. They have been known to nest in military trenches created for training dating back to 1917. As well, other artificial sites have been colonized such as railway or road cuttings, heaps of graded sand, sand pits and quarries.

For example, two artificial banks and six enhanced natural banks were built along the Sacramento River, U.S.A. as mitigation for loss of colony sites due to flood control projects. Bank Swallows occupied one of the two artificial sites and five of the six enhanced sites for up to two years following the construction. The sites were abandoned as no maintenance was conducted rendering the sites unsuitable as the vertical banks sloughed off. An important factor in successful habitat creation or enhancement is the ongoing monitoring of the projects to ensure continued suitability.

In another example, in 1996 in Hamilton, Ontario, the Royal Botanical Gardens erected an experimental artificial bank next to a former nesting area. The bank was in the form of a multiple burrow nestbox with individual nesting holes and houses for 28 pairs. This method was unsuccessful. The multiple nestbox was not installed directly into a bank and air circulation around the structure created temperature instability within the box rather than a stable temperature which would be typically found in a bank burrow. This temperature instability was thought to be a reason for failure.

There have been various attempts to create artificial habitats and Table G-25 below is a summary of case studies of artificial bank creation and enhancement projects in the United Kingdom using various methods and materials. An artificial Bank Swallow pilot habitat will be built on the existing DN site to evaluate a compensation option for the loss of Bank Swallow burrows removed as a result of the DNNP project [80]. The design of the structure is illustrated in
Figure G-21. Similar structures have been used successfully elsewhere. For example, it has been used as a Sand Martin breeding site [81].

The construction of artificial nesting colonies is a viable option and could accommodate several hundred nest burrows. The construction methods and design parameters need to be carefully considered and engineered in the light of Canadian winters and the requirements of the species.

**Figure G-21: Pilot Bank Swallow Habitat**
Table G-25: Review of Case Studies

<table>
<thead>
<tr>
<th>Type</th>
<th>Location</th>
<th>Timing</th>
<th>Materials</th>
<th>Details</th>
<th>Features</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artificial cliff</td>
<td>Forest Farm Country Park, Whitechurch, Castliff, U.K.</td>
<td>Winter 1996-1997</td>
<td>Tyrolean render (cement render mixed with silicone); ceramic sewer pipe; sand</td>
<td>12 m long x 1.8 m high; 40 access holes spaced at 80 cm horizontal and 45 cm vertical intervals; holes slope towards front for drainage; 4m away from artificial lake</td>
<td>Convexly curved; overhanging lip to shelter from rain; bird hide for observations</td>
<td>Materials not recommended as they are technically complicated; Successful every year except 1999 when a snow storm caused the birds to vacate prior to breeding</td>
</tr>
<tr>
<td>Barrels</td>
<td>Tullo Farm, Oldmeldrum, Inverurie, Aberdeenshire U.K.</td>
<td>March 1995</td>
<td>Concentrated fruit juice barrel; post; iron rod; light concrete mixture - sand to cement ratio 15:1; waterproof paper lining</td>
<td>Day time for mixture; 10-14 days; tunnel holes excavated at 13-15 cm in diameter and 35 - 75 cm long; entrance holes bored out using iron rods and are sloped for drainage; outer barrel</td>
<td>Can be constructed anywhere; low predation risks</td>
<td>Successful since 1985; approx. 15 pairs per barrel; the tunnels are cleaned out and refilled at the end of each season</td>
</tr>
<tr>
<td>Artificial cliff</td>
<td>Rudland Water (lagoon) U.K.</td>
<td>2000</td>
<td>Limestone base; hollow concrete blocks; clay pipes; sand; tyrolean render; roof beams; tar; door</td>
<td>Artificial bank 2.5 m wide x 15.25 m long; 23 cm x 46 cm hollow concrete blocks laid side by each along length; 8 cm x 30 cm clay pipes inserted and cemented in; 15 cm compartment at end of pipe; 347 holes</td>
<td>Doors fitted on back of each compartment; excellent observation capabilities; amphipod “skirt” along bottom of bank</td>
<td>Successful breeding; birds used the half empty and empty holes but not the holes that were completely filled with sand</td>
</tr>
<tr>
<td>Artificial cliff</td>
<td>Watermead Country Park U.K.</td>
<td>Winter 1993</td>
<td>Concrete slab; sand; cement; large stones; Taram; clay pipes</td>
<td>Concrete slab 1.5 m wide and 15 cm thick; 20 cm hollow cement blocks; 10 cm clay pipes; 4 cm drilled holes; rear 1.2 m x 1m filled with large stones to help drainage</td>
<td>The bank face is covered with sand and cement, more of the mixture is placed on the top to create a forward lean to make it more difficult for predators to climb</td>
<td>Successful in 1994; half the bank was covered in washed sand, other half unwashed - no preference exhibited; two types of holes used (clay pipe and drilled) - drilled holes preferred</td>
</tr>
</tbody>
</table>

**Incorporation of Artificial Habitat for Additional Aerial Foraging Species**

While this assessment is addressing the Bank Swallow, another aerial forager is rapidly declining. The Chimney Swift was recently designated by the Committee on the Status of Endangered Wildlife in Canada as "Threatened". This species appears to be declining because of a sharp and ongoing reduction in chimney stacks without internal flues and a lack of their original nesting habitat - large hollow trees. The latter is perhaps related to forestry practices and human settlement patterns. Artificial structures for this species are already being installed in Canada, and this could be considered as part of a mitigative strategy aimed at aerial foragers, not just Bank Swallows.

**Research**

The development of a partnership, for example with a post-secondary research institution, to address questions related to the population change of aerial insectivores in Ontario and specifically that of the Bank Swallow would be a useful contribution to scientific knowledge. This could have important implications for long-term conservation strategies for Bank Swallows and related species.

**Residual Effects on Bank Swallow**

All design scenarios result in the residual loss of nesting areas of active Bank Swallow burrows (based on 2007 - 2009 data). However, the mitigation presented is not directly comparable to the effect as it will not recreate the function of 1,000 active Bank Swallow burrows. If these measures were implemented it could result in advances for the species in the long-term (Section 3.4.2 [79]).

**Integration of Interpretive Opportunities**

There are considerable opportunities for the integration of interpretive and educational elements. These opportunities could range from erecting interpretative signage and constructing observation decks. The Bank Swallow is not a very well-known species although their nesting habits attract attention and are
often of interest to the public. Interpretation and education could be viewed as an important element in securing long-term support for the protection of this species, as well as other aerial foragers. Therefore it is recommended that interpretive opportunities related to the effects of the project on shoreline bluff habitat and aerial foragers be explored.

In summary, mitigative solutions are available that could be employed to compensate in part for a loss of Bank Swallow nesting areas. They range from the preferred acquisition of habitat to the provision of artificial nesting structures and indirectly related activities. Most of the techniques have been attempted with some success elsewhere, although detailed design (in the case of structures) and careful planning (e.g., location of structures) need be applied to reach a successful conclusion in a Canadian climate.

**UNCERTAINTY:**

The uncertainty for this attribute is considered moderate and directly related to the DNNP's final layout. Once the official layout is determined, the uncertainly in this attribute would be reduced.
4. Technical Performance

4.1 Technical Performance

<table>
<thead>
<tr>
<th>ATTRIBUTE SCORING CRITERIA</th>
<th>Score</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>The technology has never been applied on industrial scale</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Novel technology with limited application on industrial scale</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>The technology is mature but limited industrial use</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>The technology is mature and has been widely used with good track record, but operation is complex and requires frequent maintenance</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>The technology is mature and has been widely used with good track record, is easy to operate and maintain, but there is no experience with the technology in the nuclear industry</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>The technology is mature and has been widely used with good track record, is easy to operate and maintain, and there is extensive experience with the technology in the nuclear industry</td>
</tr>
</tbody>
</table>

FIRST PASS EVALUATION – NO ABATEMENT

SUMMARY OF EVALUATION:

OPEX and reports prepared by authoritative sources such as the World Nuclear Association and the US Department of Energy were used in the evaluation of this attribute.

The key findings are as follows:

1. Both technologies have a similar performance record.
2. However, MDCT have been found to be less efficient than OTC (~2% thermal and ~4% electrical). This translates into a loss of 48 MWe for each reactor (this has been captured in costs). However, MDCT have been utilized for a variety of different industries and have extensive operating experience.

CURRENT SCORING:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>4 Units</th>
<th>2 Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Once Through</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

SUPPORTING INFORMATION:

Maturity of Technology and Extent of Use

Once Through Cooling System / Mechanical Draft Cooling Tower

In the US, 44% of nuclear plants utilize wet recirculating cooling towers, while 38% utilize OTC, with the
remainder using cooling ponds [82]. This distribution is probably similar for continental Europe and Russia, though UK nuclear power plants located at a seashore use only OTC systems, as do all Swedish, Finnish, Canadian (Great Lakes water), South African, Japanese, Korean and Chinese plants [83]. Hence, it is inferred that both cooling technologies are mature and extensively used in the industry.

**Operations/Maintenance Complexity**

*Mechanical Draft Cooling Tower*

Compared with OTC which requires no complex operation and maintenance, there are some specific issues associated with the cooling tower technology [84], [14].

**Operation**

To operate cooling towers more efficiently, the following best practices should be carried out:

- Implement a preventive-maintenance program, including regular water treatment and maintenance of the mechanical and electrical systems.
- Reduce the temperature of water leaving the tower.
- Operate cooling towers simultaneously.
- Balance water distribution between multiple towers and within each tower.
- Consider a condenser water reset strategy.
- Close the bypass valve before starting the cooling-tower fans.
- Trend log the temperature of the water leaving the tower.

**Maintenance**

To maintain the operational safety and efficiency, the following maintenance should be performed on a regular basis:

- Effective water treatment,
- Prevent scale deposits,
- Prevent or clean clogged spray nozzles,
- Ensure adequate Airflow, and
- Ensure adequate pump performance.

**Safety issues**

There are some safety issues related to the operation and maintenance of cooling towers:

- Water Treatment: Cooling-tower water must be chemically treated regularly to prevent the growth of harmful bacteria, minimize corrosion, and inhibit the buildup of scale on the heat transfer medium.
- Maintenance Personnel: Cooling towers are often placed in precarious locations, and inspection ports can be located in awkward or exposed locations. This can create a hazardous working environment. Adequate fall-prevention measures and procedures should be implemented. In addition, lock-out and tag-out safety procedures should always be followed.

**Once Through Cooling**

**Operation and Maintenance**

- Maintenance require for periodic clean-up of intakes from clogging (weeds, mussels, algae, fish).
- Divers required for maintenance of intake and outfall structures.

**Safety issues**

- Safety issues relate to accidental or biological blocking of the intake and pump failure.

A more detailed summary of technical issues for both cooling technologies and practicable solutions can be found in Addendum A.

**Track Record**

OPEX searches were conducted for both technologies; it was found that each cooling option has a similar track record with a small number of incidents over thousands of reactor years. The most significant events are as follows:

**Mechanical Draft Cooling Tower**

(Based on searches in US NRC licensee event reporting database and COG OPEX database).

1. A fire destroyed a cooling tower at the closed Browns Ferry Nuclear Plant in 1986 [85].

2. In 2007, Partial Failure of Vermont Yankee Cooling Tower Cell CT2-4 occurred. This was a failure of several wooden support columns, due to iron salt attack, fungal attack, some excessive bolt tightening at splices, and some wood cracking from the annual freeze/thaw environment.

3. In 2008, Browns Ferry Main Control Room (MCR) received a report of smoke and an explosion at the Cooling Towers. Damage was identified as failed buswork between Cooling Tower Transformer '1' and the C/D Cooling Tower Switchgear. The Root Cause is the design drawing discrepancy of the Cooling Tower Bus Rating (3000 Amp vs. 4000 Amp) capacity, which led to erroneous information being used in inadvertently exceeding CT Bus capacity.

4. During a routine survey at Palisades power plant (Michigan), radioactive contamination concentrations were identified in the soil outside a Radioactive Waste Storage Building. The radioactive contamination was the result of historical Cooling Tower overflow events which subsequently flooded the Radioactive Waste Storage Building and washed radioactive contamination into the soil surrounding the building. Inadequate surveys after flooding events were identified as the root cause.

**Once Through Cooling Systems**

(Based on searches in OPG SCR database)

1. There are reports of structural issues with the outfall and intake, such as decrease in outfall depth due to chronic silting, and bulging of retaining walls.

2. There are reports of blockages due to weeds, algae, zebra mussels and fish. Specifically, in 2001, Pickering B sustained a rapid development of algae ingress into the intake structure; this caused surpass of capacity for the intake structure travelling screens. A large differential level developed rapidly across the travelling screens, resulting in the automatic tripping of condenser cooling water (CCW) pumps on Unit 7 and Unit 8. This was followed by turbine trips and reactor setbacks on both units. During this time, the large differential level which existed across the travelling screens could have lead to a loss of pump suction for all low pressure service water supplies to the four units. Additionally, the differential level could have resulted in collapse of the travelling screens and thereby, the loss of the heat sinks for all four units and major damage to the intake structure. Note that the primary challenging event (algae debris runs) has had mitigating actions already put in place to reduce safety and reliability impacts.

Availability of OPEX reports illustrates extensive operating experience with both options. While some operational issues have been identified in the past, both technologies are mature and in general the operating experience is positive.
Other issues

1. Efficiency and CO₂ emissions
   
   The UK Environment Agency notes that Mechanical draft cooling towers are typically ~2% less efficient (thermal) than OTC. This translates into 48 MW of reduction in electrical output for a 1,154 MWe AP-1000 plant. This equates to 0.1 to 0.3 MT of CO₂ emissions on an annual basis. A similar estimate of efficiency reduction is also given by the World Nuclear Association [83] and the US DOE [86].

2. Operational considerations
   
   The MDCT option is more complex in terms of operation [14]. Furthermore, MDCT require energy and are less efficient than other cooling options resulting in lost generation capacity. Loss of generation capacity is captured in the evaluation of cost attribute.

UNCERTAINTY:

There is a large quantity of acceptable OPEX data. There is no uncertainty associated with the scores assigned to this attribute as it is known that both technologies are mature with good track record in both the nuclear and other industries.

SECOND PASS EVALUATION - ABATEMENT

SUMMARY OF EVALUATION:

Based on the review of enhancement/mitigation/abatement systems being considered for both cooling options the following revised scoring is obtained. Plume abatement for cooling towers is mature and has been widely used with a good track record (non-nuclear fossil power plants), but there is little experience with the technology in the nuclear industry. Therefore, a score of 4 is assigned to the cooling tower option.

ABATED SCORING:

<table>
<thead>
<tr>
<th>Cooling options</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 Units</td>
</tr>
<tr>
<td>Once Through</td>
<td>5</td>
</tr>
<tr>
<td>Cooling tower</td>
<td>4</td>
</tr>
</tbody>
</table>

SUPPORTING INFORMATION:

Following the first pass evaluation four key attributes were identified for enhancement/abatement/mitigation. Each of these attributes may impact the technical performance and are discussed below.

1. Plume Abatement - Plume abatement technology (which is being considered in conjunction with the Mechanical Draft Cooling Towers) is not widely used in the nuclear industry and is considered a novel technology. The plume abatement is not utilized in the nuclear industry since it often entails:
   - High costs,
   - Increased complexity, and
   - Increased maintenance.
Since plume abatement does not eliminate the entire visible plume and nuclear power plants are often located in rural areas, this abatement measure is not considered essential.

Currently, there are no modern North American nuclear power plants that use cooling towers. However there are plans to construct such towers as part of the proposed third reactor at Calvert Cliffs [83], Maryland, at the proposed Niederamt Nuclear Power Plant in Switzerland (as a hybrid cooling system) [87] and as part of retrofitting the existing OTC system at San Onofre Nuclear Generating Station in California [88]. Such towers are also in operation at Chinon B in France [83].

2. Intake Enhancement – Design changes to enhance the intake for both cooling tower options are considered not to have any negative impacts on technical performance.

3. Discharge Enhancement - Design changes to enhance the discharge for both cooling tower options are considered not to have any negative impacts on technical performance.

4. Noise Abatement – Design changes to reduce noise from cooling towers is not considered to have any negative impacts on technical performance.

### ADDENDUM A: SUMMARY OF TECHNICAL ISSUES AND RISKS AND THEIR MANAGEMENT

#### ISSUE | ISSUE MANAGEMENT
--- | ---
**Once Through Cooling (OTC)** | 
Zebra and Quagga Mussels/algae/fish | Clogging of intake – mitigation for mussel and fish problems has been achieved by intake structure design and location at DNGS which has demonstrated good long term performance.

Additional enhancements to improve performance have been identified in a study by SENES – e.g. coatings that prevent mussel attachment, optimized intake veneer spacing that prevents clogging even if mussels attach.

Algae – An enhanced intake (deeper water) could also reduce the risk of algae clogging. CNSC comments (JRP report 5.9.2) on algal build up indicated that there are uncertainties and possible limitations regarding the long-term effectiveness of the cooling water intake proposed for the Project. CNSC staff suggested that a possible strategy to reduce the susceptibility to algal fouling would be to move the intake into deeper water, to a depth beyond the thermocline.

Frazil ice | Clogging of intake – a range of design features can be implemented to mitigate this hazard. At DNGS, recirculation of a small fraction of warmer discharge water has been used to control this hazard very effectively.

Furthermore, the design of a deeper intake could further reduce the likelihood of frazil ice being drawn into the intake.

Lake water temperature | High water temperatures in summer can cause derating to keep from exceeding the maximum allowable discharge temperature. This has occurred very infrequently for DNGS, and does not represent a significant issue. Nevertheless, it can be mitigated by extending the intake (of a new plant) into deeper, cooler water. This enhancement would improve efficiency, reduce the risk of occasional derating, and also have a lower impact on the aquatic environment.
Global warming | Potential risk for higher lake water temperatures causing derating – lake water warming would likely take longer to develop than atmospheric warming, giving the OTC option a longer operating life before problems may develop. An enhanced intake (deeper, colder water) could ensure minimal risk over the station's operating life.

### Mechanical Draft Cooling Tower (MDCT)

<table>
<thead>
<tr>
<th>Zebra and Quagga Mussels/algae/fish</th>
<th>Clogging of intakes – existing mitigation measures have been effective in minimizing this issue (e.g. copper coated wedge wire screens). Air burst systems are ‘typically’ used on smaller wedge wire screen systems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frazil ice</td>
<td>Clogging of intake - design features have been used to control this hazard very effectively.</td>
</tr>
<tr>
<td>Atmospheric events</td>
<td>Tornados and hurricanes represent a risk to the structural integrity of the cooling towers. The structural design of the cooling towers takes these risks into account. OPEX has shown that this has been adequate to control the risk from this hazard. However, some level of residual risk to the cooling system remains that is higher than for the OTC system.</td>
</tr>
<tr>
<td>Air temperature</td>
<td>High atmospheric temperatures reduce cooling efficiency and can cause deratings. Typically the maximum expected seasonal temperatures are taken into consideration and margin added to account for annual variations.</td>
</tr>
<tr>
<td>Plume abatement system reliability</td>
<td>It is assumed the design would include a system for abatement of the atmospheric plume, but such technology has not been used extensively in the nuclear industry, and there is little operating experience re. maintenance and reliability. This represents a risk to reliability.</td>
</tr>
<tr>
<td>Operational complexity</td>
<td>This system is more complex than the OTC system, with more components that require maintenance (chemical treatment of water, spray nozzles, airflow, pumps). Effective preventive maintenance programs have been used to keep this from reducing the capacity factor.</td>
</tr>
<tr>
<td>Global warming</td>
<td>Potential risk for higher air temperatures causing derating – atmospheric warming would likely occur sooner than lake warming (i.e. higher risk). Mitigation would require excess cooling capacity in the design to address potential future problems over the station’s operating life.</td>
</tr>
</tbody>
</table>
5. Cost  
5.1 Cost (Total Annual Costs)

**EVALUATION**

**SUMMARY OF EVALUATION:**
The costs associated with OTC and MDCT with and without enhancements have been determined for the case of 4 AP1000 reactors and 2 AP1000 reactors.

The OTC system TAC for 4 reactor units without enhancements was found to be less than half the costs as compared to a MDCT. Similar results were obtained for a comparison of 2 reactor units.

The OTC system TAC for 4 reactor units with enhancements was found to be approximately a third less the costs as compared to a MDCT. Similar results were obtained for a comparison of 2 reactor units.

### Summary of Cost Estimates for OTC and MDCT (expressed in TAC)

<table>
<thead>
<tr>
<th>Cooling Option</th>
<th>TAC without enhancements ($ Million)</th>
<th>TAC with enhancements ($ Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
<td>Two Units</td>
</tr>
<tr>
<td>OTC</td>
<td>38.4</td>
<td>28.2</td>
</tr>
<tr>
<td>MDCT</td>
<td>80.1</td>
<td>56.5</td>
</tr>
</tbody>
</table>

### Summary of Cost Estimates for OTC and MDCT (Expressed in NPV)

<table>
<thead>
<tr>
<th>Cooling Option</th>
<th>NPV without enhancements ($ Million)</th>
<th>NPV with enhancements ($ Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
<td>Two Units</td>
</tr>
<tr>
<td>OTC</td>
<td>538.5</td>
<td>395.6</td>
</tr>
<tr>
<td>MDCT</td>
<td>1,123.9</td>
<td>793.6</td>
</tr>
</tbody>
</table>

**SUPPORTING INFORMATION:**
The Condenser Cooling Water Option Assessment Methodology Report outlines a two-staged approach for conducting the BATEA evaluation. Stage 1 will be an initial assessment of both cooling options without any enhancements to the basic technology. Stage 2 will consider optimizations or technology enhancements for key attributes. Cost estimates are to be provided to align with this approach. For each stage, cost estimates will be provided for both 4 AP1000 reactors and 2 AP1000 reactors.

The provided cost estimates are for study purposes only and are solely for the comparison of options against each other, independent of the reactor technology. For the purposes of this study, Association of Cost Engineering (AACE) Class 4 concept study and AACE Class 5 feasibility study estimates have been used. This combined estimate is considered to have an accuracy of -30% to +70% which in this case is sufficient to differentiate between the two cooling technologies.
A list of cost items which will be considered in this evaluation are documented in Table G-26.

**Table G-26: Cost Items for Condenser Cooling Options.**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Capital Costs (base case)</td>
<td>Capital</td>
</tr>
<tr>
<td>Tunnelling and Excavation(^{16})</td>
<td>Capital</td>
</tr>
<tr>
<td>Lake Bottom/Shoreline</td>
<td>Capital</td>
</tr>
<tr>
<td>JRP Recommendations(^{17})</td>
<td>Capital</td>
</tr>
<tr>
<td>Chemical Costs</td>
<td>Operations and Maintenance (O&amp;M)</td>
</tr>
<tr>
<td>Maintenance Costs</td>
<td>O&amp;M</td>
</tr>
<tr>
<td>Water Use Costs</td>
<td>O&amp;M</td>
</tr>
<tr>
<td>Major Component Replacement Costs</td>
<td>O&amp;M</td>
</tr>
<tr>
<td>Loss Net Power Generation Revenue Costs(^{18})</td>
<td>O&amp;M</td>
</tr>
<tr>
<td>Tax Shield Credit</td>
<td>Capital</td>
</tr>
</tbody>
</table>

**Costing Assumptions**

The following assumptions apply to all evaluated cases:

- Discount Rate = 7%
- Cost of Energy = $70/MWh
- Capacity Factor = 92%
- Station Life = 60 Years
- Four a four unit station there would be a 10 year period between start of operation of Unit 1&2 and Unit 3&4.

**Cost Estimates for Cooling Options without Enhancements**

Cost estimates for both cooling options without enhancements in the case of four reactor units are presented in

---

\(^{16}\) Any costs associated with land procurement for soil disposal are assumed to be captured under this cost item.

\(^{17}\) JRP recommendations include: Round Whitefish Action Plan, Bank Swallow Habitat, Fish Habitat Compensation, Pond Compensation, Additional Impingement and Entrainment Sampling Programs, Enhanced Resolution Thermal Plume Modelling, Surface Water Risk Assessment, Evaluation to Determine the Total Area of Permanent Aquatic Effects, Contingency Plan for Construction, Operation and Decommissioning, Adaptive Management Program for Algae Hazard to the Project Cooling Water System Intake, Boater Safety Follow-up Program.

\(^{18}\) Loss generation load includes CW pumps, fan (if applicable), and losses due to thermal efficiencies.
Table G-27. Note that all cost figures presented are rounded to the nearest $100 thousand.

<table>
<thead>
<tr>
<th>Item #</th>
<th>Cost Item</th>
<th>Category</th>
<th>Cooling System Costs ($ Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>System Capital Costs</td>
<td>Capital</td>
<td>OTC: 96.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDCT: 120.0</td>
</tr>
<tr>
<td>2</td>
<td>Tunnelling and Excavation</td>
<td>Capital</td>
<td>OTC: 104.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDCT: 170.1</td>
</tr>
<tr>
<td>3</td>
<td>Lake Bottom/Shoreline</td>
<td>Capital</td>
<td>OTC: 5.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDCT: 5.0</td>
</tr>
<tr>
<td>4</td>
<td>JRP Recommendations</td>
<td>Capital</td>
<td>OTC: 6.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDCT: 4.2</td>
</tr>
<tr>
<td>5</td>
<td>Chemical Costs</td>
<td>O&amp;M</td>
<td>OTC: 0.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDCT: 45.5</td>
</tr>
<tr>
<td>6</td>
<td>Maintenance Costs</td>
<td>O&amp;M</td>
<td>OTC: 87.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDCT: 25.2</td>
</tr>
<tr>
<td>7</td>
<td>Water Use Costs</td>
<td>O&amp;M</td>
<td>OTC: 4.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDCT: 3.7</td>
</tr>
<tr>
<td>8</td>
<td>Major Component Replacement Costs</td>
<td>O&amp;M</td>
<td>OTC: 0.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDCT: 7.9</td>
</tr>
<tr>
<td>9</td>
<td>Net Power Loss Generation Revenue</td>
<td>O&amp;M</td>
<td>OTC: 272.4</td>
</tr>
<tr>
<td></td>
<td>Costs</td>
<td></td>
<td>MDCT: 797.6</td>
</tr>
<tr>
<td>10</td>
<td>Tax Shield Credit</td>
<td>Capital</td>
<td>OTC: (38.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDCT: (55.2)</td>
</tr>
</tbody>
</table>

Total Costs without Enhancements: 538.5 1,123.9

The OTC cost estimate includes:

- Capital: intake and discharge structures, the condenser cooling water pumps and associated piping. This is a Class 4 estimate.
- Tunnelling & Excavation: procurement of a tunnel boring machine, tunnelling and excavation of both intake and discharge structures. This is a Class 4 estimate.
- Lake Bottom/Shoreline: Costs to purchase aquatic habitat. This is a Class 5 estimate.
- JRP Recommendation: Costs to implement JRP recommendations associated with OTC. This is a Class 5 estimate.
- Chemical: There are no associated chemical costs with OTC.
- Maintenance: This includes maintenance to the intake and discharge structures. This is a Class 5 estimate.
- Water Use: Costs of water withdrawal from Lake Ontario. This is a Class 5 estimate.
- Major Component Replacement: There are no major components requiring replacement for OTC.
- Net Power Loss Generation: The loss of electrical output due to equipment (condenser cooling water pumps) electrical demands. This is a Class 5 estimate.
- Tax Shield Credit: A tax shield credit is provided because the interest on debt is tax deductible.
expense. For the purposes of this assessment, the tax shield credit is calculated using the capital costs, tunnelling and excavation costs, and lake bottom/shoreline costs. This is a Class 5 estimate.

The MDCT cost estimate includes:

- **Capital**: Cost of an SPX type F400 cooling tower, pumps required for the cooling towers, and condenser cooling water pumps and associated piping. This is a Class 4 estimate.
- **Tunnelling & Excavation**: This includes the cost of excavating the area for the cooling towers and tunnelling/trenching costs for the intake and discharge structures. This is a Class 5 estimate.
- **Lake Bottom/Shoreline**: Costs to purchase aquatic habitat. This is a Class 5 estimate.
- **JRP Recommendations**: Costs to implement JRP recommendations associated with MDCT. This is a Class 5 estimate.
- **Chemical**: This includes the costs of chemicals used to operate and maintain the cooling towers. This is a Class 5 estimate.
- **Maintenance**: This includes bi-annual inspections (fasteners, couplings alignment, checking and/or realignment of driveshaft), oil change and pinion shaft seal replacement, flex hose replacement, periodic replacement of gear reducer and checking of fan tip alignment for 38 cooling tower cells. This is a Class 4 estimate.
- **Water Use**: Costs of water withdrawal from Lake Ontario. This is a Class 5 estimate.
- **Major Component Replacement**: A mid-life (30 year) full tower reconstruction is required and is included here. This is a Class 4 estimate.
- **Net Power Loss Generation**: The loss of electrical output due to lower thermal cycle efficiency based on higher heat sink temperature and increased equipment (cooling tower recirculating pumps and fans) electrical demands. This is a Class 5 estimate.
- **Tax Shield Credit**: A tax shield credit is provided because the interest on debt is tax deductible expense. For the purposes of this assessment, the tax shield credit is calculated based on capital costs, tunnelling and excavation costs, and lake/shoreline procurement costs. This is a Class 5 estimate.

Exclusions:

- **Condenser**: Costs are reactor technology dependent and common to both options.
- ** Decommissioning**: Cost of decommissioning either option would be small and comparable discounted by 60 to 90 years.
- **Make-up Pump for MDCT**: Costs and load requirements would be small.

The corresponding cost estimates for the case of two reactor units is shown in Table G-28.
### Table G-28: Cost Estimate for Cooling Options without Enhancements (Two Units)

<table>
<thead>
<tr>
<th>Item #</th>
<th>Cost Item</th>
<th>Category</th>
<th>Cooling System Costs ($ Million)</th>
<th>Rationale for Change in Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>OTC</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>System Capital Costs</td>
<td>Capital</td>
<td>90.1</td>
<td>Intake and discharge</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>structures would be</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>constructed for four units</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>and therefore associated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>costs would remain the same.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Preset piping would be</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>installed. Cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>for condenser cooling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>pumps would be scaled down.</td>
</tr>
<tr>
<td>2</td>
<td>Tunnelling and Excavation</td>
<td>Capital</td>
<td>104.2</td>
<td>No cost reductions. Site</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>will be</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>excavated and tunnels</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>constructed to support</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>construction of 4 reactor</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>units.</td>
</tr>
<tr>
<td>3</td>
<td>Lake Bottom / Shoreline</td>
<td>Capital</td>
<td>5.0</td>
<td>No cost reduction.</td>
</tr>
<tr>
<td>4</td>
<td>JRP Recommendations</td>
<td>Capital</td>
<td>6.9</td>
<td>JRP Recommendations will be</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>implemented regardless of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>whether 2 reactor units or 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>reactors units are constructed.</td>
</tr>
<tr>
<td>5</td>
<td>Chemical Costs</td>
<td>O&amp;M</td>
<td>0.0</td>
<td>Costs would scale down.</td>
</tr>
<tr>
<td>6</td>
<td>Maintenance Costs</td>
<td>O&amp;M</td>
<td>44.0</td>
<td>Costs would scale down.</td>
</tr>
<tr>
<td>7</td>
<td>Water Use Costs</td>
<td>O&amp;M</td>
<td>2.2</td>
<td>Costs would scale down.</td>
</tr>
<tr>
<td>8</td>
<td>Major Component Replacement Costs</td>
<td>O&amp;M</td>
<td>0.0</td>
<td>Costs would scale down.</td>
</tr>
<tr>
<td>9</td>
<td>Net Power Loss Generation Revenue Costs</td>
<td>O&amp;M</td>
<td>180.6</td>
<td>Losses would scale down.</td>
</tr>
<tr>
<td>10</td>
<td>Tax Shield Credit</td>
<td>Capital</td>
<td>(37.3)</td>
<td>Reduction in tax shield</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>credit would scale down with</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>reduction in system capital</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>costs.</td>
</tr>
</tbody>
</table>

### Total Costs without Enhancements

| Total Costs without Enhancements | 395.6 | 793.6 |

### Cost Estimates for Cooling Options with Enhancements

Following the Stage 1 evaluation of the base technologies enhancements were considered for each of the key attributes. As part of the Stage 2 evaluation enhancements were reviewed and only cost effective enhancements were selected to improve the performance of each of the technologies. Cost effective
enhancements were selected through a high-level evaluation which included:

- Review of available enhancement technologies,
- Elimination of technologies not used at comparable facilities,
- Elimination of technically infeasible options, and
- Evaluation of performance gain and costs.

For the OTC and MDCT systems intake enhancement were considered to mitigate fish impingement and entrainment. For the MDCT system, noise abatement technologies were also considered to reduce off-site impacts. In addition, plume abatement technology was selected as an enhancement for the MDCT as requested by the Joint Review Panel (Recommendation #3). Plume abatement technologies reduce the visual plume effects including size, density, volume, number of hours of fogging/icing and the volume of water consumed (evaporative losses).

Cost estimates of the cooling systems for four reactor units can be seen in Table G-29.

<table>
<thead>
<tr>
<th>Item #</th>
<th>Cost Item</th>
<th>Category</th>
<th>Cooling System Costs ($ Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>OTC</td>
</tr>
<tr>
<td>1</td>
<td>System Capital Costs</td>
<td>Capital</td>
<td>111.5</td>
</tr>
<tr>
<td>2</td>
<td>Tunnelling and Excavation</td>
<td>Capital</td>
<td>104.2</td>
</tr>
<tr>
<td>3</td>
<td>Lake Bottom / Shoreline</td>
<td>Capital</td>
<td>5.0</td>
</tr>
<tr>
<td>4</td>
<td>JRP Recommendations</td>
<td>Capital</td>
<td>6.9</td>
</tr>
<tr>
<td>5</td>
<td>Chemical Costs</td>
<td>O&amp;M</td>
<td>0.0</td>
</tr>
<tr>
<td>6</td>
<td>Maintenance Costs</td>
<td>O&amp;M</td>
<td>80.2</td>
</tr>
<tr>
<td>7</td>
<td>Water Use Costs</td>
<td>O&amp;M</td>
<td>4.3</td>
</tr>
<tr>
<td>8</td>
<td>Major Component Replacement Costs</td>
<td>O&amp;M</td>
<td>0.0</td>
</tr>
<tr>
<td>9</td>
<td>Net Power Loss Generation Revenue Costs</td>
<td>O&amp;M</td>
<td>272.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>860.4</td>
</tr>
<tr>
<td>10</td>
<td>Tax Shield Credit</td>
<td>Capital</td>
<td>(41.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(100.0)</td>
</tr>
</tbody>
</table>

**Total Costs with Enhancements** 543.2 1,412.0

The OTC cost estimate includes:

- Capital: The enhanced OTC cooling intake includes the use of a new copper-nickel alloy screen to deter zebra mussels. The cost of this screen is a Class 5 (-50%/+100%) estimate. The Intake structure itself was also modified to reduce the overall approach velocity. This cost is a Class estimate.

- Maintenance Costs: The use of the copper-nickel alloy screen will reduce the on-going maintenance requirements to clean the intake structure. The savings associated with the use of the screen are considered to be a Class 5 estimate.
The MDCT cost estimate includes:

- **Capital:** The enhanced MDCT intake includes the use of a copper-nickel alloy wedge wire screen and airburst system. The enhanced MDCT’s also include noise abatement technology. The costs of the screen and noise abatement technologies are considered Class 5 estimates. The SPX type F400 cooling tower and pumps are replaced with an SPX ClearSky cooling tower and pump system for plume abatement. The plume abated towers are a Class 4 estimate.

- **Maintenance:** This ClearSky Cooling Tower system is made of 48 cells compared to 38 cells for the standard F400 system. The maintenance requirements are proportionally higher. This is a Class 4 estimate.

- **Major Component Replacement:** The ClearSky Cooling Towers also require a mid-life (30 year) full tower reconstruction. The reconstruction of the ClearSky Towers is much more significant than that of the F400. This is a Class 4 estimate.

- **Net Power Loss Generation:** The net power loss generation for the additional load requirements of the cooling tower fans and cooling tower pumps is included here. The ClearSky cooling tower pumps are smaller but more numerous (48 v. 38) due to the number of cells. The ClearSky fan power requirements are larger than that of the F400. There is an increase in parasitic load consumption for use of the plume abated towers. This is a Class 5 estimate.

**Exclusions:**

- **Condenser:** Costs are reactor technology dependent and common to both options.

- **Decommissioning:** Cost of decommissioning either option would be small and comparable discounted by 60 to 90 years.

- **Make-up Pump for MDCT:** Costs and load requirements would be small.

The corresponding cost estimates for the case of two reactor units is shown below in Table G-30.
### Table G-30: Cost Estimate for Cooling Options with Enhancements (Two Units)

<table>
<thead>
<tr>
<th>Item #</th>
<th>Cost Item</th>
<th>Category</th>
<th>Cooling System Costs ($ Million)</th>
<th>Rationale for Change in Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>OTC</td>
<td>MDCT</td>
</tr>
<tr>
<td>1</td>
<td>System Capital Costs</td>
<td>Capital</td>
<td>105.4</td>
<td>248.4</td>
</tr>
<tr>
<td>2</td>
<td>Tunnelling and Excavation</td>
<td>Capital</td>
<td>104.2</td>
<td>170.1</td>
</tr>
<tr>
<td>3</td>
<td>Lake Bottom/ Shoreline</td>
<td>Capital</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>4</td>
<td>JRP Recommendations</td>
<td>Capital</td>
<td>6.9</td>
<td>4.2</td>
</tr>
<tr>
<td>5</td>
<td>Chemical Costs</td>
<td>O&amp;M</td>
<td>0.0</td>
<td>22.8</td>
</tr>
<tr>
<td>6</td>
<td>Maintenance Costs</td>
<td>O&amp;M</td>
<td>40.1</td>
<td>21.1</td>
</tr>
<tr>
<td>7</td>
<td>Water Use Costs</td>
<td>O&amp;M</td>
<td>2.2</td>
<td>1.9</td>
</tr>
<tr>
<td>8</td>
<td>Major Component Replacement Costs</td>
<td>O&amp;M</td>
<td>0.0</td>
<td>21.4</td>
</tr>
<tr>
<td>9</td>
<td>Net Power Loss Generation Revenue Costs</td>
<td>O&amp;M</td>
<td>180.6</td>
<td>570.4</td>
</tr>
<tr>
<td>10</td>
<td>Tax Shield Credit</td>
<td>Capital</td>
<td>(40.2)</td>
<td>(79.3)</td>
</tr>
<tr>
<td></td>
<td><strong>Total Costs with Enhancements</strong></td>
<td></td>
<td>404.2</td>
<td>985.9</td>
</tr>
</tbody>
</table>
TAC for Cooling Options without Enhancements

Using the information in Table G-27 and Table G-28, the TAC for OTC and MDCT without enhancements can be determined. The results are shown below in Table G-31.

Table G-31: TAC for Cooling Options without Enhancements

<table>
<thead>
<tr>
<th>Cooling Option</th>
<th>TAC ($ Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>OTC</td>
<td>38.4</td>
</tr>
<tr>
<td>MDCT</td>
<td>80.1</td>
</tr>
</tbody>
</table>

TAC for Cooling Options with Enhancements

Using the information in Table G-29 and Table G-30, the TAC for OTC and MDCT with enhancements can be determined. The results are shown below in Table G-32.

Table G-32: TAC for Cooling Options with Enhancements

<table>
<thead>
<tr>
<th>Cooling Option</th>
<th>TAC ($ Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Units</td>
</tr>
<tr>
<td>OTC</td>
<td>38.7</td>
</tr>
<tr>
<td>MDCT</td>
<td>100.6</td>
</tr>
</tbody>
</table>

UNCERTAINTY:

For the purposes of this study, Class 4 concept study and Class 5 feasibility study estimates have been used. This combined estimate is considered to have an accuracy of -30% to +70% which in this case is sufficient to differentiate between the two cooling technologies.

Assuming the lower bound of the combined estimate accuracy for MDCT and the higher bound of the combined estimate accuracy for OTC, it can be seen that OTC is still judged to be the more cost efficient of the two options.
Appendix H: Baseline Design Parameter Set

Key design parameters for each of the two options, excluding enhancements, are presented in Table H-1. These parameters were used in the evaluation of option performance against the appropriate attributes.
### Table H-1: Baseline Design Parameter Set

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Baseline Once Through Cooling</th>
<th>Baseline Mechanical Draft Cooling Tower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat rejection rate</td>
<td>4 Units (8836 MWt [2])</td>
<td>4 Units (8836 MWt [2])</td>
</tr>
<tr>
<td><strong>Intake</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design concept, including screen</td>
<td>An off-shore porous veneer intake structure (10 m depth) specifically designed to reduce fish impingement. The porous modules are flush with the lake bottom and low intake approach velocity (approximately 12.2 cm/s). The porous veneer cap is made of 242 structurally-independent precast reinforced concrete modules and a reinforced concrete centre piece. Each porous veneer module consists of concrete vanes separated by a space 14 cm wide [24]. A stainless steel 6” x 6” (15 cm x 15 cm) screen overlay which is placed over each porous module [24].</td>
<td>Makeup water would be drawn from Lake Ontario using four separate water intake pipes located at a water depth of 10 m [2]</td>
</tr>
<tr>
<td>Inside Diameter</td>
<td>7.5 m [64]</td>
<td>4 x 4.0 m(^{19})</td>
</tr>
<tr>
<td>Length</td>
<td>800 m [24]</td>
<td>800 m [24]</td>
</tr>
<tr>
<td>Depth</td>
<td>10 m offshore [24]</td>
<td>10 m offshore [24]</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>228 m(^3)/s [23]</td>
<td>6 m(^3)/s [38]</td>
</tr>
</tbody>
</table>

\(^{19}\) Although the MPR report [2] indicated that the envisioned cooling tower system for DNNP would have four 1.4 m diameter pipes (see section k.1 of MPR report), four pipes with a diameter of 4.0 m are required for the approach velocity of 12.2 cm/s to achieve the flow rate of 6 m\(^3\)/s.
### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Baseline Once Through Cooling</th>
<th>Baseline Mechanical Draft Cooling Tower</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Approach Velocity</strong></td>
<td>12.2 cm/s [38]</td>
<td>12.2 cm/s [38]</td>
</tr>
<tr>
<td><strong>Design concept</strong></td>
<td>The station cooling water is discharged through a multi-port diffuser (90 nozzles) at 10 m depth in the lake and mixes with the surrounding water within the near-field mixing zone to a temperature which is acceptable to the Ministry of Environment.</td>
<td>The discharge is assumed to be through a single port with a nozzle oriented with an upward angle of 45 degrees above horizontal and located 1 m above the bottom [38].</td>
</tr>
<tr>
<td><strong>Depth</strong></td>
<td>10 – 20 m [38]</td>
<td>~ 12 m [38]</td>
</tr>
<tr>
<td><strong>Length</strong></td>
<td>The near-shore end of the DNGS staged diffuser begins at a distance of approximately 860 m from the existing shoreline, and extends an additional 900 m into Lake Ontario [38]</td>
<td>~ 900 m [38]</td>
</tr>
<tr>
<td><strong>Inside Diameter</strong></td>
<td>12.9 m² [20]</td>
<td>0.77 m [38]</td>
</tr>
<tr>
<td><strong>Flow Rate</strong></td>
<td>228 m³/s [23]</td>
<td>1.5 m³/s [38]</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>DNNP assumes a design temperature rise of 9°C above ambient lake temperature [38]</td>
<td>The discharge temperature increase on an average monthly basis is between 6 to 8°C. The maximum discharge temperature increase is 16.9°C in spring and the minimum -1.0°C in the summer [38].</td>
</tr>
</tbody>
</table>

---

20 Adapted from [38], if diffuser port velocities are maintained, the port diameters would be approximately 0.85 m diameter and the discharge tunnel diameter would be 12.9 m.
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Baseline Once Through Cooling</th>
<th>Baseline Mechanical Draft Cooling Tower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principle</td>
<td>N/A</td>
<td>Mechanical draft cooling towers use large fans to move all of the air required to achieve the design heat transfer. This system accomplishes cooling by providing intimate mixing of water and air, which results in cooling primarily by evaporation. A small portion of the water being cooled is allowed to evaporate into a moving air stream to provide significant cooling to the rest of that water stream [2]</td>
</tr>
<tr>
<td>Dimensions</td>
<td>N/A</td>
<td>Individual cooling towers would be assembled into four linear rows of cooling towers 37 m wide by 316 m long by 16 m tall for each nuclear reactor [2]</td>
</tr>
<tr>
<td>Noise abatement concept</td>
<td>N/A</td>
<td>3.3 dBA at off-site receptor location (full operation 2026) [54]</td>
</tr>
</tbody>
</table>
| Plume parameters                 | N/A                            | Worst Case Plume Dimensions (No Foliage) [71]:  
  - Height: 1,000 m  
  - Length: 10,000 m  
  - Radius: 500 m  
  - Frequency: 99% (winter) |
| Operation and Maintenance        | Water consumption rate         | 4.5 m³/s [38] |
Parameters | Baseline Once Through Cooling | Baseline Mechanical Draft Cooling Tower
---|---|---
List and quantity of chemicals | No chlorination as a means of Zebra Mussels control of the CCW as it is not practical (e.g. volume of water), although chlorination is used to control Zebra Mussels in the station service water systems | Chemicals will be used in O&M for the following purposes:
  - Disinfectant
  - pH control
  - Antiscalants or scale inhibitors
  - Blowdown treatment
The quantity and type of chemicals will be decided once the design is known. The following substances may be considered:
Conditioning (annual average):
  - Disinfectant: Sodium Hypochlorite (12% wt), annual average consumption at 69 kg/h (continuous) and 23 kg/h (shock).
  - pH control: Sulphuric Acid (93% wt), annual average consumption at 596 kg/h
  - Antiscalants or scale inhibitors (18% wt scale inhibitor, PMA (polymaleic anhydride) with 12% wt dispersant polymer, HSP2), annual average consumption at 62 kg/h
Blowdown (annual average):
  - Coagulant (FeCl₃): 206 kg/h
  - Polymer (in Clarifier): 2 kg/h
  - Polymer (in belt press): 0.2 kg/h
  - Sodium Bisulphite: 103 kg/h (continuous) and 35 kg/h (shock)
[2]-section 3.6
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Baseline Once Through Cooling</th>
<th>Baseline Mechanical Draft Cooling Tower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of lake infill</td>
<td>2 m</td>
<td>2 m</td>
</tr>
<tr>
<td>Area of total lake infill</td>
<td>12.2 ha - partial</td>
<td>19.4 ha - full</td>
</tr>
<tr>
<td>Volume of total excavated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>materials (Mm³)</td>
<td>• Bulk excavation: 8.77</td>
<td>• Bulk excavation: 11.6</td>
</tr>
<tr>
<td></td>
<td>• Lake infill: 0.457</td>
<td>• Lake infill: 0.725</td>
</tr>
<tr>
<td></td>
<td>NE Soil Stockpile: 4.5</td>
<td>NE Soil Stockpile: 4.5</td>
</tr>
<tr>
<td></td>
<td>• Off-site storage: 3.81</td>
<td>• Off-site storage: 6.43</td>
</tr>
<tr>
<td>Traffic</td>
<td>381,000 truck loads for off-site transfer (Assuming to use “conventional truck” with capacity of 10 m³) It is conservatively assumed that 10 m³ trucks will be used.</td>
<td>643,000 truck loads for off-site transfer (Assuming to use “conventional truck” with capacity of 10 m³) It is conservatively assumed that 10 m³ trucks will be used.</td>
</tr>
</tbody>
</table>
Appendix I: Design Enhancements

Technical enhancements have been considered for the design of the condenser cooling system for the DNNP. The following three enhancements were determined to be both feasible and significant in terms of mitigating potential effects:

1. Noise Abatement (MDCT)
2. Plume Abatement (MDCT)
3. Intake enhancement (OTC and MDCT option)

The description of these enhancements is provided below.

I.1 NOISE ABATEMENT

Once Through Cooling

Noise for OTC is primarily from the water flow and the noise level would not increase over the background value at receptors on or off the site. Therefore, no modification is needed to enhance the baseline OTC option.

Mechanical Draft Cooling Towers

MDCT use large fans to move all of the air required to achieve the design heat transfer. The noise from the fans, overwhelming the noise from the falling water, is the major source of noise generated during operation. There are different noise abatement technologies, as described below [65].

- Silencers

  Duct silencers can be used to reduce the noise level only at the air-inlet and air-discharge openings. Their use may be necessary for severe noise level reduction.

  The duct silencers usually contain baffles, with mineral wool packing and parallel air passages. The attenuation increases with the length and thickness of the baffles and decreases with the distance between them.

  Noise attenuation by baffles is generally given as insertion attenuation for band sound levels (expressed usually in octave band levels). This means that the same arrangement of baffles may lead to different results for attenuation when the band level of noise sources is different, even when the overall levels have the same magnitude. Hence it is necessary to know the partial band sound power levels for the cooling tower openings when determining effective noise reduction measures.

  It should be noted that the use of silencers can result in an additional pressure drop which has a substantial effect on the operating point of the fan. The supplementary pressure loss can require a significant increase in drive power and/or numbers of fan blades in order to maintain cooling performance (Section 6.2 [65]).
• Screening

The use of screens can reduce the noise pressure level in the vicinity of a cooling tower. An insertion attenuation of 10 - 15 dBA can be achieved. The characteristic length is defined as the path difference from noise source to observer, with and without the screen. The noise reduction depends on the frequency and path difference. At low frequencies only minor reductions in noise level can be achieved. Furthermore, the noise reduction effect is dependents on weather conditions.

The effect of the screen increases as the distance to the cooling tower decreases and the margin by which the screen periphery is at a higher level than the noise source. Generally the screens are used for reducing the noise which is propagated by air inlet openings and cooling tower walls. To minimize the additional pressure drop, the distance to the cooling tower should not be less than the height of the cooling tower inlet area. The side facing the cooling tower can be coated with sound absorbing material to further reduce the noise level.

The reductions in noise level which can be achieved with series cooling tower vary, even with the same geometric conditions. The reason for this is the broad spread of spectra of the noise propagated from the air inlet. It must be stated clearly that the use of screens does not reduce the noise power levels of a noise source.

When it comes to the sizing and location of such sound barrier walls, it is recommended to closely cooperate with the supplier of the cooling tower and sound barrier wall and an acoustical engineer to ensure that the acoustical requirements are met. Sound barrier walls can provide an effective solution to a problem where sound radiation is only critical in certain directions, since they offer the possibility to "partially" encapsulate (Section 6.3 [65]).

• Encapsulation

To further improve the acoustical performance of cooling tower with sound attenuation, encapsulation may be considered. By encapsulation, any noise radiation from the cooling tower shell can be reduced. Such measure is only justified if the noise radiated from the shell has a dominating influence on the total noise radiated. For this reason encapsulation is only sensible if the air, water and mechanical (motor) noise of the tower are already attenuated.

Encapsulating is often applied with smaller equipment in an indoor location. In such a case only the intake and discharge areas radiate noise to the surrounding. The noise emitted from the shell will stay inside the enclosure. The prediction of this noise not only depends on the noise coming from the shell but also the type of enclosure, as the noise will be reflected from the surrounding walls. Due to reflections, the internal noise can increase but usually the noise inside a machine room is less of a concern (protective measures may be required). For the external noise, radiation is recommended to specify partial sound power levels for the air intake and discharge areas.
When a cooling tower cannot be located indoors, it is possible to reduce the shell emissions by acoustical encapsulation. For such encapsulation to be effective, it is necessary to use insulation material with a high mass. Heat insulation material is not suitable for this purpose. With the properly selected insulation material it is possible to acoustically match an indoor installation. When applying the encapsulation it must however be assured that access to the cooling tower maintenance points is maintained, i.e. the encapsulation must not obstruct any access doors.

Encapsulation is acoustically feasible but generally requires a significant investment. It is recommended to closely cooperate with the supplier of both cooling tower and an acoustical engineer to ensure that the acoustical requirements are met.

Sound barrier walls are also a means of acoustical encapsulation. Such walls are built in the vicinity of the cooling tower either in the sound critical direction or as a total enclosure. Due to the distance between sound barrier wall and cooling tower the access to maintenance points is assured (Section 6.4 [65]).

There is also the possibility of encapsulation in the form of depth landscaping, where equipment (pumps etc.) would “sink” into the soil, which would act as a sound barrier. However, there is concern over the increase in excavation and the limitation of space; this abatement option would need additional engineering design.

**I.2 PLUME ABATEMENT**

**Once Through Cooling**

The OTC system does not produce a visible plume and therefore no technical enhancement to the baseline OTC option is warranted.

**Mechanical Draft Cooling Towers**

It has not been determined what specific technology will be utilized for plume abatement. Below is the description of several abatement technologies which could be considered to eliminate the visible plume from an evaporative cooling tower [72].

- Parallel Path Wet-Dry (PPWD) with Water-to-Air Heat Exchangers

  For this abatement factor, the plenum of the tower is extended upward to leave room for the fin tube and heating coils to be installed vertically along the sides of the tower. Hot water from the process goes into the heating coils first then into the wet section. Sometimes the water flow going to the heating coils is a fraction of the overall water flow rate; air dampers are often installed in front of the heating coils. In the summer mode of operation, the air dampers are closed so most of the cooling air goes through the wet section, but due to damper leakage some air bypasses the wet section resulting in additional energy usage. In the no-plume mode of operation, the air dampers are open and some cooling air goes through the wet section while some cooling air goes in parallel through the dry section. The air coming from the wet section is warm and saturated with moisture, while the air going through the dry section...
is hot and dry. When both flows of air mix in the plenum, the overall relative humidity of the exhaust air is less and the plume remains invisible.

PPWD is a good technology, particularly adapted to large field erected towers; however, it is usually expensive. The water-to-air heat exchangers are typically metallic fin tube bundles consisting of 10-12 fins per inch and designed in accordance with standard API 661. This technology requires higher than usual plenum heights for the water-to-air heat exchanger installation. The resultant high structural loads, due to additional weight and a higher center of gravity, become critical under seismic and wind load requirements. Baffles can be installed in the tower plenum to enhance the mixing between the hot dry air and the saturated air and provide level 2 plume abatement. A vacuum system is also added to remove the non-condensable gases trapped at the top of the tube bundles while at the same time providing a siphon that lowers considerably the operational pumping head.

- **Parallel Path Wet-Dry with Air-to-Air Heat Exchangers**
  Another PPWD technology uses air-to-air heat exchangers made of patented plastic packs in the tower plenum designed to de-saturate the leaving air by sensible heat transfer with ambient air.

- **Series Path Wet-Dry (SPWD)**
  Another way to abate the plume, more typically utilized in packaged cooling towers, is by heating the exhaust air with heating coils in the plenum above the drift eliminators or over the fan. The amount of heat required to heat the exhaust air enough to abate the plume is much greater than in the case of a PPWD system. Typically very hot water or preferably steam is used to heat the air and the heating coils have only one or two rows of tubes. In addition, the added static pressure incurred year-round from the fin coil makes the application of this technology in induced draft cooling towers often impractical, and adds to the overall fan energy.

In general, the height of the MDCT with plume abatement is significantly lower than the NDCT; and higher than the unabated MDCT. It is much smaller in width but vastly greater in length and each tower is separated by a greater distance (140 m between each tower block) than both the NDCT and MDCT [71]. The dimensions of an example of the MDCT with plume abatement are summarized in Table I-1.

<table>
<thead>
<tr>
<th>Cooling Tower Type</th>
<th>Height</th>
<th>Width at Base</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDCT with plume abatement</td>
<td>28 m, including the height of the cells</td>
<td>37 m</td>
<td>393 m</td>
</tr>
</tbody>
</table>

Table I-1: Dimension of the MDCT with Plume Abatement [71]
I.3 INTAKE ENHANCEMENT

Once Through Cooling

The porous veneer intake design has been used in Darlington Nuclear Generating Station (DNGS) to reduce fish impingement and entrainment. The design is illustrated in Figure I-1 and Figure I-2 [89].

Figure I-1: Design of DNGS Porous Veneer Intake

Figure I-2: Close-up of Porous Module Showing Location of 14 cm Slots
The proposed enhanced OTC option will use an improved porous veneer intake structure specifically designed to reduce fish impingement and entrainment.

Unlike the existing DNGS design which has a stainless steel screen (15 cm x 15 cm) placed over each porous module (5.5m X 5.5m), the following enhancement has been considered:

- Removal of concrete vanes to increase porous area of modules and reduce available area for Zebra Mussel growth;
- Installation of a finer screen (compared to DNGS) made of zebra mussel deterrent material would reduce maintenance requirements. The deterrent material is copper-nickel alloy which would minimize zebra mussel attachment.
- There is strong evidentiary basis supporting the use of such screens and demonstrating that resulting copper concentrations in lake water are negligible.
- Increase in intake structure porosity to 45% by using 10 cm opening (square) with cross members of 2.5 cm thickness (width) to reduce intake dimensions and approach velocity;
- Increase the number of porous modules to 276 to ensure that the average approach velocity is reduced from ~12 cm/s to 6 cm/s [24] assuming an intake flow rate of 228 m$^3$/s.
- The total intake structure will occupy approximately 10,500 m$^2$ which represents an increase of 79% from the existing intake structure in DNGS.
- No behavioural deterrents are included in the enhanced design as they would have to be species-specific and there is no firm evidence on their efficiency.

The comparison of the parameters of the enhanced intake structure with the existing design at DNGS and the baseline design for DNNP is provided in Table I-2.
### Table I-2: Comparison of the Intake Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Existing design at DNGS</th>
<th>Base case</th>
<th>Enhancement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proposed</td>
<td>Increase*</td>
<td>Proposed</td>
</tr>
<tr>
<td>Flow (m³/s)</td>
<td>150</td>
<td></td>
<td>228</td>
</tr>
<tr>
<td>Number of non-porous modules</td>
<td>60</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>Number of porous modules</td>
<td>124</td>
<td></td>
<td>182</td>
</tr>
<tr>
<td>Module size (length) m</td>
<td>5.5</td>
<td></td>
<td>5.5</td>
</tr>
<tr>
<td>Area center piece (m²)</td>
<td>272</td>
<td></td>
<td>272</td>
</tr>
<tr>
<td>Area of no-porous modules (m²)</td>
<td>1815</td>
<td></td>
<td>1815</td>
</tr>
<tr>
<td>Area of porous modules (m²)</td>
<td>3751</td>
<td></td>
<td>5506</td>
</tr>
<tr>
<td>Total porous area (m²)</td>
<td>1275</td>
<td></td>
<td>1872</td>
</tr>
<tr>
<td>Total area (m²)</td>
<td>5838</td>
<td></td>
<td>7593</td>
</tr>
<tr>
<td>Equivalent diameter (m)</td>
<td>86.2</td>
<td></td>
<td>98.3</td>
</tr>
<tr>
<td>Mean intake velocity (m/s)</td>
<td>0.118</td>
<td></td>
<td>0.122</td>
</tr>
</tbody>
</table>

*Increase refers to the change against the existing DNGS values.

Furthermore OPG undertook to carry out an additional fish, larvae and egg surveys, including sampling program in deeper waters. The results of this program will be used to place the intake in area with low concentration of sensitive species, such as Round Whitefish.

It is expected that moving the intake location to deeper water will reduce both impingement and entrainment. For example, at a depth of approximately 12 m, the entrainment of Round Whitefish eggs and larvae would be further reduced by avoiding depths with higher concentrations of eggs and young larvae. In addition, at 12 m depth, it is unlikely that Deepwater Sculpin will be encountered given that they are a demersal species found in deeper water.

**Mechanical Draft Cooling Towers**

Similar to the baseline cooling tower option, the enhanced cooling tower option will also use four separate water intake pipes, installed at a water depth of 10 m, to drawn makeup water from Lake Ontario [2]. However, this enhanced option will employ wedge wire screens with 2 mm slot openings [24] to reduce impingement and entrainment. The screens will be equipped with an airburst system to prevent biofouling.

Cylindrical wedgewire (CWW) screens, as illustrated in Figure I-3, are physical barriers and are available in a range of slot widths as narrow as 2 mm. For proper functioning of CWW screens, it is necessary to have sweeping or flushing currents. This sweeping/flushing current is necessary to transport both fish and debris past the screens and to increase cleaning efficiency by subsequently carrying the debris away from the screens. Adequate screen submergence is also necessary for proper functioning of CWW screens. This prevents damage to the screens from large floating debris and boats [90].
Figure I-3: Cylindrical Wedgewire Screen

CWW screens are susceptible to biofouling by Zebra Mussels, as this species could attach, grow and multiply on hard objects. A preventative solution would be to apply a permanent metal coating capable of resisting Zebra Mussels. One such option is a copper alloy metal coating that also resists corrosion. Coatings do not involve binders, VOCs or carriers, and can be applied to complex shapes with small screen openings such as wedgewire screens. There are available coatings that can be effectively applied as a thin profile with a total thickness of 0.004 inches and therefore has little effect on flow profile. Copper leach rates for these coatings are below practicable detection limits using US EPA certified test procedures and standard NSF protocols [91].

CWW screens (wide slots) have been used successfully at large freshwater facilities such as the J.H. Campbell Plant (Unit 3 only) in Michigan and the Oak Creek/Elm Road Generating Station located in Wisconsin [90].
**Appendix J: Enhanced Design Parameter Set**

Table J-1 presents parameter sets for each of the two options taking into account potential enhancements. These parameters were used against relevant attributes when evaluating the enhanced designs.
### Table J-1: Enhanced Design Parameter Set

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Enhanced Once Through Cooling</th>
<th>Enhanced Mechanical Draft Cooling Tower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat rejection rate</td>
<td>4 Units (8836 MWe [2])</td>
<td>4 Units (8836 MWe [2])</td>
</tr>
<tr>
<td><strong>Intake</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design concept, including screen</td>
<td>An improved porous veneer intake structure (at 10 m depth) specifically designed to reduce fish impingement and entrainment. The porous modules are flush with the lake bottom and have a very lower approach velocity (6 cm/s). The porous veneer cap is made of 336 structurally-independent precast reinforced concrete modules and a reinforced concrete centre piece. Finer screen will be made of a copper-alloy (or alternative material) to deter Zebra Mussels. Screen design will be sized to limit fish impingement (e.g. 10 cm opening with cross members of 2.5 cm thickness) [72]</td>
<td>Makeup water would be drawn from Lake Ontario using four separate water intake pipes at a water depth of 10 m [2] and include wedge wire screens with 2 mm slot openings [24]. The wedge wire screen will be equipped with an airburst system to prevent biofouling.</td>
</tr>
<tr>
<td>inside Diameter</td>
<td>7.5 m [64]</td>
<td>4 x 4.0 m</td>
</tr>
<tr>
<td>Length</td>
<td>800 m [24]</td>
<td>800 m [24]</td>
</tr>
<tr>
<td>Depth</td>
<td>10 m offshore [24]</td>
<td>10 m offshore [24]</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>228 m$^3$/s [23]</td>
<td>6 m$^3$/s [38]</td>
</tr>
<tr>
<td>Approach Velocity</td>
<td>6 cm/s [38]</td>
<td>12.2 cm/s [38]</td>
</tr>
<tr>
<td><strong>Discharge</strong></td>
<td>The station cooling water is discharged through a multi-port diffuser (90 nozzles) at 10 m depth in the lake and mixes with the surrounding water within the near-field mixing zone to a temperature which is acceptable to the Ministry of Environment.</td>
<td>The discharge is assumed to be through a single port with a nozzle oriented with an upward angle of 45 degrees above horizontal and located 1 m above the bottom [38] [38]</td>
</tr>
<tr>
<td>Parameters</td>
<td>Enhanced Once Through Cooling</td>
<td>Enhanced Mechanical Draft Cooling Tower</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Depth</td>
<td>10 – 20 m [38]</td>
<td>~ 12 m [38]</td>
</tr>
<tr>
<td>Length</td>
<td>The near-shore end of the DNGS staged diffuser begins at a distance of approximately 860 m from the existing shoreline, and extends an additional 900 m into Lake Ontario [38].</td>
<td>~ 900 m [38]</td>
</tr>
<tr>
<td>Inside Diameter</td>
<td>12.9 m&lt;sup&gt;21&lt;/sup&gt;</td>
<td>0.77 m [38]</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>228 m³/s [23]</td>
<td>2.4 m³/s (derived from 6 m³/s intake and 3.6 m³/s water consumption)</td>
</tr>
<tr>
<td>Temperature</td>
<td>DNNP assumes a design temperature rise of 9°C above ambient lake temperature [38].</td>
<td>The discharge temperature increase on an average monthly basis is between 6 to 8°C. The maximum discharge temperature increase is 16.9°C in spring and the minimum -1.0°C in the summer [38].</td>
</tr>
<tr>
<td>Mechanical Draft Cooling Tower</td>
<td>Principle</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Individual cooling towers would be assembled into four linear rows of cooling towers 37 m wide by 393 m long by 28 m tall for each nuclear reactor [71].</td>
<td>A MDCT with plume abatement technology (also referred to as a hybrid wet/dry cooling tower) uses the normal evaporative processes of MDCT but also involves dry heat transfer to the atmosphere. The design is larger than unabated MDCT because it has extra volume for dry heat transfer [2] Appendix B.</td>
</tr>
<tr>
<td></td>
<td>Dimensions</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<sup>21</sup> Adapted from [38], if diffuser port velocities are maintained, the port diameters would be approximately 0.85 m diameter and the discharge tunnel diameter would be 12.9 m.
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Enhanced Once Through Cooling</th>
<th>Enhanced Mechanical Draft Cooling Tower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise abatement concept</td>
<td>N/A</td>
<td>Noise abatement technologies, for example, silencers or screens, could be used which can reduce noise levels by 10-15 dBA [65]</td>
</tr>
</tbody>
</table>
| Plume parameters            | N/A                           | Worst Case Plume Dimensions (No Foliage):  
|                             |                               | • Height: 350 m  
|                             |                               | • Length: 3,500 m  
|                             |                               | • Radius: 170 m  
|                             |                               | • Frequency: 46% (winter) [71] |
| Operation and Maintenance   | Water consumption rate        | 3.6 m³/s  
<p>|                             |                               | Water consumption for MDCT is 10-30% less [2] Appendix B. A value of 20% [71] will be assumed for evaluation. |</p>
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Enhanced Once Through Cooling</th>
<th>Enhanced Mechanical Draft Cooling Tower</th>
</tr>
</thead>
</table>
| List and quantity of chemicals | No chlorination as a means of Zebra Mussels control of the CCW as it is not practical (e.g. volume of water), although chlorination is used to control Zebra Mussels in the station service water systems | Chemicals will be used in O&M for the following purposes:  
- Disinfectant  
- pH control  
- Antiscalants or scale inhibitors  
- Blowdown treatment  
The quantity and type of chemicals will be decided once the design is known. The following substances may be considered:  
Conditioning (annual average):  
- Disinfectant: Sodium Hypochlorite (12% wt), annual average consumption at 69 kg/h (continuous) and 23 kg/h (shock).  
- pH control: Sulphuric Acid (93% wt), annual average consumption at 596 kg/h  
- Antiscalants or scale inhibitors (18% wt scale inhibitor, PMA (polymaleic anhydride) with 12% wt dispersant polymer, HSP2), annual average consumption at 62 kg/hr  
Blowdown (annual average):  
- Coagulant (FeCl3): 206 kg/hr  
- Polymer (in Clarifier): 2 kg/hr  
- Polymer (in belt press): 0.2 kg/hr  
- Sodium Bisulfite: 103 kg/hr (continuous) and 35 kg/hr (shock) [2]-section 3.6 |

---

**AMEC NSS Limited**

D0077/RP/001 R00

Form 114 R21

Page 342 of 378
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Enhanced Once Through Cooling</th>
<th>Enhanced Mechanical Draft Cooling Tower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of lake infill</td>
<td>2 m</td>
<td>2 m</td>
</tr>
<tr>
<td>Area of total lake infill</td>
<td>12.2 ha</td>
<td>19.4 ha</td>
</tr>
<tr>
<td>Volume of total excavated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>materials (Mm³)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Bulk excavation:</td>
<td>8.768</td>
<td>11.6</td>
</tr>
<tr>
<td>- Lake infill:</td>
<td>0.457 (the soil storage</td>
<td>0.725 (the soil storage capacity of a</td>
</tr>
<tr>
<td></td>
<td>capacity of a 2m lake infill)</td>
<td>2m lake infill)</td>
</tr>
<tr>
<td>- NE Soil Stockpile:</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>- Off-site storage:</td>
<td>3.81</td>
<td>6.43</td>
</tr>
<tr>
<td>Traffic</td>
<td>381,100 truckloads for off-site</td>
<td>643,000 truckloads for off-site transfer</td>
</tr>
<tr>
<td>transfer (Assuming to use</td>
<td>transfer (Assuming to use</td>
<td>(Assuming to use “conventional truck”</td>
</tr>
<tr>
<td>“conventional truck” with</td>
<td>“conventional truck” with</td>
<td>with capacity of 10 m³)</td>
</tr>
<tr>
<td>capacity of 10 m³)</td>
<td>capacity of 10 m³)</td>
<td>It is conservatively assumed that 10 m³</td>
</tr>
<tr>
<td>It is conservatively</td>
<td></td>
<td>trucks will be used.</td>
</tr>
<tr>
<td>assumed that 10 m³</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Appendix K: Evaluation Alterations from Stakeholder Sessions

Table K-1 represents feedback received from stakeholder sessions and provides responses to the feedback which may have an impact on the methodology, facts and/or assumptions. Additional feedback received that does not have a substantial impact on the evaluation or that was addressed during the stakeholder session is not included. This information has been documented in the minutes of stakeholder meetings.

The stakeholder sessions include:

<table>
<thead>
<tr>
<th>Session</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roundtable Meeting #1</td>
<td>Community Interests</td>
</tr>
<tr>
<td>Roundtable Meeting #2</td>
<td>Municipal and Provincial Agencies and Select Business Interests</td>
</tr>
<tr>
<td>Roundtable Meeting #3</td>
<td>Environmental Groups</td>
</tr>
<tr>
<td>Roundtable Meeting #4</td>
<td>Darlington Community Advisory Council</td>
</tr>
<tr>
<td>Roundtable Meeting #5</td>
<td>Federal Agencies</td>
</tr>
<tr>
<td>Roundtable Meeting #6</td>
<td>William Treaty First Nations</td>
</tr>
</tbody>
</table>
### Table K-1: Stakeholder Feedback and Responses

<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Quality</td>
<td>The concentration of conventional contaminants which exceed the regulatory criteria over extended periods of time is the assessment parameter for air quality. The feedback on this attribute included the following:</td>
<td>Environmental guidelines, particle size and particulate emissions are discussed in Appendix G 2.2 Air Quality/Emission to Air.</td>
</tr>
<tr>
<td></td>
<td>- The particulate matter values for the current baseline and the Ministry of the Environment guidelines for particulate matter should be explicitly stated.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- The assessment should consider the full range of potential emissions that could affect air quality.</td>
<td>The full range of potential emissions is discussed in Appendix G 2.2 Air Quality/Emission to Air.</td>
</tr>
<tr>
<td></td>
<td>- The assessment should consider the cumulative effects of various projects in the local area on air quality, particularly given the proposed thermal treatment facility (incinerator).</td>
<td>A discussion on cumulative effects for the MDCT plume and other industrial plants, especially emissions from the planned Durham-York Energy form Waste (EFW) Facility, has been added to Appendix G 2.2: Air Quality/Emission to Air. It should be noted that there is uncertainty relating to the potential future facilities in the region and therefore uncertainty in the resulting cumulative effects.</td>
</tr>
<tr>
<td></td>
<td>- There is a need to consider air quality during the construction phase as well as during operations.</td>
<td>Both construction and operation phases have been considered. There will be releases to air due to the increase of traffic for construction. The DNNP EA stated that there would be no significant exceedance of the baseline. This is discussed in Appendix G 2.2 Air Quality/Emission to Air.</td>
</tr>
<tr>
<td></td>
<td>- The calibration for scoring this attribute should be mutually exclusive and the difference between marginal and not discernible made clear.</td>
<td>Air quality calibration and underlying assumptions are discussed in:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Section 5.4: Step 4 – Definition of Scoring Scheme</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Section 5.4.3.2: Air Quality/Emission to Air</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Appendix G 2.2 Air Quality/Emission to Air</td>
</tr>
<tr>
<td>Topic</td>
<td>Stakeholder Feedback</td>
<td>Responses</td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Aquatic Habitat</td>
<td>The assumptions regarding wind and wind modelling should be clearly stated.</td>
<td>Details of the air dispersion model are discussed in Appendix G 2.2 Air Quality/Emission to Air which is consistent with the Environmental Assessment. The calibration has been modified to ensure that it is clear and the effects are evaluated for the cooling options only, not taking the impact of the power block into account. The scoring for this attribute is consistent with the calibration scheme. This is discussed in Appendix G 3.4: Aquatic Habitat.</td>
</tr>
<tr>
<td></td>
<td>The aquatic habitat attribute was evaluated on the basis of physical loss of habitat.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The basis for the scoring calibration for this attribute should be made clear given the difference in the amount of lake infill required;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Clarity is required regarding the lake infill assumptions, including whether any is actually required for the project and why different lake infill assumptions are used for this one attribute.</td>
<td>The calibration has been modified to ensure that it’s clear and the effects are evaluated for the cooling options only, not taking the impact of the power block into account. Lake infill requirements are discussed in detail in the following sections: Section 5.2.1: Site Layout and Excavation Assumptions Section 5.4.3.4: Excavated Materials Section 5.4.4.4: Aquatic Habitat Appendix G 2.7: Excavated Material Appendix G 3.4: Aquatic Habitat</td>
</tr>
<tr>
<td></td>
<td>The assessment should consider effects on spawning habitat particularly during construction and from thermal discharge.</td>
<td>Currently it is anticipated that the time-frame for in-water construction activities for the OTC option that may impact aquatic environment will be limited to one season. Most of the construction would involve tunnelling, therefore avoiding potential disturbance. For MDCT this may extend over a period of two seasons. Most fish species, such as alewife are distributed throughout lake Ontario and any activity taking place over a period of one to two seasons in a localized area near the northern shores will not have a significant impact. Mitigation measures will be taken to minimize potential effects. Effects on spawning habitat are discussed under Thermal Discharge.</td>
</tr>
<tr>
<td>Topic</td>
<td>Stakeholder Feedback</td>
<td>Responses</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Cost   | The Net Present Value and Total Annual Costs of the two options are used for the assessment of this attribute, but are not scored. The feedback on this attribute included the following:  
  - The rationale for not scoring or calibrating a scoring scheme should be clear, as there are a number of ways a score could be calibrated (e.g., life time cost of the cooling option as a percentage of total project cost, total annual costs, impact on rate payers, etc.).  
  - Clarity is required on whether costs include:  
    - Construction costs.  
    - Use of electricity/loss of generation revenue (also discussed in sections Technical Performance attribute).  
    - Additional health care costs arising from public health and safety risks.  
  - Clarity is required on how the assessment considered different mitigation measures and their potential to affect costs (e.g., extend intake out several hundred metres would increase cost of once through cooling).                                                                                                                                                                                                                     | The reason cost isn’t assigned a score is that we only have two options and costs are already a numerically measured parameter. Assigning a score would not enhance transparency of the evaluation.  
  - An explanation is provided in Section 5.4.6: Cost  
  - Construction costs are provided in Appendix G5.0: Cost.  
  - Lost generation costs are provided in Appendix G5.0: Cost.  
  - Both options can be operated safely, without impacting public health.  
  - Referenced studies considered alternative enhancements to the intake, including the extension of the OTC intake. Economically achievable design enhancements were than selected as part of the Condenser Cooling Water Option Assessment.  
  - Details of selected enhancements can be found in Appendix I: Design Enhancements. Costs for the selected design enhancements can be found in Appendix G 5.0: Cost.                                                                                                                                                                                                                                                                                                |
<table>
<thead>
<tr>
<th><strong>Topic</strong></th>
<th><strong>Stakeholder Feedback</strong></th>
<th><strong>Responses</strong></th>
</tr>
</thead>
</table>
| Excavated Materials | The volume of excavated materials requiring off-site management was used for assessment of this attribute. The feedback on this attribute included the following:  
- The total volume of excavated materials should not be used as the baseline as it under-estimates the effects.  
- The scoring needs to reflect the difference in effects of the options.  
- It is unclear what a score of 0 means for this attribute, clarity is required.  
- It is unclear why different lake infill assumptions are used for this one attribute, clarity is required.  
- The assessment needs to include consideration of the effects of the additional traffic associated with additional excavation including the:  
  - Increase in the volume (amount and frequency) of daily truck traffic.  
  - Temporal aspect of traffic effects (the length of time the additional traffic will occur).  
  - Additional fatalities from increased traffic.  
  - Public health and safety considerations from increased traffic.  
  - Road improvements that may be necessary.  
  - Atmospheric effects on local climate, fish and wildlife. | The baseline for this attribute was changed to ensure that the cooling options are evaluated independently of the power block. Similar changes were made for the Aquatic and Terrestrial habitat attributes. The Space Requirement attribute was removed to avoid duplication.  
A new subsection was added to Section 5.2: Step 2 – Identification of cooling technologies (without enhancements) outlining the establishment of a power block baseline. This section clarifies the lake infill assumptions. |
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• The assessment needs to include consideration of the effects of material disposal (whether it is clean fill, where it will be disposed of, whether it will increase competition for and cost of disposal in the local community, etc.).</td>
<td>A survey was completed as part of the DNNP EA, which sampled for contaminants. It was determined that a majority of the soil is clean and that contaminant concentrations are below regulatory limits. This assessment assumed that suitable disposal locations would be available within 25 km from the site. See Appendix G 2.7 Excavated Material for more details.</td>
</tr>
<tr>
<td></td>
<td>There is a concern that the assessment does not consider the effects of lake infill on the quality of water required for St. Mary's or other near-shore processes (also discussed in Water Quality).</td>
<td>Some additional suspended solids may impact water quality during construction but this would generally occur during construction which is a short time period in terms of plant operation. OPG is currently completing a costal processes study, and the impacts of the infill will be known when the permit is being acquired. Costal processes are not expected to change with the addition of the infill.</td>
</tr>
</tbody>
</table>
| Fish Impingement         | The estimated reduction in the quantity of fish mortality, in unit of kg, due to impingement was used as the measuring parameter for this attribute, converted into a percentage avoided. The feedback on this attribute included the following:  
• The use of biomass and kg/annum as a metric may mask important considerations and makes it difficult to understand the actual effect. A different metric should be used or justification provided for the use of biomass.  
• Current impingement numbers at Darlington, projected reduction and volumes should be clearly stated.  
• The use of Pickering Nuclear Generating Station data for the baseline, but impingement data from Darlington Nuclear Generating Station for the DNNP is confusing – clarity is needed. | Standard practice is to represent fish loss in kg/annum. Information on specific species is available in reference materials and is represented in kg/annum.  
Quantities of fish are presented in Appendix G 3.1: Fish Impingement.  
The baseline and attribute calibration were structured to reflect Canadian and international regulatory guidance. See Appendix G 3.1 Impingement for further details. |
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>required.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The use of Pickering Nuclear Generating Station data for the baseline is problematic, as a surface intake would not be allowed – justification is required.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Clarification is required of how the scoring and calibration relate to regulatory requirements.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Justification is required to support a scoring calibration with a variable scale.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The type of fish impinged (i.e. species affected) may be an important consideration, the assessment should consider addressing this.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Species of concern, such as Round Whitefish, have been considered in the decision making process.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The assumptions used to forecast the effects over the operating life of the plant are unclear.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Although historical data are available, they were not used to determine future fish populations as it is difficult to predict what species of fish would predominate over 60 years of operation. It is assumed that impingement and entrainment percentages would not change.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Clarity is required regarding the assumptions for this attribute, including:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Whether a larger intake compared to the existing DNGS intake is required.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Whether the intake rates decrease if fewer reactor units are installed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A larger intake structure is required for a four unit OTC system than the current DNGS as the design has been modified for a higher overall intake flow rate with a lower approach velocity. The intake flow rate is proportional to the number of units constructed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Details on the design parameters for the intake structures can be found in Appendix H: Baseline Design Parameter Set and Appendix J: Enhanced Design Parameter Set.</td>
<td></td>
</tr>
<tr>
<td>Topic</td>
<td>Stakeholder Feedback</td>
<td>Responses</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>• There is much interest in possible mitigation and enhancement measures for both options against this attribute, including:</td>
<td>Best practicable means for minimizing impingement have been considered in the selection of enhancements for both cooling options.</td>
</tr>
</tbody>
</table>
|                      |   • Reducing flow rates.  
   • Increasing the # of intake valves.                                                                                           | Information on adaptability over the operating life of the plant is provided in Section 6.4.                                           |
<p>|                      | • It is unclear how the assessment considered enhancements and effect of enhancements over the operating life of the plant. Clarity is required.                                                                  |                                                                                                                                          |
| Fish Entrainment    | The estimated reduction in the quantity of eggs and larvae mortality due to entrainment was used as the measuring parameter for this attribute, converted into percent avoided. The feedback on this attribute included the following: | The baseline and attribute calibration were structured to reflect Canadian and international regulatory guidance. See Appendix G 3.2: Entrainment for further details. |
|                      |   • The use of Pickering Nuclear Generating Station data for the baseline, but entrainment data from Darlington Nuclear Generating Station requires justification.    |                                                                                                                                          |
|                      |   • The use of different baseline data for different attributes (e.g. for thermal discharge the existing DNGS data is used for the baseline and the base case) is confusing and raises concerns about consistency in the methodology - consideration should be given to using the same baseline, or justification provided regarding the use of different baselines; |                                                                                                                                          |
|                      |   • The calibrations of the scores appear to be mutually exclusive, which is positive, however the variable scale is problematic and should be corrected.                                                          |                                                                                                                                          |</p>
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Information on zebra mussel management for the intake and how this was considered in the assessment should be provided.</td>
<td>Zebra mussel management is discussed in Section 6.3.2.3: Intake Enhancements for both OTC and MDCTs. There is no chemical treatment for Zebra Mussels in relation to operation of the condenser cooling system for either option.</td>
</tr>
<tr>
<td></td>
<td>• Justification is required for the mechanical draft cooling tower intake rate.</td>
<td>The intake rate for the MDCT is consistent with the assumed design.</td>
</tr>
<tr>
<td></td>
<td>• There is interest in possible mitigation and enhancement measures for mechanical draft cooling towers against this attribute which could lower entrainment, including:</td>
<td>Best practicable means for minimizing entrainment have been considered in the selection of enhancements for both cooling options.</td>
</tr>
<tr>
<td></td>
<td>• Installation of fine mesh screens.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The efficacy of the improvements at Pickering.</td>
<td></td>
</tr>
<tr>
<td>Global Warming Adaptability</td>
<td>This attribute considered potential impacts on the economic and technical performance of the cooling options from changes due to:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Total annual precipitation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Frequency of extreme precipitation, extreme temperature events and other extreme weather events (e.g. tornadoes).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lake Ontario water temperatures and water level.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>This attribute was not scored due to the inherent difficulty of assigning any quantitative measure to</td>
<td></td>
</tr>
<tr>
<td>Topic</td>
<td>Stakeholder Feedback</td>
<td>Responses</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>global warming adaptability</td>
<td>The feedback on this attribute included the following:</td>
<td>Global Warming Adaptability was removed as an attribute. A new section was added to clearly describe potential changes, including variation in lake level and increases in lake and air temperature. It evaluates how each technology could be adapted to deal with them. See Section 6.4 for further information.</td>
</tr>
<tr>
<td></td>
<td>1. The assessment needs to consider changes in lake level, increases in lake temperature and effect on receiving environment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Clarity is required regarding the temporal aspects of this attribute (i.e. the period of time over which the identified changes may occur).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. It was suggested that this attribute include rating the options against Green House Gas emissions.</td>
<td>As noted in Appendix D, the potential for the two condenser cooling options to cause global climate change has not been assessed. This is because it is not known what electricity generation mode would be used to compensate for generation loss. The effect of global climate change on the operation of the condenser cooling has been considered under technology adaptation in Section 6.4.</td>
</tr>
<tr>
<td></td>
<td>4. More transparency is required in scoring, particularly the magnitude of the difference in power reduction and effects of bio-fouling.</td>
<td>Global Warming Adaptability was removed as an attribute. A new section was added to clearly describe potential changes and evaluate how each technology could be adapted to deal with them. See Section 6.4 for further information.</td>
</tr>
<tr>
<td>Local Climate Change</td>
<td>The duration of the adverse anthropogenic (man-made) effects on the climate from fogging and icing was used for the assessment of this attribute. The feedback on this attribute included the following:</td>
<td>The issue of bio-fouling is also discussed under the attribute Technical Performance and in Section 6. Anticipated losses due to parasitic loads and lower thermal efficiencies are considered under the “Loss Net Power Generation Revenue” as discussed in Appendix G 5.1: Cost.</td>
</tr>
<tr>
<td></td>
<td>1. Clarification of the calibration used for scoring is required, given the severity of the effects and potential health and safety risks.</td>
<td></td>
</tr>
</tbody>
</table>

Further information on the calibration scheme can be found in Appendix G 2.5: Local Climate Change. Public Health and Safety concerns with respect to local climate change are discussed in Appendix G1.1: Public Health and Safety.
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Information on the air modelling used for the assessment should be presented.</td>
<td>Information on modelling and assumptions for fogging and icing conditions are described in detail in Appendix G 2.5: Local Climate Change.</td>
</tr>
</tbody>
</table>
|       | • The assessment should consider effects of Local Climate Change on:  
  • St. Mary’s workers and operations (from icing and on incoming marine traffic).  
  • Existing off-site roadways including 401, regional and local roads.  
  • New elevated 407 structures. | St. Mary’s Cement Group is beyond the boundaries of OPG, and therefore St Mary’s employees are considered to be the public. Impacts to the public are discussed in Appendix G1.1: Public Health and Safety.  
A description of the number of hours of fogging induced by the MDCT plume and the effects on local roads and the future 407 highway are discussed in Appendix G 2.5 Local Climate Change. |
|       | • The assessment should consider the effect on public and worker health and safety of the above. | The effect on public and worker health and safety are discussed in Appendix G 2.5: Local Climate Change. |
|       | The fact base contradicts the material presented (re: hazardous fog) – this should be corrected. | A description of the number of hours of fogging induced by the MDCT plume compared to what occurs naturally was included in Appendix G 2.5 Local Climate Change, Bounding Cases, and Fogging. This discussion also included the effects that the plume would have on nearby roads. The number of hours of fogging and its extent is small compared to what occurs naturally. |

**Noise Level**

The incremental sound level over the background levels at off-site receptor locations was used for the assessment of this attribute. The feedback on this attribute included the following:

• The effects of noise on workers at DNGS and at adjacent properties should be considered in the assessment.

Noise effects on the public (including workers on adjacent properties) are considered under Public Health & Safety (Section 6.1.2.1, 6.3.3.1 and Appendix G 1.1). Noise effects on OPG workers are considered under Worker Health & Safety (Section 6.1.2.2, 6.3.3.2 and Appendix G 1.2).
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
</table>
| Public Health and Safety    | The public health and safety attribute considers the potential risk of injury to the public. Some found the risk calculation helpful in putting context on the risk assessment, other feedback included the following:  
  * The information on risk, likelihood and severity need to be presented separately.  
  * Clarity is required for the risk calculation, whether it is a product or a sum.  
  * The assessment needs to consider the health and safety risks (or provide justification as to why they aren’t considered):  
    * From construction as well as operations.  
    * From increased traffic associated with Excavated Materials and biowaste management – which can be calculated (with the caution it not be double counted).  
    * From use of chemicals (including corrosion, shipping, atmospheric releases, etc).  
    * From various transportation modes. | The Likelihood and Severity tables were separated for both Public Health and Safety and Worker Health and Safety. This was applied to the following sections:  
  * Section 5.4.1: Public Health and Safety,  
  * Appendix G 1.1: Risk to Public Health and Safety,  
  * Section 5.4.2: Worker Health and Safety, and  
  * Appendix G 1.2: Risk to Worker Health and Safety  
  
  Risk is a product of likelihood and consequence.  
  
  The site preparation period was not considered for health and safety risks since the DNNP would be a construction zone if either cooling option was chosen. It was not seen as a potential differentiator between the two options as construction would take place over a relatively short period of time compared to operation and because health and safety risks associated with this type of conventional construction for large industrial projects are generally accepted by the public. This is discussed in Appendix G1.2: Worker Health and Safety.  
  
  Appendix D states that biowaste is not considered since it is not seen as a potential differentiator.  
  
  Safety risks regarding the use of chemicals in the condenser cooling water system have been addressed for workers (Section 6.1.2.2, 6.3.3.2 and Appendix G 1.2) and for the public (Section 6.1.2.1, 6.3.3.1 and Appendix G 1.1).  
  
  The risk of transporting chemicals is discussed in Appendix G1.1: Public Health and Safety. The risk associated with handling and storage of chemicals |
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
</table>
| • On adjacent properties and businesses from Local Climate Change (e.g. fogging and icing). |  | can be found in Appendix G1.2: Worker Health and Safety. The use of rail was considered, but the train would block entrance to St. Mary's Cement and spur construction is not economically achievable. This was added to Appendix G2.7: Excavated Materials  
St. Mary's Cement Group is beyond the boundaries of OPG, and therefore St Mary's employees are considered to be the public. Noise from MDCT without noise abatement would be only slightly above background level and have no effect on St. Mary's workers. MDCT with noise abatement would have no noise impact on St. Mary's employees. This information was included in a new section in Appendix G1.1: Public Health and Safety.  
It was also found that the number of hours of fogging and icing as a result of a MDCT plume would not cause a significant increase from what occurs naturally. More information on this issue was added to Appendix G 2.5 Local Climate Change - Bounding Cases. |
| • The source of data for mechanical draft cooling tower facts and assumptions should be clear, given the limited operating experience with that technology option. |  | Although there is no data on the operation of a CANDU with MDCTs, the cooling water technology is independent of type of reactor selected. The condenser cooling water system is designed in conjunction with the condenser for maximum efficiency.  
Although OPG does not have direct experience on the operation of MDCT, a significant wealth of OPEX (operational experience) is available via participation in industry groups such as COG, INPO and WANO. OPG has made use of these resources for the purposes of this study. 
This is further described in Appendix G4.1: Technical Performance. |
<p>| • Clarity is required in distinguishing facts from assumptions.     |  | The wording for facts and assumptions was revised to address this comment. |
| First Nations noted that future health issues are fundamentally important, and long term effects on health need to be considered and they need to be considered holistically (i.e. a life-cycle perspective). |  | This study looks at the life of Darlington New Nuclear Project (DNNP). This study and the DNNP EA evaluated impacts for the project life, including the operating life time of 60 years, as well as construction and decommissioning |</p>
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
</table>
| Public Perception   | The attribute public perception is concerned with views expressed by the public with regards to the cooling options. This attribute was evaluated on a qualitative basis only. The feedback on this attribute included the following: Municipal elected officials and municipal staff reiterated their strong preference for a once through cooling system and sought assurance that their views would be reflected in the assessment. Their comments are repeated verbatim as follows:  
  - Clarington's preference is not to have cooling towers – we want to make sure our voice and opinion is well articulated.  
  - I will repeat what I've been saying to you for over two years now; it is Clarington's preference, and I believe the preference of the region that OPG select once through cooling over cooling towers.  
  - Clarington completed a report advising the council between the two options. They concluded that once through cooling was the better option since there was no empirical data on mechanical draft cooling tower plumes.  
  - The council is a reflection of the public and their views need to be considered when making a decision. There is validity to qualitative public perception that must be acknowledged.  
  - Why is this being presented to us to be commented on, we've already looked at this and responded. We do not want cooling towers. | Stakeholder’s preferences were noted. |
Other participants noted that:
- Justification is required for the assessment of public perception on MDCT, as there is a lack of information regarding public perception of mechanical draft cooling towers and it is unclear how any conclusive statements can be made regarding this technology option;
- Consideration should be given to quantifying this attribute, given the range of tools available;
- Clarity is required over how this attribute is used in the cost benefit decision logic, given the lack of information and the qualitative assessment; and
- Confirmation is required on whether public perception is double counted, since the attribute is based on visual effects which are already addressed in a separate attribute.

Stakeholder Workshops were judged to be the appropriate forum for seeking information on public perception of MDCT vs. NDCT. This is due to the need to clearly explain the differences so that informed feedback can be collected. Furthermore, Public Perception was removed as an attribute to avoid potential overlaps. The information on the available feedback is provided in Section 8.0 and Appendices K and L.

Space Requirements

The area of land required for different options was used as the parameter for assessing this attribute. The feedback on this attribute included the following:
- The baseline and scoring calibration downplays the differences between the two technology options and should be reconsidered.
- The assumption regarding the amount of lake infill required should be tested in a sensitivity analysis.

Attribute “Space Requirements” was removed as an attribute. All information and environmental impacts are captured within the Excavated Materials and Aquatic Habitat attributes. Space Requirement was also included in Appendix D, Table D-1: Rationale for exclusion of some aspects from the final attribute list.
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
</table>
| Terrestrial Habitat | The loss of bank swallow habitat was used for the assessment of this attribute. The feedback on this attribute included the following:  
- The attribute title should reflect the scoring only considers effects on species of concern (which is undefined) and then only on bank swallow habitat.  
- A rationale or justification for not having a zero score needs to be provided, as there are options (e.g. a zero score could be loss of all habitat, or a species that is regulated, etc.).  
- It is unclear whether either option affects any species at risk, now or potentially in the future – clarity is required.  
- There is a need to consider effects on terrestrial habitat (including on-site ponds and off-site habitat) and wildlife from:  
  - salt deposition, its sources (including whether any exists in the blow-off), composition and any relevant guidelines.  
  - chemicals, their treatment and potential for release and whether this results in any off-site vegetation damage.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | The only terrestrial species of concern that may be impacted by the condenser cooling water option selected are the Bank Swallows. See Appendix G 3.5: Terrestrial Habitat for additional details.  
A score of 0 was not assigned as there was no mandatory limit on this attribute. For details on the scoring scheme, see Section 5.4.4.5: Terrestrial Habitat.  
The Ministry of Natural Resources has identified Banks Swallows as a “candidate species at risk” [92] and OPG has committed to construction of man-made habitat for the resettlement of Bank Swallows to mitigate any effects of construction and operation. A detailed discussion on Bank Swallow habitat related mitigation techniques is documented in Appendix G 3.5: Terrestrial Habitat. The Environmental Assessment assumed that any impacts to the Bank Swallows from the DNNP could be fully mitigated. In the future, if Bank Swallows were to become a species at Risk or an Endangered species, additional mitigation or compensation may be required.  
Salt deposition is directly linked to the hardness of Lake Ontario; naturally occurring salts in the lake will be concentrated as the cooling water is recycled in the MDCT systems. Chemical blow-downs will be used to decrease the amount of salt deposition. This discussion was included in Appendix G 3.5: Terrestrial Habitat, Modeling Results – Salt Deposition and Damage to Vegetation.  
Discussion on blowdown and chemicals can be found in Appendix G2.1: Water Quality/Emissions to Water. |
## Stakeholder Feedback Responses

<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>- increases in construction traffic which may also affect terrestrial wildlife (through increased road kill and/or during road reconstruction).</td>
<td>Increase in truck traffic in addressed in Section 5.4.3.4: Excavated Materials and Appendix G 2.7: Excavated Material</td>
<td></td>
</tr>
<tr>
<td>- The assumption regarding extent of lake infill required should be subject to a sensitivity analysis (fewer reactors; different placement for cooling towers; etc.).</td>
<td>Sensitivity Study was updated following completion of Step 10 (Final Selection). See Section 10.0: Uncertainty and Sensitivity Analysis. It evaluated the potential impact of uncertainties in attribute scores.</td>
<td></td>
</tr>
<tr>
<td>The concern that loss of Bank Swallow habitat could over time contribute to Bank Swallows becoming a Species at Risk or an Endangered Species needs to be reflected in the assessment.</td>
<td>The Ministry of Natural Resources has identified Banks Swallows as a “candidate species at risk” [92] and OPG has committed to construction of man-made habitat for the resettlement of Bank Swallows to mitigate any effects of construction and operation. A detailed discussion on Bank Swallow habitat related mitigation techniques is documented in Appendix G 3.5: Terrestrial Habitat. The Environmental Assessment assumed that any impacts to the Bank Swallows from the DNNP could be fully mitigated. In the future, if Bank Swallows were to become a species at Risk or an Endangered species, additional mitigation or compensation may be required. The sensitivity to units constructed was considered. Even in the event of less than 4 units being constructed in the first phase, the site will be prepared for the provision of up to 4 units. This would necessitate site preparation for the whole area East of the Maple Grove road for the MDCT option, requiring full extent of 2m lake infill and resulting in the removal of all Bank Swallow habitat. OPG has initiated a program to test man-made habitat for the resettlement of Bank Swallows. The results of this program are not known at this stage. See Appendix G 3.5: Terrestrial Habitat.</td>
<td></td>
</tr>
<tr>
<td>Topic</td>
<td>Stakeholder Feedback</td>
<td>Responses</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Thermal Discharge</td>
<td>The size of the mixing zone, defined as the area which experiences a temperature difference of 2 degrees C above ambient less than 1% of the time, was selected as the primary criterion for evaluating thermal discharge to Lake Ontario. The feedback on this attribute included the following:</td>
<td>Details on the size and depth of the discharge/diffuser system can be found in Appendix H: Baseline Design Parameter Set and Appendix J: Enhanced Design Parameter Set.</td>
</tr>
<tr>
<td></td>
<td>• The size and location of the discharge/diffuser system and the assumptions regarding its placement need to be clearly described.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The amount of heat being released into the lake needs to be quantified and placed in context (e.g. average temperature of Lake Ontario at dispersion; temperature of water released; regulatory requirements if any; etc.).</td>
<td>This information can be found in the mixing zone modeling results in Appendix G 3.3: Thermal Discharge to Lake.</td>
</tr>
<tr>
<td></td>
<td>• The facts and assumptions should reflect studies on the biological effects of thermal discharge.</td>
<td>The design of the discharge is comparable to the existing DNGS diffuser design which has been found to be performing well. No discharge enhancement is required to mitigate thermal impacts. Further information is provided in Appendix G 3.3: Thermal Discharge to Lake.</td>
</tr>
<tr>
<td></td>
<td>The assessment needs to consider the following:</td>
<td>Effects on zooplankton were considered in supporting studies, see reference [24].</td>
</tr>
<tr>
<td></td>
<td>• Effects on zooplankton.</td>
<td>Seasonality and the reproductive cycle of fish have been considered in evaluating potential impact from the Thermal Discharge. These effects were considered in the assessment and are discussed in Appendix G 3.3: Thermal Discharge to Lake and referenced studies.</td>
</tr>
<tr>
<td></td>
<td>• Seasonality, particularly for the most sensitive species like Round Whitefish where the temperature at the substrate is important.</td>
<td>Effects of climate change were considered in Section 6.4. See above for issues relating to seasonality and temperatures during winter season.</td>
</tr>
<tr>
<td></td>
<td>• Effects of climate change and particularly temperatures during the winter season.</td>
<td></td>
</tr>
<tr>
<td>Topic</td>
<td>Stakeholder Feedback</td>
<td>Responses</td>
</tr>
<tr>
<td>------------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>• Chronic and acute effects.</td>
<td>Chronic and acute effects and the reproductive cycle of fish have been considered in evaluating potential impact from the Thermal Discharge.</td>
</tr>
<tr>
<td></td>
<td>• Potential effects associated with underground mining from adjacent properties.</td>
<td>This assessment is based on St Mary’s operations covered by their approved permit. Future development of St Mary’s operation that has not been approved has not been considered.</td>
</tr>
<tr>
<td></td>
<td>• This attribute was seen to have a high potential for mitigation, particular interest was in extending the diffuser into deeper water.</td>
<td>The design of the discharge is comparable to the existing DNGS diffuser design which has been found to be performing well. No discharge enhancement is required to mitigate thermal impacts.</td>
</tr>
<tr>
<td>Technical Performance</td>
<td>This attribute provides an evaluation in terms of maturity of the technology, complexity and reliability of operation and maintenance. The feedback on this attribute included the following:</td>
<td>Costs due to loss of Net Power Generation are discussed in Appendix G 5.1: Cost. Other effects, such as due to additional uranium mining or additional energy generation facilities are not considered as it is not known how the loss of power generation would be replaced.</td>
</tr>
<tr>
<td></td>
<td>• The thermal efficiency (or parasitic energy load) of the options should be considered (this is also discussed under 4.2.3 Cost, but should not be double counted).</td>
<td></td>
</tr>
<tr>
<td>Visual Effect</td>
<td>The negative changes to the visual aesthetics observed were used for the assessment of this attribute. Some participants indicated that the public would not appreciate tall towers; others indicated that they had no concerns with visible plumes. The feedback on this attribute included the following:</td>
<td></td>
</tr>
<tr>
<td>Topic</td>
<td>Stakeholder Feedback</td>
<td>Responses</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------</td>
<td>-----------</td>
</tr>
<tr>
<td></td>
<td>The facts and assumptions regarding the plume's visibility (whether it would be constant or if it would dissipate, whether it would be coloured or not, etc.) should be clearly stated.</td>
<td>The plume physical dimensions are discussed in Appendix H: Baseline Design Parameter Set and Appendix J: Enhanced Design Parameter Set. The MDCT plume would have the appearance of a white cloud. This was included in Appendix G 2.6 - Visual Effects, Mechanical Draft Cooling Tower.</td>
</tr>
<tr>
<td></td>
<td>It is unclear whether the assessment considered visibility from the surrounding landscape, from the elevated structures on the planned 407 interchange, from travelers on the 401, from boaters approaching the northern shore of Lake Ontario, etc. Clarity and justification should be provided.</td>
<td>Appendix G 2.6 was altered to state that the cooling tower structures will be visible from Highway 401, the extension of Highway 407 and Lake Ontario. The MDCT plume would not cause more of a visual distraction than an ordinary industrial site.</td>
</tr>
<tr>
<td></td>
<td>There is a need to ensure the studies used at the JRP hearings are referenced in the facts or assumptions.</td>
<td>For a description of how each JRP recommendation was addressed in the attributes selected, please see Appendix C: Linkage between JRP Recommendations and attributes selected. A new section was added to clearly describe potential changes in meteorological conditions and evaluate how each technology could be adapted to deal with them. See Section 6 for further information.</td>
</tr>
<tr>
<td></td>
<td>The visual distraction that may be presented to drivers on the new 407/Solina flyway should be considered in the assessment.</td>
<td>The MDCT and plume would be visible from the new extension of Highway 407. This was considered and discussed in Appendix G: 2.6 Visual Effect.</td>
</tr>
<tr>
<td></td>
<td>It is unclear whether any mitigation (such as the presence of a berm or the use of abatement technology) would or could affect visibility, and whether that would affect the scores. Clarity is required.</td>
<td>All options have been considered for the on-site disposal of the excavated material.</td>
</tr>
<tr>
<td>Water Consumption</td>
<td>Water consumption rate was used for the assessment of this attribute. The feedback on this attribute included the following: The fact base and scoring for water consumption fails to consider that once</td>
<td>The reasoning behind the scores is discussed in Appendix G 2.4: Water Consumption, Four Units, Once Through Cooling Option. Possibility of</td>
</tr>
<tr>
<td>Topic</td>
<td>Stakeholder Feedback</td>
<td>Responses</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>through cooling does consume water through evaporation – this should be corrected.</td>
<td>negligible evaporation for the OTC option is identified.</td>
<td></td>
</tr>
<tr>
<td>• The scoring for water consumption appears misleading given the inflow into Lake Ontario, more similarity in scores was anticipated – clarification is required.</td>
<td>The scoring is consistent with the calibration scheme for this attribute. The calibration scheme is based on the relative performance of the two options due to lack of regulatory limits for this parameter. This results in score divergence. However it is recognized that the water consumption is not a significant attribute. This is described in the following sections: • Section 6.2: Step 6 – Definition of the “Key” Attributes, o 2.4 Water Consumption, • Appendix G 2.4: Water Consumption, Four Units, Once Through Cooling Option</td>
<td></td>
</tr>
<tr>
<td>Clarification is required on whether any additional water is required for other purposes (cleaning, maintenance, etc.), and the source of that water supply (e.g. municipal supply).</td>
<td>No other fresh water source is required for either cooling system; the only supply is from Lake Ontario.</td>
<td></td>
</tr>
</tbody>
</table>
| Water Quality | Discharge that alters water quality was used as the scoring parameter for this attribute. The feedback on this attribute included the following: • The assessment needs to include consideration of other plant discharges that are released through the cooling system discharge, the resulting effluent concentration and the ability to meet regulatory requirements (particularly for tritium). | It is possible that other DNNP operational streams may be discharged using the cooling option outfall. However, the assessment of the cooling options is done independently of the operation of the rest of the plant and therefore contaminants arising from operation of the reactors are not evaluated. The reason for not including Tritium (and Radioactivity) was provided in Section 5.3: Step 3 – Identification of attributes. Radionuclide releases are reactor specific and for that reason were not included in the assessment. Total
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>quantity of radioactivity released does not depend on the condenser cooling system. While environmental concentrations of radionuclide may be affected by the choice of condenser cooling option, doses have been estimated to be significantly below the limit for both options. “Radioactivity and Tritium Concentrations in the Environment” was added as an “attribute not included” in Appendix D, Table D-1: Rationale for exclusion of some aspects from the final attribute list. Statement that all regulatory radiological requirements will be met was added to the following sections: Appendix G 2.1: Water Quality/Emission to Water, and Appendix G 2.2: Air Quality/Emission to Air.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clarity is required regarding the treatment chemicals required for the mechanical draft cooling towers, including how they are managed, the extent to which they are contained in the discharge and risks associated with improper operations.</td>
<td></td>
</tr>
</tbody>
</table>
|       | The blowdown for MDCT cannot remove all the chemicals. However all remaining trace chemicals will be within regulatory limits. This is addressed in:  
  - Appendix B.2.2: System Description, and  
  - Appendix G 2.1: Water Quality/Emissions to Water.  
Appendix G 2.1 was altered to state that trace amounts of chemicals will remain. These chemicals will be neutralized and meet regulatory water quality requirements. No chemicals are required to operate OTC. |
<p>|       | Clarity is required on whether the quality of water used requires additional treatment or management (e.g. whether there are elevated levels of suspended solids in the intake or whether the intake water contains chemical treatment from other processes, etc. which in turn may require management). |
|       | Suspended solids in the intake water are not an issue at DNGS since the intake is at a deep water depth of 10 m. This is not anticipated for DNNP, since it would also have a deep water intake, similar to DNGS. Chemical treatment of the intake water would be required with the use of MDCT (such as pH controllers, antiscalants, biocides, chlorine). No treatment is required to operate OTC. |</p>
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• The assessment needs to consider the effects of construction on water quality.</td>
<td>Some additional suspended solids may impact water quality during construction but this would generally occur during construction which is a short time period in terms of plant operation. OPG is currently completing a coastal processes study, and the impacts of the infill will be known when the permit is being acquired. Costal processes are not expected to change with the addition of the infill.</td>
</tr>
<tr>
<td></td>
<td>• Participants anticipated greater difference in the scoring of the two options – clarity is required.</td>
<td>The scoring for the Water Quality/Emission to Water attribute is fully consistent with the ranking scheme specified for this attribute. While an alternative ranking scheme can be set up, this will not enhance option evaluation or assessment transparency. The basis of evaluation is judged to be sufficiently clear.</td>
</tr>
<tr>
<td>Worker Health &amp; Safety</td>
<td>The worker health and safety attribute considers the potential risk of injury to the workers. The term worker for this assessment needs to be defined, as many assumed this attribute included all workers, not just workers on the Darlington Nuclear site. Other feedback included the following:</td>
<td>The calibration scoring scheme for Worker Health &amp; Safety is discussed in Section 5.4.2 Worker Health and Safety. A complete set of known hazards has been considered. The Likelihood and Severity tables were separated for both Public Health and Safety and Worker Health and Safety. This was applied to the following sections:</td>
</tr>
<tr>
<td></td>
<td>• The scoring for Worker Health and Safety appears to have gaps.</td>
<td>• Section 5.4.1: Public Health and Safety, Appendix G 1.1: Risk to Public Health and Safety, Section 5.4.2: Worker Health and Safety, and Appendix G 1.2: Risk to Worker Health and Safety</td>
</tr>
<tr>
<td></td>
<td>• The information on risk, likelihood and severity need to be presented separately.</td>
<td></td>
</tr>
<tr>
<td><strong>Topic</strong></td>
<td><strong>Stakeholder Feedback</strong></td>
<td><strong>Responses</strong></td>
</tr>
<tr>
<td>------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Methodology| BATEA is a formalized, comprehensive decision making technique for selecting the best technology to minimize negative environmental impact while not entailing unreasonable costs. The methodology for selecting the BATEA for the DNNP condenser cooling water system was developed by AMEC and is based on a multi-attribute assessment which includes 10 steps beginning with the definition of objectives and culminating with the Final Selection of the BATEA option. No significant issues or concerns were raised regarding the use of a multi-attribute methodology – it appeared to be fair and reasonable. Participants raised important considerations respecting the relationship of the assessment to the recently completed Environmental Assessment:  
  - Clarity is required regarding the relationship between the methodology and the DNNP environmental assessment (i.e. does it duplicate and/or replace the EA; does the Condenser Cooling Water Option assessment contradict the EA, etc.).  
  - Whether there was a need to undertake two distinct evaluations (Step 5 and Step 7) - a rationale and justification is required. | The EA provided source of many of the inputs, e.g. local climate change modelling results are based on EA values. There are no contradictions between the EA and Condenser Cooling Water Option Assessment.  
  - The approach was to take the baseline design for each cooling option and then look at enhancements to mitigate the most differentiators between the options. To understand the areas that require enhancements, it was necessary to evaluate the unenhanced options. This methodology allows focusing the effort on researching enhancements on areas which may impact the decision. |
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
</table>
|       | - The implicit weighting of certain attributes – the presented methodology did not include weighting of attributes however it appeared to some participants that there was an inherent or implicit weighting of attributes – particularly with the use of key attributes. This caused confusion and to some, may introduce a bias in the methodology. Clarification is required. | The scores are not added to derive the decision. Instead the recommendation for selecting BATEA is made on a logical basis. Therefore the subjective numerical weightings, which may be used to aggregate the sources, are not used in the assessment. Even if the scores were to be numerically added, the guidance does not permit for the aggregated weighted scores to be used as the primary/sole basis for the selection. However the relative importance of attributes is considered first by selecting the “Key Attributes” and then by evaluating relative importance of performance for the attributes. While there is also an element of subjectivity, this approach is done in a clear and transparent manner, is easy to examine and provides a clear basis for the BATEA recommendation. Detailed information is provided in the report. The report was modified to make these aspects clearer. The changes affected the following sections: 
  - Executive Summary
  - Glossary
  - Section 1.1: Background
  - Section 2.1: Review of the Key Features of BATEA and Similar Studies
    - Decision Making
  - Section 4.0: DNNP Condenser Cooling Water Assessment Methodology
    - 4. Definition of Scoring Scheme |
<p>|       | - At times, it appeared that several attributes accounted for the same effect – this raised concerns that perhaps some effects were double counted. Clarity is required. | Attribute selection was based on public views and review of other relevant studies to avoid accounting for effects multiple times. See Appendix E: Attributes Used in Other Reference studies. Public Perception attribute was removed from the assessment to address this concern, as it reflected some of the same issues that were addressed by other attributes. |
| Step 1: Define Objectives | - While the objective was generally clear, the need for or purpose of the assessment was not. To many it didn't make sense to examine options given the location and operating experience with once through cooling. To | Upon receipt of the JRP recommendations, OPG recognized the need for a transparent study without prejudice to either of the two remaining options and retained AMEC NSS to perform a Condenser Cooling Water Option Assessment for the DNNP. Both condenser cooling water options were assessed in a |</p>
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>others it appeared that OPG had already stated its preference and the assessment was being used to document those reasons. This requires clarification.</td>
<td>transparent manner.</td>
</tr>
<tr>
<td></td>
<td>• Clarity is required regarding the phrase ‘consideration of cost’. It was unclear whether it meant economically achievable, economically feasible, or simply least cost.</td>
<td>&quot;Economically Achievable&quot; relates to the selection of enhancements. If the mitigation is not achievable then we cannot do it. The total cost of each option following the selection of enhancements will be taken into consideration as part of decision making.</td>
</tr>
<tr>
<td>Step 2: Identify Technologies</td>
<td>• The size, physical characteristics and number of mechanical draft cooling towers required for the project needs to be described, including whether it is an open or closed cycle.</td>
<td>Details on the design parameters can be found in Appendix H: Baseline Design Parameter Set and Appendix J: Enhanced Design Parameter Set MDCT being described as “closed cycle” is consistent with terminology that is accepted in the industry.</td>
</tr>
<tr>
<td></td>
<td>• The size and materials for the porous veneer for the once-through cooling system and how it compared to the existing system at DNGS needs to be described.</td>
<td>Details on the design parameters can be found in Appendix H: Baseline Design Parameter Set, Appendix I: Design Enhancements, and Appendix J: Enhanced Design Parameter Set.</td>
</tr>
<tr>
<td></td>
<td>• The relationship between the cooling water system and reactor technology needs to be clearly stated, and justification provided to support the statement that the cooling options are truly independent of reactor technology: • Clarity is required regarding the assumptions used in the technology descriptions, specifically regarding the assumptions regarding thermal effects. • There is a perception that mechanical draft cooling towers are not used near large water bodies. – this should be clarified</td>
<td>The condenser cooling water system is independent of the reactor technology selected for DNNP. For the purposes of this study, only attributes directly associated with the potential impacts from operating condenser cooling system alternatives were selected. Details on the design parameters can be found in Appendix H: Baseline Design Parameter Set and Appendix J: Enhanced Design Parameter Set Cooling Towers are most often used on non-costal sites but could be placed in any location. OTC is frequently use near large water bodies. The JRP</td>
</tr>
</tbody>
</table>

---

_HPP_
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 3: Identify Attributes</strong></td>
<td>- Clarity is required on the basis for attribute selection (e.g. how attributes were identified, the basis for inclusion, rationale for exclusion).</td>
<td>Attributes were defined as the means of measuring and comparing the key safety, environmental, technological and cost characteristics and consequences of each of the options that are thought to be important and relevant at the level of detail being considered. Attributes were chosen to reflect a wide variety of issues of potential concern to different stakeholders.</td>
</tr>
<tr>
<td>Recommendations were provided regarding specific additional attributes. These should be considered for inclusion or a rationale for exclusion provided:</td>
<td></td>
<td>See Appendix D, Table D-1 on why these and some of the other issues were not considered as separate attributes. In particular:</td>
</tr>
<tr>
<td></td>
<td>- Water usage</td>
<td>- Water usage attribute was considered as “Water Consumption”. Furthermore water withdrawal was considered under Cost.</td>
</tr>
<tr>
<td></td>
<td>- Agricultural land/type of land use</td>
<td>- Agricultural/type of land use is discussed under agricultural land use.</td>
</tr>
<tr>
<td></td>
<td>- Energy/thermal efficiency</td>
<td>- Energy consumption/thermal efficiency is discussed under power consumption. This is also included under Cost.</td>
</tr>
<tr>
<td></td>
<td>- Bio waste/solid waste management</td>
<td>- Bio waste/solid waste management is discussed in Appendix D.</td>
</tr>
<tr>
<td></td>
<td>- Security and reactor safety</td>
<td>- Security is discussed in Appendix D. Reactor safety is discussed under nuclear safety.</td>
</tr>
<tr>
<td></td>
<td>- Total footprint</td>
<td>- Total footprint is discussed under Space.</td>
</tr>
<tr>
<td></td>
<td>- Communications and outreach</td>
<td>- Communications and outreach cannot be considered as separate attributes; rather they are mechanisms for collecting and distributing information. Community outreach and communication with the public regarding the DNNP project including the condenser cooling option will be part of project implementation following approval by the government. The objective of the current evaluation is to make a technical selection on a variety of different factors.</td>
</tr>
<tr>
<td>Topic</td>
<td>Stakeholder Feedback</td>
<td>Responses</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>- Consideration should be given to the creation of a socio-economic effects attribute group, which includes the attributes of visual effects, public perception, noise, public health and safety, etc.</td>
<td>These attributes are evaluated separately. Public perception was removed as an attribute to avoid potential overlaps. Information on the available feedback during the EA and Condenser Cooling Water Option Assessment Public consultation is provided in Section 8.0 and Appendices K and L.</td>
<td></td>
</tr>
<tr>
<td>- The attributes need to be mutually exclusive; it appears that some may be duplicated or double-counted.</td>
<td>Attribute selection was based on public views and review of other relevant studies to avoid accounting for effects multiple times. See Appendix E: Attributes Used in Other Reference studies.</td>
<td></td>
</tr>
</tbody>
</table>

| Step 4: Define Scoring Scheme | - The calibration schemes should be objective, mutually exclusive, and to the extent possible, consistent across attributes. | Details on the basis of the calibration for individual attributes can be found in Section 5.4 Step 4 - Definition of scoring scheme. |
| - The difference between facts and assumptions should be clear. | The wording for facts and assumptions was revised to address this comment. |
| - A rationale and/or justification is needed regarding the decision to evaluate certain attributes qualitatively. | The following two attributes have been removed:  
  - Issues related to "Global Climate Change" are now discussed in Section 6.4 Adaptability.  
  - Issues related to "Public Perception" are now discussed Appendix L: Public Perception. |
| - Scoring and calibration need to reflect the magnitude of the differences between the options and should reflect only the difference between the two options. | Various attributes were revised to ensure that the cooling options are evaluated independently of the reactor block. These changes were made for the Aquatic and Terrestrial habitat attributes as well as the Excavated Materials attribute. |

<p>| Step 5: Evaluate Options | - The evaluation should consistently consider both construction and operations phases. | This assessment considers all phases of the project, including construction, operation, and decommissioning. See the details for all attributes in Appendix G. |
| - It should be clear whether the evaluation examined effects over all four seasons in any year. | The approach was to take the baseline for each cooling option and then look at enhancements to mitigate the baseline issues. To understand the areas that require enhancements we need to spend time evaluating the unenhanced options. This methodology allows more time spent on the areas that require mitigation. |</p>
<table>
<thead>
<tr>
<th>Topic</th>
<th>Stakeholder Feedback</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• It is unclear if the evaluation examined effects over all four seasons in any year.</td>
<td>The assessment considered the effects for all seasons of the year when appropriate. For instance, the impact of the discharge temperature on larval growth during spawning was considered.</td>
<td></td>
</tr>
<tr>
<td>• It should be clear why baseline considerations vary from one attribute to the next (e.g. different treatment for Excavated Materials than for Water Quality).</td>
<td>Various attributes were revised to ensure that the cooling options are evaluated independently of the reactor block. These changes were made for the Aquatic and Terrestrial habitat attributes as well as the Excavated Materials attribute.</td>
<td></td>
</tr>
<tr>
<td>Step 6: Define Key Attributes</td>
<td>• The purpose and role of key attributes in decision making is unclear – clarity is required.</td>
<td>The key attributes are considered to be dominant contributors to the overall evaluation. These are the attributes that typically display a wide scoring margin between the cooling technologies and/or are considered to be important issues to stakeholders.</td>
</tr>
<tr>
<td></td>
<td>• The basis or approach to selecting key attributes is unclear – clarity is required.</td>
<td>The key attributes are considered to be dominant contributors to the overall evaluation. These are the attributes that typically display a wide scoring margin between the cooling technologies and/or are considered to be important issues to stakeholders.</td>
</tr>
<tr>
<td></td>
<td>• The key attributes seem to introduce a weighting system but not explicitly – an explanation is required of how key attributes influenced the decision logic.</td>
<td>The scores are not added to derive the decision. Instead the recommendation for selecting BATEA is made on a logical basis. Therefore the subjective numerical weightings are not used in the assessment. Even if the scores were to be numerically added, the guidance does not permit for the aggregated weighted scores to be used as the primary/sole basis for the selection. However the relative importance of attributes is considered first by selecting the &quot;Key Attributes&quot; and then by evaluating relative importance of performance for the attributes. While there is also an element of subjectivity, this approach is done in a clear and transparent manner, is easy to examine and understand the basis for the BATEA recommendation.</td>
</tr>
<tr>
<td>Step 7: Enhancements / Repeat Evaluation</td>
<td>• Clarity is required regarding the rationale for and selection of enhancements for each option, it was not clear how this step was performed; and</td>
<td>A number of supporting studies were carried out to determine potential design enhancements to improve performance of each option against the key attributes. For additional details, see Section 6.3 Step 7 – Evaluation of Enhanced Designs (Stage 2).</td>
</tr>
<tr>
<td>Topic</td>
<td>Stakeholder Feedback</td>
<td>Responses</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------</td>
<td>-----------</td>
</tr>
<tr>
<td><strong>Step 8: Initial Selection</strong></td>
<td>The initial selection of the BATEA was presented to roundtable participants, stakeholders in the community committee and council meetings, and was available to the public in the Public Summary and full report. No one disagreed with the results to date. Some participants indicated that they agreed with the initial selection of once-through cooling as the BATEA. However other participants felt the conclusions were less than objective. For these participants it appeared either that the assessment may have inadvertently minimized the advantages of mechanical draft cooling towers and over-emphasized the benefits of once-through cooling. For others the basis for the final decision was not clear.</td>
<td>Details of all enhancements considered can be found in Appendix I: Design Enhancements. Also, please see Appendix J: Enhanced Design Parameter Set.</td>
</tr>
<tr>
<td></td>
<td>• The assumptions regarding the improved performance of the enhancements need to be explicit.</td>
<td>Sensitivity Study was updated following completion of Step 10 (Final Selection). See Section 10.0: Uncertainty and Sensitivity Analysis. It evaluated the potential impact of uncertainties in attribute scores.</td>
</tr>
<tr>
<td></td>
<td>• A description of the sensitivity analysis and how it was used should be provided.</td>
<td>This discussion is included in Section 9.0: Step 10 – Final Selection of the BATEA for DNNP Condenser Cooling.</td>
</tr>
<tr>
<td><strong>Step 9: Stakeholder Consultation</strong></td>
<td>A number of participants appreciated the opportunity to participate or offer feedback. First Nations appreciated the information sharing, but do not consider the exercise to be consultation. Some groups were not in a position to provide feedback but sought to have their concerns acknowledged, their comments are noted.</td>
<td></td>
</tr>
<tr>
<td>Topic</td>
<td>Stakeholder Feedback</td>
<td>Responses</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>&quot;...the impact of cooling water systems on fish and fish habitat in Lake Ontario remains one of the most troubling environmental issues in our watershed; we believe very strongly that important issues such as cooling water systems analysis should have been considered fully during the review panel process. ....in an open, formal and documented process; the information should have been made available to the experts retained.....we are troubled the information is only being made available now when the hearing is over and the funds for independent expert review are no longer available&quot;.</td>
<td>Stakeholder’s preferences were noted.</td>
<td></td>
</tr>
<tr>
<td>Other feedback on the stakeholder consultation included:</td>
<td></td>
<td>A consultation program was implemented to provide the public and stakeholders with information regarding the assessment and initial selection, and to review and confirm the factual basis and assumptions used in the evaluation of attributes. The feedback and inputs from the consultation program have been incorporated into this report.</td>
</tr>
<tr>
<td>• clarity is required on whether feedback is restricted only to facts and assumptions.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Confirmation is required that all key interests are involved, many suggestions were provided to ensure all key interests had the opportunity to participate (e.g. Environment Canada or similar groups, St. Mary’s, Waterkeepers, Fish groups, municipalities, CN, etc.).</td>
<td>Informed stakeholders were invited to participate in the Roundtable sessions. Informed stakeholders are considered individuals and organizations that are familiar with the Project and have a more detailed knowledge of the environment and/or have taken part in the regulatory process.</td>
<td></td>
</tr>
<tr>
<td>• Clarity is required over the role of the regulator in the stakeholder process is not clear.</td>
<td></td>
<td>The regulators have been included as stakeholders in this process.</td>
</tr>
<tr>
<td>• The roundtable meetings were appreciated, but may be insufficient, consideration should be given to undertaking additional activities.</td>
<td></td>
<td>Stakeholder’s preferences were noted.</td>
</tr>
<tr>
<td>Topic</td>
<td>Stakeholder Feedback</td>
<td>Responses</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>• Suggestions were provided to ensure greater clarity in presentation of the material.</td>
<td>OPG released a Public Summary of the Condenser Cooling Water Option Assessment Initial Selection Report. The Public Summary is a 38 page document which provides, in simple and straightforward language an overview of the Condenser Cooling Water Option Assessment methodology, the selected attributes and their scoring, key facts and assumptions, the selected enhancements, and the initial selection of the condenser cooling water system. The detailed assessment was provided in the Condenser Cooling Water Option Assessment - Initial Selection Report (which contains the full assessment and supporting information) as well as the Public Summary Document.</td>
</tr>
<tr>
<td>Step 10: Final Selection</td>
<td>The final selection of the BATEA is to be made taking into account stakeholder feedback, however:</td>
<td>OPG will select the condenser cooling water option. The selection will be provided for regulatory approval.</td>
</tr>
</tbody>
</table>
Appendix L: EA Public Perception

Public perception of the cooling options is captured and evaluated in two EA Technical Support Documents (TSDs) [41], [42] as well as previously solicited input of stakeholders as described in the EA [1] and Intervener submissions during the JRP hearings [5]. The TSDs described details according to three study areas, namely: the Site Study Area (SSA), Local Study Area (LSA) and Regional Study Area (RSA). The assessment uses the concept of community well-being as its overall analytical framework, and the likely effects of the DNNP are identified and described according to five subcomponents, referred to as “Community Assets”, and several related parameters. The Community assets that relate to this assessment of the reactor cooling technology are primarily captured in the Social Asset involving community, recreational facilities and programs as well as community character or image which is discussed and evaluated as a Physical Asset.

Once Through Cooling System

There was no objection to the installation of an OTC system for the DNNP. The system would have no substantial change in the visual character of nearby park areas, would cause no noticeable changes in Lake Ontario, and would have no affect on the tourism industry or the housing market. Since there is no strong “stigma” against the OTC, it would be accepted by the public [42].

Mechanical Draft Cooling Towers

Housing Market

As discussed in Reference [42], the presence of cooling towers and the visibility of their plumes during the Operation and Maintenance Phase are anticipated to have a direct and adverse effect on community character in the LSA. Some literature and case studies suggest that declines in property values and increased marketing time could result from a “stigma” that results in a negative image of the community on the part of prospective homebuyers. Such “stigma” related effects on residential property values typically occurred where a facility has performed poorly (i.e., many accidents and malfunctions, demonstrated environmental effects, etc). However, recent reviews of case studies regarding property values near nuclear facilities in the United States indicate that negative imagery surrounding nuclear plants or stored nuclear waste does not necessarily have a significant detrimental influence on residential home prices in the immediate vicinity of these facilities.

The findings of a socio-economic assessment for the Calvert Cliffs 3 Nuclear Power Plant (NPP) in Maryland, United States [42] is considered relevant to the DNNP as it also involves the construction of additional reactor units and cooling towers at an existing nuclear site. This assessment considered the effect of distance from the Calvert Cliffs NPP on property values as part of a larger investigation of the impact of property values from power plants in Maryland. This study found that values of properties near the Calvert Cliffs NPP are influenced by factors other than distance to it. As such, the socio-economic assessment concluded that no adverse effects upon property values are likely as a result of the construction of an additional reactor unit at the existing nuclear site (Public Service Commission of Maryland 2008).

With respect to the effects of NDCT versus MDCT, it is concluded that NDCT option has a greater potential to adversely affect community character. This is simply
because of their uniqueness, the presence of large physical structures on the landscape and their overall visibility. Nevertheless, DN Site neighbours participating at both Roundtable meetings indicated that the noticeable vapour plumes associated with each cooling tower technology would adversely affect community character.

Finally, any negative associations between the LSA and the DNNP (with cooling towers) are expected to diminish over time as the presence of cooling towers and associated vapour plumes become familiar features; and OPG continues to improve on its positive environmental and safety record that is well communicated to the public, both within and outside the LSA. Similar conclusions regarding the likelihood that effects would diminish over time were reached in sociological studies related to a proposed high level nuclear waste repository in the United States. Here it was concluded that whether or not negative images persist will depend on whether people grow accustomed to it or desensitized to its negative connotations once the facility becomes a reality. This in turn will likely hinge on the facility’s track record once it becomes operational.

Community Character

The DNNP with cooling towers is likely to have both direct and indirect adverse effects on community character [42]. In the context of municipal growth over the Operation and Maintenance Phase, the DNNP Project although a driver for some growth in local and regional population and economic development, will not be solely responsible nor the major contributor to this trend towards greater urbanization. Consequently, the DNNP (with cooling towers) is not anticipated to have an adverse effect on individual community and recreational facilities or programs in the LSA or RSA.

Overall, the vast majority of RSA and LSA residents (i.e. between 61% and 68%) do not anticipate any changes to their use of community and recreational facilities or other areas in the vicinity of the DN site during the Operation and Maintenance Phase. However, the presence of NDCT and the visibility of their plumes during the Operation and Maintenance Phase are anticipated to have a direct and adverse affect on community character in the LSA. The presence and operation of the cooling towers could serve to make some community and recreational facilities and amenities near the DN site less attractive. In this case, some adverse effects on community and recreational facilities might occur in the LSA and RSA should a large number of residents take steps to avoid them. However, based on public attitude research, only a small proportion of residents stated such an intention:

- Up to 10% of RSA and LSA residents indicated that their birdwatching and nature viewing activities near the DN site would decrease, with up to 4% indicating their activities in the area would decrease “a great deal”;
- Up to 11% of RSA and LSA residents indicated that their use of other outdoor recreational areas in Clarington and Oshawa (e.g., trails, beaches, marinas and conservation areas) would decrease, with up to 4% indicating that their use of these areas would decrease “a great deal”; and
- Up to 10% of RSA and LSA residents indicated that their fishing and boating activities on Lake Ontario near the DN site would decrease, with up to 4% indicating that their fishing and boating activities would change “a great deal”.
- Up to 10% of RSA and LSA residents indicated that their use of the restored Waterfront Trail and the DN site would decrease, with up to 4% indicating that their use would change “a great deal”.
Some comments offered by public attitude research respondents that illustrate these effects (with cooling towers) are:

“Basically, it would be ugly. It would ruin the trails around it”

“The cooling towers would be interrupting the view of the lake”

“People will be more nervous to use the waterfront”

“..the activities will decrease of people who do things around the site because of this cooling tower”

Among these users, “occasional” users or participants are considered most likely to change their activities, while “regular” users are considered more likely to maintain their use and enjoyment of these LSA facilities and amenities. This is because the “occasional” users or participants are not likely to have developed strong preferences towards these specific locations and are therefore more likely to choose areas elsewhere. Secondly, RSA residents are also considered more likely to change their activities than LSA residents. This is because RSA residents are also more likely to choose areas nearer their homes, and then travel to the areas near the DN site which they might consider to be less attractive due to the DNNP. Thirdly, people who have strongly held views and anticipate a change in their feelings of health and sense of safety as a result of the Project are also more likely than others to change their behaviours. Approximately 4% of RSA and LSA respondents felt that their feelings of health and sense of safety might change “a great deal”.

Notwithstanding these public attitude research results, the community and recreational features on the DN site and those nearest the DN site will remain important local features that will remain accessible to community residents, tourists and other visitors. In the context of the strong population growth anticipated across the RSA and LSA during the Operations and Maintenance phase, these features will likely continue to be attractive and utilized extensively by an increasing number of users. The DNNP will not result in direct environmental effects to these features, affect their accessibility nor require any modifications to accommodate the DNNP. Any users who might choose to frequent these areas less or stop coming outright because of the presence of Natural Draft cooling towers and their associated vapour plumes are likely to be replaced by others who are more tolerant of local conditions or have fewer issues with respect to the DNNP. Overall, widespread measurable changes to people’s use and enjoyment of community and recreational features across the LSA attributable to the DNNP (with cooling towers) are not anticipated.
Subject: OPG Decision on the Condenser Cooling Water Option for the Darlington New Nuclear Project

Dear Mr. Robbins:

The purpose of this letter is to respond to your letter of January 7, 2013 [1] regarding OPG’s decision to select a once-through cooling water system as its preferred condenser cooling water option for the Darlington New Nuclear Project (DNNP), and proposed performance targets for the intake and discharge structures to mitigate potential effects on the aquatic environment. In addition, your letter requests confirmation from CNSC staff that the Condenser Cooling Water Option Assessment and methodology used by OPG has satisfied Joint Review Panel recommendation #3, as accepted by the Government of Canada.

CNSC staff, Fisheries and Oceans Canada and Environment Canada have carefully reviewed your letter and supporting documentation. As outlined in your letter, OPG previously submitted its decision on the condenser cooling water option and supporting Condenser Cooling Water Options Assessment in August 2012 [2]. CNSC staff and the above-noted federal agencies provided comments on the assessment [3], and OPG provided responses to the comments [4]. OPG subsequently revised and resubmitted the assessment [5] to address the comments received. It is acknowledged that the revision to the assessment did not change its overall conclusion, and that a once-through cooling water system remains OPG’s preferred condenser cooling water option for the DNNP.

It is CNSC staff’s overall opinion that there are no fundamental barriers to licensing a once-through cooling water system for the DNNP with the performance targets proposed [1], subject to the following conditions:

- an accepted baseline by which the 90% impingement and entrainment performance targets will be measured
- design provisions to incorporate a live fish return system, should one be required in the future
- a maximum intake approach velocity of 6 cm/s for a porous veneer design (as documented in the Condenser Cooling Water Option Assessment) or a maximum of 12 cm/s for a wedgewire screen design as measured "within the slots"; other intake structure designs to be reviewed on a case-by-case basis.

- satisfactory completion of OPG commitments [6, 7] and Joint Review Panel recommendations related to the selection of once-through cooling including, but not limited to, recommendations #30 (impingement/entrainment sampling at DNGS), #32 (location of intake and discharge structures), #34 (enhanced resolution thermal plume modelling), #35 (surface water risk assessment), #36 (adult fish monitoring) and #37 (area of aquatic effects).

It is also CNSC staff's opinion that the revised Condenser Cooling Water Option Assessment and the methodology used by OPG have satisfied Joint Review Panel recommendation #3, as accepted by the Government of Canada.

CNSC staff's analysis of these matters is documented in the attachment to this letter.

Please note that CNSC staff's opinion on these matters does not bind decisions made by the Commission with which the authority resides to issue a licence to construct a nuclear power plant. CNSC staff's licensing recommendation to the Commission can only be made once detailed design is complete and a construction licence application has been received. It is expected that OPG will continue to engage CNSC staff and the above-noted federal agencies during the design process to ensure the detailed design meets regulatory expectations.

These matters will be brought to the Commission's attention at an upcoming public meeting in August 2013. If you have any questions or require further clarification, please contact Mr. Ross Richardson, Senior Project Officer, at (613) 943-0241.

Yours sincerely,

[Signature]

D. B. Newland
Director
New Major Facilities Licensing Division

References:


Attachment: CNSC Staff Analysis of OPG’s Decision on the Condenser Cooling Water Option for the Darlington New Nuclear Project

e.c.: Barclay Howden, Patsy Thompson, Mike Rinker – CNSC
Tom Hoggarth – Fisheries and Oceans Canada
Nardia Ali – Environment Canada
CNSC Staff Analysis of OPG's Decision on the Condenser Cooling Water Option for the Darlington New Nuclear Project

Introduction

Ontario Power Generation (OPG) has selected a once-through cooling water system as its preferred cooling option for the Darlington New Nuclear Project (DNNP) and has committed to specific performance targets for the intake and discharge structures to mitigate effects on the aquatic environment. OPG has requested CNSC staff’s conditional acceptance of its selection of once-through cooling for the DNNP [1]. Additionally OPG has requested confirmation that Darlington Joint Review Panel (JRP) recommendation #3, as accepted by the Government of Canada, has been satisfied. This summary provides CNSC staff’s analysis and conclusions with respect to OPG’s requests.

Background

As part of its Environmental Assessment Report [2], the JRP recommended that:

“the Canadian Nuclear Safety Commission require that as part of the Application for a Licence to Construct a reactor, OPG must undertake a formal quantitative cost-benefit analysis for cooling tower and once-through condenser cooling water systems applying the principle of best available technology economically achievable (BATEA). This analysis must take into account the fact that lake infill should not go beyond the two-metre depth contour and should include cooling tower plume abatement technology.”

This recommendation (JRP recommendation #3) was accepted by the Government of Canada, with the acknowledgement that the analysis may be required prior to the construction licence application, given the relationship between the site layout and the choice of condenser cooling technology [3].

OPG undertook this analysis during 2011–2012, comparing once-through cooling with mechanical draft cooling towers, and has selected once-through cooling for the DNNP. This analysis included a number of roundtable discussions with stakeholders, culminating in OPG formally submitting the Condenser Cooling Water Options Assessment Report [4] to CNSC staff in August 2012. CNSC staff and other key federal departments (Fisheries and Oceans Canada (DFO) and Environment Canada) reviewed the report and provided comments in October 2012 [5]. OPG dispositioned the comments [6] and submitted a revised report [7] on January 31, 2013, for review and acceptance by CNSC staff in order to satisfy this JRP recommendation.
Analysis

CNSC staff’s analysis of OPG’s selection of once-through cooling at the DNNP is based on the body of work submitted by OPG which includes:

- the *Condenser Cooling Water Options Assessment Report* [7]
- a third-party review of OPG’s BATEA methodology [8]
- technical information on fish protection and improvements to condenser cooling water intake design [9, 10]
- performance targets that OPG has committed to [1]

The analysis also considered regulatory, scientific and industry best practices, cost benefit, and risk. Finally, CNSC staff’s analysis was informed by reviews and advice from DFO, Environment Canada, the Ontario Ministry of Natural Resources, as well as an independent third party, Pacific Northwest National Laboratories [12].

In doing its analysis, under the CNSC’s regulatory framework, CNSC staff considered new facilities being held to higher environmental performance expectations (that is, CNSC draft regulatory document RD 337 v2, *Design of New Nuclear Power Plants* – consider the use of BATEA for the design of condenser cooling water systems) than existing facilities. This is consistent with the approach the United States takes on this matter toward new and existing facilities – an amendment under the US *Clean Water Act* section 316b added a rule in 2003 [13], that holds new facilities to higher environmental performance expectations, while a different rule has been proposed and is under consideration for existing facilities [14]).

The following subsections elaborate on these matters.

**Methodology for OPG’s *Condenser Cooling Water Options Assessment Report***

JRP recommendation #3 described above referred to “quantitative cost-benefit analysis”. The supporting text noted the need for a more definitive comparison of alternative options that would include a quantitative basis for assessment and comparisons of cooling tower options as well as the use of weighting factors for different attributes [2]. OPG used a multi-criteria decision analysis (MCDA) instead of cost-benefit analysis (CBA) in addressing this JRP recommendation. CNSC staff’s opinion is that the MCDA analysis is an appropriate methodology in this case for the reasons described below.

CNSC regulatory policy P-242, *Considering Cost-benefit Information*, notes that information on costs and benefits is only one factor that may be considered in making regulatory decisions under the *Nuclear Safety and Control Act*. The CNSC staff review of the OPG methodology took this policy consideration into account and was informed by two expert
third-party review reports done independently of each other, one for OPG [8] and the other for CNSC staff [12]. The use of MCDA instead of CBA was supported by third-party reviewers due to the difficulty of attaching monetary values to the very diverse range of impacts (such as fish and bird mortality, habitat loss, visual atmospheric plume, bird habitat, noise, thermal plume) that were under discussion. Quantifying and assessing the value of these impacts is quite different from simply looking at conventional market prices [15]; many of the costs and benefits of environmental management may not be well represented or are entirely omitted by monetary measures [16, 17].

On the basis of a review of OPG’s methodology, published literature (for example, [18]) and the two third-party review reports [8, 12], CNSC staff determined that the MCDA methodology was better suited to the specific matter at hand. Having OPG use a CBA methodology that included explicit weighting factors was not expected to result in information that would alter the outcome of OPG’s report. OPG’s use of scoring and key attributes met the basics of MCDA methodology by providing information on how well each cooling option performed for an attribute and on how well the performance of each attribute in turn contributed to the overall evaluation [18]. CNSC staff’s view is that OPG has satisfied JRP recommendation #3. This conclusion is based on the review of OPG responses to federal government reviewer comments [6] and on the final Condenser Cooling Water Options Assessment Report received on January 31, 2013 [7].

**OPG’s Condenser Cooling Water Options Assessment Report**

In accord with the JRP recommendation, the *Condenser Cooling Water Options Assessment Report* took into account the fact that lake infill should not go beyond the two-metre depth contour and also considered cooling tower plume abatement technology. The report identifies once-through cooling with its associated enhancements as BATEA at the DNNP site and identifies it as the preferred option. OPG stated in its submission cover letter [19] that the environmental impacts overall did not favour one option over the other but the cost advantage combined with the adverse local community response to towers and their associated visual plume with abatement favoured once-through cooling. Adaptability is a feature of both cooling options, which varies for different attributes with no clear advantage for one option.

Table I provides a listing by CNSC staff of the relative performance of once-through cooling versus mechanical draft cooling towers for adverse attributes. Sixteen adverse attributes are listed, based on the review of the DNNP documents and readily available literature on these technologies (for example, [20, 21]). The level of effect was ranked by CNSC staff on an increasing scale as none, negligible, low, moderate or high. Both cooling options have adverse effects at this site, with once-through cooling having lesser effects on more attributes but worse effects for most of the aquatic-related attributes when compared to mechanical draft cooling towers.
Intake Performance Target – 90 Percent Reduction in Impingement and in Entrainment

OPG has committed to a 90 percent reduction both in impingement and in entrainment (fish mortality due to the condenser cooling system.) This reduction is known as the 90/90 performance target. This means that the reduction a once-through cooling system will achieve is expected to be 90 percent or greater reduction in both impingement and entrainment mortality from that which would be achieved by a mechanical draft cooling tower system at the site [1]. It is also CNSC staff’s understanding that fish mortality would be, at a minimum, similar to a 90 percent reduction in impingement and entrainment relative to the baseline (that is, unmitigated surface water intake with a standard 3/8 inch mesh travelling screen). This “baseline” definition is used in the rule for new facilities under the U.S. Clean Water Act, section 316b [13]. It is measurable for the DNNP based on the nearby Pickering Nuclear Generating Station surface water intake without the installed barrier net.

Based on the species of fish and projected numbers of fish impinged and/or entrained, DFO considers the 90/90 performance target to be acceptable. OPG has also agreed to offset the residual fish mortality through rehabilitation or creation of fish habitat. No net loss of productive capacity of fish habitats in Lake Ontario will result.

The 90/90 performance target is consistent with the regulatory requirements for new facilities in the United States (90 percent reduction in impingement and entrainment relative to the baseline) [13], policy requirements in New York State (90 percent performance relative to the baseline plus consideration of site-specific impacts) [22], and is similar to the United Kingdom (deep offshore velocity cap with enhancements such as a live fish return system and acoustic fish deterrents) [20].

From a technical perspective, the existing Darlington Nuclear Generating Station (DNGS) presently achieves a 90 percent reduction for impingement and likely for entrainment (with fish habitat offsets) relative to the baseline (that is, Pickering Nuclear Generating Station, without a barrier net). OPG’s proposed 90/90 performance target for the DNPP will likely exceed the DNGS performance and the intake fish loss will be equivalent to that from a system using towers.

It is CNSC staff’s opinion that, under the Nuclear and Safety Control Act, the 90/90 performance target will prevent unreasonable risk since the current DNGS operation performance is at an acceptable level. Furthermore, in the recent environmental assessment for the refurbishment and continued operation of the DNGS, the Commission and DFO concluded that there were no significant adverse effects, taking into consideration mitigation measures (that is, creating new fish habitat or improving enough existing habitat to offset losses from impingement and entrainment).
The Lake Ontario ecosystem, however, is currently undergoing changes (due to invasive species, for example) and will likely continue to change in the future. Once-through cooling is adaptable enough to accommodate future changes in amounts and types of fish intake losses. In the event that technology-based mitigation results in residual adverse effects such that the DNNP fails to meet the performance targets, DFO will accept fish habitat offsets from OPG or, if a species at risk is being adversely affected, may require OPG to provide additional mitigation. Mitigation measures, such as a live fish return system, are available and practicable and could be put in place should the need arise.

**Discharge Performance Target – Thermal Effects Performance Equivalent to or Better Than the Existing DNGS Diffuser**

OPG has committed to thermal effects performance equivalent to or better than the existing DNGS discharge for the DNNP.

From a regulatory perspective, the risk is low from the thermal discharge to round whitefish (one of the most thermally sensitive species) from the current DNGS, as documented in the proposed environmental assessment screening report [23] for the refurbishment and continued operation of the DNGS. It is acceptable to CNSC staff and Environment Canada and not environmentally significant. In addition, the DNGS diffuser has been meeting provincial regulatory performance requirements for thermal discharges over the past 20 years of operations.

The performance of the DNGS diffuser is consistent with the regulatory best practices for new facilities in the United States (that is, the rule under the U.S. *Clean Water Act*, section 316b) [13], as well as practices in Europe [20, 28].

It is expected that the future performance of a once-through cooling system at the DNNP will be better than the existing system at the DNGS, given the suite of enhancements expected [3, 24] such as a deeper discharge location. Additional technology and operation options are available and practicable if future changes in the Lake Ontario fish community or regulations require higher levels of risk control.

**Conclusions**

It is CNSC staff’s opinion that the enhanced once-through cooling option is BATEA for the DNNP site since its performance is expected to be equivalent to that of towers for intake fish loss, and it is expected to prevent unreasonable risk to thermally sensitive fish species (such as round whitefish), while avoiding the other adverse effects of towers (such as aquatic and terrestrial habitat removal, visual plume effects, excavation truck traffic, cost effectiveness). As such, the DNNP once-through cooling performance is expected to be equal to or better than mechanical draft cooling towers from the perspective of integrated environmental protection, consistent with the *Nuclear Safety and Control Act*’s requirement to prevent unreasonable risk to the environment, and with CNSC regulatory policy P-223, *Protection of*
It is technologically and financially practicable, allows a level of risk control proportionate to the present understanding of the level of risk, and is adaptable to respond to potential future changes in the level of environmental risk.

In addition, *Fisheries Act* regulators (DFO, Environment Canada) find the two DNPP performance targets described in this analysis to be acceptable, and the enhanced once-through cooling system proposed for the DNPP to be consistent with regulatory international best practices.

CNSC staff expect the design to be a fully enhanced once-through cooling system that incorporates the latest in mitigation technology and techniques, consistent with CNSC draft regulatory document RD-337 v2, *Design of New Nuclear Power Plants*, and with relevant OPG commitments made during the IRP process and captured in OPG’s commitments report [24, 25].

CNSC staff’s opinion on these matters does not bind decisions made by the Commission with which the authority resides to issue a licence to construct a nuclear power plant. CNSC staff’s licensing recommendation to the Commission can only be made once a detailed design is complete and a construction licence application has been received. It is expected that OPG will continue to engage CNSC staff and the above-noted federal agencies during the design process to ensure the detailed design meets regulatory expectations.
Table 1: Comparison of adverse attributes between once-through cooling and mechanical draft cooling towers
(Bold = key attributes at the DNNP site). Adapted from the UK Environment Agency [20], Viel et al [21] and the CNSC [26].

<table>
<thead>
<tr>
<th>Adverse attributes</th>
<th>Once-through cooling</th>
<th>Mechanical draft cooling tower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquatic thermal plume area</td>
<td>Moderate</td>
<td>Negligible to low</td>
</tr>
<tr>
<td>Aquatic contaminants</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Lake bottom habitat loss</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Aquatic habitat alteration</td>
<td>Moderate</td>
<td>Negligible to low</td>
</tr>
<tr>
<td>Aquatic biota intake losses</td>
<td>Moderate</td>
<td>Negligible to low</td>
</tr>
<tr>
<td>Visual impact</td>
<td>Negligible</td>
<td>Moderate</td>
</tr>
<tr>
<td>Ground fog and icing</td>
<td>Negligible</td>
<td>Low</td>
</tr>
<tr>
<td>Airborne plumes/salt drift</td>
<td>None</td>
<td>Low</td>
</tr>
<tr>
<td>Terrestrial habitat loss</td>
<td>None</td>
<td>High</td>
</tr>
<tr>
<td>Terrestrial biota mortality</td>
<td>None</td>
<td>Negligible to low</td>
</tr>
<tr>
<td>Noise</td>
<td>None</td>
<td>Low</td>
</tr>
<tr>
<td>Land use/excavated soil</td>
<td>None to low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Lack of adaptability</td>
<td>Moderate (aquatic)</td>
<td>Moderate (terrestrial)</td>
</tr>
<tr>
<td>Water consumption</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Water withdrawal</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Cost/energy penalty</td>
<td>Low to moderate</td>
<td>Moderate to high</td>
</tr>
</tbody>
</table>

1. There is a potential risk of once-through cooling (OTC) thermal plume round whitefish egg survival, but the hazard area for DNGS and DNNP diffusers combined is a small portion (<5%) of the estimated available site study area habitat so no population-level risk is expected.
2. OTC has higher contaminant dilution at the end of the pipe [7] but a potentially more direct spill pathway to the lake.
3. 13 ha OTC versus 19 ha mechanical draft cooling towers (MDCT) lake bottom construction/infill.
4. Alterations include potential hazard to aquatic biota from pulsed chronic exposure to levels of temperature and chemicals above ambient, and physical transfer offshore in diffuser jet when lake currents are low (JRP recommendation #35) [2].
5. MDCT entrainment is 2.6% of OTC since it is directly proportional to flow volume; impingement reduction would be 8% more than enhanced OTC. OTC fish egg/larvae entrainment would be reduced by optimal location of intake structure, reduced approach intake velocity and fish habitat offsets.
6. OTC water surface ripple line from diffuser turbulence in calm lake conditions. MDCT has a visible vapour plume (46% of the time during winter, 3–15% of the time during the rest of year) and tower buildings 40 m in height [7].
7. Hazard but not a risk for human health effects or adverse effects on plants. No adverse effects have been observed or are expected given standard regulatory and industry protocols and DNNP site-specific location of towers.
8. MDCT requires 40 ha of land, which would result in the complete loss of the existing bank swallow nesting habitat [7].
9. Bird strikes to MDCT structures are unlikely; however, mortality increases if birds are displaced from their habitat by the footprint of MDCT and cooling water treatment pond losses [12].
10. MDCT with abatement equivalent to OTC [7].
11. OTC is less adaptable to environmental (climate change) or regulatory changes to the aquatic environment whereas MDCT is less adaptable to such changes to the terrestrial/atmospheric environment.
12. MDCT consumes more than twice as much water as is consumed by evaporation from an OTC thermal plume [27].
13. OTC withdraws 70 times more water than MDCT. The OTC water is returned to the lake after screening through 3/8 inch debris screens, heating and biocide addition. The main issue is mortality of fish, fish eggs and larvae contained in the water. This issue is covered under another adverse attribute: aquatic biota intake losses.

14. MDCT generates 1–3.5% less electrical output than OTC due to use of warmer condenser cooling waters which lowers turbine efficiency and requires use of electricity to run pumps and fans [28]. MDCT construction, operations and maintenance costs are 2.4 times those of OTC: a difference of $500M for two units [6].

References


LOW Interrogatory #009

Ref: Canadian Nuclear Safety Commission, Record of Proceedings Including Reasons for Decision, Environmental Assessment Screening, Darlington Refurbishment

Issue Number: 4.9
Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project appropriate?

Interrogatory

Paragraph 55 referenced a Round Whitefish Action Plan (RWAP) to understand the local population status of the species. The study was also required to include a “series of assessments on the potential impacts of the diffuser on the survival of round whitefish eggs and larvae”. Please provide a copy of this study.

Response

The series of assessments on the potential impacts of the diffuser on the survival of round whitefish eggs and larvae are comprised of the following attached reports:

Attachment 1

Attachment 2

Attachment 3
TRANSMITTAL LETTER

Darlington Nuclear Generating Station Refurbishment and Continued Operation Project Environmental Assessment

Section 1

To: SENES Consultants Limited
121 Granton Drive, Unit 12
Richmond Hill, Ontario L4B 3N4

Attention: Andrea Halbert, Single Point of Contact

Sent by

☐ Mail  ☑ Enclosed
☐ Courier ☑ E-mail
☐ Hand Carried ☑ Picked-Up

Document Title:

File #: 350200

Version: Final

Deliverable #: N/A

Work Package #: WP4

Date: 9 July 2012

Certification by WP Team Leader:

The above referenced document has been reviewed and is acceptable for submission to OPG for review and comment.

WP Team Leader: John Sinnige

Company Name: Golder Associates Limited

Address: 2390 Argentia Road, Mississauga, Ontario, Canada L5N 5Z7

Phone: 905 567-4444

Fax: 905 567-6561

E-Mail: John_Sinnige@golder.com

WP Team Leader Signature

Page | 1
Section 2

To: Ontario Power Generation
   Environmental Assessment Department
   1315 Pickering Parkway
   Pickering, Ontario L1V 7G5

Attention: OPG Single Point of Contact

Editorial Review by SENES EA Consulting Team:

The above referenced document has been reviewed per requirements in the Document Review Plan and is acceptable for submission to OPG for review and comment.

WP Reviewer Linda Boeheim
EA Consulting Team: lboeheim@senes.ca
Project Manager Dr. Don Gorber
EA Consulting Team: dgorber@senes.ca
Company Name: SENES Consultants Limited
Address: 121 Granton Drive, Unit 12, Richmond Hill, ON, L4B 3N4
Phone: 905 764-9380
Fax: 905 764-9386

WP Reviewer Signature
EA Consulting Team
Project Manager Signature
EA Consulting Team
DATE: July 9, 2012
PROJECT No.: 10-1151-0202 (8000) (8006)

TO: John Peters, Bryan Yule, Jeff Phillips, Jane Borromeo
Ontario Power Generation Inc.

CC: Don Gorber, Paul Patrick (SENES Consultants Limited)

FROM: Susanne Carmelos, Gerard Van Arkel, Rein Jaagumagi

EMAIL: Susanne_Carmelos@golder.com, GerardVanArkel@golder.com, Rein_Jaagumagi@golder.com


1.0 INTRODUCTION
As part of the Darlington Nuclear Generating Station (DNGS) Refurbishment and Continued Operation Project (the Project) Environmental Assessment (EA), the potential effects of the Project on the Surface Water and Aquatic Environments (SWE and AE, respectively) were evaluated and documented in the “Surface Water Environment Technical Support Document: Darlington Nuclear Generating Station Refurbishment and Continued Operation Project Environmental Assessment” (SWE TSD) and the “Aquatic Environment Technical Support Document: Darlington Nuclear Generating Station Refurbishment and Continued Operation Project Environmental Assessment” (AE TSD).

On January 13, 2012, the 2011 Thermal and Current Monitoring Program Report (Golder 2012a) was submitted to the Canadian Nuclear Safety Commission (CNSC), Environment Canada (EC) and the Department of Fisheries and Oceans (DFO). That report described the 2011/2012 Thermal and Current Monitoring Program currently underway in Lake Ontario near the Darlington Nuclear (DN) site and provided supporting documentation to confirm conclusions made in the SWE and AE TSDs, specifically regarding potential thermal effects resulting from the thermal discharges to the lake from DNGS.

In reviewing the 2011 Thermal and Current Monitoring Program Report (Golder 2012a), CNSC and EC requested additional analysis investigating the bottom water temperature increases above ambient for the winter monitoring period in 2011. In response, a technical memorandum documenting the results of this additional analysis and the associated assessment of potential effects of the DNGS thermal discharge on round whitefish (Golder 2012b) was submitted for federal review in February 2012.

This technical memorandum (Golder 2012d) provides similar analyses/method of assessment of effects on round whitefish embryos for the winter monitoring period of December 15, 2011 through April 13, 2012. Minor changes have been made to the assessment approach as a result of federal review comments on the winter 2012 thermal effects assessment (Golder 2012c).
The recently collected temperature data (Figure 1-1 illustrates the monitoring program locations) for the period of November 2011 through May 2012 are provided in Attachments A and B, which include the measured temperature data time series plots and 7-day rolling average temperature plots, respectively. The 7-day rolling averages were calculated using the same method employed to generate the 7-day rolling average temperature plots provided in the 2011 Thermal and Current Monitoring Program Report (Golder 2012a). As such, the plots provided in Attachments A and B to this document can be directly compared to the plots provided in Appendices B and C of the 2011 Thermal and Current Monitoring Program Report (Golder 2012a)¹.

Much of the data analyses presented in Sections 3.0 and 4.0 and the assessment of temperature effects presented in Section 5.0 focus on the 2011-2012 winter monitoring period of concern with respect to temperature effects on round whitefish embryos, i.e., from the beginning of developmental Block 1 (December 15, 2011) through the end of Block 3 (April 13, 2012). Figures 1-2A and 1-2B provide a summary of the data availability for each of the loggers over the period of December 15, 2011 through April 13, 2012.

¹ The methods used for data processing and quality assurance and quality control (QA/QC) of the data are consistent with the methods used in the 2011 Thermal and Current Monitoring Program Report (Golder 2012a) and the follow-up technical memorandum providing additional analysis for bottom water temperature increases above ambient (Golder 2012b).
2.0 ASSESSMENT OF AMBIENT CONDITIONS

2.1 Comparison of Ambient Air Temperatures

This section provides a comparison of the average monthly air temperatures recorded at the Environment Canada Trenton Airport, Ontario meteorological station (Trenton A) over the winter of 2011-2012 (December through April) to historical values. The comparison is intended to provide perspective by examining the frequency at which the average monthly air temperatures observed in 2011-2012 have occurred historically.

For consistency with previous studies, the Trenton A meteorological station was selected for this analysis. The historical record ranges from 1940 to 2011 (72 years). Additional data for 2012 were also obtained.

The following table provides a statistical summary of the monthly air temperatures.

<table>
<thead>
<tr>
<th>Month</th>
<th>Historical (1940 to 2011)</th>
<th>Winter 2010-2011</th>
<th>Winter 2011-2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Average</td>
<td>Maximum</td>
</tr>
<tr>
<td>November</td>
<td>-0.1ºC</td>
<td>3.1ºC</td>
<td>6.6ºC</td>
</tr>
<tr>
<td>December</td>
<td>-12.5ºC</td>
<td>-3.9ºC</td>
<td>1.5ºC</td>
</tr>
<tr>
<td>January</td>
<td>-14.2ºC</td>
<td>-7.3ºC</td>
<td>-1.8ºC</td>
</tr>
<tr>
<td>February</td>
<td>-12.0ºC</td>
<td>-6.2ºC</td>
<td>-1.6ºC</td>
</tr>
<tr>
<td>March</td>
<td>-5.5ºC</td>
<td>-0.9ºC</td>
<td>4.4ºC</td>
</tr>
<tr>
<td>April</td>
<td>3.0ºC</td>
<td>6.4ºC</td>
<td>9.9ºC</td>
</tr>
<tr>
<td>Jan-Feb¹</td>
<td>-12.0ºC</td>
<td>-6.8ºC</td>
<td>-2.5ºC</td>
</tr>
<tr>
<td>Dec-Mar²</td>
<td>-7.4ºC</td>
<td>-4.6ºC</td>
<td>-1.2ºC¹</td>
</tr>
<tr>
<td>Dec-Apr³</td>
<td>-5.0ºC</td>
<td>-2.4ºC</td>
<td>0.5ºC</td>
</tr>
</tbody>
</table>

Notes:
1. Average air temperature from January 1st to February 28th.
2. Average air temperature from December 1st to March 31st.
3. Average air temperature from December 1st to April 30th.

Table 2.1-1 suggests that the average monthly air temperatures recorded between December 2011 and February 2012 are not necessarily the warmest on record. The percentiles suggest that these air temperatures have occurred at frequencies of approximately once every 16 years (94th percentile for January) and once every 73 years (99th percentile for December). However, when the averages for the periods of January to February and December to April are considered, the data suggest that the winter of 2011-2012 was the warmest on record.
Based on the average air temperatures for the period of December to March, the winter of 2011-2012 was approximately 5.4ºC warmer than average and approximately 2.0ºC warmer than the warmest winter (2001-2002) recorded during the period of 1940 to 2011. Based on the average air temperatures for the period of December to April, the winter of 2011-2012 was approximately 4.1ºC warmer than average and approximately 1.2ºC warmer than the previously recorded warmest winter (2001-2002). Table 2.1-2 shows that four of the five warmest winters on record have occurred since 1982.

<table>
<thead>
<tr>
<th>Period (Dec – Mar)</th>
<th>Average Temperature [ºC]</th>
<th>Period (Dec – Apr)</th>
<th>Average Temperature [ºC]</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 2011 – March 2012</td>
<td>+0.6ºC</td>
<td>December 2011 – April 2012</td>
<td>+1.7ºC</td>
</tr>
<tr>
<td>December 2001 – March 2002</td>
<td>-1.2ºC</td>
<td>December 2001 – April 2002</td>
<td>+0.5ºC</td>
</tr>
<tr>
<td>December 1952 – March 1953</td>
<td>-1.5ºC</td>
<td>December 2009 – April 2010</td>
<td>+0.2ºC</td>
</tr>
<tr>
<td>December 1997 – March 1998</td>
<td>-1.9ºC</td>
<td>December 1952 – April 1953</td>
<td>+0.1ºC</td>
</tr>
<tr>
<td>December 1982 – March 1983</td>
<td>-2.2ºC</td>
<td>December 1997 – April 1998</td>
<td>+0.1ºC</td>
</tr>
</tbody>
</table>

While the average air temperatures for the period of December to April recorded during the winter of 2010-2011 are slightly cooler than average (approximately 0.4ºC cooler than the long-term average temperature for the period of December to April based on a meteorological dataset collected from 1940 to 2011), the winter of 2011-2012 is believed to be one of the warmest winters in the past 70 years.

### 2.2 Assessment of Ambient Water Temperature

This section provides a comparison of the average daily ambient water temperatures measured during the winter of 2011-2012 to the historical average daily ambient water temperatures. For consistency with previous studies (as discussed in Section 4.2.1 of the 2011 Thermal and Current Monitoring Program Report (Golder 2012a)), the ambient water temperature for this cold period was taken to be the average of the temperatures measured at TD05-1 and DN15-1 (shown on Figure 1-1).

Figure 2.2-1 compares the average daily ambient water temperatures measured in the Darlington Nuclear study area during the winter of 2011-2012 (green line) to the historical range of average daily ambient water temperatures (shaded grey) measured between 1984 and 1996. The figure shows that during the fall cooling period through November, the average daily ambient water temperatures in 2011 were typically within the upper range of the historical range measured in the Darlington Nuclear study area. The average daily ambient water temperatures are typically above the historical range for the remainder of the data period (December through May).
In 2012 there were two occurrences where the ambient water temperature varied by 6°C or more from the historical range (mid-March and late May on Figure 2.2-1). These events are likely associated with high air temperatures during those periods.

Table 2.2-1 compares the average monthly ambient water temperatures for the winter of 2010-2011 and the winter of 2011-2012 to a statistical summary of the historical average monthly ambient water temperatures (1984 to 1996).

The table shows that the average monthly ambient water temperatures during the winter of 2010-2011 are similar to the average monthly ambient water temperatures recorded during the historical period. While the average temperature in November 2011 was comparable to the historical maximum average November temperature (period of 1984 to 1996), the average monthly ambient water temperatures recorded during the winter of 2011-2012 are consistently higher than the maximum mean monthly ambient water temperature recorded during the historical period. On average, the water temperatures recorded from December 2011 to March 2012 in the Darlington Nuclear study area (average of 3.8°C) were 2.2°C and 1.7°C warmer than the historical average and the historical maximum monthly temperatures, respectively. On average, the water temperatures recorded from December 2011 to April 2012 in the Darlington Nuclear study area (average of 4.4°C) were 2.1°C and 1.6°C warmer than the historical average and the historical maximum monthly temperatures, respectively. These observations are consistent with the differences in monthly average air temperatures discussed in Section 2.1.

Considering the period of available ambient water temperature data (i.e., 1984 to 1996 and 2011 to 2012), the ambient water temperatures observed during the winter of 2011-2012 were the warmest recorded near the Darlington Nuclear study area while the ambient water temperatures observed during the winter of 2010-2011 can be considered similar to the historical average (measured between 1984 and 1996).

### Table 2.2-1: Statistical Summary of Ambient Water Temperatures in the Darlington Nuclear Study Area

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Average</td>
<td>Maximum</td>
</tr>
<tr>
<td>November</td>
<td>4.9°C (1988)</td>
<td>6.0°C</td>
<td>7.7°C (1985)</td>
</tr>
<tr>
<td>December</td>
<td>1.7°C (1995)</td>
<td>2.7°C</td>
<td>3.4°C (1993)</td>
</tr>
<tr>
<td>January</td>
<td>0.4°C (1993)</td>
<td>1.1°C</td>
<td>1.5°C (1990)</td>
</tr>
<tr>
<td>February</td>
<td>0.3°C (1993)</td>
<td>1.0°C</td>
<td>1.8°C (1991)</td>
</tr>
<tr>
<td>March</td>
<td>0.9°C (1992)</td>
<td>1.9°C</td>
<td>2.7°C (1995)</td>
</tr>
<tr>
<td>April</td>
<td>3.6°C (1992)</td>
<td>4.8°C</td>
<td>5.9°C (1987)</td>
</tr>
<tr>
<td>Jan-Feb²</td>
<td>0.4°C (1993)</td>
<td>1.1°C</td>
<td>1.4°C (1991)</td>
</tr>
<tr>
<td>Dec-Mar³</td>
<td>1.2°C (1994-1996)</td>
<td>1.6°C</td>
<td>2.1°C (1994-1995)</td>
</tr>
<tr>
<td>Dec-Apr⁴,⁵</td>
<td>1.9°C (1992-1993)</td>
<td>2.3°C</td>
<td>2.8°C (1991-1992)</td>
</tr>
</tbody>
</table>

**Notes:**
1. No data collected before January 23, 2011.
2. Average ambient water temperature from January 1st to February 28th.
3. Average ambient water temperature from December 1st to March 31st.
4. Average ambient water temperature from December 1st to April 30th.
3.0 TEMPERATURES AT BOTTOM LOCATIONS

As described in the 2011 Thermal and Current Monitoring Program Report (Golder 2012a), one of the objectives of the 2011/2012 Darlington Nuclear Thermal and Current Monitoring Program was to assess the potential thermal effects on VEC aquatic species. Water temperatures were measured at several bottom locations where spawning of round whitefish potentially occurs. These data were used to evaluate if occurrences of thermal plume contact with the lakebed can be detected and measured and identify the locations, frequencies and durations of these events. These bottom water temperature data are subsequently used in Section 5.0 of this memo (Assessment of Temperature Effects on Round Whitefish Embryo Development).

The hourly averages of the temperature data collected during the round whitefish egg incubation period of the second winter monitoring period (i.e., December 15, 2011 through April 13, 2012 as discussed in Section 5.1) at all bottom locations are compared to the embryo survival screening criterion (discussed in Section 5.2 of the 2011 Thermal and Current Monitoring Program Report (Golder 2012a)) for:

- Offshore locations within the Mixing Zone\(^2\) characterized by depths greater than 10 m (shown on Figure 3-1);
- Offshore locations beyond the Mixing Zone characterized by depths greater than 10 m (shown on Figure 3-2);
- Nearshore locations within the Mixing Zone characterized by depths less than 10 m (shown on Figure 3-3);
- Shallow nearshore locations characterized by depths less than 10 m (shown on Figure 3-4); and
- Reference locations (shown on Figure 3-5).

Figure 3-1 includes two monitoring locations that were not assessed for the first winter monitoring period (January 2011 through March 2011) in Golder 2012a and Golder 2012b since they were first installed in November 2011: DN17-B and DN18-B located between the offshore end of the diffuser and the edge of the Mixing Zone.

Figures 3-1 through 3-5 also show the hourly bottom water temperatures at each location as an increase over the average hourly bottom water temperature. The average hourly bottom water temperature was calculated as the average of bottom temperatures measured at the reference locations (shown on Figure 3-5), the shallow nearshore locations (shown on Figure 3-4), the nearshore locations within the Mixing Zone (shown on Figure 3-3), and the offshore locations within and beyond the Mixing Zone (shown on Figures 3-1 and 3-2). This approach was used to identify locations with bottom water temperatures that differed relative to the average lake bottom conditions. These figures were only used to identify potential bottom contact of the thermal plume and are not used in any other analysis in this memo. The hourly bottom water temperatures for each location were calculated as the average of the 15-minute measurements over each hour (or, in the case of the Port Darlington ADCP location, the average of the 10-minute measurements over each hour).

A brief overview of the observed hourly bottom water temperatures is provided below. However, a more comprehensive discussion of these bottom water temperature data and potential effects on round whitefish is

\(^2\) The Mixing Zone is an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of this area, as shown on Figures 4-1 through 4-6.
The average hourly bottom water temperature (shown on Figures 3-1 through 3-5) and measured ambient water temperatures (shown on pages A-4 and A-28 of Attachment A) were generally 5°C or warmer until mid-December 2011 and generally remained above 4°C until the last week of December 2011. The measured ambient water temperatures generally decreased to between 1°C and 2°C for approximately the last two weeks of January 2012 before beginning to rise again. By mid-March 2012, the average hourly bottom water temperature and measured ambient water temperature had both increased to approximately 5°C again. From mid-March through April 13, 2012 the average hourly bottom water temperature was generally around 6°C and the measured ambient water temperatures were generally between 6°C and 8°C.

Figure 3-1 shows that in January 2012 through to mid-March 2012 (before the average hourly bottom water temperature and measured ambient water temperature had risen again to approximately 5°C), occurrences of elevated hourly bottom water temperatures were measured at offshore locations within the Mixing Zone, predominantly at location TD35-12. These events occurred primarily in February and March of 2012 and included hourly bottom water temperatures above 7°C. Occurrences of hourly bottom water temperatures above 5°C (but less than 6°C) also occurred at locations DN17-B and DN18-B (also offshore locations within the Mixing Zone, between location TD35-12 and the edge of the Mixing Zone) during this period. Very few occurrences of hourly bottom water temperatures above 5°C occurred at the other offshore locations within the Mixing Zone (locations TD55-B, TD34-B and TD45-B). These events were generally short in duration and were characterized by maximum hourly temperatures only marginally greater than 5°C. Later in March and through April 13, 2012 (when the average hourly bottom water temperature was generally around 6°C), the hourly bottom water temperatures measured at location TD35-12 exceeded 7°C more frequently. Also during this period, occurrences of hourly bottom water temperatures above 7°C were also observed at locations DN17-B and DN18-B. Although this was also observed at locations TD34-B, TD45-B and TD55-B, these occurrences were less frequent and generally short in duration.

Figure 3-2 shows that there were rare and brief occurrences of hourly bottom water temperatures above 5°C during the period of January 2012 through mid-March 2012 at offshore locations beyond the Mixing Zone and these were all well below 6°C. Later in March and through April 13, 2012 (when the average hourly bottom water temperature was generally around 6°C), the hourly bottom water temperatures measured at these locations were generally below 7°C. With the exception of location DN06-B, occurrences of hourly bottom water temperatures exceeding 7°C were infrequent and short in duration. At location DN06-B, there was one period beginning on March 24 and lasting approximately 1.5 days when the hourly bottom water temperatures remained above 7°C. However, the average hourly bottom water temperature during this period had also increased with a range of approximately 6.5°C to 7°C.

Figure 3-3 shows that there were a few short occurrences of hourly bottom water temperatures above 5°C (but well below 6°C) during the period of January 2012 through mid-March 2012 at location DN10-B (a nearshore location within the Mixing Zone approximately 150 m east of the diffuser) but they were generally short in duration. Later in March and through April 13, 2012 (when the average hourly bottom water temperature was generally around 6°C), the hourly bottom water temperatures measured at DN10-B exceeded 7°C. During the period characterized by the average hourly bottom water temperature ranging between approximately 6.5°C and 7°C, hourly bottom water temperatures exceeded 7°C at locations TD38-B and DN11-B and 8°C at locations TD42-B and DN10-B.
Figure 3-4 shows that hourly bottom water temperatures above 5°C did not generally occur at any of the shallow nearshore locations during the period of January 2012 through mid-March 2012. Later in March, hourly bottom water temperatures between 7°C and 9°C were observed at shallow nearshore locations TD31-B, DN01-B, DN02-B and DN04-B; however, during some of this period the average hourly bottom water temperature had also increased with a range of approximately 6.5°C to 7°C. Between the end of March and April 13, 2012, there were some occurrences of hourly bottom water temperatures above 7°C (but well below 8°C) at shallow nearshore locations DN01-B and DN02-B; however these were short in duration.

Figure 3-5 shows that hourly bottom water temperatures above 5°C did not generally occur at any of the reference locations during the period of January 2012 through mid-March 2012. Later in March and through April 13, 2012, the hourly bottom water temperatures measured at the shallow nearshore reference locations TD13-5 and DN15-5 generally ranged between 6°C and 9°C. During this period, the hourly bottom water temperatures measured at the deeper offshore reference locations DN12-B, DN13-B and DN14-B generally ranged between 5°C and 8°C.
4.0 BOTTOM WATER TEMPERATURE INCREASES ABOVE AMBIENT

For the frequency analysis of bottom water temperature increases over ambient lake temperatures for the 2011-2012 winter monitoring period (i.e., data collected from December 15, 2011 through April 13, 2012), ambient temperatures were defined using only the hourly average ambient surface temperatures recorded at TD05-1 and DN15-1 (shown on Figure 1-1). Since the water column is typically well mixed during the cold water period (i.e., the difference between the hourly average surface and bottom temperatures was generally less than 0.1°C between December 2011 and April 2012), it is appropriate to assess the bottom thermal plume during the cold water period using the hourly average ambient surface temperatures. This is consistent with the method used to define ambient temperatures used for the previous analyses of temperature increases above ambient presented in the 2011 Thermal and Current Monitoring Program Report (Golder 2012a) and the follow-up technical memorandums providing additional analysis for bottom water temperature increases above ambient (Golder 2012b and Golder 2012c). (The frequency analysis of bottom water temperature increases over ambient lake temperatures for the 2011 winter monitoring period (i.e., data collected from January 23, 2011 through March 2011) is presented in Golder 2012b and Golder 2012c.)

Table 4.1 provides a summary of the frequency analysis of bottom water temperature increases over ambient lake temperatures (hourly average bottom water temperature increase over hourly average ambient lake temperature is hereafter referred to as hourly average bottom DT) for the 2011-2012 winter monitoring period of concern with respect to temperature effects on round whitefish embryos, i.e., from the beginning of developmental Block 1 through the end of Block 3.

For each location shown on Figures 4-1 and 4-2, the following are provided for this period of data collection: the mean hourly average bottom DT; the observed frequencies of exceedance for hourly average bottom DTs ranging between 1°C and 5°C; and the 75th percentile and 95th percentile hourly average bottom DTs observed. (The 75th percentile and 95th percentile hourly average bottom DT values for each location are also shown on Figures 4-1 and 4-2.) When large data gaps exist for a location during a given monitoring period, the results should be interpreted with caution. For example, the results for location TD34-B for the 2011-2012 winter monitoring period (December 15, 2011 through April 13, 2012) were generated from only 966 data points since hourly data were only available from January 26, 2012 to February 5, 2012 and from March 14, 2012 to April 13, 2012. (The number of available hourly average temperature data points for this monitoring period are provided in Table 4.1 and the temperature data gaps for each location are also shown graphically in Figures 1-2A and 1.B.)

Based on the results for location TD35-12 we observe the following:

- 75% and 95% of the time the observed hourly average bottom DTs were equal to or less than 1.26°C and 2.20°C, respectively. The frequency with which an hourly average bottom DT of 2°C was exceeded was only 6.8%. (See Table 4.1 and Figures 4-1 and 4-2.)
- As can be seen in Figure 3-1, larger hourly average temperature increases above the average measured bottom water temperature (hourly average) were predominantly observed during the period of early February 2012 through mid-March 2012. This is consistent with the data collected during the first winter monitoring period (Golder 2012b).
Data presented in Table 4.1 were used to estimate the quartile (75th percentile) and maximum (95th percentile) areal extents of the thermal plume near the lake bottom for the second winter monitoring period. Figures 4-1 and 4-2 present the estimated quartile and maximum areal extents, respectively, for the period of December 15, 2011 through April 13, 2012. These figures show contour lines representing the frequencies of various hourly average bottom DTs for this period of data collection during the 2011-2012 winter. These contour lines represent the maximum distances from the diffuser that these various hourly average bottom DTs are expected to occur during this period at their respective temporal percentile, i.e., the areas within which the hourly average bottom DTs are likely to occur. These maximum distances from the diffuser and the resulting contour lines were reasonably approximated by linear interpolation of the 75th percentile and 95th percentile hourly average bottom DTs between neighboring monitoring locations.

It is important to note that the areas contained within these contour lines do not represent the actual size of the quartile and maximum bottom thermal plumes observed during this period. Depending on the conditions (ambient temperature, discharge temperature, and current speed and direction) at any given point in time, the location and size of the bottom thermal plumes varied within the areas depicted in these figures. The actual sizes of the thermal plumes were a fraction of the total areas inside the contour lines shown on these figures at any given point in time. For example, 75% of the time between December 15, 2011 and April 13, 2012 hourly average bottom DTs between 1ºC and 1.5ºC were likely contained within the estimated area bound by the 1ºC and 1.5ºC temperature increase contour lines shown on Figure 4-1 and hourly average bottom DTs greater than 1ºC did not likely occur outside of the 1ºC contour line.

In addition, the method used to define hourly average ambient temperatures may result in some overestimation of the hourly average bottom DTs at depths greater than the ambient locations TD05-1 and DN15-1 (i.e., greater than 5 m). At the deeper, offshore locations (particularly DN07-B, DN08-B AND DN09-B located at depths of approximately 18.5 m, 13.75 m and 18.5 m, respectively) the observed frequencies of average hourly bottom water temperature increases are likely a combination of cooling water discharge and a natural increase in the ambient water temperature with depth. During the winter months the bottom water temperatures further offshore (e.g., typically at depths greater than 20 m) are constant at approximately 4ºC which is 2ºC to 3ºC warmer than the temperatures measured at the ambient monitoring locations. The actual depth at which the constant 4ºC water temperatures occur varies with time due to lake-wide cooling, storm events and currents. As a result, the frequencies presented in Table 4.1 and Figures 4-1 and 4-2 are likely conservative and representative of the highest frequencies that can be expected.

Based on the preceding discussion and the results presented in Table 4.1 and Figure 4-1, it is concluded that 75% of the time during the second winter period (i.e., data collected from December 15, 2011 to April 13, 2012) the maximum hourly average bottom DT within the study area was 1.56ºC (at location DN10-B) with hourly average bottom DTs of 1.5ºC to 1.56ºC only occurring in a small area about 0.2 ha (0.002 km²) in size located approximately 150 m east of the diffuser over this location. The results also suggest that, other than this small area over location DN10-B, hourly average bottom DTs within the Mixing Zone were 1.5ºC or less. The area contained within the contour line representing an hourly average bottom DT of 1ºC (i.e., the area with hourly average bottom DTs of 1ºC or greater within the Mixing Zone) is estimated to be 75 ha (0.75 km²) and this area is predominantly characterized by depths of 10 m or greater. However, Figure 4-1 does not suggest that 75% of
the time hourly average bottom DTs between 1°C and 1.5°C occurred throughout the entire area bounded by the 1°C and 1.5°C contour lines. In addition, Figure 4-1 does not provide information related to the frequency and duration of occurrences of hourly average bottom DTs between 1°C and 1.5°C within this area during the second winter monitoring period of December 15, 2011 through April 13, 2012.

Also based on the preceding discussion as well as the results presented in Table 4.1 and Figure 4-2, it is concluded that 95% of the time during the second winter period (i.e., data collected from December 15, 2011 to April 13, 2012) the maximum hourly average bottom DT within the study area was 2.20°C (at location TD35-12). The results also suggest that 95% of the time the hourly average bottom DTs at the edge of the Mixing Zone were less than 2°C. The area contained within the contour line representing an hourly average bottom DT of 2°C (i.e., the area with hourly average bottom DTs of 2°C to 2.20°C within the Mixing Zone) is approximately 22 ha (0.22 km²) and this area is predominantly characterized by depths of 10 m or greater. Again, it must be noted that Figure 4-2 does not suggest that 95% of the time hourly average bottom DTs between 2°C and 2.20°C occurred throughout the entire 22-ha area (i.e., the area bounded by the 2°C and 2.20°C contour lines). In addition, Figure 4-2 does not provide information related to the frequency and duration of occurrences of hourly average bottom DTs between 2°C and 2.20°C within this area during the second winter monitoring period of December 15, 2011 through April 13, 2012.

The discussion of results of the frequency analysis of bottom water temperature increases over ambient lake temperatures for the 2011-2012 winter monitoring period of concern is summarized in Table 4.2.
Table 4.1: Frequency of Hourly Average Bottom Water Temperatures Increases Over Ambient - Period of 
December 15, 2011 through April 13, 2012 (Second Winter Period)

<table>
<thead>
<tr>
<th>Location</th>
<th>Water Depth (m)</th>
<th>No. of Data Points</th>
<th>Average</th>
<th>Increase Over Ambient</th>
<th>Frequency of Exceedance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75th Percentile</td>
<td>95th Percentile</td>
</tr>
<tr>
<td>Inside Mixing Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD38-B</td>
<td>10</td>
<td>1,713</td>
<td>-0.11</td>
<td>0.36</td>
<td>1.16</td>
</tr>
<tr>
<td>TD35-12</td>
<td>12</td>
<td>2,903</td>
<td>0.69</td>
<td>1.26</td>
<td>2.20</td>
</tr>
<tr>
<td>DN10-B</td>
<td>11</td>
<td>2,122</td>
<td>1.11</td>
<td>1.56</td>
<td>2.10</td>
</tr>
<tr>
<td>DN11-B</td>
<td>10</td>
<td>1,966</td>
<td>0.28</td>
<td>0.97</td>
<td>1.79</td>
</tr>
<tr>
<td>DN17-B</td>
<td>12.5</td>
<td>2,904</td>
<td>0.45</td>
<td>1.15</td>
<td>2.00</td>
</tr>
<tr>
<td>DN18-B</td>
<td>12.5</td>
<td>2,904</td>
<td>0.54</td>
<td>1.36</td>
<td>2.04</td>
</tr>
<tr>
<td>Edge of Mixing Zone (Clockwise from Nearshore – starting at TD31)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD31-B</td>
<td>6</td>
<td>2,904</td>
<td>-0.20</td>
<td>0.08</td>
<td>0.58</td>
</tr>
<tr>
<td>TD52-B</td>
<td>10</td>
<td>1,210</td>
<td>0.81</td>
<td>1.09</td>
<td>1.64</td>
</tr>
<tr>
<td>TD55-B</td>
<td>15</td>
<td>2,904</td>
<td>0.21</td>
<td>1.00</td>
<td>1.81</td>
</tr>
<tr>
<td>TD34-B</td>
<td>14</td>
<td>966</td>
<td>-0.34</td>
<td>0.56</td>
<td>1.53</td>
</tr>
<tr>
<td>TD45-B</td>
<td>10</td>
<td>2,904</td>
<td>0.13</td>
<td>0.64</td>
<td>1.32</td>
</tr>
<tr>
<td>TD42-B</td>
<td>8</td>
<td>1,875</td>
<td>0.04</td>
<td>0.47</td>
<td>1.02</td>
</tr>
<tr>
<td>Outside Regulated Mixing Zone (Clockwise from Nearshore – starting at DN01)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN01-B</td>
<td>6</td>
<td>1,030</td>
<td>-0.27</td>
<td>0.12</td>
<td>0.46</td>
</tr>
<tr>
<td>DN03-B</td>
<td>11</td>
<td>1,694</td>
<td>-0.43</td>
<td>0.23</td>
<td>0.87</td>
</tr>
<tr>
<td>DN05-B</td>
<td>15</td>
<td>2,904</td>
<td>0.18</td>
<td>0.97</td>
<td>1.65</td>
</tr>
<tr>
<td>DN07-B</td>
<td>18</td>
<td>2,904</td>
<td>0.15</td>
<td>0.94</td>
<td>1.50</td>
</tr>
<tr>
<td>DN09-B</td>
<td>18</td>
<td>2,365</td>
<td>0.01</td>
<td>0.84</td>
<td>1.50</td>
</tr>
<tr>
<td>DN08-B</td>
<td>14</td>
<td>2,904</td>
<td>0.30</td>
<td>0.95</td>
<td>1.71</td>
</tr>
<tr>
<td>DN06-B</td>
<td>12</td>
<td>1,920</td>
<td>0.03</td>
<td>0.61</td>
<td>1.28</td>
</tr>
<tr>
<td>DN04-B</td>
<td>7</td>
<td>1,921</td>
<td>-0.08</td>
<td>0.28</td>
<td>0.81</td>
</tr>
<tr>
<td>DN02-B</td>
<td>5</td>
<td>2,901</td>
<td>-0.18</td>
<td>0.08</td>
<td>0.59</td>
</tr>
</tbody>
</table>

Notes:
1. The Mixing Zone is an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of this area, as shown on Figures 4-1 through 4-4.
Table 4.2: Summary of Frequency Analysis of Hourly Average Bottom Water Temperature Increase Over Ambient for Second Winter Monitoring Period

<table>
<thead>
<tr>
<th>Location of Maximum Hourly Average Bottom Water Temperature Increase</th>
<th>Second Winter Monitoring Period (December 15, 2011 to April 13, 2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartile Extents (75th Percentile)</td>
<td></td>
</tr>
<tr>
<td>Location of Maximum Hourly Average Bottom Water Temperature Increase</td>
<td>DN10-B</td>
</tr>
<tr>
<td>Maximum Hourly Average Bottom Water Temperature Increase</td>
<td>1.56°C</td>
</tr>
<tr>
<td>Areas Contained Within Hourly Average Bottom Water Temperature Increase Contours</td>
<td></td>
</tr>
<tr>
<td>1.0°C</td>
<td>75 ha</td>
</tr>
<tr>
<td>1.5°C</td>
<td>0.2 ha</td>
</tr>
<tr>
<td>Maximum Extents (95th Percentile)</td>
<td></td>
</tr>
<tr>
<td>Location of Maximum Hourly Average Bottom Water Temperature Increase</td>
<td>TD35-12</td>
</tr>
<tr>
<td>Maximum Hourly Average Bottom Water Temperature Increase</td>
<td>2.20°C</td>
</tr>
<tr>
<td>Areas Contained Within Hourly Average Bottom Water Temperature Increase Contours</td>
<td></td>
</tr>
<tr>
<td>2.0°C</td>
<td>22 ha</td>
</tr>
</tbody>
</table>

Notes:
1. Contours above 1.5°C were not identified for quartile extents for the winter of 2011-2012 since the 75th percentile hourly average bottom DTs were below 2°C at all monitoring locations.
2. Contours above 2°C were not identified for maximum extents for the winter of 2011-2012 (December to March period) since the maximum 95th percentile hourly average bottom DT was 2.20°C (at location TD35-12).
5.0 ASSESSMENT OF TEMPERATURE EFFECTS ON ROUND WHITEFISH EMBRYO DEVELOPMENT

Two separate assessment methods were used to assess potential effects of winter bottom temperatures on round whitefish embryo development in order to determine whether there were adverse effects due to operation of the DNGS diffuser. The 7-day rolling average temperatures were calculated for each of the monitoring locations and compared to embryo survival data developed by Griffiths (1980). Since calculation of the rolling averages tends to smooth out the temperature curves (e.g., Figure 5.2-1), the hourly average temperature data were also used to assess potential effects. Use of these data permit assessment relative to temperature fluctuations or pulses (e.g., Figure 5.3-1) and represent more natural temperature regimes to which the developing embryos could be exposed. The methods are considered complimentary since they both use the same chronic data developed by Griffiths as the basis for assessing potential effects on the embryos.

The assessment of thermal effects on round whitefish embryos is conducted through the following steps:

- The time period when embryos may be present is estimated based on the developmental data provided in Griffiths (1980). Developmental times are estimated for each developmental block.
- The time period required for completion of each developmental block as defined by Griffiths (1980) is determined based on the average temperature for the period December 2011 to April 2012 for which bottom water temperatures are available.
- Typical survival (as percent) of embryos at average temperatures recorded at reference sites for each developmental block is estimated.
- Those monitoring locations where temperatures during the period of December 15, 2011 to mid-April 2012 (estimated date at which larvae will hatch) exceeded 3.5°C (continuous exposure benchmark) and 5°C (short-term exposure benchmark) are identified. These locations are subsequently assessed for potential effects on embryo survival.
- Embryo survival at the temperatures recorded from December 2011 to mid-April 2012 based on 7-day moving average temperatures and hourly average temperatures is estimated for each location and embryo developmental block where the benchmarks are exceeded.
- Changes in embryo survival at location potentially exposed to the operation of the diffuser are assessed against the maximum change in survival at the appropriate reference location.

The temperature benchmarks developed in Golder (2012a) are used in this assessment, specifically focusing on the 3.5°C benchmark for continuous exposure and the 5°C benchmark for exposure to pulses of increased temperatures. The derivation of these benchmarks is provided in Golder (2012a) and is based on the data provided by Griffiths (1980). These benchmarks are used for screening the temperature data, as described later in this section, since temperatures below these screening levels have been shown through Griffiths experiments to not result in adverse effects on embryo development. They are not developed, nor intended to be used, as temperature criteria.

Exposure was assessed on the basis of the three blocks that characterize the different embryo development stages. Griffiths (1980) noted that there were slight variations in sensitivity of the different developmental stages to temperature changes and, therefore, this approach has been used to identify if any particular development stage is more likely to experience adverse effects.
5.1 Estimate of Time Period When Embryos Are Present

Details regarding the period when round whitefish were spawning in the area during December 2011 are not available and therefore the time when embryos likely would be present is estimated based on when suitable temperatures for spawning occurred at the reference locations. A range of dates is typically provided that indicates females will move inshore to spawn beginning in late November. Therefore, spawning is considered to occur over a range of dates that, in turn, determine the periods when the different developmental stages would likely be present.

Wismer and Christie (1987) noted that the optimum temperature for spawning was 3°C to 4.5°C. Temperature data collected between November 2011 and April 2012 at the reference locations (Figure 5.3-1 and Figure 2.2-1) indicate that temperatures decreased to below 5°C by approximately December 17. Therefore, spawning and embryo development are estimated to begin in mid-December.

Griffiths provided estimates of developmental periods based on temperatures at which the developing embryos were exposed. These ranged from 168 days at a constant temperature of 1.7°C to 76 days at a constant temperature of 6.6°C. The data for the three embryo development stages (Block 1 through Block 3) tested by Griffiths as well as total development time across all three development stages are shown graphically in Figures 5.1-1 to 5.1-3 and are provided in Table 5.2. The data shown on Figure 5.2-1 indicate that average temperatures at the offshore reference locations DN13-B and DN14-B generally ranged between 3°C and 4°C during most of the winter months. Therefore, the typical development times for average years are estimated from the graphs on Figures 5.1-1 to 5.1-3 for this temperature range. The graphs give the following estimates based on the average temperatures.

- **Block 1:** Fertilization to Stage 9 – 25 to 31 days;
- **Block 2:** Stage 9 to Stage 19 – 46 to 58 days; and
- **Block 3:** Stage 19 to complete hatch – 46 to 51 days.
- **Total (Blocks 1 through 3)** – 117 to 140 days.

The hourly temperature data in Figure 5.3-1 show that under average conditions, temperatures at all reference locations decrease to below 5°C around December 17. Therefore, it is assumed that spawning begins in early to middle December and embryos are present by December 15. Based on the data provided above, embryo development time during average conditions would range between 117 to 140 days (based on average temperatures that range between 3°C and 4°C).

Embryo development times for each developmental block are estimated based on the temperatures measured during the 2011-2012 winter (i.e., the development times are specific to the winter of 2011-2012). Temperatures at the offshore reference location DN13-B ranged between 5°C and 3.5°C from mid-December 2011 to mid-January 2012 and showed a gradual decline during this period. Development time at 5°C is estimated from Griffiths’ data as 21 days (Figure 5.1-1) while development time at 3.5°C is estimated as 28 days. Since the decline in temperature was gradual, the mid-point of this range provides a reasonable estimate of development time during this period resulting in an estimated development time of 25 days for Block 1 embryos. A similar approach was taken in estimating the development times for Block 2 and Block 3 embryos using the development times calculated by Griffiths and shown on Figures 5.1-2 and 5.1-3.

Using the temperature data for the reference location DN13-B (the deeper reference location is selected since the majority of monitoring locations are at depths greater than 8 m), it is estimated that early developmental
stage embryos (i.e., Block 1) would be present from mid-December to January 9 (based on a development time of 21 to 28 days at temperatures that decreased from 5°C to 3.5°C between mid-December and mid-January). Middle developmental stage embryos (i.e., Block 2) would be present from January 9 to March 4 (based on a development time of 56 days at temperatures between 2.5°C to 4°C). Late developmental stage embryos (i.e., Block 3) would be present beginning March 4 and ending April 13 (based on a development time of 40 days at temperatures between 4°C and 7°C). Using these estimates, it is expected that larvae would hatch around mid-April, which is consistent with observations at the site.

The estimated developmental periods per block are summarized in Table 5.1.

<table>
<thead>
<tr>
<th>Block</th>
<th>Temperature range at reference location DN13-B</th>
<th>Development Time Range (days) at temperatures at reference locations</th>
<th>Development Time Midpoint (days)</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5°C – 3.5°C</td>
<td>21-28</td>
<td>25</td>
<td>Dec 15</td>
<td>Jan 9</td>
</tr>
<tr>
<td>2</td>
<td>2.5°C - 4°C</td>
<td>47-65</td>
<td>56</td>
<td>Jan 9</td>
<td>Mar 4</td>
</tr>
<tr>
<td>3</td>
<td>4°C - 7°C</td>
<td>32-47</td>
<td>40</td>
<td>Mar 4</td>
<td>Apr 13</td>
</tr>
</tbody>
</table>
Table 5.2: Mean Survival and Time Required to Complete Developmental Phase in Round Whitefish Exposed to Increases in Temperature

<table>
<thead>
<tr>
<th>Design</th>
<th>Mean Measured Temperature&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>Fertilization to Stage 9</th>
<th>Stage 9 to Stage 19</th>
<th>Stage 19 to Complete Hatch</th>
<th>Fertilization to Complete Hatch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base Temperature (°C for 18 h/day)</td>
<td>Cycle Temperature (°C for 6 h/day)</td>
<td>Time Required (days)</td>
<td>Mean Survival (%)</td>
<td>Time Required (days)</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1.7</td>
<td>41</td>
<td>93.5</td>
<td>76</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>1.9</td>
<td>37</td>
<td>89.3</td>
<td>62</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>2.0</td>
<td>30</td>
<td>86.6</td>
<td>55</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>2.3</td>
<td>24</td>
<td>42.7</td>
<td>40</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>3.9</td>
<td>26</td>
<td>90.3</td>
<td>49</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>4.0</td>
<td>22</td>
<td>85.6</td>
<td>46</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>6.6</td>
<td>17</td>
<td>74.8</td>
<td>26</td>
</tr>
</tbody>
</table>

Notes:
- Data from Griffith 1980.
- Temperature exposures began 20-22 h after fertilization and were repeated for 6 h/day for the duration of the experiment (completion of hatch).
- Measured temperatures displayed are averages from fertilization to complete hatch. Mean measured temperatures by developmental stage are reported in the source article.

<sup>(a)</sup> Measured temperatures displayed are averages from fertilization to complete hatch. Mean measured temperatures by developmental stage are reported in the source article.
5.2 7-Day Rolling Average Temperatures

The 7-day rolling average temperatures are used to assess the effects of continuous exposure of developing embryos (i.e., chronic exposure) to temperatures at the monitoring locations. The 7-day rolling average temperatures for the period of December 2011 through April 2012 are provided in Figures 5.2-1 to 5.2-10 for those locations for which full data sets were available (see Table 5.3). Locations with incomplete datasets would not allow for assessment over the complete development time for each temperature block and were, therefore, excluded (see Table 5.4). An exception is made for TD42-B where the dataset is mainly complete. Since there were few locations within the nearshore inside the Mixing Zone for which complete datasets were available an effort was made to include those locations for which substantial data were available. However, there is no indication that the locations for which full data were not available would be any different from those locations for which full data were available. Full data sets for the period December 15, 2011 to April 13, 2012 were available for the following locations:

Table 5.3: Monitoring Locations Included in the Assessment

<table>
<thead>
<tr>
<th>Location</th>
<th>Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Locations</td>
<td>TD13-5; DN15-5; DN14-B; DN13-B</td>
</tr>
<tr>
<td>Nearshore within Mixing Zone</td>
<td>TD31-B; TD42-B (mainly complete)</td>
</tr>
<tr>
<td>Nearshore outside Mixing Zone</td>
<td>DN02-B</td>
</tr>
<tr>
<td>Offshore outside Mixing Zone</td>
<td>DN05-B; DN07-B; DN08-B; DN16-B</td>
</tr>
<tr>
<td>Offshore in Mixing Zone</td>
<td>DN10-B; DN17-B; DN18-B; TD35-12; TD45-B; TD55-B</td>
</tr>
</tbody>
</table>

Table 5.4: Monitoring Locations Not Included in the Assessment

<table>
<thead>
<tr>
<th>Location</th>
<th>Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearshore within Mixing Zone</td>
<td>TD38-B</td>
</tr>
<tr>
<td>Nearshore outside Mixing Zone</td>
<td>DN01-B; DN03-B; DN04-B</td>
</tr>
<tr>
<td>Offshore outside Mixing Zone</td>
<td>DN06-B; DN09-B</td>
</tr>
<tr>
<td>Offshore in Mixing Zone</td>
<td>DN11-B; TD52-B; TD34-B;</td>
</tr>
</tbody>
</table>

The assessment of temperature effects on round whitefish embryos during the period of December 2011 to April 2012 is based on a comparison of 7-day moving average bottom temperatures at locations inside and outside of the Mixing Zone around the diffuser to bottom temperatures at reference locations. This approach permits an assessment of the effects of the operation of the diffuser against the normal temperature fluctuations in this area of Lake Ontario.

Figure 5.2-1 shows the 7-day moving average bottom temperatures at both the nearshore (TD13-5, at ~5m depth) and offshore (DN13-B, at ~11m depth) reference locations and illustrates a number of key differences between these locations:

- Bottom temperatures decreased more rapidly in the fall at the shallower nearshore locations;
Minimum winter temperatures were lower at the shallow nearshore locations than at the deeper offshore locations; and

Bottom temperatures increased more rapidly in the spring at the shallow nearshore locations.

Based on these differences, in the following assessment the changes in embryo survival in the area in and around the Mixing Zone are assessed against the predicted survival at the reference locations in order to determine whether there is a significant change in survival due to operation of the diffuser. Therefore, embryo survival at those locations that were in less than 8 m of water were compared to embryo survival in the shallow nearshore reference locations (TD13-5 and DN15-5) while embryo survival at the locations in greater than 8 m of water was compared to embryo survival at the deeper offshore reference locations (DN13-B and DN14-B).

The data for the periods December 2011 through May 2012 show there was a general warming trend beginning at the end of January that resulted in higher temperatures in February and into early March. A warming spike is also apparent during the latter half of March that was more pronounced at the shallower nearshore locations (i.e., TD13-5 and DN15-5 shown on Figures 5.2-1 and 5.2-13) than at the deeper locations (i.e., DN13-B and DN14-B shown on Figures 5.2-1 and 5.2-2). Following the warm spike, temperatures continued to increase through April with temperatures at the nearshore reference locations slightly higher than at the offshore reference locations. The general pattern of temperature changes observed at the reference locations was also noted at all of the monitoring locations within and outside of the Mixing Zone for which full datasets were available.

A number of locations also experienced an increase in temperatures from March 9 to March 23, when bottom temperatures underwent a rapid increase from approximately 3.5°C (as measured at the offshore reference locations, Figure 5.2-1) to 5.5°C. From March 23 to April 13, temperatures at most locations remained in the 5.5°C to 6°C range. Therefore, estimation of exposure temperatures during Block 1 were based on a gradual decline in temperatures from December 15 to January 9, and the midpoint of the temperature range during this period served as a reasonable estimate of exposure temperature. For Block 3 exposures, for those locations that demonstrated the temperature regime described above, the development period was subdivided into two periods, and the exposure temperatures were calculated based on the midpoints of each temperature range. Exposure was then based on the prorated exposure to each temperature range. This approach was used since calculation of the midpoint over the entire range, given the observed temperatures, was likely to under-estimate potential effects.

Temperature data were screened against the 3.5°C benchmark that Griffiths (1980) recommended as the upper limit of the optimum development temperature for developing embryos. The 3.5°C temperature was selected as a screening benchmark with the understanding that temperatures below this screening level would not result in adverse effects on developing embryos. This approach served to remove from further consideration temperatures that would not affect embryo development and focused the assessment on those periods when temperatures above this level were observed. As a result, periods where temperatures were below 3.5°C were not considered in the assessment since it was assumed these temperatures would not present risks to developing embryos.

The data show that a number of locations had consistent temperatures at or above the 3.5°C benchmark from mid-December through to early March. From early March to mid-April, temperatures at all monitoring locations, including the reference locations, exceeded 3.5°C and indicate a general warming of the lake in late winter-early spring. In all cases there was a short period of approximately three weeks in the latter half of January where temperatures dropped below the 3.5°C benchmark.
While temperatures at the majority of locations from early January through to mid-March did not exceed 4°C at the offshore and nearshore locations outside of the Mixing Zone, temperatures at three locations within the Mixing Zone (DN10-B, DN18-B and TD35-12) ranged between 3.5°C and 5°C from January 3 through January 17 and from January 31 through March 9, 2012. Temperatures at these three locations were consistently above 3.5°C. The highest 7-day rolling average temperatures were recorded at TD35-12 (Figure 5.2-2) where temperatures were generally around 4.5°C from the beginning of February until mid-March 2012.

The potential effects of changes in temperature are assessed against predicted survival at the reference locations TD13-5 (Figure 5.2-1) and DN15-5 (Figure 5.2-13) for shallow nearshore monitoring locations and DN13-B (Figure 5.2-1) and DN14-B (Figure 5.2-2) for the deeper offshore locations.

### 5.2.1 Reference Locations

#### 5.2.1.1 Nearshore Locations TD13-5 and DN15-5

Two nearshore reference locations are used in the assessment as a basis of comparison with locations within and near the Mixing Zone. TD13-5 is located approximately 3.5 km to the west of the DNGS diffuser at the 5-m depth while DN15-5, also at the 5-m depth, is located approximately 3.5 km to the east of the diffuser.

Temperatures at the shallow (5 m) reference location TD13-5 (Figure 5.2-1) ranged from approximately 4.5°C on December 15 to 2.5°C on December 31. Survival data from Griffiths (1980) are plotted on Figure 5.2-15 and show that survival at this temperature range for Block 1 embryos was 86% to 92%. Since temperatures decreased gradually during this period, the midpoint of this range, 89%, is considered as the survival rate for this reference location. Temperatures at TD13-5 ranged between 2.5°C and 3.5°C during February and gradually increased in early March to reach 3.5°C by March 10 (Figure 5.2-1). Griffiths (1980) data (plotted on Figure 5.2-16) show that for Block 2 embryos survival ranged between 97% and 99% (midpoint = 98%).

During the Block 3 development period, temperatures ranged between 3.5°C on March 4 to 6.5°C on April 13, with a short term peak above 6.5°C (maximum of just under 8°C) from approximately March 19 to March 30. Temperatures during this period indicate a gradual increase occurred and, therefore, the midpoint of the temperature range is used as the basis for estimating embryo survival at these temperatures. Based on the data developed by Griffiths (Figure 5.2-17), survival at 3.5°C is estimated as 96% and survival at 6.5°C is estimated as 60% (midpoint = 78% survival).

The temperature range at DN15-5 was similar to that described for TD13-5, and therefore TD13-5 is used as representative of nearshore conditions.

#### 5.2.1.2 Offshore Reference Locations DN13-B and DN14-B

Two reference locations were also available for comparison with the deeper offshore locations in and around the Mixing Zone. Location DN13-B is located approximately 3 km to the east of the DNGS diffuser at the 11-m depth while DN14-B is located approximately 3.5 km to the west of the diffuser at approximately the 12-m depth. Since an incomplete data set is available for DN14-B, location DN13-B is used primarily to assess conditions at the offshore reference locations.

Temperatures at reference location DN13-B (Figure 5.2-1) decreased from approximately 5°C around December 15 to approximately 3.5°C by January 9, 2012. Survival data from Griffiths (1980) is plotted on Figure 5.2-15 and shows that survival at this temperature range was 84% to 91% (midpoint = 87.5%). Temperatures remained at around 3.5°C until January 17 when temperatures began to decrease to approximately 2.5°C followed by a slow
increase to 3.5°C by February 5, 2012. Temperatures remained around 3.5°C until March 11. Based on these temperatures, Block 1 embryos could experience a 2% decrease in survival (temperatures during the period from December 15 to January 1 were similar to those at TD35-12). Block 2 embryos are likely to be unaffected since Block 2 survival data from Griffiths study (Figure 5.2-16) show that survival ranged around 98% at temperatures of approximately 4°C.

Block 3 temperatures ranged from 3.5°C on March 4 to 6°C on April 13. Survival rates within this temperature range were between 96% at 3.5°C and 66% at 6°C (midpoint = 81%). Temperatures ranged between 3.5°C and 5.5°C (midpoint = 4.5°C with predicted survival of 88%) from March 4 to approximately March 20 (i.e., 40% of Block 3 estimated development time) and between 5.5°C and 6°C (midpoint = 5.75°C with predicted survival of 71%) from March 20 to April 13 (i.e., 60% of the estimated embryo development period). Therefore, predicted survival of Block 3 embryos, based on prorated exposures is calculated as 77.8%.

Temperature data for DN14-B are lacking for the period March 4 to approximately March 19, and therefore a complete temperature range is not available for this location during Block 3 embryo development. However, data for DN14-B (the 7 day rolling average temperature for the time period available is shown on Figures 5.2-2 through 5.2-12) show that temperatures from March 19 to approximately April 7 were slightly warmer than at DN13-B, and indicate that there is some natural variability in bottom water temperatures among the reference locations.

### 5.2.2 Monitoring Location TD35-12

Temperatures during Block 1 embryo development at TD35-12 gradually decreased from approximately 5°C around December 15 to approximately 4°C by December 31 and to approximately 3.5°C by January 9 (i.e., the estimated end of Block 1 development) (Figure 5.2-2). Survival data from Griffiths (1980) are plotted on Figure 5.2-15 and show that survival at 3.5° to 5°C ranged between 84% and 91% (survival data from Griffiths (1980) is provided in Table 5.3). Figure 5.2-1 shows that during this same period, bottom water temperatures at the reference location DN13-B ranged from approximately 5°C on December 15 to 3.7°C on December 31 and 3.5°C on January 9. Therefore, Block 1 embryo survival at DN13-B would be the same as at TD35-12. Since temperatures and, therefore, survival rates occurred as ranges rather than discrete values, the midpoint for each survival range is calculated in order to facilitate the calculation of a predicted change in survival. Based on the above data, survival of Block 1 embryos is estimated at 87.5% (midpoint of 84% and 91%) at both the reference location, DN13-B and TD35-12. The data show that Block 1 embryos would not have experienced a decrease in survival at TD35-12 compared to the reference location as a result of the temperatures experienced during late December.

During the Block 2 embryo development period (January 9 to March 4) temperatures at TD35-12 ranged from a low of 2.5°C around January 21 to 4.5°C by around February 3 and remained between 4°C and 4.5°C until March 4 (i.e., the estimated end of the Block 2 development period). During this same period, while temperatures at the reference location DN13-B reached a similar low of 2.5°C in late January, temperatures from February 2 through March 4 ranged around 3.5°C. Figure 5.2-2 shows that there was a temperature difference between TD35-12 and DN13-B of up to 1°C during Block 2. Therefore, at TD35-12, during the entire Block 2 development period of 56 days, 20% of the time temperatures were below 3.5°C while 80% of the time temperatures ranged up to 4.5°C.
Figure 5.2-16 shows survival of Block 2 embryos at different sustained temperatures as determined from Griffiths (1980) experiments. The data show there were negligible differences in embryo survival between 1.7°C (the lowest sustained temperature tested by Griffiths) and 6.8°C. As a result, while there was a temperature difference of up to 1°C between the reference location DN13-B and TD35-12 during much of the Block 2 embryo development period, this does not result in any predicted difference in embryo survival.

During the Block 3 embryo development period (estimated as March 4 to April 13), temperatures at TD35-12 increased from approximately 4.5°C around March 4 to approximately 6.8°C around April 13, and reached a maximum of 7°C for a period of approximately 5 days in late March. Therefore, temperatures were below 6°C for a period of approximately 12 days and between 6°C and 7°C for a period of approximately 28 days. Therefore, exposure is estimated based on exposure to temperatures between 4.5°C and 6°C (midpoint = 5.25°C and survival of 78%) for 30% of the embryo development period and between 6°C and 7°C (midpoint 6.5°C and survival of 60%) for 70% of the time. Predicted survival rates are prorated for these exposures and result in a predicted survival of 65.4%. Comparison with predicted survival at reference location DN13-B shows a predicted decrease in survival of 12.4%.

5.2.3 Monitoring Locations DN10-B, DN17-B and DN18-B

Monitoring locations DN10-B (Figure 5.2-3), DN17-B (Figure 5.2-4) and DN18-B (Figure 5.2-5), were located in the offshore area within the Mixing Zone. These three locations all showed similar temperature profiles during the winter months and, therefore, are considered together. Of these three locations, DN10-B (located approximately mid-way along the length of the diffuser as shown in Figure 1-1) was located closest to the diffuser.

Temperatures from December 15 through January 9 (i.e., Block 1 embryo development period) decreased gradually from approximately 5.25°C (5°C at DN17-B and DN18-B) to 4°C (3.5°C at DN18-B). Therefore, the midpoint (4.65°C with estimated survival of 86.5%) is calculated using the data from DN10-B since this represents the worst case for this group of monitoring locations. Compared to the reference location DN13-B, survival is predicted to decrease by 1% at DN10-B (and slightly less at DN17-B and DN18-B). A change of 1% or less is considered to be negligible.

During Block 2 embryo development, temperatures ranged between 2.5°C and 4.5°C at DN10-B and DN18-B (and between 2.5°C and 4°C at DN17-B). Griffiths (1980) data show there is no change in embryo survival between 1.7°C and 6.8°C (Figure 5.2-16) and, therefore, there is no predicted change in survival of Block 2 embryos relative to the reference location.

During Block 3 embryo development, temperatures increased earliest at DN17-B and this location is assessed as the worst case. Temperatures at DN17-B (Figure 5.2-4) increased from approximately 3.75°C on March 4 to 5.5°C on March 16 (midpoint = 4.65 with predicted survival of 86.5% for a period of 12 days which is approximately 30% of the Block 3 development time) to between 5.5°C and 6.5°C (midpoint = 6°C with estimated survival of 66.5%) from March 16 to April 13 (i.e., 70% of the Block 3 development time). The prorated estimate of survival is 72.5%. Compared to the estimated embryo survival of 77.8% at the reference location, this represents a decrease of 5.3%.
5.2.4 Monitoring Locations TD55-B and TD45-B

Monitoring locations TD55-B and TD45-B were located at the edge of the Mixing Zone in the deeper offshore areas. Temperatures at TD55-B (Figure 5.2-6) and TD45-B (Figure 5.2-7) showed similar temperatures and, as such, are considered together. Temperatures at these locations decreased gradually from approximately 5°C (~4.75°C at TD45-B) around December 15 to approximately 3.5°C by January 9, 2012 (midpoint = 4.25°C with estimated survival of 88%). Temperatures remained at around 3.5°C until January 17 when temperatures began to decrease to approximately 2.5°C followed by a slow increase to 3.5°C by February 5, 2012. Temperatures ranged between 3.5°C and 4°C until March 4, 2012, i.e., the estimated end of Block 2 embryo development. Temperatures increased gradually from 3.5°C to 5.5°C (midpoint = 4.5°C with estimated survival of 88%) from March 4 to around March 27 (58% of total Block 3 development time), and then ranged between 5.5°C and 6°C (midpoint = 5.75°C with estimated survival of 71%) from around March 27 to April 13 (i.e., 42% of total Block 3 development time), the estimated end of Block 3 embryo development. Based on these temperatures the following estimates are made:

- Block 1 embryo survival at 88% is unchanged from the estimated survival at the offshore reference location DN13-B (87.5%) and no effect on embryo development is predicted for Block 1 embryos;
- Block 2 embryos are likely to be unaffected within the temperature ranges noted since Griffiths data showed that survival was unaffected at temperatures between 1.7°C and 6.8°C (Figure 5.2-16); and
- Block 3 embryo survival is calculated on the prorated temperature ranges experienced during March and April of 2012. Estimated survival is calculated on this basis as 81%. Estimated survival at the reference location was 77.8%. Therefore, survival at these locations is not likely to be affected by operation of the diffuser.

Therefore, overall survival of round whitefish embryos at these locations is predicted to be unaffected compared to the offshore reference location.

5.2.5 Monitoring Locations DN05-B, DN07-B, DN08-B and DN16-B

Locations DN05-B (Figure 5.2-8), DN07-B (Figure 5.2-9), and DN08-B (Figure 5.2-10) (all located in the offshore area outside of the Mixing Zone) at depths of 13.8 m or greater are also considered together due to very similar temperatures during the winter months. DN16-B (Figure 5.2-11), also located outside of the Mixing Zone (between the edge of the Mixing Zone and the DNFS intake), is situated in a slightly shallower water depth (11 m).

Temperatures during Block 1 embryo development (December 15 through January 9) showed a gradual decline from 5°C (slightly lower at DN07-B) to 3.5°C. The midpoint of this temperature range is 4.25°C which corresponds to an estimated survival of 88%. This is unchanged from estimated survival at the reference location DN13-B and, as such, there is no predicted effect on Block 1 embryo survival.

Temperatures during Block 2 embryo development were less than 4°C at all four locations and were similar to temperatures at the reference location DN13-B. Since Griffiths showed that Block 2 embryo survival was unaffected by temperatures between 1.7°C and 6.8°C, there is no predicted change in Block 2 embryo survival at these locations.
Block 3 temperatures at locations DN05-B, DN07-B and DN16-B were similar to or below the temperatures at the reference location DN13-B from March 4 to April 13 (Figures 5.2-8, 5.2-9 and 5.2-11). Therefore, there is no predicted change in Block 3 embryo survival relative to the reference locations for these monitoring locations. Temperatures at DN08-B were higher than at DN13-B from around March 8 to April 6, but were similar to temperatures at the other offshore reference location DN14-B (Figure 5.2-10). Therefore, there is no predicted change in embryo survival relative to the reference location DN14-B. Both DN13-B and DN14-B are sufficiently distant from the diffuser to represent background conditions in this area of the lake. Therefore, the maximum change in survival at the reference locations represents the change in embryo survival that could be expected under natural conditions. Therefore, the change in survival at location DN14-B is considered an appropriate reference point against which to assess potential effects of temperature changes at these monitoring locations.

5.2.6 Monitoring Locations TD42-B and TD31-B

Both of these locations are in the nearshore area within the Mixing Zone and are, therefore, considered together. While a complete data set is not available for TD42-B (Figure 5.2-12), the available data includes most of the Block 1 development period and approximately 50% of the Block 3 embryo development period.

Temperatures at TD31-B (located at a depth of 6.3 m) (Figure 5.2-13) between December 15, 2011 and April 13, 2012 temperatures were at or below the temperatures at the nearshore reference locations TD13-5 and DN15-5. As a result, there are no predicted changes in survival relative to the reference locations.

Temperatures at TD42-B (located at a depth of approximately 8 m) were similar to or colder than temperatures at the reference locations during Block 1 development. As such, no change in survival is predicted at this location due to operation of the diffuser. Temperatures during Block 3 development are only available from approximately March 18th onwards. However, with the exception of a short period from March 18th to March 30th when temperatures were slightly higher than at the reference locations, temperatures were similar to those at the reference locations for the remainder of Block 3 development. Therefore, it is reasonable to assume that temperatures during Block 3 embryo development would not differ substantially from those at the nearshore reference locations, and there would be no difference in embryo survival. A quantitative assessment of changes in embryo survival at TD42-B was not undertaken due to the incomplete data set available.

5.2.7 Monitoring Location DN02-B

Temperatures at DN02-B, located in the nearshore area outside of the Mixing Zone, were less than or equal to temperatures at the reference locations (Figure 5.2-14). Therefore, there are no predicted changes in embryo survival at this location due to operation of the diffuser.

5.2.8 Summary

The potential changes in embryo survival based on the 7-day rolling average temperatures are summarized in Table 5.5. Changes in survival at each location were estimated based on comparison with predicted survival at the reference locations. As noted, reference locations varied in depth from 5 m (nearshore) to greater than 11 m (offshore) and temperature regimes over the winter varied between the nearshore and offshore reference locations. As a result, predicted embryo survival at the deeper monitoring locations were compared to the deeper
offshore reference locations while predicted survival at the shallower monitoring locations were compared to the shallow nearshore reference locations.

The summary provided in Table 5.5 shows that there were no effects on embryo survival due to operation of the DNGS diffuser relative to conditions at reference locations during the Block 1 and Block 2 embryo development periods. In fact, no reduction in survival of Block 1 and Block 2 embryos was predicted based on temperatures at all locations. Reductions in survival during Block 3 embryo development were limited to location TD35-12 (located at the end of the diffuser) and the three deeper monitoring locations (DN17-B; DN18-B and DN10-B) situated within the Mixing Zone. There were no measurable changes at the edge of the Mixing Zone nor in the nearshore area inside or outside of the Mixing Zone.

Table 5.5: Summary of Changes in Survival Relative to Reference Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Block 1 Maximum Change from Reference (%)</th>
<th>Block 2 Maximum Change from Reference (%)</th>
<th>Block 3 Maximum Change from Reference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Offshore Within Mixing Zone</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD35-12</td>
<td>N.C.</td>
<td>N.C.</td>
<td>12.4</td>
</tr>
<tr>
<td>DN17-B</td>
<td>N.C.</td>
<td>N.C.</td>
<td>5.3</td>
</tr>
<tr>
<td>DN18-B</td>
<td>N.C.</td>
<td>N.C.</td>
<td>5.3</td>
</tr>
<tr>
<td>DN10-B</td>
<td>N.C.</td>
<td>N.C.</td>
<td>5.3</td>
</tr>
<tr>
<td>TD55-B</td>
<td>N.C.</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>TD45-B</td>
<td>N.C.</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td><strong>Offshore Outside Mixing Zone</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN05-B</td>
<td>N.C.</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN07-B</td>
<td>N.C.</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN08-B</td>
<td>N.C.</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN16-B</td>
<td>N.C.</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td><strong>Nearshore Within Mixing Zone</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD31-B</td>
<td>N.C.</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td><strong>Nearshore Outside Mixing Zone</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN02-B</td>
<td>N.C.</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
</tbody>
</table>

Notes:
N.C. = no change
5.3 Hourly Average Temperatures

In this section, the hourly average temperatures are considered in order to determine whether short term increases (i.e., pulses) in temperatures occurred during the period of December 2011 through April 2012 that could adversely affect embryo development.

The hourly average temperatures, calculated from the 15-minute temperature data, are shown on Figures 5.3-1 to 5.3-5. Since short term exceedances would occur for only limited time periods, the 5°C benchmark is used for this assessment. As with the previous assessment, the 5°C benchmark is used to screen out lower temperature pulses that would not be expected to result in adverse effects on embryo development. The 5°C benchmark is a conservative value that represents the upper range for embryo development, as defined by Griffiths (1980) and Wismer and Christie (1987). The data show that temperatures exceeded the 5°C benchmark at a limited number of locations on one or more occasions during the period of January to April 2012.

In general the data show that from December 2011 to mid-March 2012 bottom water temperatures were slightly cooler than average conditions at the shallow water reference locations (TD13-5 and DN15-5) (Figure 5.3-1) and slightly warmer than average at the deeper water reference locations (DN13-B and DN14-B) (Figure 5.3-1). From mid-March to mid-April, temperatures in the nearshore increased more rapidly and reached higher temperatures than at the offshore reference locations.

Table C-2 in Attachment C provides details on locations where temperature exceedances of 5°C occurred and also provides the maximum temperature reached during each event and the duration for which temperatures were at or above 5°C.

The approach used to assess the effects on embryo development is described below:

- The total hours for which temperatures at or above 5°C occurred and the maximum temperatures reached are calculated on a monthly basis from the data in Table C-2 in Attachment C:

- The total period of time within each developmental block during which Griffiths exposed the embryos to the higher temperature pulses (up to 6.6°C) is calculated as a percentage of the entire development period for that developmental block. This works out to a standard 25% (based on Griffiths’ exposures of 6 hours every 24 hours under 4°C to 7°C temperature increases), and continuous exposure which works out to 100% (based on Griffiths’ data for continuous exposure to 7°C).

- The percentage of time that temperatures exceeded 5°C at each monitoring location relative to the total developmental time for each block is calculated (see, for example, Table 5.6). This provides the percentage of the time during which developing embryos in each block were subjected to temperatures at or above 5°C;

- Griffiths’ (1980) data show that survival is affected by both the maximum temperature attained as well as the percentage of time over which this temperature occurred. Therefore, survival at a daily temperature increase for 6 hours from a base temperature of 3.9°C to 6.6°C is calculated from Griffiths’ data for each developmental block. Similarly, survival at a sustained temperature of 6.6°C (nominally 7°C as reported by Griffiths) is calculated for each developmental block. These data are used to produce graphs that provide the basis for estimating embryo survival under the actual exposure periods that occurred at each location and for each developmental block. The relationship between embryo survival at a nominal temperature of 7°C over different exposure periods for Block 1, Block 2 and Block 3 embryos is shown on Figures 5.3-6 5.3-7, and 5.3-8.
Changes in survival are then estimated from these data plots based on the actual hours of exposure, calculated as a percentage of total development time for that block, at each monitoring location for each developmental block. From this plot, the expected survival is determined based on the percentage of time during which temperatures above 5°C were recorded.

The change in survival is then assessed relative to the maximum change in survival at the appropriate reference locations.

Table 5.6 summarizes the length of time temperatures above 5°C occurred during each developmental block, and provides the percentage of the entire block development time during which temperatures above 5°C occurred. The table also provides the maximum temperature recorded during this period. The full dataset for each period is provided in Table C-1 in Appendix C. While Table 5.6 provides the maximum temperature attained, this does not imply that embryos were exposed to these temperatures for the entire period for which temperatures exceeded 5°C. As Figures 5.3-1 to 5.3-5 show, maximum temperatures were experienced at each location only for short periods of time, and temperature exceedances were generally less than 7°C.

5.3.1 Reference Locations

5.3.1.1 Monitoring Location DN13-B

Temperatures at DN13-B exceeded 5°C for a total of 55 hours. This represents 9% of the total Block 1 embryo development time. Interpolating from Figure 5.3-6, survival is estimated as 89.1%, or a 1.2% decrease.

A single temperature exceedance of 5°C (maximum temperature of 5.23°C) occurred on February 6, 2012, with a total duration of one hour. The effects on embryo survival are considered negligible.

Block 3 exceedances of the 5°C screening benchmark occurred for a total of 66.5% of the embryo development time. Interpolating from Figure 5.3-8, predicted survival at this exposure would be 71.5%. Compared to survival at the base temperature of 3.9°C of 95.7%, this represents a decrease of 24.2%.

5.3.1.2 Monitoring Location DN14-B

Temperatures at DN14-B exceeded 5°C for a total of 54 hours, or 9% of total Block 1 embryo development time (Table C-2 in Attachment C). The maximum temperature attained during this period was 5.6°C. This represents 9% of total Block 1 embryo development time. Interpolating from Figure 5.3-6, survival is estimated as 89.1%, or a 1.2% decrease.

Temperature data for the Block 2 development period are incomplete. As such, changes during this developmental period could not be assessed.

Temperature data for DN14-B are available from March 16 to April 13. Figure 5.3-1 shows that temperatures increased to above 5°C at DN13-B around March 15. Figure 5.3-1 shows similar temperatures for DN14-B at this same time period. Therefore, it was determined that temperature data for DN14-B were sufficiently complete to assess the effects of temperature pulses during Block 3 development. The data indicate it was unlikely there were temperature exceedances of 5°C at DN14-B prior to when data became available for this location. Since the greatest temperature changes occurred at this location during Block 3, DN14-B is used as the reference location for assessing temperature changes during Block 3 development.
Block 3 exceedances of the 5°C screening benchmark occurred for a total of 73.1% of the embryo development time. Interpolating from Figure 5.3-8, predicted survival at this exposure would be 68.5%. Compared to survival at the base temperature of 3.9°C of 95.7%, this represents a decrease of 27.2%.
### Table 5.6: Temperature Exceedances of 5°C per Embryo Development Block

<table>
<thead>
<tr>
<th>Block</th>
<th>Total Block Development Time</th>
<th>Total Hours above 5°C</th>
<th>% of Total Development Time</th>
<th>Maximum Temperature °C</th>
<th>Total Hours above 5°C</th>
<th>% of Total Development Time</th>
<th>Maximum Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block 1</td>
<td>600 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block 2</td>
<td>1344 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block 3</td>
<td>960 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Offshore Reference Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Hours above 5°C</th>
<th>Maximum Temperature °C</th>
<th>% of Total Development Time</th>
<th>Maximum Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN14-B</td>
<td>54</td>
<td>5.6</td>
<td>9.0</td>
<td>8.0</td>
</tr>
<tr>
<td>DN13-B</td>
<td>55</td>
<td>6.2</td>
<td>9.2</td>
<td>7.5</td>
</tr>
</tbody>
</table>

#### Offshore Inside Mixing Zone

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Hours above 5°C</th>
<th>Maximum Temperature °C</th>
<th>% of Total Development Time</th>
<th>Maximum Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD35-12</td>
<td>118</td>
<td>5.8</td>
<td>19.7</td>
<td>8.5</td>
</tr>
<tr>
<td>DN17-B</td>
<td>131</td>
<td>6.2</td>
<td>21.8</td>
<td>7.8</td>
</tr>
<tr>
<td>DN18-B</td>
<td>193</td>
<td>6.9</td>
<td>32.2</td>
<td>8.2</td>
</tr>
<tr>
<td>DN10-B</td>
<td>175</td>
<td>6.8</td>
<td>29.2</td>
<td>7.4</td>
</tr>
</tbody>
</table>

#### Offshore At Edge of Mixing Zone

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Hours above 5°C</th>
<th>Maximum Temperature °C</th>
<th>% of Total Development Time</th>
<th>Maximum Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD55-B</td>
<td>80</td>
<td>6.5</td>
<td>13.3</td>
<td>7.6</td>
</tr>
<tr>
<td>TD45-B</td>
<td>36</td>
<td>6.0</td>
<td>6.0</td>
<td>7.9</td>
</tr>
</tbody>
</table>

#### Offshore Outside Mixing Zone

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Hours above 5°C</th>
<th>Maximum Temperature °C</th>
<th>% of Total Development Time</th>
<th>Maximum Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN05-B</td>
<td>90</td>
<td>6.4</td>
<td>15.0</td>
<td>7.6</td>
</tr>
<tr>
<td>DN07-B</td>
<td>85</td>
<td>6.4</td>
<td>14.2</td>
<td>8.1</td>
</tr>
<tr>
<td>DN08-B</td>
<td>64</td>
<td>5.9</td>
<td>10.7</td>
<td>7.4</td>
</tr>
</tbody>
</table>

#### Nearshore Inside Mixing Zone

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Hours above 5°C</th>
<th>Maximum Temperature °C</th>
<th>% of Total Development Time</th>
<th>Maximum Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD31-B</td>
<td>30</td>
<td>5.4</td>
<td>5.0</td>
<td>8.8</td>
</tr>
</tbody>
</table>

#### Nearshore Outside Mixing Zone

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Hours above 5°C</th>
<th>Maximum Temperature °C</th>
<th>% of Total Development Time</th>
<th>Maximum Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN02-B</td>
<td>36</td>
<td>5.4</td>
<td>6.0</td>
<td>8.1</td>
</tr>
</tbody>
</table>

#### Nearshore Reference Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Hours above 5°C</th>
<th>Maximum Temperature °C</th>
<th>% of Total Development Time</th>
<th>Maximum Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>TD13-5</td>
<td>40</td>
<td>5.5</td>
<td>6.7</td>
<td>8.9</td>
</tr>
<tr>
<td>DN15-5</td>
<td>43</td>
<td>5.6</td>
<td>7.2</td>
<td>9.6</td>
</tr>
</tbody>
</table>
5.3.1.3 Monitoring Location TD13-5
Temperatures at TD13-5, located in the nearshore area at shallower depths, exceeded 5°C for a total of 40 hours, or 6.7% of total Block 1 embryo development time (Table C-2 in Attachment C). The maximum temperature attained during this period was 5.5°C. Interpolating from Figure 5.3-6, survival is estimated as 89.5%, or a 0.8% decrease from 90.3% survival at a sustained temperature of 3.9°C.

There were no exceedances of the 5°C screening benchmark during Block 2 embryo development.

Block 3 exceedances of the 5°C screening benchmark occurred for a total of 81.3% of the embryo development time. Interpolating from Figure 5.3-8, predicted survival at this exposure would be 64.3%. Compared to survival at the base temperature of 3.9°C of 95.7%, this represents a decrease of 31.4%.

5.3.1.4 Monitoring Location DN15-5
Temperatures at DN13-5, also located in the nearshore area at shallower depths, exceeded 5°C for a total of 43 hours, or 7.2% of total Block 1 embryo development time (Table C-2 in Attachment C). The maximum temperature attained during this period was 5.6°C. Interpolating from Figure 5.3-6, survival is estimated as 89.5%, or a 0.8% decrease from 90.3% survival at a sustained temperature of 3.9°C.

There were no exceedances of the 5°C screening benchmark during Block 2 embryo development.

Block 3 exceedances of the 5°C screening benchmark occurred for a total of 78.8% of the embryo development time. Interpolating from Figure 5.3-8, predicted survival at this exposure would be 65.5%. Compared to survival at the base temperature of 3.9°C of 95.7%, this represents a decrease of 30.2%.

5.3.2 Offshore Within Mixing Zone

5.3.2.1 Monitoring Location TD35-12
Temperatures at TD35-12 exceeded 5°C for a total of 118 hours and the maximum temperature reached was 5.8°C. Therefore, during Block 1 embryo development, temperatures between 5°C and 6°C occurred during 20% of the embryo development period. Interpolating from Figure 5.3-6, the expected survival at this temperature regime would be approximately 87.5%, or a decrease of 2.8%.

Temperatures at TD35-12 again increased to above 5°C beginning around February 2, 2012 and frequent exceedances occurred through to March 4, 2012. During Block 2 embryo development, temperatures above 5°C occurred for a total of 153 hours or 11% of the total development time. Interpolating from Figure 5.3-7, the expected survival at this temperature regime would be approximately 98.15%, or a decrease of 0.25% from the observed survival of 98.4% at a base temperature of 3.9°C. This change is considered negligible.

During the Block 3 development period, temperatures were above 5°C for 89.4% of the estimated embryo development time. Interpolating from Figure 5.3-8, estimated survival at this length of exposure is 59.8%. Compared to survival at a constant temperature of 3.9°C of 95.7%, this represents a decrease of 35.9%.

5.3.2.2 Monitoring Location TD55-B
Temperatures at TD55-B exceeded 5°C for a total of 80 hours, or 13.5% of the time. Therefore, total exposure to higher temperatures during Block 1 development was less than the 25% of embryo development assessed by Griffiths that resulted in a decrease in survival of 4.7% (from 90.3% at sustained temperatures of 3.9°C to 85.6%
at daily pulses from 3.9°C to 6.6°C). Interpolating from Figure 5.3-6, the expected survival at the above exposures would be 89.5%, or a reduction of 0.77%. This change is considered negligible.

Temperatures above 5°C during Block 2 embryo development occurred on four occasions between February 6 and February 24. Temperatures up to 5.44°C occurred for a total of 13 hours, with the longest exposure period lasting 6 hours. Since this represents <1% of total embryo development time in this stage, the effects on embryo survival would be negligible.

During Block 3 embryo development, temperatures exceeded the 5°C screening benchmark for 54.8% of the total Block 3 development period. Estimated survival, based on Griffiths' experiments was 77.8%. Compared to survival of 95.7% at the base temperature of 3.9°C, this represents a decrease of 17.9%.

5.3.2.3 Monitoring Location DN10-B

From December 15 to January 9, temperatures exceeded 5°C for 178 hours or 30% of the time (based on a conservative estimate of the embryo development period of 25 days). Temperature pulses that occurred 30% of the time are expected to result in 85.8% survival (interpolated from Figure 5.3-6). This represents a 4.7% reduction in survival from embryo survival observed for exposure to sustained temperatures of 3.9°C.

Temperatures above 5°C (none exceeded 6°C) during Block 2 embryo development occurred for a total of 2.8% of the total Block 2 development time. This would result in a negligible decrease in survival. As a result, no decrease in survival is expected to occur for Block 2 embryos.

During Block 3 embryo development, temperatures exceeded the 5°C screening benchmark for 61.6% of the total Block 3 development period. Estimated survival, based on Griffiths' experiments was 74.3%. Compared to 95.7% survival at the base temperature of 3.9°C, this represents a decrease of 21.4%.

5.3.2.4 Monitoring Location DN17-B

Temperatures above 5°C occurred for a total of 131 hours, or 21.8% of the time. Griffiths noted that Block 1 embryo survival decreased from 90.3% at a constant temperature of 3.9°C to 85.6% during daily pulses from 4°C to 7°C. Therefore, Block 1 embryo survival would be expected to decrease to 87.1% which represents a reduction of 3.2% under the temperature regime observed during the period of December 15, 2011 to January 9, 2012.

Temperatures during the Block 2 embryo development period exceeded the 5°C benchmark on five occasions and reached a maximum temperature of 5.21°C. The longest period of increased temperatures was four hours. Temperatures above the 5°C screening benchmark occurred for a total of 1% of the Block 2 development time and resulted in a negligible change in predicted embryo survival.

During Block 3 embryo development, temperatures exceeded the 5°C screening benchmark for 85.2% of the total Block 3 development period. Estimated survival based on Griffiths' experiments was 62.3%. Compared to 95.7% survival at the base temperature of 3.9°C, this represents a decrease of 33.4%.

5.3.2.5 Monitoring Location DN18-B

Temperatures above 5°C occurred for a total of 193 hours, or 32% of the time. From Figure 5.3-6, the expected survival of Block 1 embryos under this exposure is estimated to be 85.5%, which is a decrease of 4.8% from the 90.3% survival Griffiths observed at sustained temperatures of 3.9°C.

Temperatures above 5°C during Block 2 embryo development occurred on 18 occasions between January 10 and February 25, 2012. Temperatures during this period ranged between 5°C and 6°C, with a maximum
temperature of 5.7°C. Temperatures above 5°C were recorded for a total of 32 hours, or 2.4% of the total development time of 56 days. As a result, decreased survival resulting from these exposures is expected to be negligible.

During Block 3 embryo development, temperatures exceeded the 5°C screening benchmark for 71.9% of the total Block 3 development period. Estimated survival, based on Griffiths’ experiments was 69.0%. Compared to 95.7% survival at the base temperature of 3.9°C, this represents a decrease of 26.7%.

5.3.2.6 Monitoring Location TD45-B
Temperatures at TD45-B exceeded 5°C for a total of 36 hours, or 5.7% of the total embryo development time. Interpolating from Figure 5.3-6, the expected embryo survival is estimated to be 89.7%, which represents a decrease of 0.6%. This change is considered negligible.

There were no exceedances of the 5°C screening benchmark during the Block 2 embryo development period.

During Block 3 embryo development, temperatures exceeded the 5°C screening benchmark for 75.7% of the total Block 3 development period. Estimated survival based on Griffiths’ experiments was 67.0%. Compared to 95.7% survival at the base temperature of 3.9°C, this represents a decrease of 28.7%.

5.3.3 Offshore Outside Mixing Zone
5.3.3.1 Monitoring Location DN05-B
Temperatures above 5°C occurred for a total of 90 hours, or 15% of the time. Interpolating from Figure 5.3-6, the estimated survival under this temperature regime would be 88.2%. Compared to survival of 90.3% based on Griffiths’ exposure to sustained temperatures of 3.9°C, a reduction in survival of 2.1% could be expected for Block 1 embryos.

During Block 2 development, temperatures above 5°C (maximum temperature of 5.41°C) occurred on three occasions with a total exposure time of 11 hours. This is negligible relative to total development time (<1%) and effects on embryo development are considered to be negligible.

During Block 3 embryo development, temperatures exceeded the 5°C screening benchmark for 54.9% of the total Block 3 development period. Estimated survival based on Griffiths’ experiments was 77.8%. Compared to 95.7% survival at the base temperature of 3.9°C, this represents a decrease of 17.9%.

5.3.3.2 Monitoring Location DN07-B
Temperatures above 5°C occurred for a total of 85 hours, or 14% of the time. Interpolating from Figure 5.3-6, the estimated survival under this temperature regime would be 88.3%. Compared to a survival of 90.3% based on Griffiths’ exposure to sustained temperatures of 3.9°C, a reduction in survival of 2.0% could be expected for Block 1 embryos.

During Block 2 development, temperatures above 5°C (maximum 5.1°C) occurred on one occasion with a total exposure time of one hour. This is negligible relative to total development time and effects on embryo development are considered to be negligible.

During Block 3 embryo development, temperatures exceeded the 5°C screening benchmark for 56% of the total Block 3 development period. Estimated survival, based on Griffiths’ experiments was 77.3%. Compared to 95.7% survival at the base temperature of 3.9°C, this represents a decrease of 18.4%.
5.3.3.3 Monitoring Location DN08-B

Temperatures above 5°C occurred for a total of 64 hours, or 11% of the time. Interpolating from Figure 5.3-6, the estimated survival under this temperature regime would be 89.1%. Compared to a survival of 90.3% based on Griffiths’ exposure to sustained temperatures of 3.9°C, a reduction in survival of 1.2% could be expected for Block 1 embryos.

During Block 2 development, temperatures above 5°C (maximum temperature of 5.48°C) occurred on three occasions with a total exposure time of six hours. This is negligible relative to total development time (<1%) and effects on embryo development are considered to be negligible.

During Block 3 embryo development, temperatures exceeded the 5°C screening benchmark for 81.1% of the total Block 3 development period. Estimated survival, based on Griffiths’ experiments was 64.3%. Compared to 95.7% survival at the base temperature of 3.9°C, this represents a decrease of 31.4%.

5.3.4 Nearshore Within Mixing Zone

5.3.4.1 Monitoring Location TD31-B

Temperatures above 5°C occurred for a total of 30 hours, or 5% of the time. Interpolating from Figure 5.3-6, the estimated survival under this temperature regime would be 89.8%. Compared to a survival of 90.3% based on Griffiths’ exposure to sustained temperatures of 3.9°C, a reduction in survival of 0.5% could be expected for Block 1 embryos.

During Block 2 development, there were no occurrences of temperatures above 5°C.

During Block 3 embryo development, temperatures exceeded the 5°C screening benchmark for 77.8% of the total Block 3 development period. Estimated survival, based on Griffiths’ experiments was 66.0%. Compared to 95.7% survival at the base temperature of 3.9°C, this represents a decrease of 29.7%.

5.3.5 Nearshore Outside Mixing Zone

5.3.5.1 Monitoring Location DN02-B

Temperatures above 5°C occurred for a total of 36 hours, or 6% of the time. Interpolating from Figure 5.3-6, the estimated survival under this temperature regime would be 89.6%. Compared to a survival of 90.3% based on Griffiths’ exposure to sustained temperatures of 3.9°C, a reduction in survival of 0.7% could be expected for Block 1 embryos.

During Block 2 development, there were no occurrences of temperatures above 5°C.

During Block 3 embryo development, temperatures exceeded the 5°C screening benchmark for 81.8% of the total Block 3 development period. Estimated survival, based on Griffiths’ experiments was 64.0%. Compared to 95.7% survival at the base temperature of 3.9°C, this represents a decrease of 31.7%.

5.3.6 Summary

Potential effects from short-term exposures to temperatures above 5°C are summarized in Table 5.7. Changes are assessed as decreases in survival from the base case of exposure to sustained temperatures of 3.9°C.
Table 5.7 includes an assessment of changes in survival at the reference locations since reference locations also yielded predicted changes in survival based on the measured temperatures. In Table 5.7 only predicted decreases in survival have been included in the final calculation. Where predicted survival was better than reference this has not been included in the calculation in order to maintain a conservative approach to the assessment. As shown in Table 5.7, during the Block 3 development period, temperatures increased at all locations, including the reference locations. The final assessment of potential effects on round whitefish embryo survival is, therefore, based on the changes at the locations in and around the diffuser relative to the reference locations. The maximum change at nearshore and offshore reference locations has been used as the basis for calculating the change in predicted survival at each of the locations around the diffuser. Since the lowest survival rate occurred at DN14-B, it is appropriate to use this as a measure of the greatest change that could occur at the reference locations.

These data show that the effects of bottom water temperatures above 5°C during the period of December 2011 to April 2012 primarily occur during Block 3 embryo development. The greatest impact was noted at TD35-12, located at the offshore end of the diffuser. Summing the effects through all three blocks resulted in a predicted decrease in embryo survival of 10.6% relative to predicted survival at the offshore reference locations. Location DN17-B, an offshore location within the Mixing Zone, resulted in a predicted 8.2% decrease in survival across all three blocks. Reductions in survival of less than 5% occurred at locations within the Mixing Zone (DN18-B, DN10-B) and outside of the Mixing zone offshore of the end of the diffuser (DN08-B, Figure 1-1).
## Table 5.7: Summary of Changes in Survival Due to Exposures Above 5°C

<table>
<thead>
<tr>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival (%)</td>
<td>Change from Base Temp of 3.9°C (%)</td>
<td>Change Relative to Reference (%)</td>
<td>Survival (%)</td>
<td>Change from Base Temp of 3.9°C (%)</td>
<td>Change Relative to Reference (%)</td>
<td>Survival (%)</td>
<td>Change from Base Temp of 3.9°C (%)</td>
</tr>
<tr>
<td>DN14-B</td>
<td>89.1</td>
<td>-1.2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>68.5</td>
<td>-27.2</td>
</tr>
<tr>
<td>DN13-B</td>
<td>89.1</td>
<td>-1.2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>71.5</td>
<td>-24.2</td>
</tr>
<tr>
<td>Offshore Inside Mixing Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD35-12</td>
<td>87.5</td>
<td>-2.8</td>
<td>-0.25</td>
<td>98.15</td>
<td>-25</td>
<td>59.8</td>
<td>-35.9</td>
</tr>
<tr>
<td>DN17-B</td>
<td>87.1</td>
<td>-3.2</td>
<td>-2</td>
<td>-</td>
<td>-</td>
<td>62.3</td>
<td>-33.4</td>
</tr>
<tr>
<td>DN18-B</td>
<td>85.5</td>
<td>-4.8</td>
<td>-3.6</td>
<td>-</td>
<td>-</td>
<td>69</td>
<td>-26.7</td>
</tr>
<tr>
<td>DN10-B</td>
<td>85.8</td>
<td>-4.5</td>
<td>-3.3</td>
<td>-</td>
<td>-</td>
<td>74.3</td>
<td>-21.4</td>
</tr>
<tr>
<td>Offshore At Edge of Mixing Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD55-B</td>
<td>89.5</td>
<td>-0.8</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>77.8</td>
<td>-17.9</td>
</tr>
<tr>
<td>TD45-B</td>
<td>89.7</td>
<td>-0.6</td>
<td>0.6</td>
<td>-</td>
<td>-</td>
<td>67</td>
<td>-28.7</td>
</tr>
<tr>
<td>Offshore Outside Mixing Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN05-B</td>
<td>88.2</td>
<td>-2.1</td>
<td>-0.9</td>
<td>-</td>
<td>-</td>
<td>77.8</td>
<td>-17.9</td>
</tr>
<tr>
<td>DN07-B</td>
<td>88.3</td>
<td>-2</td>
<td>-0.8</td>
<td>-</td>
<td>-</td>
<td>77.3</td>
<td>-18.4</td>
</tr>
<tr>
<td>DN08-B</td>
<td>89.1</td>
<td>-1.2</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>64.3</td>
<td>-31.4</td>
</tr>
<tr>
<td>Nearshore Inside Mixing Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD31-B</td>
<td>89.8</td>
<td>-0.5</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>66</td>
<td>-29.7</td>
</tr>
<tr>
<td>Nearshore Outside Mixing Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN02-B</td>
<td>89.6</td>
<td>-0.7</td>
<td>-0.2</td>
<td>-</td>
<td>-</td>
<td>64</td>
<td>-31.7</td>
</tr>
<tr>
<td>Nearshore Reference Locations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD13-5</td>
<td>89.5</td>
<td>-0.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>64.3</td>
<td>-31.4</td>
</tr>
<tr>
<td>DN15-5</td>
<td>89.5</td>
<td>-0.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>65.5</td>
<td>-30.2</td>
</tr>
</tbody>
</table>
5.4 Summary of Effects on Round Whitefish Embryo Development

Both the 7-day moving average and the hourly average temperature predictions used in this assessment indicate that potential effects on round whitefish embryos are limited to a small area around the offshore (i.e., located in deeper water) end of the diffuser and the area enclosed by the defined Mixing Zone. Figures 5.4-1 and 5.4-2 show the extent of temperature changes within the area around the DNGS diffuser based on the two assessment methods. The assessment also shows that temperature changes resulted in minor reductions in survival and no effects would be expected to occur on the local population. Each method provides an alternative means of considering the potential for effects. Thus, the methods used are complimentary and the results are not additive since they measure the same effects through different assessment methods and use the same chronic exposure data for embryos. However, similar results were obtained with each method and serve to reinforce the prediction that effects would be localized within a small area around the diffuser.

Both assessments show that the greatest changes relative to the reference locations, occurred in the deeper offshore locations close to the diffuser, and were generally confined to depths greater than 10m. Since the preferred spawning depths for round whitefish have been identified as typically ranging between the 5m and 10m depths, the effects of temperature changes due to operation of the diffuser would be expected to have minimal effect on round whitefish embryo development.

The assessment of effects on local populations is based on a screening benchmark of a 10% reduction in survival. Reductions of 20% in survival of individuals has commonly been considered as the level at which changes could occur in local populations. Therefore, a 10% reduction represents a conservative benchmark, below which there is negligible anticipated effect on local populations. A reduction in survival of greater than 10% has potential to result in effects on populations with the risk of effects increasing as the reduction in survival decreases. The actual effect on a population depends both on the amount by which survival is decreased, the areal extent of the effect, and the degree to which the local habitat is used by the local population. The slight exceedances of the 10% benchmark (to a maximum of 12.4% decrease) indicate that effects on embryo development in the area around the diffuser are likely to be negligible.

The maximum area affected (based on the area shown in Figure 5.4-1) by a decrease in survival of 10% or more has been calculated as 1.4 ha. In comparison, the area of Lake Ontario included in the Site Study Area as defined in the DNGS Refurbishment and Continued Operation Project EA has been calculated as 462 ha. Therefore, the area potentially affected represents 0.3% of the Site Study Area.

The assessment also points to the conservative nature of the assessment. The prediction of effects during Block 3 for both reference areas and locations around the diffuser shows that the data developed by Griffiths are highly conservative. The over-prediction of effects during Block 3 development for the reference locations is likely explained by the test procedure, in which temperatures were rapidly elevated during the tests conducted by Griffiths. The tests also did not include a gradual increase in temperatures during Block 3 embryo development. As the measured temperature data show, lake temperatures increase gradually during the Block 3 period and developing embryos would be able to acclimatize to these changes. A more natural temperature change during the laboratory tests would likely have resulted in higher predicted survival at the reference locations.

The lack of full data sets for some locations is not likely to affect the assessment of effects, since data for similar locations is available. While data for TD38-B were not available, this location is outside of the area shown to be influenced by higher bottom temperatures, and therefore, not potentially affected. Similarly, potential changes at locations at the edge of the Mixing Zone (TD52-B and TD34-B) are assessed by nearby locations for which full data were available. Location DN11-B, inside the Mixing Zone, is expected to be affected to a similar degree as
location DN10-B. Since effects did not extend outside of the Mixing Zone, the locations for which data were available would sufficiently address any changes anticipated at these locations. Based on the assessed area influenced by the diffuser, the lack of data for these locations is not likely to affect the outcome of the assessment.

5.5 Conclusions

Temperature effects during the period of December 2011 to April 2012 were assessed with respect to the 3.5°C benchmark for the 7-day rolling average temperatures and against the 5°C benchmark for the hourly average temperatures.

As noted in Section 2.0, air and water temperatures during this period were warmer than average due to an unusually mild winter. While the average monthly air temperatures recorded between December 2011 and February 2012 were not necessarily the warmest on record, the average temperatures for January to February 2012 and December to April 2012 suggest that the winter of 2011-2012 was the warmest on record. The ambient water temperatures were typically above the historical range for the period of December 2011 through April 2012. Based on the data, the ambient water temperatures observed during the winter of 2011-2012 were the warmest recorded in the Darlington Nuclear study area. Nonetheless, the higher temperatures in bottom waters did not result in a significant decrease in embryo survival. The major changes observed were:

- Relative to reference conditions, temperatures decreased more slowly in some locations in December such that Block 1 embryos could have experienced warmer temperatures than normal. The localized areas affected included the end of the diffuser (TD35-12) and deeper, offshore areas within the diffuser Mixing Zone (TD55-B, DN17-B and DN18-B). The slightly warmer temperatures at these locations resulted in no predicted decrease in survival when considering the 7-day rolling average temperatures and up to a 3.6% predicted decrease in survival when considering the hourly average temperatures.

- The 7-day rolling average temperatures increased in late January/early February at some locations to between 3.5°C and 4°C and remained elevated throughout the remainder of the Block 2 embryo development period, which ended in early March 2012. The higher temperatures affected locations at the end of the diffuser (TD35-12) and offshore locations within the Mixing Zone (DN17-B and TD55-B). The slightly warmer temperatures at these locations resulted in a predicted negligible decrease in survival when considering the 7-day rolling average temperatures.

- Both the 7-day rolling average temperatures and the hourly average temperatures resulted in predicted decreases in survival at location TD35-12 situated at the end of the diffuser that ranged between 10% and 12% and at the offshore locations inside the Mixing Zone (DN17-B, DN18-B and DN10-B) that ranged up to 8% but were generally less than 5%.

- The changes affected a very small area around the end of the DNGS diffuser.

Therefore, the effects of temperature increases on the local population, even under unusually warm winter conditions, are expected to be minor and likely limited to small areas around the diffuser. The effects would likely not be measurable on the local populations and further confirms the conclusions of the EIS.
6.0 REFERENCES


FIGURES
TEMPERATURE DATA AVAILABILITY:
DECEMBER 15, 2011 THROUGH APRIL 13, 2012:
PART B
Ambient Water Temperature (°C) - Daily Average

Historical Range (1984-1996)
Historical Average (1984-1996)
Winter 2010/2011
Winter 2011/2012
Measured Temperature at Bottom for Offshore Locations Within Mixing Zone

Temperature Increase over Average at Bottom for Offshore Locations Within Mixing Zone
Measured Temperature at Bottom for Offshore Locations Beyond Mixing Zone

Temperature Increase over Average at Bottom for Offshore Locations Beyond Mixing Zone
Measured Temperature at Bottom for Nearshore Locations Within Mixing Zone

Temperature Increase over Average at Bottom for Nearshore Locations Within Mixing Zone
Measured Temperature at Bottom for Shallow Nearshore Locations

Temperature Increase over Average at Bottom for Shallow Nearshore Locations
**Measured Temperature at Bottom for Reference Locations**

- **TD13-5.5 m**
- **DN12-B (6.0 m)**
- **DN13-B (11.0 m)**
- **DN14-B (12.3 m)**
- **DN15-5 (5.0 m)**

**Average Temperature Criteria**

**Temperature Increase over Average at Bottom for Reference Locations**

- **TD13-5.5 m**
- **DN12-B (6.0 m)**
- **DN13-B (11.0 m)**
- **DN14-B (12.3 m)**
- **DN15-5 (5.0 m)**
The Mixing Zone depicted on this figure represents an area around the diffuser that is used to verify the diffuser design through temperature analysis results that were inconsistent with neighbouring monitoring locations for which these data gaps do not exist. As such, the results were not considered to be sufficiently reliable for estimating the temperature increase contours and were not used for this analysis.

+ Data gaps at these monitoring locations during this period resulted in frequency analysis results that were inconsistent with neighbouring monitoring locations for which these data gaps do not exist. As such, the results were not considered to be sufficiently reliable for estimating the temperature increase contours and were not used for this analysis.

**REFERENCE**

Base Data - MNR NRVIS, obtained 2004, CANMAP v2005.4

Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queen's Printer 2006

Datum: NAD 83 Projection: UTM Zone 17N
Legends:

- Monitoring Locations
- Monitoring Locations not used to Estimate Temperature Increase contours
- 95th Percentile Temperature Increase Contours (°C)
- Estimated 95th Percentile Temperature Increase Contours (°C)
- Channel
- Diffuser
- Bathymetry (m)
- Mixing Zone *

Notes:

* The Mixing Zone depicted on this figure represents an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of the Mixing Zone.

+ Data gaps at these monitoring locations during this period resulted in frequency analysis results that were inconsistent with neighbouring monitoring locations for which these data gaps do not exist. As such, the results were not considered to be sufficiently reliable for estimating the temperature increase contours and were not used for this analysis.
Mean Temperature (°C) vs Time Required (Days)
Time Required (Days)

Mean Temperature (°C)
Mean Temperature (°C)

Time Required (Days)
7 DAY ROLLING AVERAGE TEMPERATURE: TD55-B

PROJECT: DNGS REFURBISHMENT AND CONTINUED OPERATIONS PROJECT
ENVIRONMENTAL ASSESSMENT

FIGURE: 5.2-6
7 DAY ROLLING AVERAGE TEMPERATURE: DN05-B

Temperature (°C)

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-Nov-2011</td>
<td></td>
</tr>
<tr>
<td>16-Nov-2011</td>
<td></td>
</tr>
<tr>
<td>01-Dec-2011</td>
<td></td>
</tr>
<tr>
<td>16-Dec-2011</td>
<td></td>
</tr>
<tr>
<td>31-Dec-2011</td>
<td></td>
</tr>
<tr>
<td>15-Jan-2012</td>
<td></td>
</tr>
<tr>
<td>30-Jan-2012</td>
<td></td>
</tr>
<tr>
<td>15-Feb-2012</td>
<td></td>
</tr>
<tr>
<td>29-Feb-2012</td>
<td></td>
</tr>
<tr>
<td>14-Mar-2012</td>
<td></td>
</tr>
<tr>
<td>29-Mar-2012</td>
<td></td>
</tr>
<tr>
<td>14-Apr-2012</td>
<td></td>
</tr>
<tr>
<td>29-Apr-2012</td>
<td></td>
</tr>
<tr>
<td>14-May-2012</td>
<td></td>
</tr>
<tr>
<td>29-May-2012</td>
<td></td>
</tr>
</tbody>
</table>

PROJECT
DNRS REFURBISHMENT AND CONTINUED OPERATIONS PROJECT
ENVIRONMENTAL ASSESSMENT

FIGURE: 5.2-8
% of time exposed vs % survival for Block 1 survival at different durations of exposure to 7°C.
Potential Changes in Survival of Round Whitefish Embryos Based on 7-Day Rolling Average Temperatures

- Monitoring Locations
- Diffuser
- Bathymetry (m)
- Mixing Zone

NOTE

* The Mixing Zone depicted on this figure represents an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of the Mixing Zone.

REFERENCE

Base Data - MFN NRVIS, obtained 2004, CANMAP v2005.4
Produced by Golden Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queen’s Printer 2006
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DNGS REFURBISHMENT AND CONTINUED OPERATIONS PROJECT
ENVIRONMENTAL ASSESSMENT

ESTIMATED AREAL EXTENT OF POTENTIAL CHANGES IN SURVIVAL OF ROUND WHITEFISH EMBRYOS BASED ON 7-DAY ROLLING AVERAGE TEMPERATURES
DECEMBER 15, 2011 THROUGH APRIL 13, 2012

FIGURE: 5.4-1
NOTE

*The Mixing Zone depicted on this figure represents an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of the Mixing Zone.
ATTACHMENT A

MEASUREMENTED TEMPERATURE DATA TIME SERIES PLOTS: NOVEMBER 1, 2011 THROUGH MAY, 2012
MEASUREMENT TEMPERATURE AT LOCATION: CM01

Temperature (°C)

CM01-15 (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: CM29

Temperature (°C)

CM29-17 (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D1

Temperature (°C)

TD05-1 (15 Minute Data)  TD13-5 (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D3A

Temperature (°C)

DN16-1 (15 Minute Data)  DN16-5 (15 Minute Data)  DN16-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D4

- TD53-1 (15 Minute Data)
- TD54-5 (15 Minute Data)
- TD55-B (15 Minute Data)
- TD55-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D5

- TD32-1 (15 Minute Data)
- TD33-5 (15 Minute Data)
- TD34-B (15 Minute Data)
- TD34-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D7

TD40-1 (15 Minute Data)  TD40-1 QAQC (15 Minute Data)  TD41-5 (15 Minute Data)  TD42-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D8
MEASURED TEMPERATURE AT LOCATION: D10

Temperature (°C)


TD18-1 (15 Minute Data)  DN03-5 (15 Minute Data)  DN03-B (15 Minute Data)  DN03-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D11

- DN01-1 (15 Minute Data)
- DN01-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D12

Temperature (°C)

- DN02-1 (15 Minute Data)
- DN02-B (15 Minute Data)

01-Nov-2011 - 29-May-2012
MEASURED TEMPERATURE AT LOCATION: D14

Temperature (°C)


DN05-1 (15 Minute Data)  DN05-5 (15 Minute Data)  DN05-B (15 Minute Data)  DN05-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D15

Temperature (°C)

- DN06-1 (15 Minute Data)
- DN06-5 (15 Minute Data)
- DN06-B (15 Minute Data)
- DN06-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D16

- DN07-1 (15 Minute Data)
- DN07-5 (15 Minute Data)
- DN07-10 (15 Minute Data)
- DN07-B (15 Minute Data)
- DN07-B QAQC (15 Minute Data)

Temperature (°C)

01-Nov-2011 to 29-May-2012
MEASURED TEMPERATURE AT LOCATION: D17

Temperature (°C)

- DN08-1 (15 Minute Data)
- DN08-5 (15 Minute Data)
- DN08-10 (15 Minute Data)
- DN08-B (15 Minute Data)
- DN08-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D18

- DN09-1 (15 Minute Data)
- DN09-5 (15 Minute Data)
- DN09-10 (15 Minute Data)
- DN09-B (15 Minute Data)
- DN09-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D19

Temperature (°C)

DN10-B (15 Minute Data)  DN10-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D20

![Graph showing temperature data from 01-Nov-2011 to 29-May-2012]

- DN11-B (15 Minute Data)
- DN11-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D21

- DN12-1 (15 Minute Data)
- DN12-B (15 Minute Data)
- DN12-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D22

Temperature (°C)

- DN13-1 (15 Minute Data)
- DN13-5 (15 Minute Data)
- DN13-B (15 Minute Data)
- DN13-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D23

Temperature (°C)


DN14-1 (15 Minute Data) DN14-1 QAQC (15 Minute Data) DN14-5 (15 Minute Data) DN14-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D24

Temperature (°C)


DN15-1 (15 Minute Data) DN15-5 (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D25

Temperature (°C)

DN17-1 (15 Minute Data)
DN17-5 (15 Minute Data)
DN17-10 (15 Minute Data)
DN17-B (15 Minute Data)
DN17-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D26

Temperature (°C)

MEASUREMENT TEMPERATURE AT LOCATION: PG1

---

PG1-1 (15 Minute Data)  PG1-5 (15 Minute Data)  PG1-B (15 Minute Data)
ATTACHMENT B

7-DAY ROLLING AVERAGE TEMPERATURE PLOTS:
NOVEMBER 1, 2011 THROUGH MAY, 2012
7 DAY ROLLING AVERAGE TEMPERATURE: ADCP

Temperature (°C)


ADCP
7 DAY ROLLING AVERAGE TEMPERATURE: CM01

Temperature (°C)

CM01-15


0 5 10 15 20 25

Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 1
7 DAY ROLLING AVERAGE TEMPERATURE: CM29

Temperature (°C)


CM29-17

Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 1
7 DAY ROLLING AVERAGE TEMPERATURE: D1

Temperature (°C)

TD05-1
TD13-5

01-Nov-2011
16-Nov-2011
01-Dec-2011
16-Dec-2011
31-Dec-2011
15-Jan-2012
30-Jan-2012
14-Feb-2012
29-Feb-2012
15-Mar-2012
30-Mar-2012
14-Apr-2012
29-Apr-2012
14-May-2012
29-May-2012
7 DAY ROLLING AVERAGE TEMPERATURE: D2

Temperature (°C)

TD30-1  TD31-B


Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 1
7 DAY ROLLING AVERAGE TEMPERATURE: D3A

Temperature (°C)
7 DAY ROLLING AVERAGE TEMPERATURE: D6

Temperature (°C)

7 DAY ROLLING AVERAGE TEMPERATURE: D7

Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 1
7 DAY ROLLING AVERAGE TEMPERATURE: D15

Temperature (°C)

DN06-1  DN06-5  DN06-B  DN06-B QAQC


Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 1
7 DAY ROLLING AVERAGE TEMPERATURE: D17

- DN08-1
- DN08-5
- DN08-10
- DN08-B
- DN08-B QAQC

Temperature (°C)

- 01-Nov-2011
- 16-Nov-2011
- 01-Dec-2011
- 16-Dec-2011
- 31-Dec-2011
- 15-Jan-2012
- 30-Jan-2012
- 14-Feb-2012
- 29-Feb-2012
- 15-Mar-2012
- 30-Mar-2012
- 14-Apr-2012
- 29-Apr-2012
- 14-May-2012
- 29-May-2012
7 DAY ROLLING AVERAGE TEMPERATURE: D18

Temperature (°C)

RN09-1 | DN09-5 | DN09-10 | DN09-B | DN09-B QAQC

7 DAY ROLLING AVERAGE TEMPERATURE: D21

Temperature (°C)


0 5 10 15 20 25
7 DAY ROLLING AVERAGE TEMPERATURE: D24

Temperature (°C)

DN15-1  DN15-5

7 DAY ROLLING AVERAGE TEMPERATURE: D25

Temperature (°C)

0  5  10  15  20  25


Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 1
7 DAY ROLLING AVERAGE TEMPERATURES: TD31-B
7 DAY ROLLING AVERAGE TEMPERATURES: TD42-B

1990
1991
1992
1993
1994
1995
1996
2011
2012

Average
Maximum

Temperature (°C)

Day of Year

Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 1
7 DAY ROLLING AVERAGE TEMPERATURES: TD52-B

Day of Year

Temperature (°C)


Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 1
ATTACHMENT C

TABLE C-1: BOTTOM WATER TEMPERATURES: DURATION AND PEAK TEMPERATURES FOR PERIODS EXCEEDING 5°C
July 2012

Filed: 2014-03-19
10-1151-0202
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 1

Table C-1: Bottom Water Temperatures: Durations and Peak Temperatures for Periods Exceeding 5°C

Start Date/Time

ADCP
Maximum
Temperature
(°C)

Duration
(hrs)

TD35-12 (12.0 m)
Maximum
Temperature
(°C)
Start Date/Time

Duration
(hrs)

TD34-B (14.5 m)
Maximum
Temperature
(°C)
Start Date/Time

Duration
(hrs)

TD55-B (14.8 m)
Maximum
Temperature
(°C)
Start Date/Time

Duration
(hrs)

December-2011

TD45-B (10.0 m)
Maximum
Temperature
(°C)
Start Date/Time

Duration
(hrs)

DN17-B (12.5 m)
Maximum
Temperature
(°C)
Start Date/Time

Duration
(hrs)

DN18-B (12.5 m)
Maximum
Temperature
(°C)
Start Date/Time

Duration
(hrs)

December-2011

2011-Dec-16 08:00

5.84

13.0

2011-Dec-15 03:00

5.02

1.0

2011-Dec-15 20:00

6.49

34.0

2011-Dec-15 12:00

5.47

32.0

2011-Dec-15 13:00

5.43

20.0

2011-Dec-15 12:00

6.76

25.0

2011-Dec-26 00:00

5.06

1.0

2011-Dec-15 07:00

5.34

4.0

2011-Dec-19 04:00

5.02

1.0

2011-Dec-25 11:00

5.33

4.0

2011-Dec-16 10:00

5.05

2.0

2011-Dec-17 02:00

6.47

27.0

2011-Dec-26 03:00

5.01

1.0

2011-Dec-15 14:00

5.45

32.0

2011-Dec-19 06:00

5.29

6.0

2011-Dec-18 05:00

5.26

1.0

2011-Dec-18 20:00

5.75

6.0

2011-Dec-17 22:00
2011-Dec-18 00:00
2011-Dec-18 12:00
2011-Dec-20 04:00
2011-Dec-21 22:00
2011-Dec-22 08:00
2011-Dec-23 19:00
2011-Dec-24 00:00
2011-Dec-24 17:00
2011-Dec-25 11:00
2011-Dec-27 18:00

5.17
5.25
5.23
5.43
5.07
5.80
5.01
5.79
5.20
5.30
5.31

1.0
11.0
9.0
6.0
2.0
25.0
1.0
16.0
1.0
3.0
6.0

2011-Dec-19 14:00
2011-Dec-20 01:00
2011-Dec-22 11:00
2011-Dec-22 13:00
2011-Dec-22 23:00
2011-Dec-23 08:00
2011-Dec-23 11:00
2011-Dec-23 23:00
2011-Dec-25 08:00
2011-Dec-25 11:00
2011-Dec-26 10:00
2011-Dec-28 13:00

5.63
5.09
5.01
5.02
5.06
5.04
5.35
5.23
5.11
6.22
5.19
5.13

5.0
1.0
1.0
2.0
2.0
1.0
7.0
5.0
1.0
6.0
5.0
3.0

2011-Dec-18 07:00
2011-Dec-18 10:00
2011-Dec-18 16:00
2011-Dec-20 03:00
2011-Dec-20 06:00
2011-Dec-22 08:00
2011-Dec-22 16:00
2011-Dec-23 09:00
2011-Dec-24 05:00
2011-Dec-25 05:00
2011-Dec-27 17:00
2011-Dec-27 19:00
2011-Dec-29 14:00

5.06
5.06
5.16
5.33
6.15
5.04
5.58
5.28
6.22
5.52
5.03
5.18
5.45

2.0
3.0
2.0
2.0
39.0
1.0
16.0
1.0
22.0
12.0
1.0
5.0
2.0

2011-Dec-19 18:00
2011-Dec-21 23:00
2011-Dec-25 02:00
2011-Dec-26 07:00
2011-Dec-27 00:00
2011-Dec-27 06:00
2011-Dec-27 16:00
2011-Dec-28 00:00
2011-Dec-28 21:00

5.98
6.22
6.88
5.48
5.82
5.56
5.06
5.63
5.52

9.0
54.0
28.0
11.0
2.0
9.0
2.0
7.0
8.0

Total Duration

118.0

Total Duration

80.0

Total Duration

131.0

Total Duration

188.0

5.24

5.0

5.24
5.13
5.00
5.10
5.04
5.24

1.0
1.0
1.0
2.0
1.0
1.0

Total Duration

5.0

Total Duration

7.0

5.16
5.17
5.07
5.02
5.21

4.0
4.0
1.0
1.0
3.0

5.53
5.02
5.07
5.29
5.21
5.06
5.06
5.69
5.40
5.07
5.11
5.09
5.49
5.03
5.09
5.23
5.04

4.0
1.0
1.0
2.0
1.0
1.0
1.0
3.0
2.0
1.0
1.0
1.0
6.0
1.0
1.0
2.0
1.0

Total Duration

13.0

Total Duration

30.0

Total Duration

15.0

Total Duration

0.0

January-2012
2012-Jan-13 07:00

Total Duration

0.0

Total Duration

0.0

Total Duration

0.0

5.06

1.0

Total Duration

1.0

February-2012
2012-Feb-02 10:00
2012-Feb-02 16:00
2012-Feb-03 05:00
2012-Feb-04 18:00
2012-Feb-05 14:00
2012-Feb-06 04:00
2012-Feb-06 07:00
2012-Feb-06 11:00
2012-Feb-06 18:00
2012-Feb-08 00:00
2012-Feb-09 09:00
2012-Feb-09 14:00
2012-Feb-09 16:00
2012-Feb-10 21:00
2012-Feb-11 07:00
2012-Feb-11 10:00
2012-Feb-14 08:00
2012-Feb-15 13:00
2012-Feb-16 08:00
2012-Feb-16 23:00
2012-Feb-18 10:00
2012-Feb-18 16:00
2012-Feb-20 04:00
2012-Feb-20 07:00
2012-Feb-20 23:00
2012-Feb-21 02:00
2012-Feb-21 09:00
2012-Feb-21 17:00
2012-Feb-21 19:00
2012-Feb-22 08:00
2012-Feb-22 15:00
2012-Feb-24 05:00
2012-Feb-24 16:00
2012-Feb-25 06:00
2012-Feb-26 00:00
2012-Feb-27 00:00
2012-Feb-28 05:00
2012-Feb-28 20:00
Total Duration

0.0

Total Duration

36.0

January-2012
2012-Jan-12 20:00

Total Duration

0.0

2012-Jan-07 14:00
2012-Jan-07 18:00
2012-Jan-08 03:00
2012-Jan-08 09:00
2012-Jan-10 23:00
2012-Jan-30 20:00

February-2012

5.38
5.17
5.11
5.78
5.53
5.31
5.29
6.01
7.19
5.23
5.61
5.55
5.38
6.29
5.00
5.64
6.91
6.18
5.58
5.19
5.64
5.39
5.04
5.47
5.35
5.22
5.01
5.03
5.11
7.07
7.29
5.40
5.33
5.31
6.73
5.63
5.97
5.78

4.0
2.0
1.0
13.0
6.0
2.0
2.0
1.0
13.0
1.0
3.0
1.0
1.0
4.0
1.0
7.0
7.0
4.0
2.0
2.0
3.0
5.0
1.0
8.0
2.0
2.0
1.0
1.0
1.0
5.0
15.0
2.0
2.0
1.0
6.0
12.0
2.0
7.0

Total Duration

153.0

2012-Feb-02 09:00

5.08

1.0

Total Duration

1.0

2012-Feb-06 04:00
2012-Feb-22 10:00
2012-Feb-24 20:00
2012-Feb-24 23:00

5.44
5.31
5.25
5.05

6.0
3.0
1.0
2.0

Total Duration

12.0

Golder Associates Ltd.

2012-Feb-04 22:00
2012-Feb-05 14:00
2012-Feb-24 17:00
2012-Feb-27 03:00
2012-Feb-29 01:00

Total Duration

0.0

2012-Feb-01 19:00
2012-Feb-03 15:00
2012-Feb-05 23:00
2012-Feb-06 01:00
2012-Feb-08 20:00
2012-Feb-08 23:00
2012-Feb-09 08:00
2012-Feb-09 11:00
2012-Feb-14 14:00
2012-Feb-15 17:00
2012-Feb-17 06:00
2012-Feb-17 11:00
2012-Feb-22 02:00
2012-Feb-22 14:00
2012-Feb-23 06:00
2012-Feb-24 19:00
2012-Feb-26 03:00


<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-Mar-21 12:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-04 08:00</td>
<td>5.16</td>
<td>1.0</td>
<td>2012-Mar-14 11:00</td>
<td>6.06</td>
<td>20.0</td>
<td>2012-Mar-24 04:00</td>
<td>7.08</td>
<td>477.0</td>
</tr>
<tr>
<td>2012-Mar-22 02:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-04 12:00</td>
<td>5.26</td>
<td>0.0</td>
<td>2012-Mar-14 13:00</td>
<td>5.64</td>
<td>1.0</td>
<td>2012-Mar-25 10:00</td>
<td>7.04</td>
<td>480.0</td>
</tr>
<tr>
<td>2012-Mar-23 21:00</td>
<td>5.26</td>
<td>26.0</td>
<td>2012-Mar-04 16:00</td>
<td>5.13</td>
<td>1.0</td>
<td>2012-Mar-15 01:00</td>
<td>5.73</td>
<td>1.0</td>
<td>2012-Mar-25 10:00</td>
<td>5.00</td>
<td>5.0</td>
</tr>
<tr>
<td>2012-Mar-24 04:00</td>
<td>5.06</td>
<td>477.0</td>
<td>2012-Mar-14 01:00</td>
<td>5.08</td>
<td>5.0</td>
<td>2012-Mar-15 11:00</td>
<td>6.06</td>
<td>1.0</td>
<td>2012-Mar-26 00:00</td>
<td>5.19</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Mar-25 02:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 00:00</td>
<td>5.37</td>
<td>1.0</td>
<td>2012-Mar-15 11:00</td>
<td>7.04</td>
<td>1.0</td>
<td>2012-Mar-26 00:00</td>
<td>5.13</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Mar-25 10:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>5.03</td>
<td>1.0</td>
<td>2012-Mar-15 11:00</td>
<td>7.03</td>
<td>1.0</td>
<td>2012-Mar-26 00:00</td>
<td>5.13</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Mar-26 04:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>5.27</td>
<td>1.0</td>
<td>2012-Mar-15 11:00</td>
<td>5.03</td>
<td>1.0</td>
<td>2012-Mar-26 00:00</td>
<td>5.08</td>
<td>2.0</td>
</tr>
<tr>
<td>2012-Mar-28 00:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>5.27</td>
<td>1.0</td>
<td>2012-Mar-15 11:00</td>
<td>7.03</td>
<td>1.0</td>
<td>2012-Mar-26 00:00</td>
<td>5.07</td>
<td>2.0</td>
</tr>
<tr>
<td>2012-Mar-28 10:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>7.03</td>
<td>1.0</td>
<td>2012-Mar-26 00:00</td>
<td>5.07</td>
<td>2.0</td>
</tr>
<tr>
<td>2012-Mar-28 15:00</td>
<td>5.04</td>
<td>1.0</td>
<td>2012-Mar-15 11:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>7.03</td>
<td>1.0</td>
<td>2012-Mar-26 00:00</td>
<td>5.07</td>
<td>2.0</td>
</tr>
<tr>
<td>2012-Mar-28 17:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>7.03</td>
<td>1.0</td>
<td>2012-Mar-26 00:00</td>
<td>5.07</td>
<td>2.0</td>
</tr>
<tr>
<td>2012-Mar-29 00:00</td>
<td>5.04</td>
<td>176.0</td>
<td>2012-Mar-15 11:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>7.03</td>
<td>1.0</td>
<td>2012-Mar-26 00:00</td>
<td>5.07</td>
<td>2.0</td>
</tr>
<tr>
<td>2012-Mar-30 00:00</td>
<td>5.04</td>
<td>3120.0</td>
<td>2012-Mar-15 11:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>7.03</td>
<td>1.0</td>
<td>2012-Mar-26 00:00</td>
<td>5.07</td>
<td>2.0</td>
</tr>
<tr>
<td>2012-Apr-01 00:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>7.03</td>
<td>1.0</td>
<td>2012-Mar-26 00:00</td>
<td>5.07</td>
<td>2.0</td>
</tr>
<tr>
<td>2012-Apr-01 06:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Mar-15 11:00</td>
<td>7.03</td>
<td>1.0</td>
<td>2012-Mar-26 00:00</td>
<td>5.07</td>
<td>2.0</td>
</tr>
<tr>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>---------------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>---------------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>---------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>2011-Dec-15 18:00</td>
<td>5.40</td>
<td>30.0</td>
<td>2011-Dec-15 22:00</td>
<td>6.37</td>
<td>32.0</td>
<td>2011-Dec-15 11:00</td>
<td>5.43</td>
<td>34.0</td>
<td>2011-Dec-15 14:00</td>
<td>6.39</td>
<td>32.0</td>
</tr>
<tr>
<td>2011-Dec-17 07:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2011-Dec-25 10:00</td>
<td>5.32</td>
<td>3.0</td>
<td>2011-Dec-16 02:00</td>
<td>5.19</td>
<td>3.0</td>
<td>2011-Dec-16 07:00</td>
<td>5.05</td>
<td>1.0</td>
</tr>
<tr>
<td>2011-Dec-17 12:00</td>
<td>5.28</td>
<td>12.0</td>
<td>2011-Dec-17 03:00</td>
<td>5.91</td>
<td>15.0</td>
<td>2011-Dec-20 09:00</td>
<td>5.68</td>
<td>16.0</td>
<td>2011-Dec-18 22:00</td>
<td>5.38</td>
<td>1.0</td>
</tr>
<tr>
<td>2011-Dec-19 14:00</td>
<td>5.61</td>
<td>5.0</td>
<td>2011-Dec-19 19:00</td>
<td>5.39</td>
<td>3.0</td>
<td>2011-Dec-24 12:00</td>
<td>5.94</td>
<td>27.0</td>
<td>2011-Dec-18 22:00</td>
<td>5.38</td>
<td>1.0</td>
</tr>
<tr>
<td>2011-Dec-19 22:00</td>
<td>5.18</td>
<td>2.0</td>
<td>2011-Dec-22 10:00</td>
<td>5.06</td>
<td>3.0</td>
<td>2011-Dec-29 15:00</td>
<td>5.31</td>
<td>1.0</td>
<td>2011-Dec-20 00:00</td>
<td>5.26</td>
<td>4.0</td>
</tr>
<tr>
<td>2011-Dec-22 11:00</td>
<td>5.01</td>
<td>1.0</td>
<td>2011-Dec-22 22:00</td>
<td>5.09</td>
<td>3.0</td>
<td>2011-Dec-21 22:00</td>
<td>5.26</td>
<td>4.0</td>
<td>2011-Dec-22 11:00</td>
<td>5.39</td>
<td>10.0</td>
</tr>
<tr>
<td>2011-Dec-23 12:00</td>
<td>5.07</td>
<td>2.0</td>
<td>2011-Dec-23 23:00</td>
<td>5.13</td>
<td>8.0</td>
<td>2011-Dec-23 17:00</td>
<td>5.54</td>
<td>1.0</td>
<td>2011-Dec-23 08:00</td>
<td>6.20</td>
<td>15.0</td>
</tr>
<tr>
<td>2011-Dec-25 07:00</td>
<td>5.02</td>
<td>1.0</td>
<td>2011-Dec-26 13:00</td>
<td>5.25</td>
<td>4.0</td>
<td>2011-Dec-25 04:00</td>
<td>5.36</td>
<td>1.0</td>
<td>2011-Dec-25 05:00</td>
<td>5.44</td>
<td>4.0</td>
</tr>
<tr>
<td>2011-Dec-25 11:00</td>
<td>6.22</td>
<td>6.0</td>
<td>2011-Dec-28 05:00</td>
<td>5.21</td>
<td>2.0</td>
<td>2011-Dec-25 06:00</td>
<td>5.30</td>
<td>1.0</td>
<td>2011-Dec-25 10:00</td>
<td>6.27</td>
<td>17.0</td>
</tr>
<tr>
<td>2011-Dec-25 20:00</td>
<td>5.13</td>
<td>2.0</td>
<td>2011-Dec-28 23:00</td>
<td>5.04</td>
<td>1.0</td>
<td>2011-Dec-26 07:00</td>
<td>5.17</td>
<td>3.0</td>
<td>2011-Dec-26 12:00</td>
<td>5.52</td>
<td>6.0</td>
</tr>
<tr>
<td>2011-Dec-26 02:00</td>
<td>5.31</td>
<td>8.0</td>
<td>2011-Dec-26 11:00</td>
<td>5.19</td>
<td>1.0</td>
<td>2011-Dec-27 12:00</td>
<td>5.13</td>
<td>2.0</td>
<td>2011-Dec-26 18:00</td>
<td>5.15</td>
<td>2.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-Jan-07 18:00</td>
<td>5.20</td>
<td>1.0</td>
<td>2012-Jan-07 20:00</td>
<td>5.00</td>
<td>1.0</td>
<td>2012-Jan-10 23:00</td>
<td>5.00</td>
<td>1.0</td>
<td>2012-Jan-13 07:00</td>
<td>5.00</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Jan-13 09:00</td>
<td>5.05</td>
<td>1.0</td>
<td>2012-Feb-01 15:00</td>
<td>5.10</td>
<td>3.0</td>
<td>2012-Feb-01 18:00</td>
<td>5.11</td>
<td>2.0</td>
<td>2012-Feb-22 11:00</td>
<td>5.15</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Feb-06 02:00</td>
<td>5.22</td>
<td>1.0</td>
<td>2012-Feb-06 04:00</td>
<td>5.61</td>
<td>8.0</td>
<td>2012-Feb-08 22:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2012-Feb-17 08:00</td>
<td>5.17</td>
<td>2.0</td>
</tr>
<tr>
<td>2012-Feb-22 05:00</td>
<td>5.60</td>
<td>5.0</td>
<td>2012-Feb-22 12:00</td>
<td>5.20</td>
<td>3.0</td>
<td>2012-Feb-24 21:00</td>
<td>5.40</td>
<td>3.0</td>
<td>2012-Feb-27 17:00</td>
<td>5.09</td>
<td>1.0</td>
</tr>
<tr>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>--------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>2012-Mar-13 22:00</td>
<td>5.10</td>
<td>3.0</td>
<td>2012-Mar-20 02:00</td>
<td>5.10</td>
<td>3.0</td>
<td>2012-Mar-27 05:00</td>
<td>5.10</td>
<td>3.0</td>
<td>2012-Mar-04 22:00</td>
<td>5.10</td>
<td>3.0</td>
</tr>
<tr>
<td>2012-Mar-14 09:00</td>
<td>5.34</td>
<td>6.0</td>
<td>2012-Mar-17 01:00</td>
<td>5.20</td>
<td>12.0</td>
<td>2012-Mar-20 11:00</td>
<td>5.20</td>
<td>12.0</td>
<td>2012-Mar-11 22:00</td>
<td>5.20</td>
<td>12.0</td>
</tr>
<tr>
<td>2012-Mar-15 03:00</td>
<td>5.08</td>
<td>1.0</td>
<td>2012-Mar-17 18:00</td>
<td>5.00</td>
<td>3.0</td>
<td>2012-Mar-20 21:00</td>
<td>5.00</td>
<td>3.0</td>
<td>2012-Mar-12 05:00</td>
<td>5.00</td>
<td>3.0</td>
</tr>
<tr>
<td>2012-Mar-16 03:00</td>
<td>8.68</td>
<td>742.0</td>
<td>2012-Mar-17 18:00</td>
<td>8.20</td>
<td>703.0</td>
<td>2012-Mar-19 16:00</td>
<td>5.21</td>
<td>6.0</td>
<td>2012-Mar-15 21:00</td>
<td>5.43</td>
<td>9.0</td>
</tr>
<tr>
<td>2012-Mar-16 11:00</td>
<td>5.17</td>
<td>1.0</td>
<td>2012-Mar-18 21:00</td>
<td>5.62</td>
<td>1.0</td>
<td>2012-Mar-19 00:00</td>
<td>5.79</td>
<td>1.0</td>
<td>2012-Mar-16 21:00</td>
<td>5.15</td>
<td>10.0</td>
</tr>
<tr>
<td>2012-Mar-16 16:00</td>
<td>5.14</td>
<td>1.0</td>
<td>2012-Mar-19 02:00</td>
<td>5.28</td>
<td>1.0</td>
<td>2012-Mar-20 05:00</td>
<td>5.89</td>
<td>3.0</td>
<td>2012-Mar-17 22:00</td>
<td>5.89</td>
<td>3.0</td>
</tr>
<tr>
<td>2012-Mar-16 20:00</td>
<td>5.47</td>
<td>4.0</td>
<td>2012-Mar-20 08:00</td>
<td>5.28</td>
<td>1.0</td>
<td>2012-Mar-21 05:00</td>
<td>5.65</td>
<td>7.0</td>
<td>2012-Mar-22 23:00</td>
<td>5.89</td>
<td>3.0</td>
</tr>
<tr>
<td>2012-Mar-17 01:00</td>
<td>5.57</td>
<td>12.0</td>
<td>2012-Mar-21 08:00</td>
<td>5.44</td>
<td>2.0</td>
<td>2012-Mar-22 14:00</td>
<td>5.44</td>
<td>2.0</td>
<td>2012-Mar-23 05:00</td>
<td>5.89</td>
<td>3.0</td>
</tr>
<tr>
<td>2012-Mar-17 14:00</td>
<td>7.44</td>
<td>707.0</td>
<td>2012-Mar-22 17:00</td>
<td>6.48</td>
<td>4.0</td>
<td>2012-Mar-23 23:00</td>
<td>5.44</td>
<td>2.0</td>
<td>2012-Mar-24 05:00</td>
<td>5.89</td>
<td>3.0</td>
</tr>
<tr>
<td>2012-Mar-17 20:00</td>
<td>5.22</td>
<td>1.0</td>
<td>2012-Mar-23 05:00</td>
<td>5.09</td>
<td>1.0</td>
<td>2012-Mar-24 15:00</td>
<td>5.31</td>
<td>14.0</td>
<td>2012-Apr-09 09:00</td>
<td>7.12</td>
<td>96.0</td>
</tr>
<tr>
<td>2012-Mar-18 02:00</td>
<td>5.46</td>
<td>487.0</td>
<td>2012-Mar-24 15:00</td>
<td>5.44</td>
<td>3.0</td>
<td>2012-Mar-24 21:00</td>
<td>5.44</td>
<td>4.0</td>
<td>2012-Apr-14 20:00</td>
<td>6.93</td>
<td>263.0</td>
</tr>
<tr>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td>-----------------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td>-----------------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-15 13:00</td>
<td>5.48</td>
<td>30.0</td>
<td>2011-Dec-15 19:00</td>
<td>5.38</td>
<td>46.0</td>
<td>2011-Dec-15 12:00</td>
<td>5.98</td>
<td>46.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-20 07:00</td>
<td>5.74</td>
<td>36.0</td>
<td>2011-Dec-23 03:00</td>
<td>5.07</td>
<td>12.0</td>
<td>2011-Dec-24 03:00</td>
<td>5.08</td>
<td>11.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-23 00:00</td>
<td>5.01</td>
<td>1.0</td>
<td>2011-Dec-24 05:00</td>
<td>6.05</td>
<td>21.0</td>
<td>2011-Dec-25 11:00</td>
<td>5.39</td>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-29 14:00</td>
<td>5.21</td>
<td>4.0</td>
<td>2011-Dec-25 11:00</td>
<td>5.39</td>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Durations

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Total Duration</th>
<th>Temperature</th>
<th>Total Duration</th>
<th>Temperature</th>
<th>Total Duration</th>
<th>Temperature</th>
<th>Total Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>December 2011</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-15 13:00</td>
<td>30.0</td>
<td>2011-Dec-15 19:00</td>
<td>46.0</td>
<td>2011-Dec-15 12:00</td>
<td>46.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-20 07:00</td>
<td>36.0</td>
<td>2011-Dec-23 03:00</td>
<td>12.0</td>
<td>2011-Dec-24 03:00</td>
<td>11.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-23 00:00</td>
<td>1.0</td>
<td>2011-Dec-24 05:00</td>
<td>21.0</td>
<td>2011-Dec-25 11:00</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-29 14:00</td>
<td>4.0</td>
<td>2011-Dec-25 11:00</td>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Durations

<table>
<thead>
<tr>
<th>Total Duration</th>
<th>Total Duration</th>
<th>Total Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>February 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>March 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>October 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>November 2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>December 2012</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Golder Associates Ltd.
## Table C-1: Bottom Water Temperatures: Durations and Peak Temperatures for Periods Exceeding 5°C

<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-Mar-12 13:00</td>
<td>5.36</td>
<td>14.0</td>
<td>2012-Mar-12 20:00</td>
<td>5.07</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Mar-12 15:00</td>
<td>5.21</td>
<td>13.0</td>
<td>2012-Mar-16 10:00</td>
<td>5.09</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Mar-13 15:00</td>
<td>5.21</td>
<td>13.0</td>
<td>2012-Mar-17 14:00</td>
<td>8.28</td>
<td>46.0</td>
</tr>
<tr>
<td>2012-Mar-14 13:00</td>
<td>5.03</td>
<td>12.0</td>
<td>2012-Mar-15 21:00</td>
<td>8.12</td>
<td>748.0</td>
</tr>
<tr>
<td>2012-Mar-15 00:00</td>
<td>5.74</td>
<td>5.0</td>
<td>2012-Mar-15 22:00</td>
<td>5.23</td>
<td>5.0</td>
</tr>
<tr>
<td>2012-Mar-19 15:00</td>
<td>8.75</td>
<td>658.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-15 03:00</td>
<td>5.09</td>
<td>3.0</td>
<td>2012-Mar-17 14:00</td>
<td>8.28</td>
<td>6.0</td>
</tr>
<tr>
<td>2012-Mar-19 15:00</td>
<td>9.12</td>
<td>672.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-16 12:00</td>
<td>6.13</td>
<td>72.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-16 15:00</td>
<td>7.80</td>
<td>734.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Total Durations

<table>
<thead>
<tr>
<th>Total Duration</th>
<th>Total Duration</th>
<th>Total Duration</th>
<th>Total Duration</th>
<th>Total Duration</th>
<th>Total Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>753.0</td>
<td>748.0</td>
<td>758.0</td>
<td>747.0</td>
<td>753.0</td>
<td>765.0</td>
</tr>
<tr>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>2011-Dec-15 09:00</td>
<td>5.48</td>
<td>40.0</td>
<td>2011-Dec-17 14:00</td>
<td>5.11</td>
<td>18.0</td>
</tr>
<tr>
<td>2011-Dec-21 06:00</td>
<td>5.20</td>
<td>29.0</td>
<td>2011-Dec-17 04:00</td>
<td>5.30</td>
<td>12.0</td>
</tr>
<tr>
<td>2011-Dec-25 18:00</td>
<td>5.82</td>
<td>15.0</td>
<td>2011-Dec-19 14:00</td>
<td>5.16</td>
<td>8.0</td>
</tr>
</tbody>
</table>

**December-2011**

**TD13-5 (5.0 m)**

<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>December-2011</td>
<td></td>
<td></td>
<td>January-2012</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Durations**

- December-2011: 60.0
- January-2012: 60.0
- February-2012: 30.0

Golder Associates Ltd.
<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-Mar-17 08:00</td>
<td>5.19</td>
<td>2.0</td>
<td>2012-Mar-13 15:00</td>
<td>5.57</td>
<td>38.0</td>
<td>2012-Mar-16 13:00</td>
<td>5.27</td>
<td>7.0</td>
<td>2012-Mar-16 15:00</td>
<td>5.70</td>
<td>14.0</td>
</tr>
<tr>
<td>2012-Mar-17 17:00</td>
<td>5.16</td>
<td>3.0</td>
<td>2012-Mar-15 07:00</td>
<td>5.74</td>
<td>8.0</td>
<td>2012-Mar-16 19:00</td>
<td>5.96</td>
<td>60.0</td>
<td>2012-Mar-16 13:00</td>
<td>5.32</td>
<td>14.0</td>
</tr>
<tr>
<td>2012-Mar-21 09:00</td>
<td>5.32</td>
<td>11.0</td>
<td>2012-Mar-16 11:00</td>
<td>8.84</td>
<td>736.0</td>
<td>2012-Mar-20 10:00</td>
<td>7.96</td>
<td>83.3</td>
<td>2012-Mar-19 19:00</td>
<td>5.06</td>
<td>11.0</td>
</tr>
<tr>
<td>2012-Mar-23 19:00</td>
<td>7.47</td>
<td>512.0</td>
<td>2012-Mar-20 09:00</td>
<td>5.69</td>
<td>61.0</td>
<td>2012-Mar-20 16:00</td>
<td>7.92</td>
<td>714.0</td>
<td>2012-Mar-21 02:00</td>
<td>6.75</td>
<td>47.0</td>
</tr>
<tr>
<td>2012-Apr-14 11:00</td>
<td>6.05</td>
<td>38.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.55</td>
<td>67.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
</tr>
<tr>
<td>2012-Apr-14 11:00</td>
<td>6.55</td>
<td>67.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
</tr>
<tr>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
</tr>
<tr>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
</tr>
<tr>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
<td>2012-Apr-14 11:00</td>
<td>6.87</td>
<td>505.0</td>
</tr>
</tbody>
</table>

Total Duration: 588.0 hours
Total Duration: 588.0 hours
Total Duration: 588.0 hours
Total Duration: 588.0 hours
Total Duration: 686.0 hours
Total Duration: 756.0 hours

Total Duration: 588.0 hours
Total Duration: 588.0 hours
Total Duration: 588.0 hours
Total Duration: 588.0 hours
Total Duration: 686.0 hours
Total Duration: 756.0 hours
TRANSMITTAL LETTER

Darlington Nuclear Generating Station Refurbishment and Continued Operation Project Environmental Assessment

Section 1

To: SENES Consultants Limited
121 Granton Drive, Unit 12
Richmond Hill, Ontario L4B 3N4

Attention: Andrea Halbert, Single Point of Contact

Sent by

[ ] Mail [ ] Enclosed
[ ] Courier [ ] E-mail
[ ] Hand Carried [ ] Picked-Up

Document Title:

File #: 350200

Version: Final

Deliverable #: N/A

Work Package #: WP4

Date: 11 May 2012

Data Gap Description of Gap Date Revised WP Will Be Available

Certification by WP Team Leader:

The above referenced document has been reviewed and is acceptable for submission to OPG for review and comment.

WP Team Leader: John Sinnige
Company Name: Golder Associates Limited
Address: 2390 Argentia Road, Mississauga, Ontario, Canada L5N 5Z7
Phone: 905 567-4444
Fax: 905 567-6561
E-Mail: John_Sinnige@golder.com

WP Team Leader Signature

Page | 1
Section 2

To: Ontario Power Generation
    Environmental Assessment Department
    1315 Pickering Parkway
    Pickering, Ontario L1V 7G5

Attention: OPG Single Point of Contact

Editorial Review by SENES EA Consulting Team:

The above referenced document has been reviewed per requirements in the Document Review Plan and is acceptable for submission to OPG for review and comment.

WP Reviewer: Linda Boeheim
EA Consulting Team: lboeheim@senes.ca
Project Manager: Dr. Don Gorber
EA Consulting Team: dgorber@senes.ca
Company Name: SENES Consultants Limited
Address: 121 Granton Drive, Unit 12, Richmond Hill, ON, L4B 3N4
Phone: 905 764-9380
Fax: 905 764-9386

WP Reviewer Signature
EA Consulting Team

Project Manager Signature
EA Consulting Team
1.0 INTRODUCTION

As part of the Darlington Nuclear Generating Station (DNGS) Refurbishment and Continued Operation Project (the Project) Environmental Assessment (EA), the potential effects of the Project on the Surface Water and Aquatic Environments (SWE and AE, respectively) were evaluated and documented in the “Surface Water Environment Technical Support Document: Darlington Nuclear Generating Station Refurbishment and Continued Operation Project Environmental Assessment” (SWE TSD) and the “Aquatic Environment Technical Support Document: Darlington Nuclear Generating Station Refurbishment and Continued Operation Project Environmental Assessment” (AE TSD).

On January 13, 2012, the 2011 Thermal and Current Monitoring Program Report (Golder 2012a) was submitted to the Canadian Nuclear Safety Commission (CNSC), Environment Canada (EC) and the Department of Fisheries and Oceans (DFO). That report described the 2011/2012 Thermal and Current Monitoring Program currently underway in Lake Ontario near the Darlington Nuclear (DN) site and provided supporting documentation to confirm conclusions made in the SWE and AE TSDs, specifically regarding potential thermal effects resulting from the thermal discharges to the lake from DNGS.

In reviewing the 2011 Thermal and Current Monitoring Program Report (Golder 2012a), CNSC and EC requested additional analysis investigating the bottom water temperature increases above ambient for the winter monitoring period in 2011. In response, a technical memorandum documenting the results of this additional analysis and the associated assessment of potential effects of the DNGS thermal discharge on round whitefish (Golder 2012b) was submitted for federal review in February 2012 (Golder 2012b).

This technical memorandum (Golder 2012c) provides similar data/information for the winter monitoring period of December 2011 through March 2012.

The recently collected temperature data (Figure 1-1 illustrates the monitoring program locations) for the 2011/2012 winter monitoring period (December 2011 through mid-March 2012) are provided in Attachments A and B, which include the measured temperature data time series plots and 7-day rolling average temperature
plots, respectively. The 7-day rolling averages were calculated using the same method employed to generate the 7-day rolling average temperature plots provided in the 2011 Thermal and Current Monitoring Program Report (Golder 2012a). As such, the plots provided in Attachments A and B to this document can be directly compared to the plots provided in Appendices B and C of the 2011 Thermal and Current Monitoring Program Report (Golder 2012a)\(^1\).

---

\(^1\) The methods used for data processing and quality assurance and quality control (QA/QC) of the data are consistent with the methods used in the 2011 Thermal and Current Monitoring Program Report (Golder 2012a) and the follow-up technical memorandum providing additional analysis for bottom water temperature increases above ambient (Golder 2012b).
2.0 ASSESSMENT OF AMBIENT CONDITIONS

2.1 Comparison of Ambient Air Temperatures

This section provides a comparison of the average monthly air temperatures recorded at the Environment Canada Trenton Airport, Ontario meteorological station (Trenton A) over the winter of 2011-2012 (December through March) to historical values. The comparison is intended to provide perspective by examining the frequency at which the average monthly air temperatures observed in 2011-2012 have occurred historically.

For consistency with previous studies, the Trenton A meteorological station was selected for this analysis. The historical record ranges from 1940 to 2011 (72 years). Additional provisional data for 2012 were also obtained.

The following table provides a statistical summary of the monthly air temperatures.

### Table 2.1-1: Statistical Summary of Monthly Air Temperatures at Trenton

<table>
<thead>
<tr>
<th>Month</th>
<th>Historical (1940 to 2011)</th>
<th>Winter 2010-2011</th>
<th>Winter 2011-2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Average</td>
<td>Maximum</td>
</tr>
<tr>
<td>November</td>
<td>-0.1°C</td>
<td>3.1°C</td>
<td>6.6°C</td>
</tr>
<tr>
<td>(1996)</td>
<td></td>
<td></td>
<td>(1948)</td>
</tr>
<tr>
<td>December</td>
<td>-12.5°C</td>
<td>-3.9°C</td>
<td>1.5°C</td>
</tr>
<tr>
<td>January</td>
<td>-14.2°C</td>
<td>-7.3°C</td>
<td>-1.8°C</td>
</tr>
<tr>
<td>February</td>
<td>-12.0°C</td>
<td>-6.2°C</td>
<td>-1.6°C</td>
</tr>
<tr>
<td>(1979)</td>
<td></td>
<td></td>
<td>(1954)</td>
</tr>
<tr>
<td>March</td>
<td>-5.5°C</td>
<td>-0.9°C</td>
<td>4.4°C</td>
</tr>
<tr>
<td>Jan-Feb²</td>
<td>-12.0°C</td>
<td>-6.8°C</td>
<td>-2.5°C</td>
</tr>
<tr>
<td>Dec-Mar³</td>
<td>-7.4°C</td>
<td>-4.6°C</td>
<td>-1.2°C</td>
</tr>
</tbody>
</table>

Notes:
1. Based on provisional data for 2012.
2. Average air temperature from January 1st to February 28th.
3. Average air temperature from December 1st to March 31st.
4. New maximum monthly average – not confirmed since data is provisional.

Table 2.1-1 suggests that the average monthly air temperatures recorded between December 2011 and February 2012 are not necessarily the warmest on record. The percentiles suggest that these air temperatures have occurred at frequencies of approximately once every 16 years (94th percentile for January) and once every 73 years (99th percentile for December). However, when the averages for the periods of January to February and December to March are considered, the data suggest that the winter of 2011-2012 was the warmest on record.

Based on the average air temperatures for the period of December to March, the winter of 2011-2012 was approximately 5.4°C warmer than average and approximately 2°C warmer than the previously recorded warmest
winter (2001-2002). Table 2.1-2 shows that four of the five warmest winters on record have occurred since 1982.

Table 2.1-2: Five Warmest Winters on Record for Period of 1940 to 2012

<table>
<thead>
<tr>
<th>Period</th>
<th>Average Temperature [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1952 – March 1953</td>
<td>-1.5°C</td>
</tr>
<tr>
<td>December 1982 – March 1983</td>
<td>-2.2°C</td>
</tr>
<tr>
<td>December 1997 – March 1998</td>
<td>-1.9°C</td>
</tr>
<tr>
<td>December 2001 – March 2002</td>
<td>-1.2°C</td>
</tr>
<tr>
<td>December 2011 – March 2012</td>
<td>+0.8°C</td>
</tr>
</tbody>
</table>

Table 2.1-1 shows that average air temperatures for the period of December to March recorded during the winter of 2010-2011 are slightly cooler than average (approximately 0.3°C cooler than the long-term average temperature for the period of January to April based on a meteorological dataset collected from 1940 to 2011) while the winter of 2011-2012 is believed to be one of the warmest winters in the past 70 years.

2.2 Assessment of Ambient Water Temperature

This section provides a comparison of the average daily ambient water temperatures measured during the winter of 2011-2012 to the historical average daily ambient water temperatures. For consistency with previous studies (as discussed in Section 4.2.1 of the 2011 Thermal and Current Monitoring Program Report (Golder 2012a)), the ambient water temperature for this cold period was taken to be the average of the temperatures measured at TD05-1 and DN15-1 (shown on Figure 1-1).

Figure 2.2-1 compares the average daily ambient water temperatures measured in the Darlington Nuclear study area during the winter of 2011-2012 (green line) to the historical range of average daily ambient water temperatures (shaded grey). The figure shows that during the fall cooling period through November, the average daily ambient water temperatures in 2011 were typically within the upper range of the historical range measured in the Darlington Nuclear study area. The average daily ambient water temperatures are typically above the historical range for the remainder of the data period (December through March).

Table 2.2-1 compares the average monthly ambient water temperatures for the winter of 2010-2011 and the winter of 2011-2012 to a statistical summary of the historical average monthly ambient water temperatures (1984 to 1996).

The table shows that the average monthly ambient water temperatures during the winter of 2010-2011 are similar to the average monthly ambient water temperatures recorded during the historical period. While the average temperature in November 2011 was comparable to the historical maximum average November temperature (period of 1984 to 1996), the average monthly ambient water temperatures recorded during the winter of 2011-2012 are consistently higher than the maximum mean monthly ambient water temperature recorded during the historical period. On average, the water temperatures recorded from December 2011 to March 2012 in the Darlington Nuclear study area (average of 3.4°C) were 1.8°C and 1.3°C warmer than the
historical average and the historical maximum monthly temperatures, respectively. These observations are consistent with the differences in monthly average air temperatures discussed in Section 2.1.

Considering the period of available ambient water temperature data (i.e., 1984 to 1996 and 2011 to 2012), the ambient water temperatures observed during the winter of 2011-2012 were the warmest recorded near the Darlington Nuclear study area while the ambient water temperatures observed during the winter of 2010-2011 can be considered slightly cooler than average.

Table 2.2-1: Statistical Summary of Ambient Water Temperatures in the Darlington Nuclear Study Area

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Average</td>
<td>Maximum</td>
</tr>
<tr>
<td>November</td>
<td>4.9°C (1988)</td>
<td>6.0°C</td>
<td>7.7°C (1985)</td>
</tr>
<tr>
<td>December</td>
<td>1.7°C (1995)</td>
<td>2.7°C</td>
<td>3.4°C (1993)</td>
</tr>
<tr>
<td>January</td>
<td>0.4°C (1993)</td>
<td>1.1°C</td>
<td>1.5°C (1990)</td>
</tr>
<tr>
<td>February</td>
<td>0.3°C (1993)</td>
<td>1.0°C</td>
<td>1.8°C (1991)</td>
</tr>
<tr>
<td>March</td>
<td>0.9°C (1992)</td>
<td>1.9°C</td>
<td>2.7°C (1995)</td>
</tr>
<tr>
<td>Jan-Feb</td>
<td>0.4°C (1993)</td>
<td>1.1°C</td>
<td>1.4°C (1991)</td>
</tr>
<tr>
<td>Dec-Mar</td>
<td>1.2°C (1994-1996)</td>
<td>1.6°C</td>
<td>2.1°C (1994-1995)</td>
</tr>
</tbody>
</table>

Notes:
1. No data collected before January 23, 2011.
2. Average ambient water temperature from January 1\(^{st}\) to February 28\(^{th}\).
3. Average ambient water temperature from December 1\(^{st}\) to March 31\(^{st}\).
3.0 TEMPERATURES AT BOTTOM LOCATIONS

As described in the 2011 Thermal and Current Monitoring Program Report (Golder 2012a), one of the objectives of the 2011/2012 Darlington Nuclear Thermal and Current Monitoring Program was to assess the potential thermal effects on VEC aquatic species. Water temperatures were measured at several bottom locations where spawning of round whitefish potentially occurs. These data were used to evaluate if occurrences of thermal plume contact with the lakebed can be detected and measured and identify the locations, frequencies and durations of these events. These bottom water temperature data are subsequently used in Section 5.0 of this memo (Assessment of Temperature Effects on Round Whitefish Embryo Development).

The hourly averages of the temperature data collected during the egg incubation period of the second winter monitoring period (December 2011 through March 2012) at all bottom locations are compared to the embryo survival criteria (discussed in Section 5.2 of the 2011 Thermal and Current Monitoring Program Report (Golder 2012a)) for:

- Offshore locations within the Mixing Zone\(^2\) characterized by depths greater than 10 m (shown on Figure 3-1);
- Offshore locations beyond the Mixing Zone characterized by depths greater than 10 m (shown on Figure 3-2);
- Nearshore locations within the Mixing Zone characterized by depths less than 10 m (shown on Figure 3-3);
- Shallow nearshore locations characterized by depths less than 10 m (shown on Figure 3-4); and
- Reference locations (shown on Figure 3-5).

Figure 3-1 includes two additional monitoring locations: DN17-B and DN18-B located between the offshore end of the diffuser and the edge of the Mixing Zone. Temperatures at these locations were not assessed for the first winter monitoring period (January 2011 through March 2011) since they were first installed in November 2011.

Figures 3-1 through 3-5 also show the hourly average bottom water temperatures as an increase over the hourly average bottom water temperature. The hourly average bottom water temperature was calculated as the average of temperatures measured at all of the bottom locations, with the exception of the Port Darlington ADCP and Port Granby locations. This approach was used to identify locations with bottom water temperatures that differed relative to the average lake bottom conditions.

A brief overview of the observed hourly average bottom water temperatures is provided below. However, a more comprehensive discussion of these bottom water temperature data and potential effects on round whitefish is provided in Section 5.0 of this memo (Assessment of Temperature Effects on Round Whitefish Embryo Development).

- The hourly average bottom water temperatures (shown on Figures 3-1 through 3-5) and measured ambient water temperatures (shown on pages A-4 and A-28 of Appendix A) were generally 5ºC or warmer until mid-December 2011 and generally remained above 4ºC until the last week of December 2011. The measured ambient water temperatures generally decreased to between 1ºC and 2ºC for approximately the last two weeks of January 2012 before beginning to rise again. By mid-March 2012, the hourly average bottom

---

\(^2\) The Mixing Zone is an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of this area, as shown on Figures 4-1 through 4-4.
water temperature and measured ambient water temperature had both increased to approximately 5°C again.

- In January 2012 through to mid-March 2012 (before the hourly average bottom water temperatures and measured ambient water temperatures had risen again to approximately 5°C), occurrences of elevated hourly average bottom water temperatures were measured at offshore locations within the Mixing Zone, predominantly at location TD35-12. These events occurred primarily in February and March of 2012 and included hourly average bottom water temperatures above 7°C. Occurrences of hourly average bottom water temperatures above 5°C (but less than 6°C) also occurred at locations DN17-B and DN18-B (also offshore locations within the Mixing Zone, between location TD35-12 and the edge of the Mixing Zone) during this period. Very few occurrences of hourly average bottom water temperatures above 5°C occurred at the other offshore locations within the Mixing Zone (locations TD55-B, TD34-B and TD45-B). These events were generally short in duration and were characterized by maximum hourly average temperatures only marginally greater than 5°C. (See Figure 3-1.)

- As can be seen in Figure 3-2, there were rare and brief occurrences of hourly average bottom water temperatures above 5°C during the period of January 2012 through mid-March 2012 at offshore locations beyond the Mixing Zone and these were all well below 6°C.

- Figure 3-3 shows that there were a few short occurrences of hourly average bottom water temperatures above 5°C (but well below 6°C) during the period of January 2012 through mid-March 2012 at location DN10-B (a nearshore location within the Mixing Zone approximately 150 m east of the diffuser) but they were generally short in duration.

- Figures 3-4 and 3-5 show that hourly average bottom water temperatures above 5°C did not generally occur at any of the shallow nearshore locations or reference locations during the period of January 2012 through mid-March 2012.
4.0 BOTTOM WATER TEMPERATURE INCREASES ABOVE AMBIENT

For the frequency analysis of bottom water temperature increases over ambient lake temperatures for the 2011/2012 winter monitoring period (i.e., data collected from December 2011 through March 2012), ambient temperatures were defined using only the hourly average ambient surface temperatures recorded at TD05-1 and DN15-1 (shown on Figure 1-1) for the 2011/2012 winter monitoring period. Since the water column is typically well mixed during the cold water period (i.e., the difference between the hourly average surface and bottom temperatures was generally less than 0.1°C between December 2011 and March 2012), it is appropriate to assess the bottom thermal plume during the cold water period using the hourly average ambient surface temperatures. This is consistent with the method used to define ambient temperatures used for the previous analyses of temperature increases above ambient presented in the 2011 Thermal and Current Monitoring Program Report (Golder 2012a) and the follow-up technical memorandum providing additional analysis for bottom water temperature increases above ambient (Golder 2012b).

Tables 4.1, 4.2 and 4.3 provide a summary of the frequency analysis of bottom water temperature increases over ambient lake temperatures (hourly average bottom water temperature increase over hourly average ambient lake temperature is hereafter referred to as hourly average bottom DT) for the following three winter monitoring periods, respectively:

- **Table 4.1**: December 2011 through mid-March 2012: all available data corresponding to the second winter monitoring period of concern with respect to temperature effects on round whitefish.
- **Table 4.2**: January 23, 2012 through mid-March 2012: subset of the available data for the second winter monitoring period used for direct comparison to observations made for the first winter monitoring period. (Since the period of data availability for the first winter monitoring is January 23, 2011 through March 2011, the results obtained for the period of December 2011 through mid-March 2012 are not directly comparable to the results obtained for the first winter monitoring period.)
- **Table 4.3**: January 23, 2011 through March 2011: first winter monitoring period for comparison to Table 4.2 (taken from Golder 2012b).

For each location shown on Figures 4-1 through 4-6, the following are provided for each of the three periods of data collection listed above: the mean hourly average bottom DT; the observed frequencies of exceedance for hourly average bottom DTs ranging between 1°C and 5°C; and the 75th percentile and 95th percentile hourly average bottom DTs observed. (The 75th percentile and 95th percentile hourly average bottom DT values for each location are also shown on Figures 4-1 through 4-6.) When large data gaps exist for a location during a given monitoring period, the results should be interpreted with caution. For example, the results for location TD34-B for the second winter monitoring period (December 2011 through mid-March 2012) were generated from only 232 data points since hourly data were only available from January 26, 2012 to February 5, 2012. (The number of available hourly average temperature data points for each location for each monitoring period described above are also provided in Tables 4.1 through 4.3.)

Comparing the results for location TD35-12 we observe the following:

- Data collected during the January 2011 through March 2011 winter monitoring period (see Table 4.3 and Figures 4-5 and 4-6) indicated that 75% and 95% of the time the observed hourly average bottom DTs were equal to or less than 2.26°C and 4.02°C, respectively. The frequency with which an hourly average bottom DT of 2°C was exceeded was 40%.
- Data collected between January 23, 2012 and mid-March 2012 during the second winter monitoring period (see Table 4.2 and Figures 4-3 through 4-6) indicated that 75% and 95% of the time the observed hourly average bottom DTs were equal to or less than 1.63°C and 2.81°C, respectively. The frequency with which an hourly average bottom DT of 2°C was exceeded was only 17%.

- Based on all of the data available for the second winter monitoring period of concern with respect to temperature effects on round whitefish (i.e., data collected from December 2011 to mid-March 2012 – see Table 4.1 and Figures 4-1 and 4-2), 75% and 95% of the time the observed hourly average bottom DTs were equal to or less than 1.30°C and 2.27°C, respectively. The frequency with which an hourly average bottom DT of 2°C was exceeded was only 8.1%.

- It is noted that during the first winter monitoring period (January 23, 2011 through March 2011) data were available for location TD35-12 only for the period of late January through early March. However, during the second winter monitoring period data were collected for the entire period of December 2011 through mid-March 2012. As can be seen in Figure 3-1, larger hourly average temperature increases above the average measured bottom water temperature (hourly average) were predominantly observed during the period of early February 2012 through mid-March 2012. This is consistent with the data collected during the first winter monitoring period.

Data presented in Tables 4.1 and 4.2 were used to estimate the quartile (75th percentile) and maximum (95th percentile) areal extents of the thermal plume near the lake bottom for the second winter monitoring period. Figures 4-1 and 4-2 present the estimated quartile and maximum areal extents, respectively, for the period of December 2011 through mid-March 2012. Figures 4-3 and 4-4 present the estimated quartile and maximum areal extents, respectively, for the period of January 23, 2012 through mid-March 2012. Figures 4-5 and 4-6 provide a comparison of the estimated quartile and maximum areal extents, respectively, for the periods of January 23, 2011 through March 2011 and January 23, 2012 through mid-March 2012. These figures show contour lines representing the frequencies of various hourly average bottom DTs for these periods of data collection during the second winter. These contour lines represent the maximum distances from the diffuser that these various hourly average bottom DTs are expected to occur during these periods at their respective temporal percentile, i.e., the areas within which the hourly average bottom DTs are likely to occur. These maximum distances from the diffuser and the resulting contour lines were reasonably approximated by linear interpolation of the 75th percentile and 95th percentile hourly average bottom DTs between neighbouring monitoring locations.

It is important to note that the areas contained within these contour lines do not represent the actual size of the quartile and maximum bottom thermal plumes observed during these periods. Depending on the conditions (ambient temperature, discharge temperature, and current speed and direction) at any given point in time, the location and size of the bottom thermal plumes varied within the areas depicted in these figures. The actual sizes of the thermal plumes were a fraction of the total areas inside the contour lines shown on these figures at any given point in time. For example, 95% of the time between January 23, 2012 and mid-March 2012 hourly average bottom DTs between 2°C and 2.5°C were likely contained within the estimated area bound by the 2°C and 2.5°C temperature increase contour lines shown in Figure 4-4 and hourly average bottom DTs greater than 2°C did not likely occur outside of the 2°C contour line. However, Figure 4-4 does not suggest that 95% of the time hourly average bottom DTs between 2°C and 2.5°C occurred throughout the entire area bounded by the 2°C and 2.5°C contour lines. In addition, Figure 4-4 does not provide information related to the frequency and duration of occurrences of hourly average bottom DTs between 2°C and 2.5°C within this area during the second winter monitoring period of January 23, 2012 through mid-March 2012.
In addition, the method used to define hourly average ambient temperatures may result in some over estimation of the hourly average bottom DTs at depths greater than the ambient locations TD05-1 and DN15-1 (i.e., greater than 5 m). At the deeper, offshore locations (particularly DN07-B, DN08-B AND DN09-B located at depths of approximately 18.5, 13.75 and 18.5, respectively) the observed frequencies of average hourly bottom water temperature increases are likely a combination of cooling water discharge and a natural increase in the ambient water temperature with depth. During the winter months the bottom water temperatures further offshore (e.g., typically at depths greater than 20 m) are constant at approximately 4°C which is 2°C to 3°C warmer than the temperatures measured at the ambient monitoring locations. The actual depth at which the constant 4°C water temperatures occur varies with time due to lake-wide cooling, storm events and currents. As a result, the frequencies presented in Tables 4.1 through 4.3 and Figures 4-1 through 4-6 are likely conservative and representative of the highest frequencies that can be expected.

Based on the preceding discussion and the results presented in Table 4.1 and Figure 4-1, it is concluded that 75% of the time during the second winter period (i.e., data collected from December 2011 to mid-March 2012) the maximum hourly average bottom DT within the study area was 1.53°C (at location DN10-B) with hourly average bottom DTs of 1.5°C to 1.53°C only occurring in a small area of less than 0.2 ha (0.002 km²) approximately 150 m east of the diffuser over this location. The results also suggest that, other than this small area over location DN10-B, hourly average bottom DTs within the Mixing Zone were 1.5°C or less.

Also based on the preceding discussion as well as the results presented in Table 4.1 and Figure 4-2, it is concluded that 95% of the time during the second winter period (i.e., data collected from December 2011 to mid-March 2012) the maximum hourly average bottom DT within the study area was 2.27°C (at location TD35-12) and the hourly average bottom DTs at the edge of the Mixing Zone were generally within 2°C. The area contained within the contour line representing an hourly average bottom DT of 2°C (i.e., the area with hourly average bottom DTs of 2°C to 2.27°C within the Mixing Zone) is approximately 36 ha (0.36 km²) and this area is predominantly characterized by depths of 10 m or greater.

As documented in the technical memorandum providing additional analysis for hourly average bottom water temperature increases above ambient (Golder 2012b) as follow-up to the 2011 Thermal and Current Monitoring Program Report (Golder 2012a) and shown in Figure 4-5, it was concluded that 75% of the time during the first winter monitoring period (i.e., January 23, 2011 through March 2011) the maximum hourly average bottom DT within the study area was 2.26°C (at location TD35-12) and the hourly average bottom DTs were generally within 1°C at the edge of the Mixing Zone. The areas contained within the 1.5°C and 2°C contour lines (i.e., the areas with hourly average bottom DTs of 1.5°C and 2°C or greater, respectively) were approximately 20 ha (0.2 km²) and 1.7 ha (0.02 km²), respectively, and these areas were predominantly characterized by depths of 10 m or greater. It was also concluded that 95% of the time during the first winter monitoring period the maximum hourly average bottom DT within the study area was 4.02°C (at location TD35-12 as shown in Figure 4-6) and the hourly average bottom DTs at the edge of the Mixing Zone were less than 2°C. The areas contained within the 2°C and 3°C contour lines (i.e., the areas with hourly average bottom DTs of 2°C and 3°C or greater, respectively) were 41 ha (0.4 km²) and 8.7 ha (0.09 km²), respectively. Approximately two-thirds of these areas were characterized by depths of 10 m or greater. 95% of the time the area contained within the 4°C contour line (i.e., the area with hourly average bottom DTs between 4°C and 4.02°C) was approximately 30 m² and was located over the offshore end of the diffuser, i.e. around monitoring location TD35-12.

As shown in Table 4.2 and Figures 4-3 and 4-5, during the second winter monitoring period comparable to the first winter monitoring period (i.e., January 23, 2012 to mid-March 2012), 75% of the time the hourly average bottom DTs did not reach 2°C within the study area (the maximum hourly average bottom DT was only 1.63°C at
location TD35-12). The hourly average bottom DTs were less than 1.5°C at the edge of the Mixing Zone. The area within the Mixing Zone contained within the 1.5°C contour line (i.e., the area with hourly average bottom DTs between 1.5°C and 1.63°C) was approximately 11 ha (0.1 km²). As shown in Table 4.2 and Figures 4-4 and 4-6, 95% of the time the hourly average bottom DTs did not reach 3°C within the study area (the maximum hourly average bottom DT was 2.81°C at location TD35-12). The hourly average bottom DTs at the edge of the Mixing Zone were generally 2°C or less. The areas contained within the 2°C and 2.5°C contour lines (i.e., the areas with hourly average bottom DTs of 2°C and 2.5°C or greater, respectively) were 32 ha (0.3 km²) and 2.5 ha (0.02 km²), respectively.

The discussion of results of the frequency analysis of bottom water temperature increases over ambient lake temperatures for the two winter monitoring periods is summarized in Tables 4.4 and 4.5.
Table 4.1: Frequency of Hourly Average Bottom Water Temperatures Increases Over Ambient - Period of December 2011 through mid-March 2012

<table>
<thead>
<tr>
<th>Location</th>
<th>Water Depth (m)</th>
<th>No. of Data Points</th>
<th>Increase Over Ambient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside Mixing Zone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD38-B</td>
<td>10</td>
<td>932</td>
<td>0.33</td>
</tr>
<tr>
<td>TD35-12</td>
<td>12</td>
<td>2,449</td>
<td>0.89</td>
</tr>
<tr>
<td>DN10-B</td>
<td>11</td>
<td>2,458</td>
<td>1.04</td>
</tr>
<tr>
<td>DN11-B</td>
<td>10</td>
<td>1,522</td>
<td>0.76</td>
</tr>
<tr>
<td>DN17-B</td>
<td>12.5</td>
<td>2,508</td>
<td>0.80</td>
</tr>
<tr>
<td>DN18-B</td>
<td>12.5</td>
<td>2,463</td>
<td>0.94</td>
</tr>
<tr>
<td>Edge of Mixing Zone (Clockwise from Nearshore – starting at TD31)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD31-B</td>
<td>6</td>
<td>2,556</td>
<td>-0.12</td>
</tr>
<tr>
<td>TD52-B</td>
<td>10</td>
<td>1,546</td>
<td>0.75</td>
</tr>
<tr>
<td>TD55-B</td>
<td>15</td>
<td>2,463</td>
<td>0.73</td>
</tr>
<tr>
<td>TD34-B</td>
<td>14</td>
<td>232</td>
<td>0.95</td>
</tr>
<tr>
<td>TD45-B</td>
<td>10</td>
<td>2,508</td>
<td>0.40</td>
</tr>
<tr>
<td>TD42-B</td>
<td>8</td>
<td>1,524</td>
<td>0.35</td>
</tr>
<tr>
<td>Outside Regulated Mixing Zone (Clockwise from Nearshore – starting at DN01)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN01-B</td>
<td>6</td>
<td>681</td>
<td>-0.27</td>
</tr>
<tr>
<td>DN03-B</td>
<td>11</td>
<td>916</td>
<td>0.23</td>
</tr>
<tr>
<td>DN05-B</td>
<td>15</td>
<td>2,505</td>
<td>0.69</td>
</tr>
<tr>
<td>DN07-B</td>
<td>18</td>
<td>2,505</td>
<td>0.63</td>
</tr>
<tr>
<td>DN09-B</td>
<td>18</td>
<td>1,967</td>
<td>0.50</td>
</tr>
<tr>
<td>DN08-B</td>
<td>14</td>
<td>2,507</td>
<td>0.66</td>
</tr>
<tr>
<td>DN06-B</td>
<td>12</td>
<td>1,524</td>
<td>0.46</td>
</tr>
<tr>
<td>DN04-B</td>
<td>7</td>
<td>1,526</td>
<td>0.15</td>
</tr>
<tr>
<td>DN02-B</td>
<td>5</td>
<td>2,551</td>
<td>-0.89</td>
</tr>
</tbody>
</table>

Notes:
1. The Mixing Zone is an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of this area, as shown on Figures 4-1 through 4-4.
Table 4.2: Frequency of Hourly Average Bottom Water Temperatures Increases Over Ambient - Period of January 23, 2012 through mid-March 2012

<table>
<thead>
<tr>
<th>Location</th>
<th>Water Depth (m)</th>
<th>No. of Data Points</th>
<th>Average</th>
<th>Increase Over Ambient</th>
<th>Frequency of Exceedance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>75&lt;sup&gt;th&lt;/sup&gt;</td>
<td>95&lt;sup&gt;th&lt;/sup&gt;</td>
<td>1°C</td>
</tr>
<tr>
<td>Inside Mixing Zone</td>
<td></td>
<td></td>
<td>Percentile</td>
<td>Percentile</td>
<td></td>
</tr>
<tr>
<td>TD38-B</td>
<td>10</td>
<td>932</td>
<td>0.33</td>
<td>0.68</td>
<td>1.37</td>
</tr>
<tr>
<td>TD35-12</td>
<td>12</td>
<td>1,186</td>
<td>1.15</td>
<td>1.63</td>
<td>2.81</td>
</tr>
<tr>
<td>DN10-B</td>
<td>11</td>
<td>1,186</td>
<td>1.10</td>
<td>1.58</td>
<td>2.07</td>
</tr>
<tr>
<td>DN11-B</td>
<td>10</td>
<td>250</td>
<td>0.95</td>
<td>1.38</td>
<td>1.71</td>
</tr>
<tr>
<td>DN17-B</td>
<td>12.5</td>
<td>1,236</td>
<td>0.70</td>
<td>1.22</td>
<td>1.89</td>
</tr>
<tr>
<td>DN18-B</td>
<td>12.5</td>
<td>1,191</td>
<td>0.96</td>
<td>1.53</td>
<td>2.14</td>
</tr>
<tr>
<td>Edge of Mixing Zone (Clockwise from Nearshore – starting at TD31)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD31-B</td>
<td>6</td>
<td>1,284</td>
<td>-0.11</td>
<td>0.12</td>
<td>0.62</td>
</tr>
<tr>
<td>TD52-B</td>
<td>10</td>
<td>274</td>
<td>0.87</td>
<td>1.20</td>
<td>1.65</td>
</tr>
<tr>
<td>TD55-B</td>
<td>15</td>
<td>1,191</td>
<td>0.67</td>
<td>1.12</td>
<td>1.89</td>
</tr>
<tr>
<td>TD34-B</td>
<td>14</td>
<td>232</td>
<td>0.95</td>
<td>1.44</td>
<td>2.03</td>
</tr>
<tr>
<td>TD45-B</td>
<td>10</td>
<td>1,236</td>
<td>0.34</td>
<td>0.72</td>
<td>1.31</td>
</tr>
<tr>
<td>TD42-B</td>
<td>8</td>
<td>252</td>
<td>0.26</td>
<td>0.51</td>
<td>1.02</td>
</tr>
<tr>
<td>Outside Regulated Mixing Zone (Clockwise from Nearshore – starting at DN01)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN01-B</td>
<td>No data for the period of January 23, 2012 through March 2012.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN03-B</td>
<td>11</td>
<td>916</td>
<td>0.23</td>
<td>0.55</td>
<td>1.01</td>
</tr>
<tr>
<td>DN05-B</td>
<td>15</td>
<td>1,233</td>
<td>0.61</td>
<td>1.03</td>
<td>1.81</td>
</tr>
<tr>
<td>DN07-B</td>
<td>18</td>
<td>1,233</td>
<td>0.59</td>
<td>0.98</td>
<td>1.41</td>
</tr>
<tr>
<td>DN09-B</td>
<td>18</td>
<td>1,151</td>
<td>0.51</td>
<td>0.95</td>
<td>1.60</td>
</tr>
<tr>
<td>DN08-B</td>
<td>14</td>
<td>1,235</td>
<td>0.59</td>
<td>1.05</td>
<td>1.64</td>
</tr>
<tr>
<td>DN06-B</td>
<td>12</td>
<td>252</td>
<td>0.63</td>
<td>0.94</td>
<td>1.42</td>
</tr>
<tr>
<td>DN04-B</td>
<td>7</td>
<td>254</td>
<td>0.22</td>
<td>0.50</td>
<td>0.99</td>
</tr>
<tr>
<td>DN02-B</td>
<td>5</td>
<td>1,279</td>
<td>-0.15</td>
<td>0.06</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Notes:
1 The Mixing Zone is an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of this area, as shown on Figures 4-1 through 4-4.
Table 4.3: Frequency of Hourly Average Bottom Water Temperature Increases Over Ambient – Period of January 23, 2011 through March 2011 (First Winter Period)

<table>
<thead>
<tr>
<th>Location</th>
<th>Water Depth (m)</th>
<th>Number of Data Points</th>
<th>Increase Over Ambient Average</th>
<th>75th Percentile</th>
<th>95th Percentile</th>
<th>Frequency of Exceedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside Mixing Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD38-B</td>
<td>10</td>
<td>1527</td>
<td>0.50</td>
<td>0.83</td>
<td>1.38</td>
<td>17% 0.0% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>TD35-12</td>
<td>12</td>
<td>841</td>
<td>1.82</td>
<td>2.26</td>
<td>4.02</td>
<td>81% 40% 9.6% 5.2% 1.1%</td>
</tr>
<tr>
<td>DN10-B</td>
<td>11</td>
<td>1527</td>
<td>0.52</td>
<td>1.00</td>
<td>1.73</td>
<td>25% 24% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>DN11-B</td>
<td>10</td>
<td>1525</td>
<td>0.50</td>
<td>0.98</td>
<td>1.58</td>
<td>24% 0.1% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>DN17-B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No data collected before November 23, 2011.</td>
</tr>
<tr>
<td>DN18-B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edge of Mixing Zone (Clockwise from Nearshore – starting at TD31)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD31-B</td>
<td>6</td>
<td>1012</td>
<td>0.04</td>
<td>0.34</td>
<td>0.75</td>
<td>1.0% 0.0% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>TD52-B</td>
<td>10</td>
<td>1617</td>
<td>0.15</td>
<td>0.44</td>
<td>1.03</td>
<td>5.4% 0.1% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>TD55-B</td>
<td>15</td>
<td>1617</td>
<td>0.50</td>
<td>1.05</td>
<td>1.69</td>
<td>27% 2.8% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>TD34-B</td>
<td>14</td>
<td>1617</td>
<td>0.65</td>
<td>1.16</td>
<td>1.85</td>
<td>31% 1.9% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>TD45-B</td>
<td>10</td>
<td>1617</td>
<td>0.38</td>
<td>0.80</td>
<td>1.19</td>
<td>12% 0.0% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>TD42-B</td>
<td>8</td>
<td>1617</td>
<td>-0.04</td>
<td>0.14</td>
<td>0.50</td>
<td>0.1% 0.0% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>Outside Regulated Mixing Zone (Clockwise from Nearshore – starting at DN01)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN01-B</td>
<td>6</td>
<td>1525</td>
<td>-0.04</td>
<td>0.14</td>
<td>0.58</td>
<td>0.4% 0.0% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>DN03-B</td>
<td>11</td>
<td>1617</td>
<td>0.17</td>
<td>0.47</td>
<td>1.03</td>
<td>5.4% 0.1% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>DN05-B</td>
<td>15</td>
<td>1617</td>
<td>0.41</td>
<td>0.85</td>
<td>1.48</td>
<td>20% 1.2% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>DN07-B</td>
<td>18</td>
<td>937</td>
<td>0.50</td>
<td>1.00</td>
<td>1.53</td>
<td>25% 0.1% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>DN09-B</td>
<td>18</td>
<td>1617</td>
<td>0.54</td>
<td>1.02</td>
<td>1.65</td>
<td>26% 0.1% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>DN08-B</td>
<td>14</td>
<td>938</td>
<td>0.93</td>
<td>1.42</td>
<td>1.78</td>
<td>51% 1.2% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>DN06-B</td>
<td>12</td>
<td>1617</td>
<td>0.28</td>
<td>0.70</td>
<td>1.05</td>
<td>7.5% 0.0% 0.0% 0.0% 0.0%</td>
</tr>
<tr>
<td>DN04-B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No data for the period of January through March 2011.</td>
</tr>
<tr>
<td>DN02-B</td>
<td>5</td>
<td>936</td>
<td>-0.79</td>
<td>-0.54</td>
<td>0.28</td>
<td>0.2% 0.0% 0.0% 0.0% 0.0%</td>
</tr>
</tbody>
</table>

Notes:
1. The Mixing Zone is an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of this area, as shown on Figures 4-1 through 4-4.
Table 4.4: Comparison of Hourly Average Bottom Water Temperature Increases Over Ambient at Location TD35-12 for 2010/2011 and 2011/2012 Winter Monitoring Periods

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartile Extents (75th Percentile)</td>
<td>2.26°C</td>
<td>1.63°C</td>
<td>1.30°C</td>
</tr>
<tr>
<td>Maximum Extents (95th Percentile)</td>
<td>4.02°C</td>
<td>2.81°C</td>
<td>2.27°C</td>
</tr>
<tr>
<td>2°C Frequency of Exceedance</td>
<td>40%</td>
<td>17%</td>
<td>8.1%</td>
</tr>
</tbody>
</table>

Table 4.5: Summary Comparison of Frequency Analysis of Hourly Average Bottom Water Temperature Increase Over Ambient for Two Winter Monitoring Periods

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartile Extents (75th Percentile)</td>
<td>TD35-12</td>
<td>TD35-12</td>
<td>DN10-B</td>
</tr>
<tr>
<td>Maximum Hourly Average Bottom Water Temperature Increase</td>
<td>2.26°C</td>
<td>1.63°C</td>
<td>1.53°C</td>
</tr>
<tr>
<td>Areas Contained Within Hourly Average Bottom Water Temperature Increase Contours</td>
<td>2.0°C</td>
<td>11 ha</td>
<td>0.2 ha</td>
</tr>
<tr>
<td>2.0°C</td>
<td>1.7 ha</td>
<td>N/A²</td>
<td>N/A²</td>
</tr>
<tr>
<td>Maximum Extents (95th Percentile)</td>
<td>TD35-12</td>
<td>TD35-12</td>
<td>TD35-12</td>
</tr>
<tr>
<td>Maximum Hourly Average Bottom Water Temperature Increase</td>
<td>4.02°C</td>
<td>2.81°C</td>
<td>2.27°C</td>
</tr>
<tr>
<td>Areas Contained Within Hourly Average Bottom Water Temperature Increase Contours</td>
<td>2.0°C</td>
<td>32 ha</td>
<td>36 ha</td>
</tr>
<tr>
<td>2.5°C</td>
<td>N/A²</td>
<td>2.5 ha</td>
<td>N/A²</td>
</tr>
<tr>
<td>3.0°C</td>
<td>8.7 ha</td>
<td>N/A⁴</td>
<td>N/A⁴</td>
</tr>
</tbody>
</table>

Notes:
1. Contours above 1.5°C were not identified for quartile extents for the winter of 2011-2012 since the 75th percentile hourly average bottom DTs were below 2°C at all monitoring locations.
2. 2.5°C contour for maximum extents was not estimated for the winter of 2010-2011.
3. Contours above 2°C were not identified for maximum extents for the winter of 2011-2012 (December to March period) since the maximum 95th percentile hourly average bottom DT was 2.27°C (at location TD35-12).
4. 3°C contours not identified for maximum extents for the winter of 2011-2012 since the 95th percentile hourly average bottom DTs were below 3°C at all monitoring locations.
5.0 ASSESSMENT OF TEMPERATURE EFFECTS ON ROUND WHITEFISH EMBRYO DEVELOPMENT

The assessment of temperature effects on round whitefish embryos during the period of December 2011 to March 2012 was conducted through the following steps:

- The time period when embryos may be present is estimated based on the developmental data provided in Griffiths (1980). Developmental times are estimated for each developmental block.
- The time period required for completion of each developmental block as defined by Griffiths (1980) is determined, based on the average temperature for the period December 2011 to March 2012 for which bottom water temperatures are available.
- Typical survival (as percent) of embryos at average temperatures recorded at reference sites for each developmental block is estimated.
- Those monitoring locations where temperatures during the period of December 15 to mid-March (last date for which data are available) exceeded 3.5°C (continuous exposure benchmark) and 5°C (short-term exposure benchmark) are identified. These locations are subsequently assessed for potential effects on embryo survival.
- Embryo survival at the temperatures recorded from December 2011 to mid-March 2012 based on 7-day moving average temperatures and hourly average temperatures is estimated for each location and embryo developmental block where the above benchmarks are exceeded.

The temperature benchmarks developed in Golder (2012a) are used in this assessment, specifically focusing on the 3.5°C benchmark for continuous exposure and the 5°C benchmark for exposure to pulses of increased temperatures. The derivation of these benchmarks is provided in Golder (2012a), and is based on the data provided by Griffiths (1980).

Exposure was assessed on the basis of the three blocks that characterize the different larval development stages. Griffiths (1980) noted that there were slight variations in sensitivity of the different life stages to temperature changes and, therefore, this approach has been used to identify if any particular development stage is more likely to experience adverse effects.

5.1 Estimate of Time Period When Embryos Are Present

Details regarding the period when round whitefish were spawning in the area during December 2011 are not available and therefore the time when embryos likely would be present is estimated based on when suitable temperatures for spawning occurred at the reference locations. A range of dates is typically provided that indicates females will move inshore to spawn beginning in late November. Therefore, spawning is considered to occur over a range of dates that, in turn, determine the periods when the different developmental stages would likely be present.

Wismer and Christie (1987) noted that the optimum temperature for spawning was 3°C to 4.5°C. Temperature data collected between November 2011 and March 2012 at the reference locations (Figure 5.3-1 and Figure 2.2-1) indicate that temperatures decreased to below 5°C by approximately December 17. Therefore, spawning and embryo development are estimated to begin in mid-December.
Griffiths provided estimates of developmental periods based on temperatures at which the developing embryos were exposed. These ranged from 168 days at a constant temperature of 1.7°C to 76 days at a constant temperature of 6.6°C. The data for the three embryo development stages (Block 1 through Block 3) tested by Griffiths as well as total development time across all three development stages is shown graphically in Figures 5.1-1 to 5.1-4 and is provided in Table 5.2. The data shown on Figure 5.3-1 indicate that average temperatures at reference locations generally ranged between 3°C and 4°C during most of the winter months. Therefore, the typical development times for average years are estimated from the graphs on Figures 5.1-1 to 5.1-3 for this temperature range. The graphs give the following estimates based on the average temperatures.

- Block 1: Fertilization to Stage 9 – 25 to 31 days;
- Block 2: Stage 9 to Stage 19 – 46 to 58 days; and
- Block 3: Stage 19 to complete hatch – 46 to 51 days.
- Total (Blocks 1 through 3) – 117 to 140 days.

As previously indicated, the hourly temperature data in Figure 5.3-1 show that under average conditions, temperatures at the reference locations decrease to below 5°C around December 17. Therefore it is assumed that spawning begins in early to middle December and embryos are present by December 15. Based on the data provided above, embryo development time during average conditions would range between 117 to 140 days (based on average temperatures that range between 3 and 4°C).

Using these data, it is estimated that early developmental stage embryos would be present from mid-December to January 9-15 (based on a development time of 25-31 days at temperatures of 3-4°C), middle developmental stage embryos (i.e., Block 2) would be present from January 9-15 to February 24-March 14 (based on a development time of 46-58 days at temperatures between 3-4°C) and late developmental stage embryos would be present beginning February 24 to March 14 and ending April 11 to May 5 (based on a development time of 46-51 days at temperatures between 3 and 4°C). Based on these estimates, larvae would be expected to hatch between early April and early May, which is consistent with observations at the site.

The estimated developmental periods per block are summarized in Table 5.1.

<table>
<thead>
<tr>
<th>Block</th>
<th>Range at 3-4°C</th>
<th>Start Date (low range)</th>
<th>End Date (low range)</th>
<th>Start Date (high range)</th>
<th>End Date (high range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25-31</td>
<td>Dec 15</td>
<td>Jan 9</td>
<td>Dec 15</td>
<td>Jan 15</td>
</tr>
<tr>
<td>2</td>
<td>46-58</td>
<td>Jan 9</td>
<td>Feb 24</td>
<td>Jan 15</td>
<td>Mar 14</td>
</tr>
<tr>
<td>3</td>
<td>46-51</td>
<td>Feb 24</td>
<td>Apr 11</td>
<td>Mar 14</td>
<td>May 5</td>
</tr>
</tbody>
</table>

Since data are available from December through to mid-March, during this time period Block 1 and Block 2 embryos are estimated to have completed development. Some embryos may have reached the Block 3 stage, particularly if some females spawned earlier than the estimated time of mid-December.
Table 5.2: Mean Survival and Time Required to Complete Developmental Phase in Round Whitefish Exposed to Increases in Temperature

<table>
<thead>
<tr>
<th>Design</th>
<th>Mean Measured Temperature(^{(a)})</th>
<th>Fertilization to Stage 9</th>
<th>Stage 9 to Stage 19</th>
<th>Stage 19 to Complete Hatch</th>
<th>Fertilization to Complete Hatch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Temperature (°C for 18 h/day)</td>
<td>Base Temperature (°C for 18 h/day)</td>
<td>Cycle Temperature (°C for 6 h/day)</td>
<td>Mean Temperature (°C for 18 h/day)</td>
<td>Cycle Temperature (°C for 6 h/day)</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1.7</td>
<td>1.7</td>
<td>41</td>
<td>93.5</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>1.9</td>
<td>3.9</td>
<td>37</td>
<td>89.3</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>2.0</td>
<td>6.8</td>
<td>30</td>
<td>86.6</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>2.3</td>
<td>9.8</td>
<td>24</td>
<td>42.7</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>3.9</td>
<td>3.9</td>
<td>26</td>
<td>90.3</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>4.00</td>
<td>6.8</td>
<td>22</td>
<td>85.6</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>6.6</td>
<td>6.6</td>
<td>17</td>
<td>74.8</td>
</tr>
</tbody>
</table>

Notes:
Data from Griffith 1980.
Temperature exposures began 20-22 h after fertilization and were repeated for 6 h/day for the duration of the experiment (completion of hatch).

\(^{(a)}\) Measured temperatures displayed are averages from fertilization to complete hatch. Mean measured temperatures by developmental stage are reported in the source article.
5.2 7-Day Rolling Average Temperatures

The 7-day rolling average temperatures are used to assess the effects of continuous exposure of developing embryos (i.e., chronic exposure) to temperatures at the monitoring locations. The 7-day rolling average temperatures for the period of December 2011 through March 2012 are provided in Figures 5.2-1 to 5.2-10 for those locations for which full data sets were available. Incomplete datasets would not allow for assessment over the complete development time for each temperature block and were therefore excluded. However, there is no indication that the locations for which full data were not available would be any different from those locations for which full data were available. Temperature data were assessed against the 3.5°C benchmark that Griffiths (1980) recommended as the upper limit of the optimum development temperature for developing embryos. The data show that a number of locations had consistent temperatures at or above the 3.5°C benchmark from mid-December through mid-March. In all cases there was a short period of approximately three weeks in the latter half of January where temperatures dropped below the 3.5°C benchmark. The temperature data are summarized in the following table according to consistency of exceedances.

Table 5.3: Ranking of Monitoring Locations Relative to 3.5°C Benchmark

<table>
<thead>
<tr>
<th>Location</th>
<th>Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 3.5°C benchmark</td>
<td>Reference Locations PG1-B; TD13-5; DN13-B</td>
</tr>
<tr>
<td></td>
<td>Nearshore within Mixing Zone TD31-B; TD45-B</td>
</tr>
<tr>
<td></td>
<td>Nearshore outside Mixing Zone DN02-B</td>
</tr>
<tr>
<td></td>
<td>Offshore outside Mixing Zone DN16-B</td>
</tr>
<tr>
<td>At or above 3.5°C benchmark</td>
<td>Nearshore in Mixing Zone DN10-B</td>
</tr>
<tr>
<td></td>
<td>Offshore in Mixing Zone DN17-B; DN18-B; TD35-12; TD55-B</td>
</tr>
<tr>
<td></td>
<td>Offshore outside Mixing Zone DN08-B; DN07-B; DN05-B</td>
</tr>
</tbody>
</table>

Notes:
1. PG1-B is control/reference location near Port Granby (approximately 40 km east of DNGS) in a water depth of approximately 8 m. (See Figure 1-1, inset.) This location is far removed from any thermal discharges and may be used for comparison to the nearshore ambient temperature locations near DNGS (TD05-1/TD13-5 and DN15-1/DN15-5).

As noted above, the remaining locations had incomplete datasets and were not considered in this assessment.

The data show there was a general warming trend beginning at the end of January that resulted in higher temperatures in February and March. This warming trend was apparent at all monitoring locations for which full datasets were available, though the increases did not result in exceedances of the 3.5°C benchmark at all of these locations.

While temperatures at the majority of locations from early January through to mid-March did not exceed 4°C at the offshore and nearshore locations outside of the Mixing Zone, temperatures at three locations within the Mixing Zone (DN10-B, DN18-B and TD35-12) ranged between 3.5°C and 5°C from January 3 through January 17 and from January 31 through March 9, 2012. Temperatures at these three locations were consistently above 3.5°C. The highest 7-day rolling average temperatures were recorded at TD35-12 (Figure 5.2-3) where temperatures were generally around 4.5°C from the beginning of February until mid-March 2012. The exceedances of the 3.5°C benchmark are provided in Table C-1 (Attachment C) and are based on hourly averages of the 15-minute measured data.
The potential effects of changes in temperature are assessed against predicted survival at the reference locations TD13-5 (Figure 5.2-1) and DN13-B (Figure 5.2-10).

5.2.1 Reference Locations

5.2.1.1 Location TD13-5
Temperatures at the shallow (5 m) reference location TD13-5 (Figure 5.2-1) ranged from approximately 4.5°C on December 15 to 2.5°C on December 31. Survival data from Griffiths (1980) is plotted on Figure 5.2-11 and shows that survival at this temperature range for Block 1 embryos was 86% to 92%. Since temperatures decreased gradually during this period, the midpoint of this range, 89%, is considered as the survival rate for this reference location. Temperatures at TD13-5, ranged between 2.5°C and 3.5°C during February and gradually increased in early March to reach 3.5°C by March 10 (Figure 5.2-3). Griffiths (1980) data (plotted on Figure 5.2-12) show that for Block 2 embryos, survival ranged between 97% and 99% (midpoint of 98%). The same data (Figure 5.2-12) show that at temperatures between 4°C and 5°C, survival ranged around 98%. Therefore, it is estimated that Block 2 embryo survival remains unaffected by the higher temperatures.

5.2.1.2 Location DN13-B
Temperatures at reference location DN13-B (Figure 5.2-10), located in deeper water (11 m) decreased from approximately 5°C around December 15 to approximately 3.5°C by January 1, 2012. Survival data from Griffiths (1980) is plotted on Figure 5.2-11 and shows that survival at this temperature range was 84% to 90% (midpoint 87%). Temperatures remained at around 3.5°C until January 17 when temperatures began to decrease to approximately 2.5°C followed by a slow increase to 3.5°C by February 5, 2012. Temperatures remained around 3.5°C until March 11, 2012. Based on these temperatures Block 1 embryos could experience a 2% decrease in survival (temperatures during the period from December 15 to January 1 were similar to those at TD35-12). Block 2 embryos are likely to be unaffected, since Block 2 survival data from Griffiths study (Figure 5.2-12) show that at temperatures around 4°C, survival ranged around 98%.

5.2.2 Monitoring Location TD35-12
Higher temperatures from mid-December would coincide with the Block 1 development period. Temperatures during this period at TD35-12 gradually decreased from approximately 5°C around December 15, to approximately 4°C by December 31 (Figure 5.2-3). Survival data from Griffiths (1980) is plotted on Figure 5.2-11 and shows that survival at 4°C-5°C ranged between 84% and 90% (survival data from Griffiths (1980) is provided in Table 5.3). Figure 5.2-1 shows that during this same period, bottom water temperatures at the reference location TD13-5 ranged from approximately 4.5°C on December 15 to 2.5°C on December 31. Figure 5.2-11 shows that survival of Block 1 embryos in this temperature range was 86% to 92%. Since temperatures and, therefore, survival rates occurred as ranges rather than discrete values, the midpoint for each survival range is calculated in order to facilitate the calculation of a predicted change in survival. Based on the above data, survival of Block 1 embryos is estimated at 87% (midpoint of 84% and 90%) at TD35-12, while survival at the reference location is estimated as 89% (midpoint of 86% and 92%). The data show that Block 1 embryos could have experienced a 2% decrease in survival at TD35-12 as a result of the warmer temperatures during late December.
The sustained temperatures above 3.5°C occurred at TD35-12 during February and March, which would coincide with Block 2 and 3 embryo development stages (Figure 5.2-3). Since temperatures increased the most at TD35-12, this location is considered to be the worst case.

The data indicate that at TD35-12, there could be a 2% reduction in survival of Block 1 embryos. Survival of Block 2 embryos would not be expected to be affected. Therefore, overall survival at TD35-12 is estimated to be 87%. Since this is well above the 75% that Griffiths (1980) estimated as the threshold below which the local population could be affected, the reduction is not likely to affect round whitefish populations in the local area.

5.2.3 Monitoring Locations DN10-B, DN17-B, DN18-B, TD55-B, DN05-B, DN07-B, and DN08-B

Temperatures at DN10-B (Figure 5.2-2), located in the nearshore within the Mixing Zone, and locations DN17-B (Figure 5.2-5), DN18-B (Figure 5.2.4) and TD55-B (Figure 5.2-6) (located within the Mixing Zone) and at DN05-B (Figure 5.2-7), DN07-B (Figure 5.2-8), and DN08-B (Figure 5.2-9) (all located in the offshore outside of the Mixing Zone) showed similar temperatures and, as such, are considered together. Temperatures at these locations decreased from approximately 5°C around December 15 to approximately 3.5°C by January 1, 2012. Temperatures remained at around 3.5°C until January 17 when temperatures began to decrease to approximately 2.5°C followed by a slow increase to 3.5°C by February 5, 2012. Temperatures remained around 3.5°C until March 11, 2012. Based on these temperatures the following estimates are made:

- Block 1 embryos could experience a 2% decrease in survival (temperatures during the period from December 15 to January 1 were similar to those at TD35-12);
- Block 2 embryos are likely to be unaffected; and

Therefore, overall survival of round whitefish embryos at these locations is predicted to decrease by a maximum of 2% compared to the most conservative reference location.

5.2.4 Summary

The potential changes in embryo survival, based on the 7-day rolling average temperatures are summarized in the table below. Since survival at the reference locations ranged between 87% at DN13-B, the deeper location, and 89% at TD13-5, the shallower, nearshore location, a conservative approach is taken and the maximum change in embryo survival, relative to location TD13-5, is presented in Table 5.4. It should be noted that relative to the deeper reference location, DN13-B, there is no change in survival.

The above summary shows that there were no effects on embryo survival due to operation of the DNGS diffuser, relative to conditions at reference locations, and that temperatures at all locations resulted in a 2% predicted reduction in survival of Block 1 embryos relative to the shallow reference location TD13-5, and a negligible change relative to the deeper reference location DN13-B. However, survival at 87% was well above the 75% benchmark below which adverse effects on the local population could occur as suggested by Griffiths (1980). The temperature data for the deeper offshore areas, including both the reference area and the offshore locations outside of the Mixing Zone indicate that the deeper offshore areas in general experienced slightly higher temperatures in December 2011 than shallower nearshore areas, and suggest that the deeper areas cooled down more slowly in the fall than the shallower nearshore area.
The data show the extent of effects on Figures 4-1 through 4-4.

### Table 5.4: Summary of Changes in Survival Relative to the 3.5°C Benchmark

<table>
<thead>
<tr>
<th>Location</th>
<th>Block 1 Survival (%)</th>
<th>Maximum Change from Reference (%)</th>
<th>Block 2 Survival (%)</th>
<th>Maximum Change from Reference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Offshore Within Mixing Zone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD35-12</td>
<td>87</td>
<td>2</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN17-B</td>
<td>87</td>
<td>2</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN18-B</td>
<td>87</td>
<td>2</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>TD55-B</td>
<td>87</td>
<td>2</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td><strong>Offshore Outside Mixing Zone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN05-B</td>
<td>87</td>
<td>2</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN07-B</td>
<td>87</td>
<td>2</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN08-B</td>
<td>87</td>
<td>2</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td><strong>Nearshore Within Mixing Zone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN10-B</td>
<td>87</td>
<td>2</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td><strong>Reference Locations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN-13-B</td>
<td>87</td>
<td>2</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
</tbody>
</table>

**Notes:**
N.C. = no change

#### 5.3 Hourly Average Temperatures

In this section, the hourly average temperatures are considered in order to determine whether there are short term increases (i.e., acute exposures) in temperatures that could adversely affect embryo development.

The hourly average temperatures, calculated from the 15-minute temperature data, are shown on Figures 5.3-1 to 5.3-5. Since short term exceedances would occur for only limited time periods, the 5°C benchmark is used for this assessment. The 5°C benchmark is a conservative value that represents the upper range for embryo development, as defined by Griffiths (1980), and Wismer and Christie (1987). The data show that temperatures exceeded the 5°C benchmark at a limited number of locations on one or more occasions during the period of January to March 2012:

- Nearshore within the Mixing Zone (DN10-B, Figure 5.3-2 and Table C-2 in Attachment C);
- Offshore within the Mixing Zone (TD35-12, DN18-B, TD55-B, TD34-B, TD45-B, and DN17-B, Figure 5.3-3 and Table C-2 in Attachment C);
- Offshore outside of the Mixing Zone (DN05-B, DN06-B, DN07-B, DN08-B, and DN09-B, Figure 5.3-5 and Table C-2 in Attachment C); and
- Reference Location (DN13-B, Figure 5.3-1 and Table C-2 in Attachment C).

In general the data show that from December 2011 to mid-March 2012 bottom water temperatures were slightly cooler than average conditions at the shallow water reference locations (TD13-5 and DN15-5) (Figure 5.2-1) and...
slightly warmer than average at the deeper water reference locations (DN12-B, DN13-B and DN14-B) (Figure 5.3-1).

Table C-2 in Attachment C provides details on locations where temperature exceedances of 5°C occurred and also provides the maximum temperature reached during each event and the duration for which temperatures were at or above 5°C.

The approach used to assess the effects on embryo development is based on the following steps:

- The total hours for which temperatures at or above 5°C occurred and the maximum temperatures reached are calculated on a monthly basis from the data in Table C-2 in Attachment C:

- The total period of time within each developmental block during which Griffiths exposed the embryos to the higher temperature pulses (up to 6.6°C) is calculated as a percentage of the entire development period for that developmental block. This works out to a standard 25% (based on Griffiths' exposures of 6 hours every 24 hours under 4°C to 7°C temperature increases), and continuous exposure which works out to 100% (based on Griffiths’ data for continuous exposure to 7°C).

- The percentage of time that temperatures exceeded 5°C at each monitoring location relative to the total developmental time for each block is calculated. This provides the percentage of the time during which developing embryos in each block were subjected to temperatures at or above 5°C;

- Griffiths (1980) data show that survival is affected by both the maximum temperature attained as well as the percentage of time over which this temperature occurred. Therefore, survival at a daily temperature increase for 6 hours from a base temperature of 3.9 °C to 6.6°C is calculated from Griffiths’ data for each developmental block. Similarly survival at a sustained temperature of 6.6 °C (nominally 7°C as reported by Griffiths) is calculated for each developmental block. These data are used to produce graphs that provide the basis for estimating embryo survival under the actual exposure periods that occurred at each location, and for each developmental block. The relationship between embryo survival at a nominal temperature of 7°C over different exposure periods for Block 1 and Block 2 embryos is shown on Figures 5.3-6 and 5.3-7.;

- Changes in survival are then estimated from these data plots based on the actual hours of exposure at each monitoring location for each developmental block. From this plot, the expected survival is determined based on the percentage of time during which temperatures above 5°C were recorded.

- Figures 5.2-1 to 5.2-10 showed that temperatures from mid-December to early January ranged between 5°C and 2.5°C at the reference locations TD13-5 and DN13-B. The midpoint of this range is calculated as 3.75°C. Therefore, for Block 1 embryo development, the changes in embryo survival are assessed against the data provided by Griffiths (1980) for survival at a sustained temperature of 3.9°C.

The following sections focus on potential effects on Block 1 and Block 2 embryo development stages. An assessment of the potential effects on Block 3 embryo development could not be completed, since temperature data were only available until mid-March. Since Block 3 embryo development would occur into late April, a complete dataset upon which to base the assessment was not available.
5.3.1 Nearshore Within Mixing Zone

5.3.1.1 Monitoring Location DN10-B

Location DN10-B was the only location in the nearshore within the Mixing Zone where temperatures above 5°C were recorded. From December 15 to December 31, temperatures exceeded 5°C on ten days (17 separate events). The event of maximum duration began on December 15 and lasted for 63 hours during which time temperatures reached a maximum of 6.8°C (Table C-2 in Attachment C). During two other events (December 23 - 15 hours and December 25 - 17 hours), temperatures reached a maximum 6.20°C and 6.27°C, respectively. During five other events (December 18 - 13 hours, December 19 - 11 hours, December 22 - 10 hours, and December 28 - two separate events of 9 hours and 7 hours), temperatures ranged between 5°C and 6°C for more than 6 hours. In January there were five occurrences of temperatures reaching or slightly exceeding 5°C. Each occasion lasted only for one hour. In total, during the period of Block 1 embryo development, temperatures exceeded the 5°C benchmark for 178 hours or 30% of the time (based on a conservative estimate of the embryo development period of 25 days).

Griffiths (1980) increased temperatures to which developing embryos were exposed on a daily basis for 6 hours each day during his experiments. Therefore, over the 25-day Block 1 embryo development stage, he would have exposed Block 1 embryos to higher temperatures for 25% of the time. Griffiths noted that exposing Block 1 embryos to pulses of temperatures of 6.8°C decreased survival to 86.6% compared to 93.5% survival at the base temperature of 1.7°C (Table 5.2). At sustained temperatures of 6.6°C, survival of Block 1 embryos decreased to 74.82%. Extrapolating from these data, temperature pulses that occurred 30% of the time are expected to result in 85.8% survival (interpolated from Figure 5.3-6). This represents a 4.7% reduction in survival over sustained temperatures of 3.9°C. (As noted in Section 5.2.1, temperatures at the reference location TD13-5 ranged between 4.5°C and 2.5°C (median 3.5°C) during the period of Block 1 development. Therefore, the change in survival at DN10-B is assessed relative to the predicted survival of 90.5% at 3.9°C at the reference location).

Temperatures above 5°C (none exceeded 6°C) during February occurred on 14 separate occasions (Table C-2 in Attachment C). The longest duration was for 8 hours on February 6, while the remaining exposures were all 3 hours or less. In total, temperatures above 5°C were recorded for 35 hours. Temperatures between 5°C and 6°C occurred on seven occasions in March and lasted for a total of 47 hours. Assuming that development times are reduced due to the warmer temperatures, the February data are taken as coinciding with the Block 2 development period and March data are taken as coinciding with the Block 3 development period. Therefore, conservatively assuming that Block 2 embryos would be exposed for 46 days (since base temperatures at this location ranged around 3.5°C and 4°C, the development time developed by Griffiths for the 7°C exposure from a base temperature of 4°C exposure is used in the calculation), exposure to higher temperatures for 35 hours would represent exposure over 3% of the total development time for this developmental stage. This would result in a negligible decrease in survival. As a result, no decrease in survival is expected to occur for Block 2 embryos.

5.3.2 Offshore Within Mixing Zone

5.3.2.1 Monitoring Location TD35-12

Temperatures at TD35-12 exceeded 5°C on 14 separate occasions between December 15 and January 9 (Table C-2 in Attachment C). These included three extended periods of time during which temperatures exceeded 5°C: December 15 for 32 hours, December 22 for 25 hours, and December 24 for 16 hours. In total, temperatures above 5°C were recorded for 118 hours and the maximum temperature reached was 5.8°C. Therefore, during
Block 1 embryo development, temperatures between 5°C and 6°C occurred during 20% of the embryo development period.

Griffiths exposed Block 1 embryos to temperature increases up to 6.6°C from a base temperature of 3.9°C for 25% of the time (6 hours daily for 25 to 31 days) and observed a decrease in survival from 90.3% at sustained temperatures of 3.9°C to 85.58%. Interpolating from Figure 5.3-6, the expected survival at this temperature regime would be approximately 87.5%, or a decrease of 2.8%.

Temperatures at TD35-12 again increased to above 5°C beginning around February 2, 2012 and frequent exceedances occurred through to March 12, 2012. Since ambient temperatures in the area ranged between 3°C and 4°C, the shorter development time of 46 days for Block 2 embryos is assumed as the base case. Therefore, the temperature exceedances that occurred before February 25 are considered to all have occurred during Block 2 embryo development while the increases that occurred between February 25 and March 12 are considered to have occurred during Block 3 embryo development.

During Block 2, the majority of temperatures above 5°C were below 6°C. However, temperatures above 6°C were reported on four occasions: on February 6, a maximum temperature of 7.2°C was attained; on February 10, a maximum temperature of 6.3°C was attained; on February 14, a maximum temperature of 6.9°C was attained; and on February 22, a maximum temperature of 7.3°C was attained. Temperature exceedances above 5°C occurred over a total of 126 hours during Block 2 embryo development, or 11% of the time. The data from Griffiths shows that embryo survival at constant exposure to 6.6°C resulted in a decrease in survival of Block 2 embryos to 97.2% from 98.4% at a constant temperature of 3.9°C. Interpolating from Figure 5.2-12, embryo survival at the maximum temperature recorded during 2012 would be expected to be approximately 90%. However, since temperature increases above 7°C occurred only on three occasions and for a total period of less than 32 hours, it is not reasonable to estimate exposure based on the maximum temperatures attained. Thus, survival is based on the 6.6°C data provided by Griffiths.

Since the total period over which temperatures were above 5°C was 126 hours or 11% of the embryo development period, this is less than the exposures used by Griffiths, that resulted in a 1.2% decrease in survival. Interpolating from Figure 5.3-7, the effects on survival are likely to be a 0.15% reduction.

Temperature increases from February 25 to March 12 would coincide with the expected Block 3 development period. However, data are available for only 15 days, whereas embryo development at this stage would be expected to take 46 days. Therefore, there is insufficient data at this time to predict effects on Block 3 embryos.

In conclusion, Block 1 embryos could experience up to a 2.8% decrease in survival while Block 2 embryos could experience a 0.15 % reduction in survival as a result of periodic temperature increases above 5°C.

5.3.2.2 Monitoring Location TD34-B

Temperatures at TD34-B exceeded the 5°C benchmark on a single occasion: February 2, 2012 (Table C-2 in Attachment C). The maximum temperature reached was 5.08°C and the duration was one hour. Based on this exceedance, there is no anticipated change in embryo survival.
5.3.2.3 Monitoring Location TD55-B

Temperatures at TD55-B exceeded 5°C on 16 occasions during the Block 1 embryo development period of December 15 to January 9 (Table C-2 in Attachment C). During this period the majority of temperature increases ranged between 5°C and 6°C, though temperatures ranged above 6°C on two occasions: December 15 (maximum temperature of 6.5°C) and December 25 (maximum temperature of 6.2°C). The total time that temperatures exceeded 5°C was 81 hours or 13.5% of the time. Therefore, total exposure to higher temperatures during Block 1 development was less than the 25% of embryo development assessed by Griffiths that resulted in a decrease in survival of 4.7% (from 90.3% at sustained temperatures of 3.9°C to 85.6% at daily pulses from 3.9°C to 6.6°C). Interpolating from Figure 5.3-6, the expected survival at the above exposures would be 89.5%, or a reduction of 0.77%.

Temperatures above 5°C during Block 2 embryo development occurred on four occasions between February 6 and February 24. Temperatures up to 5.44°C occurred for a total of 12 hours, with the longest exposure period lasting 6 hours. Since this represents <1% of total embryo development time in this stage, the effects on embryo survival would be negligible.

5.3.2.4 Monitoring Location DN17-B

Temperatures above 5°C occurred on 17 separate occasions during the Block 1 development period (Table C-2 in Attachment C). Temperatures ranged between 5°C and 6°C for the majority of time; however, on two occasions temperatures up to 6.22°C were reached. Temperatures above 5°C occurred for a total of 136 hours, or 23% of the time. Griffiths noted that Block 1 embryo survival decreased from 90.3% at a constant temperature of 3.9°C to 85.6% during daily pulses from 4°C to 7°C. Therefore, Block 1 embryo survival would be expected to decrease by 4.7% to 85.6% under the temperature regime observed during the period of December 15, 2011 to January 12, 2012.

Temperatures during the Block 2 embryo development period exceeded the 5°C benchmark on five occasions and reached a maximum temperature of 5.21°C. The longest period of increased temperatures was four hours. Therefore, the effects on embryo development are considered to be negligible.

5.3.2.5 Monitoring Location DN18-B

Temperatures above 5°C occurred on 16 occasions between December 15 and January 9 (Table C-2 in Attachment C). Temperatures reached a maximum of 6.9°C and the total time during which temperatures exceeded 5°C was 193 hours, or 32% of the time. From Figure 5.3-6, the expected survival of Block 1 embryos under this exposure is estimated to be 85.5%, which is a decrease of 4.8% from the 90.3% survival Griffiths observed at sustained temperatures of 3.9°C.

Temperatures above 5°C during Block 2 embryo development occurred on 18 occasions between January 10 and February 25, 2012. Temperatures during this period ranged between 5°C and 6°C, with a maximum temperature of 5.7°C. Temperatures above 5°C were recorded for a total of 31 hours, or 2.8% of the total development time of 46 days. As a result, decreased survival resulting from these exposures is expected to be negligible.
5.3.2.6 Monitoring Location TD45-B

Temperatures at TD45-B exceeded 5°C on two occasions in December. The maximum temperature reached was 5.47°C and the maximum duration was 36 hours. One sustained temperature increase was observed for 32 of these 36 hours. (Table C-2 in Attachment C). These increases occurred during the period when Block 1 embryos would likely be present. Based on an embryo development period of 26 days (at a sustained temperature of 3.9°C), this represents 5.7% of the total embryo development time. Interpolating from Figure 5.3-6, the expected embryo survival is estimated to be 89.7%, which represents a decrease of 0.6%

One additional exceedance occurred on March 14, 2012, when a maximum temperature of 5.08°C was reached. However, a complete dataset is not available at this time to assess effects on Block 3 embryo development.

5.3.3 Offshore Outside Mixing Zone

5.3.3.1 Monitoring Location DN05-B

Temperatures above 5°C occurred on 14 occasions during Block 1 embryo development (Table C-2 in Attachment C). The majority of temperature increases were between 5°C and 6°C; however, temperatures above 6°C (maximum 6.4°C) were attained on two occasions. Temperatures exceeded 5°C for a total of 90 hours, or 15% of the time. Interpolating from Figure 5.3-6, the estimated survival under this temperature regime would be 88.2%. Compared to survival of 90.3% based on Griffiths exposure to sustained temperatures of 3.9°C, a reduction in survival of 2.1% could be expected for Block 1 embryos.

During Block 2 development, temperatures above 5°C (maximum temperature of 5.41°C) occurred on 3 occasions with a total exposure time of 11 hours. This is negligible relative to total development time (<1%) and effects on embryo development are considered to be negligible.

5.3.3.2 Monitoring Location DN06-B

Temperatures above 5°C occurred on 2 occasions during Block 1 embryo development (Table C-2 in Attachment C). The temperature increases were between 5°C and 6°C; and exceeded 5°C for a total of 37 hours, or 6% of the time. Interpolating from Figure 5.3-6, the estimated survival under this temperature regime would be 89.8%. Compared to survival of 90.3% based on Griffiths exposure to sustained temperatures of 3.9°C, a reduction in survival of 0.5% could be expected for Block 1 embryos.

During Block 2 development, temperatures did not exceed 5°C and no effects on embryo development are expected in Block 2.

5.3.3.3 Monitoring Location DN07-B

Temperatures above 5°C occurred on 13 occasions during Block 1 embryo development (Table C-2 in Attachment C). The majority of temperature increases were between 5°C and 6°C; however, temperatures above 6°C (maximum 6.4°C) were attained on two occasions. Temperatures exceeded 5°C for a total of 85 hours, or 14% of the time. Interpolating from Figure 5.3-6, the estimated survival under this temperature regime would be 88.3%. Compared to a survival of 90.3% based on Griffiths exposure to sustained temperatures of 3.9°C, a reduction in survival of 2.0% could be expected for Block 1 embryos.
During Block 2 development, temperatures above 5°C (maximum 5.1°C) occurred on one occasion, for a total exposure time of one hour. This is negligible relative to total development time and effects on embryo development are considered to be negligible.

Effects on Block 3 embryos could not be estimated due to lack of data for this period.

5.3.3.4 Monitoring Location DN08-B

Temperatures above 5°C occurred on six occasions during Block 1 embryo development (Table C-2 in Attachment C). The temperature increases ranged between 5°C and 6°C (maximum temperature of 5.94°C). Temperatures exceeded 5°C for a total of 64 hours, or 11% of the time. Interpolating from Figure 5.3-6, the estimated survival under this temperature regime would be 89.1%. Compared to a survival of 90.3% based on Griffiths exposure to sustained temperatures of 3.9°C, a reduction in survival of 1.2% could be expected for Block 1 embryos.

During Block 2 development, temperatures above 5°C (maximum temperature of 5.48°C) occurred on three occasions, for a total exposure time of six hours. This is negligible relative to total development time (<1%) and effects on embryo development are considered to be negligible.

Effects on Block 3 embryos could not be estimated due to lack of data for this period.

5.3.3.5 Monitoring Location DN09-B

Temperatures above 5°C occurred on 16 occasions during Block 1 embryo development (Table C-2 in Attachment C). The temperature increases ranged between 5°C and 6°C (maximum temperature of 5.91°C). Temperatures exceeded 5°C for a total of 78 hours, or 13% of the time. Interpolating from Figure 5.3-6, the estimated survival under this temperature regime would be 88.5%. Compared to a survival of 90.3% based on Griffiths exposure to sustained temperatures of 3.9°C, a reduction in survival of 1.8% could be expected for Block 1 embryos.

Temperatures did not exceed the 5°C benchmark during Block 2 development.

There is insufficient data to assess effects on Block 3 development.

5.3.4 Reference Locations

5.3.4.1 Monitoring Location DN13-B

Temperatures at DN13-B exceeded 5°C on four occasions in December 2011 (Table C-2 in Attachment C). The maximum temperature attained on December 16 was 6.18°C, while temperatures were below 6°C on the remaining three occasions. The duration ranged from eight hours on December 19 to 20 hours on December 16. Total duration of temperatures above 5°C was 55 hours. This represents 9% of total Block 1 embryo development time. Interpolating from Figure 5.3-6, survival is estimated as 89.1%, or a 1.2% decrease.

A single temperature exceedance of 5°C (maximum temperature of 5.23°C) occurred on February 6, 2012, with a total duration of one hour. The effects on embryo survival are considered negligible.
5.3.5 Summary

Potential effects from short-term exposures to temperatures above 5°C are summarized in the Table 5.5. Changes are assessed as decreases in survival from the base case of exposure to sustained temperatures of 3.9°C.

These data indicate that the effects of bottom water temperatures above 5°C during December 2011 to March 2012 primarily occur during December, and would affect Block 1 embryo development. The greatest impact was noted at DN18-B, an offshore location within the Mixing Zone. Reductions in survival of approximately 5% occurred at locations within the Mixing Zone, offshore of the end of the diffuser (DN17-B and DN18-B, Figure 1-1).

The reductions in survival in all cases resulted in a predicted survival rate above 80%, which is well above the 75% benchmark below which Griffiths indicates there could be effects on the local population.

Table 5.5 shows that the greatest potential effect on Block 1 embryo survival occurred at station DN10-B, in the nearshore area within the Mixing Zone, and at DN17-B and DN18-B, two locations offshore within the Mixing Zone. The predicted effects are mainly due to the slower temperature decrease in December that resulted in longer exposures to temperatures above 5°C in December. The late January temperature increase that was observed at all stations did not result in a decrease in survival of Block 2 embryos, since temperatures above 5°C did not occur for sustained periods. At the remaining locations within the Mixing Zone (i.e., TD35-12, TD55-B and TD45-B) the changes were minimal (2.8% at TD35-12 and <1% at TD55-B and TD45-B). Despite these minor decreases in survival, overall survival during Block 1 and Block 2 embryo development remained above 85%, and were well above the 75% benchmark developed by Griffiths.

At the offshore locations outside of the Mixing Zone, the decrease in survival was 2% or less, and decreases were confined to Block 1 embryos. Predicted survival remained above 88% at all locations, and no measureable effect is likely on round whitefish populations. The data show that temperature incursions above 5°C also occurred at one of the reference locations (DN13-B), and that temperature increases were not confined to the area around the diffuser, but occurred generally as a result of the unusually warm winter. The main effects of the warmer winter appeared to be an increase in the number of occasions when temperatures exceeded 5°C at the deeper reference location and at the deeper offshore locations inside and outside of the Mixing Zone during late fall (December) as water temperatures cooled more slowly at the deeper locations. The warmer temperatures in February and March also resulted in occasional temperature exceedances of 5°C at all of the deeper locations, including the reference location (DN13-B), as well as a number of the offshore locations outside of the Mixing Zone and suggest that this phenomenon was not confined to the area around the diffuser but occurred broadly as a result of the unusual weather conditions.

The data show that even under much warmer than average conditions, there was no significant change in embryo survival during Block 1 and Block 2 embryo development at those locations most affected by temperature increases. Since changes in Block 1 embryo survival also occurred at the deeper reference location (DN13-B) due to the general climatic conditions and not the operation of the DNGS diffuser, the changes in survival at locations both within and outside of the Mixing Zone should be considered relative to the 1.2% decrease in survival of Block 1 embryos at DN13-B. Considered in this context, the incremental changes in survival of Block 1 embryos both inside and outside the Mixing Zones are likely to have a negligible effect on the local population.
Table 5.5: Summary of Changes in Survival Due to Exposures Above 5°C

<table>
<thead>
<tr>
<th>Location</th>
<th>Block 1 Survival (%)</th>
<th>Change from Base Temperature of 3.9°C (%)</th>
<th>Block 2 Survival (%)</th>
<th>Change from Base Temperature of 3.9°C (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offshore Within Mixing Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD35-12</td>
<td>87.5</td>
<td>2.8</td>
<td>98.25</td>
<td>0.15</td>
</tr>
<tr>
<td>TD55-B</td>
<td>89.5</td>
<td>0.8</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN17-B</td>
<td>85.6</td>
<td>4.7</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN18-B</td>
<td>85.5</td>
<td>4.8</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>TD45-B</td>
<td>89.7</td>
<td>0.5</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>Offshore Outside of Mixing Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN05-B</td>
<td>88.2</td>
<td>2.1</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN06-B</td>
<td>89.8</td>
<td>0.5</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN07-B</td>
<td>88.3</td>
<td>2.0</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN08-B</td>
<td>89.1</td>
<td>1.2</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>DN09-B</td>
<td>88.5</td>
<td>1.8</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>Nearshore Within Mixing Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN10-B</td>
<td>85.8</td>
<td>4.7</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
<tr>
<td>Reference Locations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN13-B</td>
<td>89.1</td>
<td>1.2</td>
<td>N.C.</td>
<td>N.C.</td>
</tr>
</tbody>
</table>

Notes:
N.C. = no change

5.3.6 Comparison to January – March 2011 Results

The result of the current assessment of hourly average temperature effects are compared to the results of the assessment reported by Golder (2012a and 2012b) for the period January to March 2011. As noted in Golder (2012a) and Section 2.1 above, the winter of 2011 (January to April) was slightly cooler than average (approximately 0.3°C cooler than the long-term average temperature for the period of January to April based on a meteorological dataset collected from 1940 to 2011) and, as such, is not a suitable basis for predicting effects under long term climate change under which bottom water temperatures could increase. Therefore, the degree and extent of potential effects predicted under average years as reported by Golder (2012a and 2012b), is compared with the predicted effects in a much warmer than average year as reported in this assessment.

The potential effects of hourly average temperature that exceeded the 5°C benchmark on developing embryos of round whitefish during the January to March period of 2011 were limited to location TD35-12. The hourly average temperature exceedances were limited to 8 occasions between February 5, 2011 and March 3, 2011 that lasted for a total of 25 hours. Therefore, the temperature exceedances would coincide with Block 2 embryo development. The 25 hours represents 2.3% of the total development time for this developmental Block, and therefore the expected decrease in embryo survival is less <1%. (Data for developmental Block1 were not available for 2011).

The data for January-March 2012, similarly show that there is no expected effect on Block 2 embryos, despite the higher temperatures that occurred not only at TD35-12, but also a number of locations inside and outside the
Mixing Zone. Therefore, the much warmer temperatures experienced during the January to March 2012 period, did not have a measurable effect on round whitefish Block 2 embryo survival.

5.4 Conclusions
Temperature effects during the period December 2011 to March 2012 were assessed with respect to the 3.5°C benchmark for the 7-day rolling average temperatures and against the 5°C benchmark for the hourly average temperatures.

As noted in Section 2.0, air and water temperatures during this period were warmer than average due to an unusually mild winter. While the average monthly air temperatures recorded between December 2011 and February 2012 were not necessarily the warmest on record, the average temperatures for January to February 2012 and December to March 2012 suggest that the winter of 2011-2012 was the warmest on record. The ambient water temperatures were typically above the historical range for the period of December 2011 through March 2012. Based on the data, the ambient water temperatures observed during the winter of 2011-2012 were the warmest recorded in the Darlington Nuclear study area. Nonetheless, the higher temperatures in bottom waters did not result in a significant decrease in embryo survival. The major changes observed were:

- Relative to reference conditions, temperatures decreased more slowly in some locations in December such that Block 1 embryos could have experienced warmer temperatures than normal. The localized areas affected included the end of the diffuser (TD35-12) and deeper, offshore areas within the diffuser Mixing Zone (TD55-B, DN17-B and DN18-B) and the deep reference location (DN13-B). The slightly warmer temperatures at these locations resulted in a maximum predicted 2% decrease in survival to 87% under the 7-day rolling average temperatures and up to a 4.8% predicted decrease in survival to 85.5% under the hourly maximum temperatures. Survival remained well above the 75% benchmark below which effects on local population may occur.

- The 7-day rolling average temperatures increased in late January/early February at some locations to between 3.5°C and 4°C and remained elevated throughout the monitoring period, which ended in mid-March 2012. The higher temperatures affected locations at the end of the diffuser (TD35-12) and offshore locations within the Mixing Zone (DN17-B and TD55-B). The slightly warmer temperatures at these locations resulted in a predicted negligible decrease in survival under the 7-day rolling average temperatures.

- The 7-day rolling average temperatures increased at some offshore locations outside of the Mixing Zone to around 3.5°C as compared to average conditions. Temperatures decreased more slowly during December, and increased to approximately 3.5°C in February and March. The predicted maximum decrease in survival of Block 1 embryos was 2%, from 89% to 87%. Survival remained well above the 75% benchmark below which effects on local populations may occur.

- Hourly average temperatures at one nearshore location within the Mixing Zone (DN10-B) and two offshore locations in the Mixing Zone (DN17-B and DN18-B) resulted in a predicted 4.7% to 4.8% decrease in Block 1 embryo survival. Predicted survival was 85.5%, which is well above the 75% survival benchmark below which effects on local populations may occur.

- The hourly average temperatures at remaining locations inside the Mixing Zone (locations TD35-12, TD55-B and TD45-B) during Block 1 embryo development (i.e., mid-December 2011 to early January 2012) were
higher than at reference locations and resulted in a predicted decrease in survival to 87.5% at TD35-12, located at the end of the diffuser. The remaining locations had predicted survival rate of greater than 89%.

- Block 2 embryo development was not significantly affected by the higher temperatures in February and March. Survival was predicted to decrease by 0.15% (to 98.25%) at only one location, TD35-12. Negligible effects on survival were predicted at the remaining locations. Survival remained well above the 75% benchmark below which effects on local populations may occur.

- Hourly average temperatures at some offshore locations outside of the Mixing Zone resulted in a predicted decrease in survival of Block 1 embryos of up to a 2%. The lowest predicted survival at these locations was 88.2%. There was no predicted change in Block 2 embryo survival. Survival remained well above the 75% benchmark below which effects on local populations may occur.

Since reduction in survival of embryos in each of the developmental Blocks ultimately depends on the survival rate in the previous developmental block, the effects from each developmental block would be additive. Therefore, the predicted survival rates of Block 1 along with the predicted survival rate for Block 2 embryos would determine the extent of effects on the local populations. The most pronounced temperature increases occurred in Block 1, and the worst-case exposure resulted in a predicted survival rate of 85.5% at DN18-B. The general predicted survival rate of Block 1 embryos at the remaining affected locations within the Mixing Zone and outside of the Mixing Zone was >85%. The negligible effects of temperature increases on Block 2 embryo survival did not decrease the survival rate at any of the locations.

Therefore, the effects of temperature increases on the local population, even under unusually warm winter conditions, are expected to be minor, and likely limited to small areas around the diffuser. The effects would likely not be measurable on the local populations and further confirms the conclusions of the EIS.
6.0 REFERENCES


SLC/GVA/RJ

\mis1-s-filesrv1\data\active\2010\1151\10-1151-0202 opg dngs - refurb. ea - clarington/phase 8000 thermal effects report\11may2012tm_dn_2ndwinter_final.docx
FIGURES
Ambient Water Temperature (°C) - Daily Average

- Historical Range (1984-1996)
- Historical Average (1984-1996)
- Winter 2010/2011
- Winter 2011/2012
Measured Temperature at Bottom for Offshore Locations Within Mixing Zone

Temperature Increase over Average at Bottom for Offshore Locations Within Mixing Zone

Ver. 1.0

FIGURE: 3-1
**Measured Temperature at Bottom for Offshore Locations Beyond Mixing Zone**

**Temperature Increase over Average at Bottom for Offshore Locations Beyond Mixing Zone**

### Project Details:
- **Title:** Measured Temperature at Bottom for Offshore Locations Beyond Mixing Zone
- **Period:** 2011/2012 Winter Period
- **Location:** Darlington NGS

### Diagram Details:
- **Figure:** 3-2
- **Scale:** 1:10,000
- **Project No.:** 10-1151-0202
- **Authors:** KD (30 Apr. 2012), SC (30 Apr. 2012)

### Temperature Data:
- **Locations:** DN05-B (15.3 m), DN06-B (11.3 m), DN07-B (18.5 m), DN08-B (13.8 m), DN09-B (18.5 m)
- **Temperature Criteria:**
  - **Below Average:** -3°C
  - **Below Average:** -2°C
  - **Below Average:** -1°C
  - **Below Average:** 0°C
  - **Below Average:** 1°C
  - **Below Average:** 2°C
  - **Below Average:** 3°C
  - **Below Average:** 4°C
  - **Below Average:** 5°C
  - **Below Average:** 6°C

### Graphs:
- **Graph 1:** Measured Temperature at Bottom for Offshore Locations Beyond Mixing Zone
- **Graph 2:** Temperature Increase over Average at Bottom for Offshore Locations Beyond Mixing Zone
Measured Temperature at Bottom for Nearshore Locations Within Mixing Zone

Temperature Increase over Average at Bottom for Nearshore Locations Within Mixing Zone
Measured Temperature at Bottom for Shallow Nearshore Locations

Temperature Increase over Average at Bottom for Shallow Nearshore Locations
Measured Temperature at Bottom for Reference Locations

Temperature Increase over Average at Bottom for Reference Locations
**NOTE**

The Mixing Zone depicted on this figure represents an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of the Mixing Zone.
The Mixing Zone depicted on this figure represents an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of the Mixing Zone.
Monitoring Locations

- 75th Percentile Temperature Increase Contours (°C)
- Estimated 75th Percentile Temperature Increase Contours (°C)
- Channel
- Diffuser
- Bathymetry (m)
- Mixing Zone *

Base Data - NRW NRVIS, obtained 2004, CANMAP v2005.4
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2006
Datum: NAD 83 Projection: UTM Zone 17N

NOTE
* The Mixing Zone depicted on this figure represents an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of the Mixing Zone.
Monitoring Locations

LEGEND

- Monitoring Locations
- 95th Percentile Temperature Increase Contours (°C)
- Channel
- Diffuser
- Bathymetry (m)
- Mixing Zone *

NOTE

* The Mixing Zone depicted on this figure represents an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of the Mixing Zone.

REFERENCE

Base Data - MNRF INKSS, obtained 2004. CANMAP v2005.4
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2006
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DNGS REFURBISHMENT AND CONTINUED OPERATIONS PROJECT
ENVIRONMENTAL ASSESSMENT

TITLE

MAXIMUM AREAL EXTENTS OF THERMAL PLUME NEAR THE LAKE BOTTOM
JANUARY 23, 2012 THROUGH MARCH 2012

VER. 1.0

G:\Projects\2010\10-1151-0202_Darlington_NGS_Refurbishment\GIS\MXDs\Draft\Thermal_Effects\fig_4-4_Plume_Maximum_Bottom_Jan2012-Mar2012.mxd
Monitoring Locations

- 75th Percentile Temperature Increase Contours (°C)
- Estimated 75th Percentile Temperature Increase Contours (°C)
- Channel
- Diffuser
- Bathymetry (m)
- Mixing Zone *

**NOTE**

*The Mixing Zone depicted on this figure represents an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of the Mixing Zone.*

**REFERENCE**

- Base Data: MNR NRVIS, obtained 2004, CANMAP v2005.4
- Produced by Golden Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2006
- Datum: NAD 83 Projection: UTM Zone 17N

**PROJECT**

DNGS REFURBISHMENT AND CONTINUED OPERATIONS PROJECT

ENVIRONMENTAL ASSESSMENT

**TITLE**

QUARTILE AREAL EXTENTS OF THE THERMAL PLUME NEAR THE LAKE BOTTOM

2 WINTER MONITORING PERIODS

**FIGURE:** 4-5

1:14,000 SCALE

January 23, 2011 through March 2011

January 23, 2012 through March 2012
**LEGEND**

- Monitoring Locations
- 95th Percentile Temperature Increase Contours (°C)
- Channel
- Diffuser
- Bathymetry (m)
- Mixing Zone

**NOTE**

*The Mixing Zone depicted on this figure represents an area around the diffuser that is used to verify the diffuser design through temperature monitoring data collected near the water surface at the locations shown within and at the edge of the Mixing Zone.*

---

**REFERENCE**

Base Data - MNR INFWS, obtained 2004. CANMAP v2005-4

Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queensa Printer 2006

Datum: NAD 83 Projection: UTM Zone 17N

**PROJECT**

DNGS REFURBISHMENT AND CONTINUED OPERATIONS PROJECT ENVIRONMENTAL ASSESSMENT

**TITLE**

MAXIMUM AREAL EXTENTS OF THE THERMAL PLUME NEAR THE LAKE BOTTOM 2 WINTER MONITORING PERIODS

**FIGURE:** 4-6

---

**First Winter Monitoring Period:**
January 23, 2011 through March 2011

**Second Winter Monitoring Period:**
January 23, 2012 through March 2012
TIME REQUIRED FOR COMPLETE HATCH

Mean Temperature (°C) vs. Time Required (Days)
Temperature (°C)

TD35-12

3.5°C Criteria

7-DAY ROLLING AVERAGE
TEMPERATURE: TD35-12

F-20 of 36
Temperature (°C)

DN18-B

3.5°C Criteria

PROJECT
DNGS Refurbishment and Continued Operations Project
Environmental Assessment

TITLE
7-DAY ROLLING AVERAGE TEMPERATURE: DN18-B

F-21 of 36
Temperature (°C)

G:\Projects\2010\10-1151-0202_Darlington_NGS_Refurbishment\GIS\MXDs\Draft\Thermal_Effects\fig_5.2-7_7-Day Rolling Average Temperature DN05-B.mxd

REV. 0

Mississauga, Ontario

DESIGN

CHECK

REVIEW

DNGS Refurbishment and Continued Operations Project
Environmental Assessment

7-DAY ROLLING AVERAGE TEMPERATURE: DN05-B

FIGURE: 5.2-7
MEASURED TEMPERATURE AT BOTTOM FOR NEARSHORE LOCATIONS WITHIN MIXING ZONE

DN10-B (10.0 m)  DN11-B (10.0 m)  TD38-B (9.5 m)  TD42-B (8.5 m)  TD52-B (10.5 m)  Average  Temperature Criteria
MEASURED TEMPERATURE AT BOTTOM FOR SHALLOW NEARSHORE LOCATIONS

FIGURE: 5.3-4

Scale: 1:10,000

PROJECT
DNGS REFURBISHMENT AND CONTINUED OPERATIONS PROJECT
ENVIRONMENTAL ASSESSMENT

MEASURED TEMPERATURE AT BOTTOM FOR SHALLOW NEARSHORE LOCATIONS

Temperature (ºC)

TD31-B (6.3 m)  DN01-B (5.5 m)  DN02-B (4.5 m)  DN03-B (5.0 m)  Average  Temperature Criteria
MEASURED TEMPERATURE AT BOTTOM FOR OFFSHORE LOCATIONS BEYOND MIXING ZONE

G:\Projects\2010\10-1151-0202_Darlington_NGS_Refurbishment\GIS\MXDs\Draft\Thermal_Effects\fig_5.3-5_Measured Temperature at Bottom for Offshore Locations Beyond Mixing Zone.mxd
ATTACHMENT A

MEASURED TEMPERATURE DATA TIME SERIES
PLOTS: NOVEMBER 1, 2011 THROUGH MARCH, 2012
MEASURED TEMPERATURE AT LOCATION: ADCP

Temperature (°C)

ADCP (10 Minute Data)
MEASURED TEMPERATURE AT LOCATION: CM01

CM01-15 (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: CM29

Temperature (°C)

CM29-17 (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D1

Temperature (°C)

TD05-1 (15 Minute Data)
TD13-5 (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D3

Temperature (°C)

TD50-1 (15 Minute Data)  TD51-5 (15 Minute Data)  TD52-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D4

Temperature (°C)

TD53-1 (15 Minute Data)  TD54-5 (15 Minute Data)  TD55-B (15 Minute Data)  TD55-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D6

Temperature (°C)

TD43-1 (15 Minute Data)  TD43-1 QAQC (15 Minute Data)  TD44-5 (15 Minute Data)  TD45-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D7

Temperature (°C)
MEASURED TEMPERATURE AT LOCATION: D8

Temperature (°C)

TD26-1 (15 Minute Data)  TD27-5 (15 Minute Data)  TD28-8 (15 Minute Data)  TD38-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D9

Temperature (°C)

TD22-1 (15 Minute Data)  TD24-5 (15 Minute Data)  TD25-8 (15 Minute Data)  TD35-12 (15 Minute Data)
MEASUREMENT TEMPERATURE AT LOCATION: D10

TD18-1 (15 Minute Data)  DN03-5 (15 Minute Data)  DN03-B (15 Minute Data)  DN03-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D11

Temperature (°C)

DN01-1 (15 Minute Data)  DN01-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D12

Temperature (°C)

DN02-1 (15 Minute Data)  DN02-B (15 Minute Data)

MEASURED TEMPERATURE AT LOCATION: D13

Temperature (°C)


DN04-1 (15 Minute Data)  DN04-B (15 Minute Data)  DN04-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D14

Temperature (°C)


DN05-1 (15 Minute Data)  DN05-5 (15 Minute Data)  DN05-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D15

Temperature (°C)

- DN06-1 (15 Minute Data)
- DN06-5 (15 Minute Data)
- DN06-B (15 Minute Data)
- DN06-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D16

Temperature (°C)

01-Nov-2011
16-Nov-2011
01-Dec-2011
16-Dec-2011
31-Dec-2011
15-Jan-2012
30-Jan-2012
14-Feb-2012
29-Feb-2012
15-Mar-2012
30-Mar-2012

DN07-1  (15 Minute Data)  DN07-5  (15 Minute Data)  DN07-10  (15 Minute Data)  DN07-B  (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D17

Temperature (°C)

DN08-1 (15 Minute Data)  DN08-5 (15 Minute Data)  DN08-10 (15 Minute Data)
DN08-B (15 Minute Data)  DN08-B QAQC (15 Minute Data)

MEASURED TEMPERATURE AT LOCATION: D18

Temperature (°C)

- DN09-1 (15 Minute Data)
- DN09-5 (15 Minute Data)
- DN09-10 (15 Minute Data)
- DN09-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D19

Temperature (°C)

DN10-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D20

Temperature (°C)


DN11-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D21

Temperature (°C)

DN12-1 (15 Minute Data)  DN12-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D22

Temperature (°C)

- DN13-1 (15 Minute Data)
- DN13-5 (15 Minute Data)
- DN13-B (15 Minute Data)
- DN13-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D23

Temperature (°C)

- DN14-1 (15 Minute Data)
- DN14-1 QAQC (15 Minute Data)
- DN14-5 (15 Minute Data)
- DN14-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D24

Temperature (°C)

- DN15-1 (15 Minute Data)
- DN15-5 (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D25

- DN17-1 (15 Minute Data)
- DN17-5 (15 Minute Data)
- DN17-10 (15 Minute Data)
- DN17-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D26

Temperature (°C)

DN18-1 (15 Minute Data)  DN18-5 (15 Minute Data)  DN18-10 (15 Minute Data)  DN18-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: PG1

Temperature (°C)

PG1-1 (15 Minute Data)  PG1-5 (15 Minute Data)  PG1-B (15 Minute Data)
ATTACHMENT B

7-DAY ROLLING AVERAGE TEMPERATURE PLOTS: NOVEMBER 1, 2011 THROUGH MARCH, 2012
7 DAY ROLLING AVERAGE TEMPERATURE: ADCP
7 DAY ROLLING AVERAGE TEMPERATURE: CM01

Temperature (°C)

CM01-15
7 DAY ROLLING AVERAGE TEMPERATURE: D1

Temperature (°C)

TD05-1
TD13-5

01-Nov-2011
16-Nov-2011
01-Dec-2011
16-Dec-2011
31-Dec-2011
15-Jan-2012
30-Jan-2012
14-Feb-2012
29-Feb-2012
15-Mar-2012
30-Mar-2012
7 DAY ROLLING AVERAGE TEMPERATURE: D2

Temperature (°C)

01-Nov-2011
01-Dec-2011
16-Dec-2011
31-Dec-2011
15-Jan-2012
16-Jan-2012
30-Jan-2012
14-Feb-2012
29-Feb-2012
15-Mar-2012
30-Mar-2012
7 DAY ROLLING AVERAGE TEMPERATURE: D3

Temperature (°C)

TD50-1  TD51-5  TD52-B

7 DAY ROLLING AVERAGE TEMPERATURE: D4

Temperature (°C)

TD53-1
TD54-5
TD55-B
TD55-B QAQC

01-Nov-2011
16-Nov-2011
01-Dec-2011
16-Dec-2011
31-Dec-2011
15-Jan-2012
30-Jan-2012
14-Feb-2012
29-Feb-2012
15-Mar-2012
30-Mar-2012
7 DAY ROLLING AVERAGE TEMPERATURE: D8

Temperature (°C)

TD26-1  TD27-5  TD28-8  TD38-B

7 DAY ROLLING AVERAGE TEMPERATURE: D9

Temperature (°C)

TD22-1  TD24-5  TD25-8  TD35-12

7 DAY ROLLING AVERAGE TEMPERATURE: D11

Temperature (°C)

- DN01-1
- DN01-B

01-Nov-2011 to 30-Mar-2012
7 DAY ROLLING AVERAGE TEMPERATURE: D12

- Temperature (°C)
- 7 DAY ROLLING AVERAGE TEMPERATURE: D12
- Data from 01-Nov-2011 to 30-Mar-2012
- Graph showing temperature trends over the specified period
- Lines indicating DN02-1 and DN02-B temperatures
7 DAY ROLLING AVERAGE TEMPERATURE: D13

Temperature (°C)

DN04-1
DN04-B
DN04-B QAQC

01-Nov-2011
16-Nov-2011
01-Dec-2011
16-Dec-2011
31-Dec-2011
15-Jan-2012
30-Jan-2012
14-Feb-2012
29-Feb-2012
15-Mar-2012
30-Mar-2012
7 DAY ROLLING AVERAGE TEMPERATURE: D17
7 DAY ROLLING AVERAGE TEMPERATURE: D20

Temperature (°C)

DN11-B

01-Nov-2011
16-Nov-2011
01-Dec-2011
16-Dec-2011
31-Dec-2011
15-Jan-2012
30-Jan-2012
14-Feb-2012
29-Feb-2012
15-Mar-2012
30-Mar-2012
7 DAY ROLLING AVERAGE TEMPERATURE: D21

Temperature (°C)

DN12-1
DN12-B

01-Nov-2011
16-Nov-2011
01-Dec-2011
16-Dec-2011
31-Dec-2011
15-Jan-2012
30-Jan-2012
14-Feb-2012
29-Feb-2012
15-Mar-2012
30-Mar-2012
7 DAY ROLLING AVERAGE TEMPERATURE: D22

Temperature (°C)

- DN13-1
- DN13-5
- DN13-B
- DN13-B QAQC

Dates:
- 01-Nov-2011
- 16-Nov-2011
- 01-Dec-2011
- 16-Dec-2011
- 31-Dec-2011
- 15-Jan-2012
- 30-Jan-2012
- 15-Feb-2012
- 29-Feb-2012
- 15-Mar-2012
- 30-Mar-2012
7 DAY ROLLING AVERAGE TEMPERATURE: D23
7 DAY ROLLING AVERAGE TEMPERATURE: D24

Temperature (°C)

DN15-1  DN15-5
7 DAY ROLLING AVERAGE TEMPERATURE: PG1
7 DAY ROLLING AVERAGE TEMPERATURES: DN03-B

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)

Day of Year

Temperature (°C)
7 DAY ROLLING AVERAGE TEMPERATURES: TD31-B

Temperature (°C)

Day of Year
7 DAY ROLLING AVERAGE TEMPERATURES: TD38-B

Temperature (°C)

Day of Year


Temperature (°C)
7 DAY ROLLING AVERAGE TEMPERATURES: TD42-B

Temperature (°C)

Day of Year

Temperature (°C)

-45 -30 -15 0 15 30 45 60 75 90 105 120 135

ATTACHMENT C

TABLE C-1: BOTTOM WATER TEMPERATURES: DURATION AND PEAK TEMPERATURES FOR PERIODS EXCEEDING 3.5°C

TABLE C-2: BOTTOM WATER TEMPERATURES: DURATION AND PEAK TEMPERATURES FOR PERIODS EXCEEDING 5°C
<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-Dec-27 12:00</td>
<td>5.31</td>
<td>21.0</td>
<td>2011-Dec-27 13:00</td>
<td>5.13</td>
<td>42.0</td>
<td>2011-Dec-28 10:00</td>
<td>4.73</td>
<td>52.0</td>
<td>2011-Dec-29 09:00</td>
<td>4.35</td>
<td>28.0</td>
</tr>
<tr>
<td>2011-Dec-31 13:00</td>
<td>3.98</td>
<td>3.0</td>
<td>2011-Dec-31 22:00</td>
<td>4.59</td>
<td>60.0</td>
<td>2012-Jan-02 04:00</td>
<td>3.88</td>
<td>10.0</td>
<td>2012-Jan-00 00:00</td>
<td>3.62</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Jan-02 17:00</td>
<td>3.55</td>
<td>2.0</td>
<td>2012-Jan-03 09:00</td>
<td>3.78</td>
<td>1.0</td>
<td>2012-Jan-04 11:00</td>
<td>3.75</td>
<td>4.0</td>
<td>2012-Jan-11 14:00</td>
<td>3.54</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Jan-19 09:00</td>
<td>3.90</td>
<td>3.0</td>
<td>2012-Jan-19 12:00</td>
<td>4.17</td>
<td>1.0</td>
<td>2012-Jan-20 12:00</td>
<td>4.11</td>
<td>7.0</td>
<td>2012-Jan-27 13:00</td>
<td>4.19</td>
<td>5.0</td>
</tr>
<tr>
<td>2012-Jan-27 19:00</td>
<td>3.79</td>
<td>7.0</td>
<td>2012-Jan-28 01:00</td>
<td>3.79</td>
<td>5.0</td>
<td>2012-Jan-28 02:00</td>
<td>3.78</td>
<td>2.0</td>
<td>2012-Jan-30 01:00</td>
<td>3.61</td>
<td>10.0</td>
</tr>
<tr>
<td>2012-Jan-30 04:00</td>
<td>3.62</td>
<td>2.0</td>
<td>2012-Jan-30 05:00</td>
<td>3.62</td>
<td>2.0</td>
<td>2012-Jan-30 17:00</td>
<td>4.11</td>
<td>7.0</td>
<td>2012-Jan-31 01:00</td>
<td>4.19</td>
<td>5.0</td>
</tr>
<tr>
<td>2012-Jan-31 02:00</td>
<td>3.63</td>
<td>2.0</td>
<td>2012-Jan-31 08:00</td>
<td>3.78</td>
<td>2.0</td>
<td>2012-Jan-31 13:00</td>
<td>3.86</td>
<td>1.0</td>
<td>2012-Jan-31 15:00</td>
<td>4.59</td>
<td>60.0</td>
</tr>
<tr>
<td>2012-Jan-31 10:00</td>
<td>3.89</td>
<td>4.0</td>
<td>2012-Jan-31 16:00</td>
<td>4.11</td>
<td>7.0</td>
<td>2012-Jan-31 17:00</td>
<td>4.59</td>
<td>60.0</td>
<td>2012-Jan-31 22:00</td>
<td>4.59</td>
<td>60.0</td>
</tr>
<tr>
<td>2012-Jan-31 23:00</td>
<td>4.59</td>
<td>1.0</td>
<td>2012-Jan-31 00:00</td>
<td>4.59</td>
<td>1.0</td>
<td>2012-Jan-31 01:00</td>
<td>4.59</td>
<td>1.0</td>
<td>2012-Jan-31 02:00</td>
<td>3.67</td>
<td>2.0</td>
</tr>
</tbody>
</table>
May 2012

Start Date/Time

Table C-1: Bottom Water Temperatures: Duration and Peak Temperatures for Periods Exceeding 3.5°C

ADCP
Maximum
Temperature
(°C)

Duration
(hrs)

TD35-12 (12 m)
Maximum
Temperature
(°C)
Start Date/Time

Duration
(hrs)

TD34-B (14.5 m)
Maximum
Temperature
(°C)
Start Date/Time

Duration
(hrs)

TD55-B (14.8 m)
Maximum
Temperature
(°C)
Start Date/Time

Duration
(hrs)

February-2012

10-1151-0202

TD45-B (10.0 m)
Maximum
Temperature
(°C)
Start Date/Time

Duration
(hrs)

DN17-B (12.5 m)
Maximum
Temperature
(°C)
Start Date/Time

Duration
(hrs)

February-2012

2012-Feb-04 04:00

4.03

20.0

2012-Feb-01 03:00

3.81

9.0

2012-Feb-01 11:00

4.55

3.0

2012-Feb-02 03:00

4.15

9.0

2012-Feb-01 17:00

4.15

13.0

2012-Feb-01 17:00

4.74

23.0

2012-Feb-06 15:00

4.60

10.0

2012-Feb-01 18:00

4.34

15.0

2012-Feb-01 16:00

5.08

49.0

2012-Feb-02 23:00

4.36

10.0

2012-Feb-03 00:00

3.53

1.0

2012-Feb-02 17:00

4.08

3.0

2012-Feb-09 19:00

4.38

9.0

2012-Feb-02 10:00

5.38

20.0

2012-Feb-04 07:00

4.79

21.0

2012-Feb-04 11:00

4.22

20.0

2012-Feb-05 05:00

3.97

18.0

2012-Feb-02 21:00

3.56

1.0

2012-Feb-10 17:00

3.89

6.0

2012-Feb-03 07:00

4.78

9.0

2012-Feb-05 12:00

5.44

44.0

2012-Feb-06 00:00

4.67

8.0

2012-Feb-02 23:00

4.51

17.0

2012-Feb-11 01:00

3.70

4.0

2012-Feb-04 07:00

7.19

73.0

2012-Feb-08 14:00

3.50

1.0

2012-Feb-08 10:00

3.80

4.0

2012-Feb-04 15:00

5.17

29.0

2012-Feb-11 09:00

3.77

10.0

2012-Feb-07 10:00

3.50

1.0

2012-Feb-08 18:00

4.03

3.0

2012-Feb-08 16:00

3.51

1.0

2012-Feb-05 22:00

4.45

16.0

2012-Feb-14 07:00

3.56

2.0

2012-Feb-07 20:00

3.84

1.0

2012-Feb-08 22:00

4.74

63.0

2012-Feb-09 00:00

3.79

2.0

2012-Feb-08 01:00

3.64

1.0

2012-Feb-22 18:00

4.54

59.0

2012-Feb-07 23:00

5.61

44.0

2012-Feb-12 21:00

3.50

1.0

2012-Feb-09 08:00

3.84

4.0

2012-Feb-08 03:00

4.06

3.0

5.0

2012-Feb-10 04:00

9.0

2012-Feb-13 01:00

7.0

2012-Feb-09 23:00

1.0

2012-Feb-08 07:00

4.43

11.0

2012-Feb-25 06:00

4.18

4.38

3.82

3.51

2012-Feb-25 12:00

3.72

4.0

2012-Feb-10 15:00

6.29

11.0

2012-Feb-13 12:00

3.86

17.0

2012-Feb-10 05:00

3.73

5.0

2012-Feb-08 21:00

3.74

5.0

2012-Feb-25 19:00

3.59

1.0

2012-Feb-11 05:00

5.64

20.0

2012-Feb-14 07:00

4.23

9.0

2012-Feb-10 12:00

3.78

3.0

2012-Feb-09 11:00

3.87

3.0

2012-Feb-25 22:00

3.63

8.0

2012-Feb-12 02:00

4.86

13.0

2012-Feb-15 02:00

3.64

5.0

2012-Feb-16 12:00

4.41

7.0

2012-Feb-10 03:00

3.89

4.0

2012-Feb-26 11:00

3.71

11.0

2012-Feb-12 16:00

4.02

3.0

2012-Feb-15 10:00

4.17

12.0

2012-Feb-17 01:00

3.95

8.0

2012-Feb-11 07:00

4.85

12.0

2012-Feb-27 16:00

3.55

3.0

2012-Feb-13 15:00

4.26

2.0

2012-Feb-16 05:00

3.91

3.0

2012-Feb-18 16:00

3.61

6.0

2012-Feb-11 20:00

4.14

2.0

2012-Feb-28 04:00

3.62

2.0

2012-Feb-13 19:00

4.59

5.0

2012-Feb-17 12:00

3.50

1.0

2012-Feb-21 10:00

4.22

6.0

2012-Feb-11 23:00

3.70

1.0

2012-Feb-14 01:00

3.55

1.0

2012-Feb-18 03:00

4.06

9.0

2012-Feb-21 21:00

3.57

1.0

2012-Feb-12 14:00

3.66

1.0

2012-Feb-14 06:00

6.91

12.0

2012-Feb-18 14:00

3.98

22.0

2012-Feb-22 00:00

4.38

6.0

2012-Feb-16 06:00

4.83

19.0

2012-Feb-15 11:00

3.65

1.0

2012-Feb-19 15:00

3.50

1.0

2012-Feb-22 08:00

4.39

4.0

2012-Feb-17 02:00

3.97

7.0

2012-Feb-15 13:00

6.18

6.0

2012-Feb-19 17:00

3.83

34.0

2012-Feb-22 18:00

3.93

3.0

2012-Feb-17 11:00

3.70

2.0

2012-Feb-15 20:00

4.97

2.0

2012-Feb-21 06:00

3.57

2.0

2012-Feb-24 08:00

4.74

22.0

2012-Feb-18 07:00

4.97

16.0

2012-Feb-16 03:00

5.58

23.0

2012-Feb-21 11:00

3.54

3.0

2012-Feb-25 18:00

3.76

6.0

2012-Feb-19 02:00

3.57

1.0

2012-Feb-17 03:00

4.22

3.0

2012-Feb-22 08:00

5.31

22.0

2012-Feb-26 01:00

3.69

4.0

2012-Feb-19 04:00

4.17

7.0

2012-Feb-17 07:00

3.92

8.0

2012-Feb-23 18:00

3.51

1.0

2012-Feb-29 03:00

4.66

32.0

2012-Feb-19 12:00

4.11

4.0

2012-Feb-17 19:00

3.59

1.0

2012-Feb-24 03:00

3.78

6.0

2012-Feb-19 20:00

3.86

2.0

2012-Feb-18 00:00

3.78

1.0

2012-Feb-24 15:00

5.25

42.0

2012-Feb-19 23:00

4.06

2.0

2012-Feb-18 02:00

4.04

1.0

2012-Feb-26 23:00

4.39

35.0

2012-Feb-20 03:00

4.74

17.0

2012-Feb-18 07:00

5.64

40.0

2012-Feb-28 14:00

4.06

16.0

2012-Feb-20 21:00

4.89

24.0

2012-Feb-20 00:00

7.29

82.0

2012-Feb-21 22:00

4.30

26.0

23.0

2012-Feb-24 04:00

4.89

6.0

5.07

2012-Feb-24 01:00

Total Duration

5.40

2012-Feb-25 02:00

5.31

8.0

2012-Feb-24 15:00

2012-Feb-25 15:00

6.73

17.0

2012-Feb-25 14:00

3.83

7.0

2012-Feb-26 17:00

4.20

3.0

2012-Feb-27 00:00

5.02

13.0

2012-Feb-26 21:00

5.63

17.0

2012-Feb-28 14:00

3.77

1.0

2012-Feb-28 03:00

5.97

8.0

2012-Feb-28 19:00

5.21

14.0

2012-Feb-28 13:00

5.78
Total Duration

154.0

8.0

108.0
Total Duration

600.0

Total Duration

73.0

Total Duration

398.0

March-2012

Total Duration

165.0

308.0

March-2012

2012-Mar-03 19:00

3.73

9.0

2012-Mar-04 02:00

5.16

12.0

2012-Mar-03 04:00

4.65

49.0

2012-Mar-02 12:00

4.17

37.0

2012-Mar-01 00:00

4.77

2012-Mar-09 12:00

4.29

17.0

2012-Mar-04 15:00

6.83

14.0

2012-Mar-06 01:00

3.56

3.0

2012-Mar-04 03:00

3.53

3.0

2012-Mar-03 02:00

4.27

6.0

2012-Mar-11 11:00

5.80

398.0

2012-Mar-05 06:00

4.14

4.0

2012-Mar-08 14:00

4.62

21.0

2012-Mar-05 04:00

3.50

2.0

2012-Mar-03 09:00

4.02

16.0

2012-Mar-28 08:00

5.50

89.0

2012-Mar-05 11:00

4.55

5.0

2012-Mar-09 13:00

4.58

21.0

2012-Mar-06 17:00

4.20

10.0

2012-Mar-04 02:00

3.55

3.0

2012-Mar-05 19:00

4.19

2.0

2012-Mar-10 18:00

3.70

3.0

2012-Mar-07 15:00

3.51

1.0

2012-Mar-04 21:00

3.58

7.0

2012-Mar-05 23:00

4.49

1.0

2012-Mar-11 03:00

4.37

37.0

2012-Mar-07 18:00

4.41

36.0

2012-Mar-06 04:00

3.93

1.0

2012-Mar-06 01:00

5.64

89.0

2012-Mar-09 11:00

3.61

10.0

2012-Mar-06 06:00

4.85

83.0

2012-Mar-10 03:00

6.02

18.0

2012-Mar-10 10:00

4.03

16.0

2012-Mar-10 10:00

3.79

9.0

2012-Mar-10 23:00

4.41

3.0

2012-Mar-11 09:00

5.08

76.0

2012-Mar-11 11:00

5.85

74.0

2012-Mar-11 03:00

4.65

2.0

2012-Mar-11 06:00

4.16

3.0

2012-Mar-11 11:00

5.62
Total Duration

25.0

Total Duration

513.0

178.0

Total Duration

Total Duration

0.0

Golder Associates Ltd.

C-2 of 16

134.0

Total Duration

191.0

Total Duration

43.0

242.0


<table>
<thead>
<tr>
<th>Maximum Temperature (°C)</th>
<th>Start Date/Time</th>
<th>Duration (hrs)</th>
<th>Maximum Temperature (°C)</th>
<th>Start Date/Time</th>
<th>Duration (hrs)</th>
<th>Maximum Temperature (°C)</th>
<th>Start Date/Time</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.62</td>
<td>2011-Dec-31 17:00</td>
<td>1.0</td>
<td>4.68</td>
<td>2011-Dec-31 20:00</td>
<td>59.0</td>
<td>4.67</td>
<td>2011-Dec-30 20:00</td>
<td>2.0</td>
</tr>
<tr>
<td>4.46</td>
<td>2011-Dec-25 11:00</td>
<td>48.0</td>
<td>3.84</td>
<td>2011-Dec-31 19:00</td>
<td>37.0</td>
<td>4.05</td>
<td>2011-Dec-31 19:00</td>
<td>3.74</td>
</tr>
<tr>
<td>3.83</td>
<td>2011-Dec-28 00:00</td>
<td>8.0</td>
<td>3.62</td>
<td>2011-Dec-31 19:00</td>
<td>1.0</td>
<td>3.74</td>
<td>2011-Dec-31 19:00</td>
<td>3.72</td>
</tr>
<tr>
<td>2011-Dec-31 19:00</td>
<td>2.0</td>
<td>3.83</td>
<td>2011-Dec-31 19:00</td>
<td>3.72</td>
<td>2.0</td>
<td>3.50</td>
<td>2011-Dec-31 19:00</td>
<td>3.74</td>
</tr>
<tr>
<td>3.91</td>
<td>2011-Dec-30 21:00</td>
<td>14.0</td>
<td>3.89</td>
<td>2011-Dec-31 19:00</td>
<td>1.0</td>
<td>4.05</td>
<td>2011-Dec-31 19:00</td>
<td>3.72</td>
</tr>
<tr>
<td>3.92</td>
<td>2011-Dec-29 18:00</td>
<td>7.0</td>
<td>3.82</td>
<td>2011-Dec-31 19:00</td>
<td>1.0</td>
<td>4.05</td>
<td>2011-Dec-31 19:00</td>
<td>3.72</td>
</tr>
</tbody>
</table>

**Total Duration**

<table>
<thead>
<tr>
<th>December-2011</th>
<th>Total Duration</th>
<th>Total Duration</th>
<th>Total Duration</th>
<th>Total Duration</th>
<th>Total Duration</th>
<th>Total Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>80.0</td>
<td>22.0</td>
<td>69.0</td>
<td>330.0</td>
<td>12.0</td>
<td>253.0</td>
<td>184.0</td>
</tr>
<tr>
<td>99.0</td>
<td>12.0</td>
<td>194.0</td>
<td>229.0</td>
<td>229.0</td>
<td>229.0</td>
<td>229.0</td>
</tr>
</tbody>
</table>

Golder Associates Ltd.

C-3 of 16
## Table C-1: Bottom Water Temperatures: Duration and Peak Temperatures for Periods Exceeding 3.5°C

<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-Feb-01 12:00</td>
<td>5.53</td>
<td>91.0</td>
<td>2012-Feb-02 01:00</td>
<td>4.24</td>
<td>16.0</td>
<td>2012-Feb-01 16:00</td>
<td>4.18</td>
<td>14.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-05 13:00</td>
<td>5.29</td>
<td>26.0</td>
<td>2012-Feb-03 00:00</td>
<td>4.04</td>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-06 19:00</td>
<td>3.53</td>
<td>1.0</td>
<td>2012-Feb-03 18:00</td>
<td>3.88</td>
<td>10.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-08 21:00</td>
<td>4.99</td>
<td>35.0</td>
<td>2012-Feb-04 09:00</td>
<td>4.23</td>
<td>22.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-09 12:00</td>
<td>5.69</td>
<td>29.0</td>
<td>2012-Feb-05 12:00</td>
<td>3.95</td>
<td>7.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-10 02:00</td>
<td>3.87</td>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-25 15:00</td>
<td>3.53</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-25 08:00</td>
<td>3.80</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-17 08:00</td>
<td>3.94</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-24 19:00</td>
<td>5.10</td>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-24 16:00</td>
<td>4.23</td>
<td>22.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-20 01:00</td>
<td>4.22</td>
<td>12.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-14 08:00</td>
<td>5.40</td>
<td>50.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-17 02:00</td>
<td>5.11</td>
<td>35.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-18 02:00</td>
<td>4.71</td>
<td>62.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-21 09:00</td>
<td>3.61</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-21 14:00</td>
<td>3.54</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-26 11:00</td>
<td>3.53</td>
<td>23.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-27 04:00</td>
<td>3.72</td>
<td>27.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-11 10:00</td>
<td>3.56</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-12 11:00</td>
<td>3.59</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-21 05:00</td>
<td>3.54</td>
<td>27.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-22 10:00</td>
<td>5.41</td>
<td>21.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-28 06:00</td>
<td>4.94</td>
<td>24.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-28 10:00</td>
<td>3.51</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-29 19:00</td>
<td>3.52</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-03 04:00</td>
<td>4.35</td>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-03 18:00</td>
<td>3.91</td>
<td>15.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-04 22:00</td>
<td>3.64</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-05 05:00</td>
<td>4.53</td>
<td>41.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-06 13:00</td>
<td>4.50</td>
<td>52.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-07 23:00</td>
<td>3.95</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-08 13:00</td>
<td>4.53</td>
<td>79.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-09 01:00</td>
<td>5.51</td>
<td>32.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-09 08:00</td>
<td>5.04</td>
<td>18.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-10 05:00</td>
<td>3.32</td>
<td>21.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-11 03:00</td>
<td>3.78</td>
<td>37.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Duration**

<table>
<thead>
<tr>
<th>Total Duration (hrs)</th>
<th>Total Duration (hrs)</th>
<th>Total Duration (hrs)</th>
<th>Total Duration (hrs)</th>
<th>Total Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>520.0</td>
<td>416.0</td>
<td>14.0</td>
<td>442.0</td>
<td>295.0</td>
</tr>
</tbody>
</table>

**Month-2012**

- 2012-Mar-03 04:00 | 4.35 | 4.0 |
- 2012-Mar-03 18:00 | 3.91 | 15.0 |
- 2012-Mar-04 05:00 | 4.53 | 41.0 |
- 2012-Mar-05 05:00 | 3.64 | 5.0 |
- 2012-Mar-06 13:00 | 4.50 | 52.0 |
- 2012-Mar-07 23:00 | 3.95 | 3.0 |
- 2012-Mar-08 13:00 | 4.53 | 79.0 |
- 2012-Mar-09 01:00 | 5.51 | 32.0 |
- 2012-Mar-09 08:00 | 5.04 | 18.0 |
- 2012-Mar-10 05:00 | 3.32 | 21.0 |
- 2012-Mar-11 03:00 | 3.78 | 37.0 |

**March-2012**

- 2012-Mar-03 04:00 | 4.07 | 2.0 |
- 2012-Mar-03 05:00 | 4.17 | 4.0 |
- 2012-Mar-03 10:00 | 3.77 | 7.0 |
- 2012-Mar-03 15:00 | 3.93 | 14.0 |
- 2012-Mar-04 05:00 | 4.52 | 16.0 |
- 2012-Mar-05 17:00 | 3.60 | 6.0 |
- 2012-Mar-06 01:00 | 4.62 | 7.0 |
- 2012-Mar-06 02:00 | 4.70 | 18.0 |
- 2012-Mar-06 08:00 | 4.35 | 38.0 |
- 2012-Mar-09 01:00 | 3.60 | 6.0 |
- 2012-Mar-10 05:00 | 5.55 | 74.0 |

**Total Duration**

<table>
<thead>
<tr>
<th>Total Duration (hrs)</th>
<th>Total Duration (hrs)</th>
<th>Total Duration (hrs)</th>
<th>Total Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>159.0</td>
<td>184.0</td>
<td>167.0</td>
<td>205.0</td>
</tr>
</tbody>
</table>

Golder Associates Ltd.
<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-Dec-31 20:00</td>
<td>4.12</td>
<td>36.0</td>
<td>2011-Dec-29 11:00</td>
<td>4.23</td>
<td>25.0</td>
<td>2011-Dec-27 10:00</td>
<td>4.21</td>
<td>106.0</td>
<td>2011-Dec-29 05:00</td>
<td>4.27</td>
<td>41.0</td>
</tr>
<tr>
<td>2011-Dec-31 23:00</td>
<td>4.44</td>
<td>78.0</td>
<td>2011-Dec-31 14:00</td>
<td>4.22</td>
<td>66.0</td>
<td>2011-Dec-31 22:00</td>
<td>4.97</td>
<td>32.0</td>
<td>2011-Dec-25 14:00</td>
<td>4.33</td>
<td>4.0</td>
</tr>
<tr>
<td>2011-Dec-22 22:00</td>
<td>4.72</td>
<td>14.0</td>
<td>2011-Dec-23 13:00</td>
<td>4.72</td>
<td>14.0</td>
<td>2011-Dec-26 13:00</td>
<td>3.74</td>
<td>7.0</td>
<td>2011-Dec-29 17:00</td>
<td>3.86</td>
<td>6.0</td>
</tr>
<tr>
<td>2011-Dec-23 14:00</td>
<td>3.72</td>
<td>7.0</td>
<td>2011-Dec-23 22:00</td>
<td>4.97</td>
<td>32.0</td>
<td>2011-Dec-23 02:00</td>
<td>4.00</td>
<td>1.0</td>
<td>2012-Jan-04 06:00</td>
<td>3.56</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Jan-04 02:00</td>
<td>3.56</td>
<td>1.0</td>
<td>2012-Jan-04 22:00</td>
<td>3.52</td>
<td>2.0</td>
<td>2012-Jan-05 03:00</td>
<td>4.00</td>
<td>11.0</td>
<td>2012-Jan-11 03:00</td>
<td>3.70</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Jan-11 03:00</td>
<td>3.70</td>
<td>4.0</td>
<td>2012-Jan-11 10:00</td>
<td>3.69</td>
<td>7.0</td>
<td>2012-Jan-12 19:00</td>
<td>3.78</td>
<td>6.0</td>
<td>2012-Jan-29 12:00</td>
<td>3.86</td>
<td>3.0</td>
</tr>
<tr>
<td>2012-Jan-12 19:00</td>
<td>3.78</td>
<td>6.0</td>
<td>2012-Jan-02 05:00</td>
<td>3.61</td>
<td>4.0</td>
<td>2012-Jan-13 08:00</td>
<td>3.95</td>
<td>1.0</td>
<td>2012-Jan-30 23:00</td>
<td>3.83</td>
<td>11.0</td>
</tr>
<tr>
<td>2012-Jan-13 08:00</td>
<td>3.95</td>
<td>1.0</td>
<td>2012-Jan-13 10:00</td>
<td>3.70</td>
<td>4.0</td>
<td>2012-Jan-13 16:00</td>
<td>3.78</td>
<td>6.0</td>
<td>2012-Jan-04 14:00</td>
<td>3.83</td>
<td>11.0</td>
</tr>
<tr>
<td>2012-Jan-13 16:00</td>
<td>3.78</td>
<td>6.0</td>
<td>2012-Jan-16 00:00</td>
<td>3.56</td>
<td>11.0</td>
<td>2012-Jan-12 20:00</td>
<td>3.54</td>
<td>3.0</td>
<td>2012-Jan-14 04:00</td>
<td>4.00</td>
<td>10.0</td>
</tr>
<tr>
<td>2012-Jan-14 04:00</td>
<td>4.00</td>
<td>10.0</td>
<td>2012-Jan-14 12:00</td>
<td>3.93</td>
<td>3.0</td>
<td>2012-Jan-17 00:00</td>
<td>3.54</td>
<td>3.0</td>
<td>2012-Jan-16 10:00</td>
<td>3.61</td>
<td>3.0</td>
</tr>
<tr>
<td>2012-Jan-17 00:00</td>
<td>3.54</td>
<td>3.0</td>
<td>2012-Jan-16 10:00</td>
<td>3.64</td>
<td>4.0</td>
<td>2012-Jan-17 20:00</td>
<td>4.39</td>
<td>40.0</td>
<td>2012-Jan-22 00:00</td>
<td>3.86</td>
<td>7.0</td>
</tr>
<tr>
<td>2012-Jan-22 00:00</td>
<td>3.86</td>
<td>7.0</td>
<td>2012-Jan-17 20:00</td>
<td>4.39</td>
<td>4.0</td>
<td>2012-Jan-23 00:00</td>
<td>3.82</td>
<td>1.0</td>
<td>2012-Jan-29 17:00</td>
<td>4.79</td>
<td>15.0</td>
</tr>
<tr>
<td>2012-Jan-23 00:00</td>
<td>3.82</td>
<td>1.0</td>
<td>2012-Jan-29 17:00</td>
<td>4.79</td>
<td>15.0</td>
<td>2012-Jan-30 11:00</td>
<td>3.83</td>
<td>7.0</td>
<td>2012-Jan-30 20:00</td>
<td>3.62</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Jan-30 20:00</td>
<td>3.62</td>
<td>4.0</td>
<td>2012-Jan-31 03:00</td>
<td>3.57</td>
<td>2.0</td>
<td>2012-Jan-31 15:00</td>
<td>3.70</td>
<td>6.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.80</td>
<td>15.0</td>
</tr>
<tr>
<td>2012-Jan-31 23:00</td>
<td>4.80</td>
<td>15.0</td>
<td>2012-Jan-31 17:00</td>
<td>4.79</td>
<td>15.0</td>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
<td>2012-Jan-31 23:00</td>
<td>3.94</td>
<td>5.0</td>
<td>2012-Jan-31 23:00</td>
<td>4.00</td>
<td>4.0</td>
</tr>
<tr>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------</td>
<td>---------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>---------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>---------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>2012-Feb-01 13:00</td>
<td>3.72</td>
<td>1.0</td>
<td>2012-Feb-01 12:00</td>
<td>5.15</td>
<td>1.0</td>
<td>2012-Feb-01 17:00</td>
<td>4.09</td>
<td>14.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-01 17:00</td>
<td>4.81</td>
<td>18.0</td>
<td>2012-Feb-02 04:00</td>
<td>4.01</td>
<td>6.0</td>
<td>2012-Feb-02 08:00</td>
<td>3.58</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-02 12:00</td>
<td>3.51</td>
<td>3.0</td>
<td>2012-Feb-02 12:00</td>
<td>3.80</td>
<td>3.0</td>
<td>2012-Feb-02 12:00</td>
<td>4.31</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-04 07:00</td>
<td>4.78</td>
<td>26.0</td>
<td>2012-Feb-02 20:00</td>
<td>5.27</td>
<td>63.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-05 20:00</td>
<td>4.62</td>
<td>9.0</td>
<td>2012-Feb-05 15:00</td>
<td>5.61</td>
<td>147.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-06 15:00</td>
<td>4.12</td>
<td>3.0</td>
<td>2012-Feb-11 21:00</td>
<td>4.39</td>
<td>14.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-07 19:00</td>
<td>4.75</td>
<td>30.0</td>
<td>2012-Feb-12 14:00</td>
<td>4.34</td>
<td>10.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-09 13:00</td>
<td>3.71</td>
<td>2.0</td>
<td>2012-Feb-13 03:00</td>
<td>3.27</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-10 02:00</td>
<td>3.78</td>
<td>2.0</td>
<td>2012-Feb-13 05:00</td>
<td>3.62</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-11 04:00</td>
<td>4.41</td>
<td>8.0</td>
<td>2012-Feb-13 08:00</td>
<td>3.51</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-11 16:00</td>
<td>4.10</td>
<td>18.0</td>
<td>2012-Feb-13 17:00</td>
<td>3.81</td>
<td>13.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-12 11:00</td>
<td>3.55</td>
<td>1.0</td>
<td>2012-Feb-14 09:00</td>
<td>4.57</td>
<td>52.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-12 13:00</td>
<td>4.01</td>
<td>7.0</td>
<td>2012-Feb-17 04:00</td>
<td>5.17</td>
<td>37.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-16 04:00</td>
<td>3.54</td>
<td>1.0</td>
<td>2012-Feb-18 18:00</td>
<td>4.93</td>
<td>60.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-16 06:00</td>
<td>3.90</td>
<td>7.0</td>
<td>2012-Feb-21 11:00</td>
<td>3.56</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-17 02:00</td>
<td>4.34</td>
<td>15.0</td>
<td>2012-Feb-21 15:00</td>
<td>3.54</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-17 21:00</td>
<td>3.83</td>
<td>1.0</td>
<td>2012-Feb-22 00:00</td>
<td>5.60</td>
<td>63.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-18 02:00</td>
<td>4.90</td>
<td>74.0</td>
<td>2012-Feb-24 18:00</td>
<td>5.40</td>
<td>56.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-21 06:00</td>
<td>3.51</td>
<td>2.0</td>
<td>2012-Feb-27 04:00</td>
<td>5.15</td>
<td>53.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-21 10:00</td>
<td>3.51</td>
<td>3.0</td>
<td>2012-Feb-29 11:00</td>
<td>3.53</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-21 15:00</td>
<td>3.53</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td>------------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td>------------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-19 02:00</td>
<td>4.03</td>
<td>2.0</td>
<td>2011-Dec-21 16:00</td>
<td>4.36</td>
<td>70</td>
<td>2011-Dec-31 10:00</td>
<td>4.04</td>
<td>29.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-19 06:00</td>
<td>3.92</td>
<td>8.0</td>
<td>2011-Dec-24 17:00</td>
<td>3.70</td>
<td>4</td>
<td>2011-Dec-28 23:00</td>
<td>3.76</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-19 15:00</td>
<td>3.97</td>
<td>3.0</td>
<td>2011-Dec-25 04:00</td>
<td>3.93</td>
<td>4</td>
<td>2011-Dec-29 06:00</td>
<td>4.26</td>
<td>10.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-20 09:00</td>
<td>3.95</td>
<td>2.0</td>
<td>2011-Dec-25 15:00</td>
<td>3.64</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-20 12:00</td>
<td>4.21</td>
<td>46.0</td>
<td>2011-Dec-26 15:00</td>
<td>3.87</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-23 00:00</td>
<td>4.33</td>
<td>11.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-24 02:00</td>
<td>4.70</td>
<td>14.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-24 19:00</td>
<td>3.98</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-25 02:00</td>
<td>3.54</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-25 04:00</td>
<td>3.54</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-25 07:00</td>
<td>4.24</td>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-25 14:00</td>
<td>3.58</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-26 16:00</td>
<td>3.62</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-27 19:00</td>
<td>3.59</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-Dec-29 21:00</td>
<td>3.62</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Duration</td>
<td>110.0</td>
<td></td>
<td>Total Duration</td>
<td>99.0</td>
<td></td>
<td>Total Duration</td>
<td>29.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Duration</td>
<td>0.0</td>
<td></td>
<td>Total Duration</td>
<td>5.0</td>
<td></td>
<td>Total Duration</td>
<td>288.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Duration</td>
<td>217.0</td>
<td></td>
<td>Total Duration</td>
<td>15.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>--------------------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>--------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>2012-Feb-04 21:00</td>
<td>3.78</td>
<td>19.0</td>
<td>2012-Feb-09 13:00</td>
<td>3.74</td>
<td>1</td>
<td>2012-Feb-01 02:00</td>
<td>4.07</td>
<td>16.0</td>
<td>2012-Feb-03 17:00</td>
<td>4.45</td>
<td>40.0</td>
</tr>
<tr>
<td>2012-Feb-05 21:00</td>
<td>3.59</td>
<td>2.0</td>
<td>2012-Feb-10 00:00</td>
<td>3.72</td>
<td>1</td>
<td>2012-Feb-01 22:00</td>
<td>3.64</td>
<td>2.0</td>
<td>2012-Feb-06 07:00</td>
<td>5.23</td>
<td>39.0</td>
</tr>
<tr>
<td>2012-Feb-06 21:00</td>
<td>3.50</td>
<td>10.0</td>
<td>2012-Feb-24 18:00</td>
<td>3.93</td>
<td>2</td>
<td>2012-Feb-02 02:00</td>
<td>3.65</td>
<td>5.0</td>
<td>2012-Feb-07 23:00</td>
<td>3.64</td>
<td>10.0</td>
</tr>
<tr>
<td>2012-Feb-01 14:00</td>
<td>3.17</td>
<td>1.0</td>
<td>2012-Feb-09 04:00</td>
<td>3.50</td>
<td>1</td>
<td>2012-Feb-03 16:00</td>
<td>3.72</td>
<td>7</td>
<td>2012-Feb-09 14:00</td>
<td>3.57</td>
<td>12</td>
</tr>
<tr>
<td>2012-Feb-16 18:00</td>
<td>3.62</td>
<td>3.0</td>
<td>2012-Feb-09 06:00</td>
<td>4.57</td>
<td>50.0</td>
<td>2012-Feb-11 01:00</td>
<td>3.55</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-18 22:00</td>
<td>3.53</td>
<td>2.0</td>
<td>2012-Feb-13 05:00</td>
<td>3.57</td>
<td>8.0</td>
<td>2012-Feb-11 04:00</td>
<td>3.58</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-18 14:00</td>
<td>3.50</td>
<td>6.0</td>
<td>2012-Feb-13 15:00</td>
<td>3.57</td>
<td>5.0</td>
<td>2012-Feb-15 01:00</td>
<td>3.63</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-24 09:00</td>
<td>4.06</td>
<td>6.0</td>
<td>2012-Feb-14 00:00</td>
<td>3.64</td>
<td>8.0</td>
<td>2012-Feb-17 14:00</td>
<td>3.51</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-24 18:00</td>
<td>3.60</td>
<td>4.0</td>
<td>2012-Feb-14 14:00</td>
<td>3.85</td>
<td>11.0</td>
<td>2012-Feb-23 07:00</td>
<td>3.76</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-15 03:00</td>
<td>3.83</td>
<td>12.0</td>
<td>2012-Feb-15 18:00</td>
<td>4.11</td>
<td>10.0</td>
<td>2012-Feb-24 16:00</td>
<td>3.61</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-15 13:00</td>
<td>3.65</td>
<td>3.0</td>
<td>2012-Feb-25 00:00</td>
<td>3.56</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-16 18:00</td>
<td>3.51</td>
<td>1.0</td>
<td>2012-Feb-25 03:00</td>
<td>3.51</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-17 23:00</td>
<td>3.92</td>
<td>12.0</td>
<td>2012-Feb-26 07:00</td>
<td>3.52</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-18 20:00</td>
<td>3.51</td>
<td>2.0</td>
<td>2012-Feb-28 12:00</td>
<td>4.01</td>
<td>33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-20 12:00</td>
<td>3.56</td>
<td>14.0</td>
<td>2012-Feb-28 14:00</td>
<td>3.96</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-22 15:00</td>
<td>3.51</td>
<td>1.0</td>
<td>2012-Feb-28 17:00</td>
<td>3.55</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-25 20:00</td>
<td>4.69</td>
<td>14.0</td>
<td>2012-Feb-28 14:00</td>
<td>3.96</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-26 14:00</td>
<td>4.03</td>
<td>5.0</td>
<td>2012-Feb-26 21:00</td>
<td>3.65</td>
<td>22.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-27 20:00</td>
<td>4.18</td>
<td>16.0</td>
<td>2012-Feb-28 14:00</td>
<td>3.68</td>
<td>17.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Duration: 176.0

<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-Mar-03 10:00</td>
<td>3.90</td>
<td>9.0</td>
<td>2012-Mar-03 08:00</td>
<td>4.04</td>
<td>17</td>
<td>2012-Mar-03 07:00</td>
<td>4.72</td>
<td>36.0</td>
</tr>
<tr>
<td>2012-Mar-06 18:00</td>
<td>3.57</td>
<td>5.0</td>
<td>2012-Mar-04 13:00</td>
<td>3.73</td>
<td>9</td>
<td>2012-Mar-05 06:00</td>
<td>3.74</td>
<td>24.0</td>
</tr>
<tr>
<td>2012-Mar-07 13:00</td>
<td>4.45</td>
<td>39.0</td>
<td>2012-Mar-07 15:00</td>
<td>4.60</td>
<td>52</td>
<td>2012-Mar-06 02:00</td>
<td>3.53</td>
<td>4.9</td>
</tr>
<tr>
<td>2012-Mar-09 12:00</td>
<td>3.78</td>
<td>7.0</td>
<td>2012-Mar-10 15:00</td>
<td>4.02</td>
<td>11</td>
<td>2012-Mar-09 07:00</td>
<td>4.33</td>
<td>20.0</td>
</tr>
<tr>
<td>2012-Mar-11 15:00</td>
<td>6.12</td>
<td>116</td>
<td>2012-Mar-11 03:00</td>
<td>5.74</td>
<td>135</td>
<td>2012-Mar-10 09:00</td>
<td>3.88</td>
<td>17.0</td>
</tr>
<tr>
<td>2012-Mar-11 03:00</td>
<td>3.83</td>
<td>5.0</td>
<td>2012-Mar-10 09:00</td>
<td>3.88</td>
<td>17.0</td>
<td>2012-Mar-11 17:00</td>
<td>4.00</td>
<td>52</td>
</tr>
<tr>
<td>2012-Mar-11 09:00</td>
<td>4.94</td>
<td>126</td>
<td>2012-Mar-10 16:00</td>
<td>3.58</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-10 22:00</td>
<td>3.64</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-11 03:00</td>
<td>3.61</td>
<td>1</td>
<td>2012-Mar-11 11:00</td>
<td>5.62</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Duration: 219.0

Total Duration: 252.0

Golder Associates Ltd.

C-8 of 16
### Table C-2: Bottom Water Temperatures: Durations and Peak Temperatures for Periods Exceeding 5°C

<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-Dec-15 00:00</td>
<td>5.02</td>
<td>1.0</td>
<td>2011-Dec-15 03:00</td>
<td>5.0</td>
<td>1.0</td>
<td>2011-Dec-15 20:00</td>
<td>5.29</td>
<td>6.0</td>
<td>2011-Dec-15 13:00</td>
<td>5.43</td>
<td>20.0</td>
<td>2011-Dec-15 07:00</td>
<td>5.02</td>
<td>1.0</td>
</tr>
<tr>
<td>2011-Dec-15 12:00</td>
<td>5.47</td>
<td>32.0</td>
<td>2011-Dec-15 13:00</td>
<td>5.43</td>
<td>20.0</td>
<td>2011-Dec-15 12:00</td>
<td>5.47</td>
<td>32.0</td>
<td>2011-Dec-15 07:00</td>
<td>5.02</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Jan-13 07:00</td>
<td>5.06</td>
<td>1.0</td>
<td>2012-Jan-12 20:00</td>
<td>5.24</td>
<td>5.0</td>
<td>2012-Jan-12 20:00</td>
<td>5.24</td>
<td>5.0</td>
<td>2012-Feb-02 07:00</td>
<td>5.22</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Duration**: 15.0

### ADCP

The table includes data for ADCP TD35-12 (12 m), TD34-B (14.5 m), TD55-B (14.8 m), TD45-B (10.0 m), and DN17-B (12.5 m) for the months of December 2011 and February 2012.
<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-Feb-22 15:00</td>
<td>7.29</td>
<td>15.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-24 05:00</td>
<td>5.40</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-24 16:00</td>
<td>5.33</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-25 06:00</td>
<td>5.31</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-26 00:00</td>
<td>6.73</td>
<td>12.0</td>
<td>2012-Feb-26 00:00</td>
<td>6.73</td>
<td>12.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-27 00:00</td>
<td>5.63</td>
<td>12.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-28 05:00</td>
<td>5.97</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Feb-28 20:00</td>
<td>5.78</td>
<td>7.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Duration</td>
<td></td>
<td></td>
<td>Total Duration</td>
<td></td>
<td></td>
<td>Total Duration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Duration</td>
<td>153.0</td>
<td></td>
<td>Total Duration</td>
<td>1.0</td>
<td></td>
<td>Total Duration</td>
<td>12.0</td>
<td></td>
<td>Total Duration</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>
### Table C-2: Bottom Water Temperatures: Durations and Peak Temperatures for Periods Exceeding 5°C

<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-Dec-15 12:00</td>
<td>6.76</td>
<td>25.0</td>
<td>2011-Dec-15 18:00</td>
<td>6.37</td>
<td>32.0</td>
<td>2011-Dec-15 11:00</td>
<td>5.43</td>
<td>34.0</td>
<td>2011-Dec-15 14:00</td>
<td>6.39</td>
<td>11.0</td>
</tr>
<tr>
<td>2011-Dec-15 17:00</td>
<td>6.47</td>
<td>27.0</td>
<td>2011-Dec-15 21:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2011-Dec-25 10:00</td>
<td>5.32</td>
<td>3.0</td>
<td>2011-Dec-16 02:00</td>
<td>5.19</td>
<td>3.0</td>
</tr>
<tr>
<td>2011-Dec-18 18:00</td>
<td>5.75</td>
<td>6.0</td>
<td>2011-Dec-17 12:00</td>
<td>5.28</td>
<td>12.0</td>
<td>2011-Dec-19 01:00</td>
<td>5.44</td>
<td>1.0</td>
<td>2011-Dec-21 18:00</td>
<td>5.03</td>
<td>1.0</td>
</tr>
<tr>
<td>2011-Dec-21 00:00</td>
<td>6.22</td>
<td>31.0</td>
<td>2011-Dec-19 14:00</td>
<td>5.61</td>
<td>5.0</td>
<td>2011-Dec-19 19:00</td>
<td>5.39</td>
<td>3.0</td>
<td>2011-Dec-24 12:00</td>
<td>5.94</td>
<td>27.0</td>
</tr>
<tr>
<td>2011-Dec-25 02:00</td>
<td>6.88</td>
<td>28.0</td>
<td>2011-Dec-19 22:00</td>
<td>5.18</td>
<td>2.0</td>
<td>2011-Dec-22 10:00</td>
<td>5.06</td>
<td>3.0</td>
<td>2011-Dec-29 15:00</td>
<td>5.31</td>
<td>3.0</td>
</tr>
<tr>
<td>2011-Dec-26 00:00</td>
<td>5.48</td>
<td>11.0</td>
<td>2011-Dec-22 11:00</td>
<td>5.01</td>
<td>1.0</td>
<td>2011-Dec-22 22:00</td>
<td>5.09</td>
<td>3.0</td>
<td>2011-Dec-22 21:00</td>
<td>5.04</td>
<td>1.0</td>
</tr>
<tr>
<td>2011-Dec-26 00:00</td>
<td>5.62</td>
<td>3.0</td>
<td>2011-Dec-22 21:00</td>
<td>5.08</td>
<td>3.0</td>
<td>2011-Dec-23 09:00</td>
<td>5.39</td>
<td>10.0</td>
<td>2011-Dec-23 06:00</td>
<td>5.13</td>
<td>8.0</td>
</tr>
<tr>
<td>2011-Dec-27 00:00</td>
<td>5.56</td>
<td>9.0</td>
<td>2011-Dec-23 12:00</td>
<td>5.07</td>
<td>2.0</td>
<td>2011-Dec-23 23:00</td>
<td>5.13</td>
<td>8.0</td>
<td>2011-Dec-25 00:00</td>
<td>5.27</td>
<td>8.0</td>
</tr>
<tr>
<td>2011-Dec-27 00:00</td>
<td>5.06</td>
<td>2.0</td>
<td>2011-Dec-23 20:00</td>
<td>5.27</td>
<td>8.0</td>
<td>2011-Dec-25 05:00</td>
<td>6.07</td>
<td>21.0</td>
<td>2011-Dec-26 00:00</td>
<td>5.02</td>
<td>1.0</td>
</tr>
<tr>
<td>2011-Dec-28 00:00</td>
<td>5.63</td>
<td>7.0</td>
<td>2011-Dec-25 07:00</td>
<td>5.02</td>
<td>1.0</td>
<td>2011-Dec-26 13:00</td>
<td>5.25</td>
<td>4.0</td>
<td>2011-Dec-28 21:00</td>
<td>5.21</td>
<td>2.0</td>
</tr>
<tr>
<td>2011-Dec-29 00:00</td>
<td>5.52</td>
<td>8.0</td>
<td>2011-Dec-25 11:00</td>
<td>6.22</td>
<td>6.0</td>
<td>2011-Dec-28 05:00</td>
<td>5.21</td>
<td>2.0</td>
<td>2011-Dec-28 23:00</td>
<td>5.04</td>
<td>1.0</td>
</tr>
<tr>
<td>2011-Dec-31 00:00</td>
<td>5.31</td>
<td>8.0</td>
<td>2011-Dec-26 02:00</td>
<td>5.31</td>
<td>2.0</td>
<td>2011-Dec-29 23:00</td>
<td>5.28</td>
<td>3.0</td>
<td>2011-Dec-29 23:00</td>
<td>5.04</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**January-2012**

<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-Jan-07 14:00</td>
<td>5.24</td>
<td>1.0</td>
<td>2012-Jan-07 18:00</td>
<td>5.13</td>
<td>1.0</td>
<td>2012-Jan-08 03:00</td>
<td>5.00</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Jan-08 09:00</td>
<td>5.10</td>
<td>2.0</td>
<td>2012-Jan-10 15:00</td>
<td>5.04</td>
<td>1.0</td>
<td>2012-Jan-10 20:00</td>
<td>5.24</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Jan-10 20:00</td>
<td>5.24</td>
<td>1.0</td>
<td>2012-Jan-11 10:00</td>
<td>5.30</td>
<td>6.0</td>
<td>2012-Feb-01 19:00</td>
<td>5.53</td>
<td>4.0</td>
</tr>
<tr>
<td>2012-Feb-01 19:00</td>
<td>5.53</td>
<td>4.0</td>
<td>2012-Feb-03 15:00</td>
<td>5.02</td>
<td>1.0</td>
<td>2012-Feb-03 23:00</td>
<td>5.07</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Feb-03 23:00</td>
<td>5.07</td>
<td>1.0</td>
<td>2012-Feb-06 01:00</td>
<td>5.29</td>
<td>2.0</td>
<td>2012-Feb-06 23:00</td>
<td>5.06</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Feb-06 23:00</td>
<td>5.06</td>
<td>1.0</td>
<td>2012-Feb-09 09:00</td>
<td>5.06</td>
<td>1.0</td>
<td>2012-Feb-09 11:00</td>
<td>5.69</td>
<td>3.0</td>
</tr>
<tr>
<td>2012-Feb-09 11:00</td>
<td>5.69</td>
<td>3.0</td>
<td>2012-Feb-14 14:00</td>
<td>5.40</td>
<td>2.0</td>
<td>2012-Feb-15 17:00</td>
<td>5.07</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Feb-15 17:00</td>
<td>5.07</td>
<td>1.0</td>
<td>2012-Feb-17 11:00</td>
<td>5.09</td>
<td>1.0</td>
<td>2012-Feb-20 22:00</td>
<td>5.49</td>
<td>6.0</td>
</tr>
<tr>
<td>2012-Feb-20 22:00</td>
<td>5.49</td>
<td>6.0</td>
<td>2012-Feb-23 00:00</td>
<td>5.03</td>
<td>1.0</td>
<td>2012-Feb-23 21:00</td>
<td>5.09</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Feb-23 21:00</td>
<td>5.09</td>
<td>1.0</td>
<td>2012-Feb-24 19:00</td>
<td>5.23</td>
<td>2.0</td>
<td>2012-Feb-26 03:00</td>
<td>5.04</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**February-2012**

<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January-2012</td>
<td>Total Duration 188.0</td>
<td>Total Duration 90.0</td>
<td>Total Duration 37.0</td>
<td>Total Duration 85.0</td>
<td>Total Duration 64.0</td>
</tr>
<tr>
<td>February-2012</td>
<td>Total Duration 7.0</td>
<td>Total Duration 1.0</td>
<td>Total Duration 1.0</td>
<td>Total Duration 1.0</td>
<td>Total Duration 1.0</td>
</tr>
<tr>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
<td>Start Date/Time</td>
<td>Maximum Temperature (°C)</td>
<td>Duration (hrs)</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------</td>
<td>---------------</td>
<td>----------------</td>
<td>--------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>2012-Mar-05 00:00</td>
<td>5.13</td>
<td>2.0</td>
<td>2012-Mar-05 01:00</td>
<td>5.13</td>
<td>2.0</td>
</tr>
<tr>
<td>2012-Mar-08 13:00</td>
<td>5.65</td>
<td>15.0</td>
<td>2012-Mar-08 14:00</td>
<td>5.65</td>
<td>15.0</td>
</tr>
<tr>
<td>2012-Mar-09 05:00</td>
<td>5.12</td>
<td>1.0</td>
<td>2012-Mar-09 06:00</td>
<td>5.12</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Mar-09 10:00</td>
<td>5.07</td>
<td>2.0</td>
<td>2012-Mar-09 11:00</td>
<td>5.07</td>
<td>2.0</td>
</tr>
<tr>
<td>2012-Mar-09 13:00</td>
<td>5.01</td>
<td>1.0</td>
<td>2012-Mar-10 08:00</td>
<td>5.29</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Mar-10 10:00</td>
<td>5.16</td>
<td>1.0</td>
<td>2012-Mar-10 11:00</td>
<td>5.32</td>
<td>11.0</td>
</tr>
<tr>
<td>2012-Mar-11 06:00</td>
<td>5.08</td>
<td>1.0</td>
<td>2012-Mar-11 09:00</td>
<td>5.02</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Mar-11 17:00</td>
<td>5.12</td>
<td>1.0</td>
<td>2012-Mar-11 18:00</td>
<td>5.12</td>
<td>1.0</td>
</tr>
<tr>
<td>2012-Mar-13 01:00</td>
<td>5.34</td>
<td>3.0</td>
<td>2012-Mar-13 02:00</td>
<td>5.34</td>
<td>3.0</td>
</tr>
<tr>
<td>2012-Mar-13 09:00</td>
<td>5.29</td>
<td>8.0</td>
<td>2012-Mar-13 10:00</td>
<td>5.29</td>
<td>8.0</td>
</tr>
<tr>
<td>2012-Mar-13 17:00</td>
<td>5.12</td>
<td>10.0</td>
<td>2012-Mar-13 18:00</td>
<td>5.12</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Golder Associates Ltd.

C-12 of 16
### Table C-2: Bottom Water Temperatures: Durations and Peak Temperatures for Periods Exceeding 5°C

<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-Dec-15 10:00</td>
<td>5.46</td>
<td>3.0</td>
<td>2011-Dec-15 12:00</td>
<td>6.80</td>
<td>63.0</td>
<td>2011-Dec-15 13:00</td>
<td>5.48</td>
<td>30.0</td>
</tr>
<tr>
<td>2011-Dec-15 14:00</td>
<td>5.35</td>
<td>3.0</td>
<td>2011-Dec-18 23:00</td>
<td>5.72</td>
<td>13.0</td>
<td>2011-Dec-20 07:00</td>
<td>5.74</td>
<td>36.0</td>
</tr>
<tr>
<td>2011-Dec-15 20:00</td>
<td>5.06</td>
<td>2.0</td>
<td>2011-Dec-19 13:00</td>
<td>5.69</td>
<td>11.0</td>
<td>2011-Dec-23 00:00</td>
<td>5.01</td>
<td>1.0</td>
</tr>
<tr>
<td>2011-Dec-17 21:00</td>
<td>5.68</td>
<td>4.0</td>
<td>2011-Dec-22 01:00</td>
<td>5.04</td>
<td>2.0</td>
<td>2011-Dec-24 05:00</td>
<td>6.08</td>
<td>21.0</td>
</tr>
<tr>
<td>2011-Dec-18 22:00</td>
<td>5.38</td>
<td>1.0</td>
<td>2011-Dec-22 05:00</td>
<td>5.19</td>
<td>2.0</td>
<td>2011-Dec-25 11:00</td>
<td>5.39</td>
<td>6.0</td>
</tr>
<tr>
<td>2011-Dec-20 00:00</td>
<td>5.26</td>
<td>4.0</td>
<td>2011-Dec-22 09:00</td>
<td>5.05</td>
<td>1.0</td>
<td>2011-Dec-29 14:00</td>
<td>5.21</td>
<td>4.0</td>
</tr>
<tr>
<td>2011-Dec-21 22:00</td>
<td>5.26</td>
<td>4.0</td>
<td>2011-Dec-22 11:00</td>
<td>5.39</td>
<td>10.0</td>
<td>2011-Dec-23 01:00</td>
<td>5.09</td>
<td>2.0</td>
</tr>
<tr>
<td>2011-Dec-23 17:00</td>
<td>5.54</td>
<td>1.0</td>
<td>2011-Dec-23 08:00</td>
<td>6.20</td>
<td>15.0</td>
<td>2011-Dec-23 19:00</td>
<td>5.58</td>
<td>0.0</td>
</tr>
<tr>
<td>2011-Dec-25 04:00</td>
<td>5.36</td>
<td>1.0</td>
<td>2011-Dec-25 05:00</td>
<td>5.44</td>
<td>4.0</td>
<td>2011-Dec-26 07:00</td>
<td>5.17</td>
<td>3.0</td>
</tr>
<tr>
<td>2011-Dec-26 11:00</td>
<td>5.19</td>
<td>1.0</td>
<td>2011-Dec-27 12:00</td>
<td>5.13</td>
<td>2.0</td>
<td>2011-Dec-27 17:00</td>
<td>5.08</td>
<td>1.0</td>
</tr>
<tr>
<td>2011-Dec-28 00:00</td>
<td>5.44</td>
<td>4.0</td>
<td>2011-Dec-28 11:00</td>
<td>5.15</td>
<td>9.0</td>
<td>2011-Dec-28 21:00</td>
<td>5.23</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Duration</td>
<td>78.0</td>
<td></td>
<td>Total Duration</td>
<td>173.0</td>
<td></td>
<td>Total Duration</td>
<td>98.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**December-2011**
<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature °C</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature °C</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature °C</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature °C</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-Mar-12 03:00</td>
<td>5.20</td>
<td>1.0</td>
<td>2012-Mar-08 15:00</td>
<td>5.85</td>
<td>15.0</td>
<td>2012-Mar-14 04:00</td>
<td>5.05</td>
<td>2.0</td>
<td>2012-Mar-14 03:00</td>
<td>5.73</td>
<td>12.0</td>
</tr>
<tr>
<td>2012-Mar-13 20:00</td>
<td>5.28</td>
<td>2.0</td>
<td>2012-Mar-09 14:00</td>
<td>5.10</td>
<td>1.0</td>
<td>2012-Mar-14 13:00</td>
<td>5.73</td>
<td>12.0</td>
<td>2012-Mar-15 21:00</td>
<td>5.19</td>
<td>16.0</td>
</tr>
<tr>
<td>2012-Mar-14 10:00</td>
<td>5.35</td>
<td>1.0</td>
<td>2012-Mar-09 16:00</td>
<td>5.09</td>
<td>1.0</td>
<td>2012-Mar-15 14:00</td>
<td>5.19</td>
<td>16.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-10 17:00</td>
<td>5.37</td>
<td>10.0</td>
<td>2012-Mar-11 05:00</td>
<td>5.38</td>
<td>6.0</td>
<td>2012-Mar-15 14:00</td>
<td>5.19</td>
<td>16.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-11 17:00</td>
<td>5.86</td>
<td>14.0</td>
<td>2012-Mar-12 02:00</td>
<td>5.58</td>
<td>1.0</td>
<td>2012-Mar-15 14:00</td>
<td>5.19</td>
<td>16.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-12 12:00</td>
<td>5.58</td>
<td>1.0</td>
<td>2012-Mar-15 14:00</td>
<td>5.19</td>
<td>16.0</td>
<td>2012-Mar-15 14:00</td>
<td>5.19</td>
<td>16.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Total Duration  | 0.0 | Total Duration | 35.0 | Total Duration  | 0.0 | Total Duration | 0.0 | Total Duration | 0.0 | Total Duration | 30.0 |

The table above summarizes the peak temperatures and durations for water temperatures exceeding 5°C, with specific dates and times for each occurrence.
<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011-Dec-15 10:00</td>
<td>5.38</td>
<td>23.0</td>
<td>2011-Dec-15 09:00</td>
<td>5.48</td>
<td>40.0</td>
<td>2011-Dec-17 14:00</td>
<td>5.11</td>
<td>18.0</td>
<td>2011-Dec-16 04:00</td>
<td>6.18</td>
<td>26.0</td>
</tr>
<tr>
<td>2011-Dec-16 12:00</td>
<td>5.08</td>
<td>13.0</td>
<td></td>
<td></td>
<td></td>
<td>2011-Dec-21 06:00</td>
<td>5.20</td>
<td>29.0</td>
<td>2011-Dec-17 04:00</td>
<td>5.30</td>
<td>12.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2011-Dec-25 04:00</td>
<td>5.58</td>
<td>7.0</td>
<td>2011-Dec-19 14:00</td>
<td>5.16</td>
<td>8.0</td>
<td>2011-Dec-26 12:00</td>
<td>5.19</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2011-Dec-25 18:00</td>
<td>5.82</td>
<td>15.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Duration</td>
<td>36.0</td>
<td></td>
<td>Total Duration</td>
<td>40.0</td>
<td></td>
<td>Total Duration</td>
<td>54.0</td>
<td></td>
<td>Total Duration</td>
<td>55.0</td>
<td></td>
</tr>
</tbody>
</table>

December 2011

January-2012

<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-Feb-08 13:00</td>
<td>5.23</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

February-2012
<table>
<thead>
<tr>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
<th>Start Date/Time</th>
<th>Maximum Temperature (°C)</th>
<th>Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-Mar-13 15:00</td>
<td>6.12</td>
<td>36.0</td>
<td>2012-Mar-13 15:00</td>
<td>5.57</td>
<td>38.0</td>
<td>2012-Mar-15 13:00</td>
<td>5.62</td>
<td>27.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-15 10:00</td>
<td>5.01</td>
<td>1.0</td>
<td>2012-Mar-15 07:00</td>
<td>5.74</td>
<td>8.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-Mar-15 11:00</td>
<td>5.37</td>
<td>14.0</td>
<td>2012-Mar-16 11:00</td>
<td>5.21</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Duration: 51.0

March-2012
2011 THERMAL AND CURRENT MONITORING PROGRAM
DARLINGTON NUCLEAR GENERATION STATION
REFURBISHMENT AND CONTINUED OPERATION PROJECT
ENVIRONMENTAL ASSESSMENT
NK38-REP-07730-10019-R000

Submitted to:
Nuclear Generation Development
Ontario Power Generation Inc.
1315 Pickering Parkway, 3rd Floor
Pickering, Ontario
L1V 7G5

by: DNGS Refurbishment EA Consulting Team

Prepared by: Susanne Carnclos, Ph.D., Gerard Van Arkel, M.Eng., P.Eng
Golder Associates Limited
EA Consulting Team

Prepared by: Rein Jaagumagi
Golder Associates Limited
EA Consulting Team

Reviewed by: John Sinnige, P.Eng.
Golder Associates Limited
EA Consulting Team

Approved by: Dr. Don Gorber
SENES Consultants Limited
Project Manager, EA Consulting Team

Reviewed by: Bryan Yule
DNGS Refurbishment EA Project Review Team
Ontario Power Generation Inc.

Accepted by: John Peters
DNGS Refurbishment EA Project Manager
Ontario Power Generation Inc.

January 12, 2012

January 12, 2012

January 12, 2012

January 13, 2012

Jan 13/12
# Table of Contents

1.0 INTRODUCTION AND BACKGROUND ........................................................................................................................... 1

2.0 MONITORING LOCATIONS AND DATA COLLECTION ........................................................................................................... 3

2.1 Continuous Temperature Data ............................................................................................................................................ 3

2.1.1 Historical Temperature Monitoring Locations ......................................................................................................... 7

2.1.2 2011: Additional Temperature Monitoring Locations .................................................................................................. 8

2.2 Current Speed and Direction ............................................................................................................................................. 9

2.2.1 Historical Current Monitoring Locations ..................................................................................................................... 9

2.2.2 Permanent Current Meter at Port Darlington ............................................................................................................... 10

2.2.3 Additional Current Meters Near the DN Site .............................................................................................................. 10

2.3 Vertical Temperature Profiles ......................................................................................................................................... 10

2.4 External Data Sources ................................................................................................................................................... 11

2.4.1 Lake Ontario Water Level ........................................................................................................................................ 11

2.4.2 Meteorological Data ............................................................................................................................................ 11

2.4.3 DNGS Operational Data ................................................................................................................................... 11

3.0 DATA PROCESSING AND QA/QC ................................................................................................................................ 13

3.1 Data Availability ....................................................................................................................................................... 13

3.2 Temperature Data ...................................................................................................................................................... 13

3.3 Current Data .......................................................................................................................................................... 14

4.0 DATA ANALYSIS ........................................................................................................................................................... 15

4.1 Current Data .......................................................................................................................................................... 15

4.2 Temperature Data ...................................................................................................................................................... 15

4.2.1 Ambient Conditions ........................................................................................................................................ 16

4.2.2 Temperatures at Bottom Locations (Sinking Plumes) ......................................................................................... 18

4.2.3 Diffuser Performance ................................................................................................................................... 19

5.0 ASSESSMENT OF TEMPERATURE EFFECTS ON ROUND WHITEFISH ................................................................... 22

5.1 Assessment Approach ........................................................................................................................................ 22

5.2 Temperature Benchmarks ..................................................................................................................................... 23

5.3 Habitat Assessment .................................................................................................................................................. 27
5.4  Thermal Effects Assessment .............................................................................................................. 27
5.4.1  7-Day Rolling Average Temperature (Chronic) Assessment ....................................................... 28
5.4.1.1  Existing DNGS Diffuser ........................................................................................................... 28
5.4.1.2  Reference Locations ................................................................................................................ 29
5.4.2  Maximum Hourly Temperatures (Acute) Assessment ................................................................. 29
5.4.2.1  Existing DNGS Diffuser ........................................................................................................... 29
5.4.2.2  Reference Locations ................................................................................................................ 30
5.5  Conclusions ....................................................................................................................................... 31

6.0  REFERENCES .................................................................................................................................... 33

TABLES
Table 2.1  2011 and Historical Monitoring Locations Near the DN Site .................................................. 4
Table 2.2  2011 and Historical Current Meter Locations Near the DN Site ............................................. 7
Table 4.2.3-1  Summary of Diffuser Performance: Frequency of Surface Temperature Increases Over Ambient .... 21
Table 5.2-1  Mean Survival and Time Required to Complete Developmental Phase in Round Whitefish Exposed to Increases in Temperature ................................................................. 26

FIGURES
Figure 2.1  Darlington Thermal and Current Monitoring Program Locations
Figure 2.4.1-1  Historical Water Levels in Lake Ontario
Figure 2.4.2-1  Historical Annual Air Temperatures at Trenton A Met Station
Figure 2.4.2-2  Historical Air Temperatures at Trenton A Met Station: January thru April
Figure 3.1-1  2011 Temperature and Current Data Availability
Figure 4.2.1-1  Measured Temperature at Ambient Nearshore Locations
Figure 4.2.1-2  Measured Temperature at Ambient Offshore Locations
Figure 4.2.1-3  Measured Temperature at Port Granby
Figure 4.2.2-1:  Measured Temperature at Bottom for Offshore Locations Within Mixing Zone
Figure 4.2.2-2:  Measured Temperature at Bottom for Offshore Locations Beyond the Mixing Zone
Figure 4.2.2-3:  Measured Temperature at Bottom for Nearshore Locations Within the Mixing Zone
Figure 4.2.2-4:  Measured Temperature at Bottom for Shallow Nearshore Locations
Figure 4.2.2-5:  Measured Temperature at Bottom for Reference Locations
Figure 4.2.2-6: Measured Temperature at Bottom for Offshore Locations Within Mixing Zone and Alongshore and Offshore Current Component at CM01 and the Port Darlington ADCP

Figure 4.2.3-1: Temperature Change from Ambient at End of Diffuser and Beyond

Figure 4.2.3-2: Quartile Areal Extents of Thermal Plume

Figure 4.2.3-3: Maximum Areal Extents of Thermal Plume

Figure 5.4-1 7-Day Moving Average Temperatures at Offshore Locations Inside the Mixing Zone

Figure 5.4-2 7-Day Moving Average Temperatures at Inshore Locations < 6 m Depth

Figure 5.4-3 7-Day Moving Average Temperatures at Nearshore Locations at 6-10 m Depths

Figure 5.4-4 7-Day Moving Average Temperatures at Offshore Locations Outside the Mixing Zone at > 10 m Depths

Figure 5.4-5 7-Day Moving Average Temperatures at Reference Locations

Figure 5.4-6 Occurrence and Duration of Temperatures Above 5°C Threshold at TD35-12

APPENDICES

APPENDIX A
Current Data

APPENDIX B
Temperature Time Series Plots

APPENDIX C
7 Day Averages
1.0 INTRODUCTION AND BACKGROUND

As part of the Darlington Nuclear Generating Station (DNGS) Refurbishment and Continued Operation Project (the Project) Environmental Assessment (EA), the potential effects of the Project on the Surface Water and Aquatic Environments (SWE and AE, respectively) were evaluated and documented in the “Surface Water Environment Technical Support Document: Darlington Nuclear Generating Station Refurbishment and Continued Operation Project Environmental Assessment” (SWE TSD) and the “Aquatic Environment Technical Support Document: Darlington Nuclear Generating Station Refurbishment and Continued Operation Project Environmental Assessment” (AE TSD).

This report describes the 2011 Thermal and Current Monitoring Program currently underway in Lake Ontario near the Darlington Nuclear (DN) site and provides supporting documentation to confirm conclusions made in the SWE and AE TSDs, specifically regarding potential thermal effects resulting from the thermal discharges to the lake from DNGS. The main objective of this report is to characterize the current DNGS Condenser Cooling Water (CCW) thermal discharge and assess the potential for aquatic effects.

DNGS Thermal Discharges

Existing withdrawals of water from Lake Ontario by DNGS occur via a deepwater intake with discharges made through a diffuser manifold located at a depth in excess of 10 m. The maximum design cooling water (or CCW water) discharge rate from DNGS is 155 m³/s; however, the expected rate of water withdrawal and discharge for DNGS during normal operation is approximately 144 m³/s with four units in operation at full generation (Lawler 1997, Armstrong and Burchat 1999).

During normal operation, the water temperature increases between the intake temperature and the discharge temperature averaged approximately 12.3°C (based on data from 1993 to 2010 with all four units operating).

The design objectives of the DNGS diffuser, with respect to the aquatic environment, are to minimize thermal effects of the plant cooling water discharge through turbulent mixing, i.e., the mixing and dispersion is dominated by the characteristics of the diffuser (e.g. exit velocity, port orientation, port size) and the flow dynamics are governed by momentum. The diffuser is a 90-port submerged staged diffuser. The entire structure extends approximately 1,600 metres into Lake Ontario with a diffuser length of 900 metres. The first pipe segment from shore to 700 metres offshore is a tunnel beneath the lake bottom. The second diffuser segment, from 700 to 1,600 metres offshore, has exit ports that protrude through the lake bottom at depth contours of 10 to 12 metres (Ontario Hydro 1997).

The DNGS discharge is regulated by the Ontario Ministry of the Environment (MOE) Amended Certificate of Approval Industrial Sewage Works (No. 4720-6QALBY) under the Ontario Water Resources Act dated Aug 17, 2006, which states that the DNGS diffuser is “designed to limit the surface water temperature rise to a maximum of 2 degrees Celsius above ambient lake temperature at the edge of a one kilometre square mixing zone” [MOE, 2006].

The Mixing Zone used for this assessment and shown on Figure 2-1 is defined by the locations historically monitored by OPG (formerly Ontario Hydro) to verify the diffuser performance.
2011 Thermal and Current Monitoring Program

In response to recommendations made by Environment Canada, and the Canadian Nuclear Safety Commission (CNSC) as part of the New Nuclear – Darlington (NND) Environmental Assessment (EA), the 2011 Thermal and Current Monitoring Program was undertaken in Lake Ontario near the DN site to investigate potential thermal effects of the existing DNGS diffuser and the proposed NND diffuser on Valued Ecosystem Component (VEC) aquatic species.

Specific objectives of the 2011 Thermal and Current Monitoring Program are:

- Supplement the historical Lake Ontario temperature and current data near the DN site by collecting additional data at historical monitoring locations as well as at additional locations beyond the Mixing Zone (shown in Figure 2-1);

- Support a detailed assessment of potential thermal effects of the existing DNGS diffuser discharge on VEC aquatic species (round whitefish); and

- Verify that the current Darlington Nuclear Generating Station (DNGS) diffuser performance today is similar to the historical performance, i.e., the 2011 thermal monitoring data are similar to the thermal monitoring data collected during the early years of DNGS operation.
2.0 MONITORING LOCATIONS AND DATA COLLECTION

The 2011 Thermal and Current Monitoring Program includes the collection and analysis of:

- Continuous temperature data at 31 locations (25 of these locations provide continuous temperature data at two or more depths);
- Continuous current speed and direction data at 3 of these locations; and
- Vertical temperature profiles at one mid-lake location.

The following sections provide details of the data collected during the 2011 Thermal and Current Monitoring Program. Figure 2.1 shows all of the 2011 temperature and current monitoring locations and indicates which of these locations were also monitored historically. Tables 2.1 and 2.2 provide details for each 2011 thermal monitoring location and current meter location, respectively, as well as historical monitoring locations near the DN site (including those historical locations not monitored in 2011).

Instruments used for data collection include: RBR TR-1060P submersible temperature loggers for bottom temperature monitoring (accuracy: ±0.002°C for -5°C to +35°C); Onset Tidbit v2 waterproof temperature data logger (UTBI-001) (accuracy: ±0.2°C for 0°C to 50°C) for mid-depth and surface temperature monitoring; and SonTek Argonaut XR (0.75 MHz) (range: ±6 m/s, resolution: 0.1 cm/s) Acoustic Doppler Current Profilers to record current profiles through the water column.

2.1 Continuous Temperature Data

Thermal monitoring conducted in 2011 has included the placement of temperature loggers (and/or current meters) at various depths in the water column for the continuous measurement of temperatures at 10 historical locations and 21 additional locations as described in the following sections. The temperature loggers (and current meters) were deployed in January 2011 and bi-monthly downloads have been completed. This report presents the data collected up to and including the September 2011 download event. Data collection will continue through to the spring of 2012.
Table 2.1 2011 and Historical Temperature Monitoring Locations Near the DN Site

<table>
<thead>
<tr>
<th>Location ID</th>
<th>Depth Below Surface</th>
<th>Location Description</th>
<th>In DNGS Diffuser MZ?</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN01-1</td>
<td>1</td>
<td>DNGS Outside MZ North</td>
<td>NO</td>
</tr>
<tr>
<td>DN01-B</td>
<td>5.5</td>
<td>DNGS Outside MZ North</td>
<td>NO</td>
</tr>
<tr>
<td>DN02-1</td>
<td>1</td>
<td>DNGS Outside MZ North</td>
<td>NO</td>
</tr>
<tr>
<td>DN02-B</td>
<td>4.5</td>
<td>DNGS Outside MZ North</td>
<td>NO</td>
</tr>
<tr>
<td>TD18-1 *</td>
<td>1</td>
<td>DNGS Intake</td>
<td>NO</td>
</tr>
<tr>
<td>DN03-5</td>
<td>5</td>
<td>DNGS Intake</td>
<td>NO</td>
</tr>
<tr>
<td>DN03-B * .</td>
<td>11</td>
<td>DNGS Intake</td>
<td>NO</td>
</tr>
<tr>
<td>DN04-1</td>
<td>1</td>
<td>DNGS Outside MZ Northwest</td>
<td>NO</td>
</tr>
<tr>
<td>DN04-B</td>
<td>7.5</td>
<td>DNGS Outside MZ Northwest</td>
<td>NO</td>
</tr>
<tr>
<td>DN05-1</td>
<td>1</td>
<td>DNGS Outside MZ East</td>
<td>NO</td>
</tr>
<tr>
<td>DN05-5</td>
<td>5</td>
<td>DNGS Outside MZ East</td>
<td>NO</td>
</tr>
<tr>
<td>DN05-B</td>
<td>15.25</td>
<td>DNGS Outside MZ West</td>
<td>NO</td>
</tr>
<tr>
<td>DN06-1</td>
<td>1</td>
<td>DNGS Outside MZ West</td>
<td>NO</td>
</tr>
<tr>
<td>DN06-5</td>
<td>5</td>
<td>DNGS Outside MZ West</td>
<td>NO</td>
</tr>
<tr>
<td>DN06-B</td>
<td>11.25</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN07-1</td>
<td>1</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN07-5</td>
<td>5</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN07-10</td>
<td>10</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN07-B</td>
<td>18.5</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN08-1</td>
<td>1</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN08-5</td>
<td>5</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN08-10</td>
<td>10</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN08-B</td>
<td>13.75</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN09-1</td>
<td>1</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN09-5</td>
<td>5</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN09-10</td>
<td>10</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN09-B</td>
<td>18.5</td>
<td>DNGS Outside MZ SouthEast</td>
<td>NO</td>
</tr>
<tr>
<td>DN10-1</td>
<td>11</td>
<td>DNGS Diffuser East</td>
<td>YES</td>
</tr>
<tr>
<td>DN11-B</td>
<td>10</td>
<td>DNGS Diffuser West</td>
<td>YES</td>
</tr>
<tr>
<td>DN12-1</td>
<td>1</td>
<td>NND Proposed Diffuser North</td>
<td>NO</td>
</tr>
<tr>
<td>DN12-B</td>
<td>6</td>
<td>NND Proposed Diffuser North</td>
<td>NO</td>
</tr>
<tr>
<td>DN13-1</td>
<td>1</td>
<td>NND Proposed Diffuser Nearshore End</td>
<td>NO</td>
</tr>
<tr>
<td>DN13-5</td>
<td>5</td>
<td>NND Proposed Diffuser Nearshore End</td>
<td>NO</td>
</tr>
<tr>
<td>DN13-B</td>
<td>11</td>
<td>NND Proposed Diffuser Nearshore End</td>
<td>NO</td>
</tr>
<tr>
<td>DN14-1</td>
<td>1</td>
<td>Ambient West Offshore</td>
<td>NO</td>
</tr>
<tr>
<td>DN14-5</td>
<td>5</td>
<td>Ambient West Offshore</td>
<td>NO</td>
</tr>
<tr>
<td>DN14-B</td>
<td>12.25</td>
<td>Ambient West Offshore</td>
<td>NO</td>
</tr>
<tr>
<td>Location ID</td>
<td>Depth Below Surface</td>
<td>Location Description</td>
<td>In DNGS Diffuser MZ?</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------</td>
<td>----------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>DN15-1</td>
<td>1</td>
<td>Ambient East Nearshore</td>
<td>NO</td>
</tr>
<tr>
<td>DN15-5</td>
<td>7.5</td>
<td>West of DNGS Intake</td>
<td>NO</td>
</tr>
<tr>
<td>DN16-1</td>
<td>1</td>
<td>West of DNGS Intake</td>
<td>NO</td>
</tr>
<tr>
<td>DN16-5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN16-B</td>
<td>10.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD26-1</td>
<td>1</td>
<td>DNGS Diffuser Nearshore End</td>
<td>YES</td>
</tr>
<tr>
<td>TD27-5</td>
<td>5</td>
<td>DNGS Diffuser Offshore End</td>
<td>YES</td>
</tr>
<tr>
<td>TD28-8</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD38-B</td>
<td>9.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD22-1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD24-5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD25-8</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD35-12</td>
<td>11.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD30-1</td>
<td>1</td>
<td>MZ North</td>
<td>YES</td>
</tr>
<tr>
<td>TD31-B</td>
<td>6.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD40-1</td>
<td>1</td>
<td>MZ NorthWest</td>
<td>YES</td>
</tr>
<tr>
<td>TD41-5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD42-B</td>
<td>8.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD50-1</td>
<td>1</td>
<td>MZ NorthEast</td>
<td>YES</td>
</tr>
<tr>
<td>TD51-5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD52-B</td>
<td>10.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD43-1</td>
<td>1</td>
<td>MZ SouthWest</td>
<td>YES</td>
</tr>
<tr>
<td>TD44-5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD45-B</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD53-1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD54-5</td>
<td>5</td>
<td>MZ SouthEast</td>
<td>YES</td>
</tr>
<tr>
<td>TD55-B</td>
<td>14.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD32-1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD33-5</td>
<td>5</td>
<td>MZ South</td>
<td>YES</td>
</tr>
<tr>
<td>TD34-B</td>
<td>14.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD05-1</td>
<td>1</td>
<td>Ambient West Nearshore</td>
<td>NO</td>
</tr>
<tr>
<td>TD13-5</td>
<td>5.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PG1-1</td>
<td>1</td>
<td>Port Granby</td>
<td>NO</td>
</tr>
<tr>
<td>PG1-5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PG1-B</td>
<td>7.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN25-1</td>
<td>1</td>
<td>West MZ Btwn End of Diffuser &amp; Edge</td>
<td>YES</td>
</tr>
<tr>
<td>DN25-5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN25-10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location ID</td>
<td>Depth Below Surface</td>
<td>Location Description</td>
<td>In DNGS Diffuser MZ?</td>
</tr>
<tr>
<td>------------</td>
<td>---------------------</td>
<td>---------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>DN25-B 7</td>
<td>12.5</td>
<td>West MZ Btwn End of Diffuser &amp; Edge</td>
<td>YES</td>
</tr>
<tr>
<td>DN26-1 7</td>
<td>1</td>
<td>East MZ Btwn End of Diffuser &amp; Edge</td>
<td>YES</td>
</tr>
<tr>
<td>DN26-5 7</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN26-10 7</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN26-B 7</td>
<td>12.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD15-1 *</td>
<td>1</td>
<td>Ambient East Nearshore</td>
<td></td>
</tr>
<tr>
<td>TD16-5 *</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD08-01 *</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD12-05 *</td>
<td>5</td>
<td>East of MZ</td>
<td>NO</td>
</tr>
<tr>
<td>TD06-12 *</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD60-01 *</td>
<td>1</td>
<td>Ambient West Nearshore</td>
<td>NO</td>
</tr>
<tr>
<td>TD61-08 *</td>
<td>8</td>
<td>Ambient West Nearshore</td>
<td>NO</td>
</tr>
</tbody>
</table>

**Notes:**
1. DNGS = Darlington Nuclear Generating Station
2. MZ = Mixing Zone
3. NND = New Nuclear – Darlington
4. For all historical and 2011 monitoring locations, the location IDs indicate the approximate depth of installation of the thermal logger/current meter, e.g., CM10-15 is a current meter installed at a depth of approximately 15 m.
5. Locations shown in grey text represent historical data collection points for which data are not presented in this report.
6. "*" indicates an historical monitoring location.
8. This location corresponds to historical monitoring location CM10-B which was a current meter location. Currents were not measured at this location in 2011.
Table 2.2 2011 and Historical Current Meter Locations Near the DN Site

<table>
<thead>
<tr>
<th>Location ID</th>
<th>Depth Below Surface</th>
<th>Location Description</th>
<th>In DNGS Diffuser MZ?</th>
</tr>
</thead>
<tbody>
<tr>
<td>PD-ADCP (since 1997)</td>
<td>15</td>
<td>Ambient East Port Darlington</td>
<td>NO</td>
</tr>
<tr>
<td>CM01-15</td>
<td>15</td>
<td>East of MZ</td>
<td>NO</td>
</tr>
<tr>
<td>CM29-17</td>
<td>17</td>
<td>DNGS Outside MZ South</td>
<td>NO</td>
</tr>
<tr>
<td>CM01-08 *</td>
<td>8</td>
<td>East of DNGS</td>
<td>NO</td>
</tr>
<tr>
<td>CM10-B *</td>
<td>10</td>
<td>DNGS Intake (comparable to DN03-B)</td>
<td>NO</td>
</tr>
<tr>
<td>CM29-08 *</td>
<td>8</td>
<td>DNGS Outside MZ South</td>
<td>NO</td>
</tr>
<tr>
<td>CM63-08 *</td>
<td>8</td>
<td>DNGS Outside MZ West</td>
<td>NO</td>
</tr>
</tbody>
</table>

Notes:
1. DNGS = Darlington Nuclear Generating Station
2. MZ = Mixing Zone
3. For all historical and 2011 monitoring locations, the location IDs indicate the approximate depth of installation of the thermal logger/current meter, e.g., CM10-15 is a current meter installed at a depth of approximately 15 m.
4. Locations shown in grey text represent historical data collection points for which data are not presented in this report.
5. '*' indicates an historical monitoring location.

2.1.1 Historical Temperature Monitoring Locations

OPG (formerly Ontario Hydro) has intermittently collected detailed temperature data in the vicinity of the DN site since 1971 at up to 18 locations to support pre- and post-operation studies. At 12 of these locations, temperatures were measured at two or more depths. Prior to the operation of any of the DNGS units (before October 1990), the number of temperature monitoring locations varied from year to year depending on the associated studies purpose. In many cases the temperature was recorded year round at strategic locations (Ontario Hydro 1997, Lawler 1995). The historic temperature monitoring locations used in the 2011 Thermal Monitoring Study are identified by the "TD" designation in the station number and are shown as green circles on Figure 2.1. The temperature loggers were deployed as close to the historical locations as possible to ensure consistency between the historical data and the 2011 data.

The historical locations used in this monitoring program included 8 locations over the DNGS diffuser and at the edge of the Mixing Zone (shown as a dashed line on Figure 2.1) with loggers installed at various depths. A total of 25 temperature loggers were deployed at various depths at these 8 locations. These locations and depths were previously used to verify the diffuser design.

Historically, there were two locations used to determine the ambient lake water temperature, TD05-1/TD13-5 to the west and TD15-1/TD16-5 to the east. Each of these locations included a temperature logger near the surface (1-m depth) and at a depth of 5 m (i.e., near the bottom). The ambient location to the east (TD15-1/TD16-5) was not used in the 2011 study since it is situated in an area projected to potentially become the NND infill area. This location was replaced by DN15-1/DN15-5 (see Section 2.1.2). The ambient location to the west (TD05-1/TD13-5) was used in the 2011 study. For the “1990-1996 Darlington NGD - Lake Ontario Thermal Plume Study”, ambient temperatures were defined using the average bottom temperatures measured at the
ambient locations (TD13-5/TD16-5) during the cold period (less than 4°C) and the average surface temperatures measured at the ambient locations (TD05-1/TD15-1) during the warm period (greater than 4°C) (Burchat and Romanchuk 1997).

The 2011 study also included a historical temperature monitoring location over the DNGS intake: TD18-1 located near the water surface. In 2011, temperatures were also measured over the intake at a depth of 5 m (DN03-5) and near the bottom (DN03-B). Location DN03-B corresponds to the historic current meter location CM10-B where temperatures were measured near the bottom in addition to currents. A current meter was not deployed over the intake in 2011 since additional current data at this location were not required to meet the objectives of the 2011 analysis.

Temperature data were collected at historical monitoring locations TD08-1/TD12-5/TD06-12 from the early 1970s to the mid-1980s only. Given that temperature data were not collected at these locations during the DNGS commissioning and operational periods and several other locations east of the DNGS Mixing Zone were added in 2011, these locations were not monitored in 2011.

Historical temperature monitoring stations TD60-01/TD61-08 were also not monitored in 2011. These stations were located approximately mid-way between the DNGS diffuser and historical ambient monitoring locations TD05-1/TD13-5 but further offshore in a depth of approximately 8 m. These locations may be considered unsuitable to be used as ambient temperature locations since they are much closer to the DNGS diffuser. In addition, several other locations west of the DNGS Mixing Zone were added in 2011, including DN14-1,5,B; DN02-1,B; DN04-1,B; DN06-1,5,B; and DN08-1,5,10,B.

2.1.2 2011: Additional Temperature Monitoring Locations

The 2011 study included 21 additional locations to enhance the resolution of the historic study design. 20 of these locations were selected in 2011 to meet the study objectives discussed earlier. Temperature loggers were installed at multiple depths at 16 of these locations. Only bottom temperatures were recorded at five of these locations, three of which are current meter installations and the other two were included to provide increased resolution at the bottom depths within the Mixing Zone (DN10-B and DN11-B). To differentiate the new temperature monitoring locations from the historical locations, all of the new locations used the “DN” designation in the location name and are shown as yellow squares on Figure 2.1.

One of these additional locations, an existing Acoustic Doppler Current Profiler (ADCP) located near Port Darlington (see location PD-ADCP in Figure 2.1), has been continuously collecting current data at various depths and temperature data near the bottom since 1997.

There is a ring of locations around the Mixing Zone (approximately 300 to 500 m from the edge of the Mixing Zone). These locations (DN01 through DN09) were included to further assess the performance of the diffuser and identify potential thermal impacts at round whitefish spawning depths. The current meter at location CM29-17 also measures bottom temperatures at an offshore location approximately 400 m southeast of the edge of the Mixing Zone.

One location, approximately located mid-way between the DNGS intake and the edge of the Mixing Zone (DN16) and measuring temperatures at depths of 1 and 5 m and near bottom, was included to investigate the occurrence, if any, of recirculation of the thermal discharges into the intake.
Also, there are two additional locations (DN10 and DN11) inside the Mixing Zone approximately 100 m east and west of the diffuser. Temperature loggers were installed at these locations at the bottom only and were intended to enhance the study resolution to better characterize potential thermal impacts at the bottom that may occur between the diffuser and the locations at the edge of the Mixing Zone.

In November 2011, two additional bottom locations (DN25 and DN26) were added inside the Mixing Zone approximately 200 m southwest and southeast of the end of the diffuser, respectively, as requested by Environment Canada to further investigate the potential occurrence of sinking plumes. Temperatures were measured at these locations at depths of 1, 5, 10 and 12.5 m (i.e., bottom) below the water surface. These locations are shown on Figure 2.1 but are not included in any subsequent analysis since data downloads will not be completed until spring 2012.

Since the data collected as part of this monitoring program could potentially support the NND Project, two additional locations in the area of the proposed NND diffuser (DN12 and DN13) were included in the temperature monitoring program for potential NND baseline data collection purposes.

As mentioned earlier, the ambient location at TD15-1/TD16-5 was situated within the proposed NND infill area and was replaced with DN15-1/DN15-5 which is located approximately 250 m east of the historical location. DN15 had temperature loggers deployed near the surface (1 m) and at a depth of 5 m. This location was also selected since it lies within the artificial embayment that could potentially be created by the proposed NND infill area.

Additional temperature loggers were deployed at DN14 (at depths of 1 and 5 m and at bottom) which is located the same distance west as TD05/TD13 but is located approximately 1.5 km from the shoreline at a depth of approximately 12 m. Temperature data collected at DN14 was used to compare the ambient water temperatures in offshore areas (and areas potentially inhabited by round whitefish) to those in nearshore areas.

To further assess the ambient water temperatures, a control location was added 40 km east of DNGS near Port Granby at a depth of approximately 8 m (shown as PG1 on Figure 2.1, inset). This location was selected since it is far removed from any thermal discharges and can be used for comparison to the nearshore ambient temperature locations near DNGS (TD05/TD13, DN14, and DN15) during the winter months.

Finally, the current meter installed at CM01-15 measures bottom temperatures east of the DNGS diffuser, midway between the diffuser and ambient location DN15 and offshore at a depth of approximately 15 m.

### 2.2 Current Speed and Direction

The following sections provide details regarding the collection of current data in the vicinity of the DN site. The sections include brief discussions of data collection during the DNGS pre-construction period through to the 2011 Thermal and Current Monitoring program.

#### 2.2.1 Historical Current Monitoring Locations

Currents in the vicinity of the DN site have been previously recorded by the Water Resources Division of the former Ontario Hydro at four nearshore locations using impellor style recording current meters. The data cover a
substantial period of historic DNGS conditions: prior to commissioning (1971 to 1989, excluding 1973, 1974 and 1976); during commissioning (1990 to 1992); fully operational (1993 to early 1996). Three of the historic current monitoring locations (CM01-8, CM10-B, and CM29-8) are identified by the “CM” designation in the location ID. These locations are not shown on Figure 2.1. Two of these historical current meters were located near 2011 current monitoring locations and are described as follows: CM01-8 was located near the 2011 location CM01-15; and CM29-8 was located just southwest of 2011 locations CM29-17 and DN09. Current meters were not deployed over the intake in 2011 (i.e., at historical location CM10-B) or at the fourth historic current monitoring location (CM63-8), located approximately 2 km west of the DNGS diffuser, since additional current data at these locations were not required to meet the objectives of the 2011 analysis.

2.2.2 Permanent Current Meter at Port Darlington

As previously cited, the nearshore current monitoring data collected in the vicinity of the DN site until 1996 was subsequently augmented in January 1997 by means of a permanent ADCP installation off Port Darlington, which has been collecting current data ever since. Although the data were collected during the operational years at the DN site, and therefore reflect existing conditions, the distance between this and previous current monitoring locations, the differences in the orientation of the shoreline and local bathymetry, as well as the fact that currents measured at CM01-8, CM29-8 and CM63-8 could have been affected by station operations mean that the 1993 to 1996 and 1997 to 2007 data are not directly comparable.

2.2.3 Additional Current Meters Near the DN Site

In addition to the existing Port Darlington ADCP, the 2011 Thermal and Current Monitoring Program included the deployment of current meters at two of the three historical locations discussed in Section 2.2.1. These ADCP type current meters were deployed at CM01-15 and CM29-17 as shown on Figure 2.1. In comparison to the impellor type current meters used historically that only measured the current speed and direction at one depth, the ADCP type current meters can measure current speed and direction at multiple depths over the entire water column. Current speed and direction were measured at seven depths at CM01-15 and at eight depths at CM29-17.

2.3 Vertical Temperature Profiles

Approximately bi-monthly vertical temperature profiles were measured at a location approximately 20 km offshore from DNGS at a depth of approximately 100 m (shown as TP1 on Figure 2.1, inset). This location was included to provide information regarding the thermocline depth in an offshore location at various times of the year. These data may be used for verification of a lake-wide hydrodynamic model and is not used in any subsequent analysis in this report.
2.4 External Data Sources

In addition to the temperature and current data collected during this monitoring program, several other sources were used to obtain data required for the analysis provided in Section 4. The following sections provide brief descriptions of the external data obtained for this report.

2.4.1 Lake Ontario Water Level

Water levels and depths in the Great Lakes are referenced against the International Great Lakes Datum (IGLD). This datum is revised periodically to reflect long term changes in the Great Lakes basin and is generally referenced against the mean sea level at Rimouski, Quebec. The latest revision was published in 1985 (IGLD 1985) and was implemented in 1992. Each lake is assigned a chart datum to reference depths and water levels. In the case of Lake Ontario the chart datum is 74.2 m based on the low water level at Kingston, Ontario (EC 2005).

The National Oceanographic and Atmospheric Administration (NOAA) and the US Army Corps of Engineers (USACE) have recorded Great Lakes water levels (including Lake Ontario) since 1900 (NOAA 2008, USACE 2011). Lake Ontario water levels have been regulated since the completion of the St. Lawrence Power Project in 1958. At present, the level in the lake is regulated at the Iroquois Dam and Lock by the International St. Lawrence Board of Control of the International Joint Commission.

Figure 2.4.1-1 shows the mean monthly water levels for Lake Ontario from 1900 to the present. The figure shows that the monthly water levels ranged from 73.76 to 75.78 m IGLD. The effects of the seaway construction can be seen as a reduced variability in the monthly water levels. Since 1970, the average water level is 74.83 m IGLD. Over the same period there is a downward trend in the monthly water level of approximately 2.7 mm/year.

2.4.2 Meteorological Data

Average annual air temperatures from 1940 to 2011 were calculated for the Environment Canada Trenton Airport, Ontario meteorological station (Trenton A) and compared to the long term climatic average (7.0°C) as shown on Figure 2.4.2-1. For the subsequent analysis in this study, Figure 2.4.2-2 compares the average winter air temperatures (January to April) to the long term average winter air temperature (-2.2°C) at the Trenton A station for the same period.

Figures 2.4.2-1 and 2.4.2-2 show that, while the average annual temperature for 2011 was approximately 1.3°C warmer than the climatic normal, the winter period (January to April) was slightly cooler (approximately 0.3°C) than the long term average for the winter period.

2.4.3 DNGS Operational Data

In order to assess the thermal effects, information regarding the flow rate in the CCW system is required. An outage in one of the units at DNGS can reduce the flow and thermal load to Lake Ontario by approximately 25%. While the discharge rate from the CCW system is not specifically measured, OPG did provide information...
regarding the electrical production at DNGS between January and September of 2011. The plant was generating at full capacity for the entire period with the following exceptions (outages):

- Unit 1 - March 15 to May 19
- Unit 1 - September 9 to 15
- Unit 2 - September 13
- Unit 3 - July 28 to 30
3.0 DATA PROCESSING AND QA/QC

The following sections provide details regarding the availability of the data collected between January and September 2011 as well as the steps involved in the processing, quality assurance and quality control (QA/QC) of the data. At the completion of these steps, all of the data collected was consolidated into a single Microsoft Access 2007 database. Any subsequent data analysis was then completed based on the data in the database.

3.1 Data Availability

All temperature loggers and current meters were deployed during the period January 19 to 22, 2011 with the exception of the following locations;

- DN16 (between the DNGS intake and the edge of the Mixing Zone): deployment on June 2, 2011;
- PG1 (control location at Port Granby): deployment on June 10, 2011; and
- DN25 and DN26 (within the Mixing Zone southwest and southeast of the end of the DNGS diffuser): deployment in November of 2011.

The temperature loggers and current meters were downloaded on an approximately bi-monthly basis during the study period. Some download periods spanned several days due to weather conditions. During downloads the instruments were also inspected for battery life and any missing loggers were replaced. The data downloads and instrument inspections were completed during the following periods:

- March 3 to 7, 2011
- May 20 to June 2, 2011
- July 19 to 22, 2011
- September 12 to 24, 2011

In general, most of the loggers and current meters provided continuous records of temperature and current with only short data gaps that occurred during the downloads. Figure 3.1-1 provides a summary of the data availability for each of the loggers. The larger breaks in the available data for any of the loggers are either the result of a malfunctioning instrument or the loss of an instrument.

3.2 Temperature Data

Data from each temperature logger were manually inspected to ensure that all data imported into the database were correct. The following points outline some of the particular items that were considered during the inspection:

- Data points measured by the loggers before or after the logger was physically in the water were removed from the database (e.g., cases where the loggers continued to record data after the array was removed from the water but before the data was downloaded);
Single data points where the recorded temperature increased or decreased sharply for one time increment (e.g., increases over 20°C) were removed from the dataset. These points were considered to be erroneous;

- Recorded temperatures of less than -0.5°C were considered to be representative of ice accumulation on the data logger and were removed from the dataset; and

- Visual inspection of plotted data and identification of data that appeared to be “suspect” were examined in greater detail by comparing to other data (e.g., temperatures at nearby locations and similar depths, and current conditions near the DN site) and reviewing field notes that may indicate any issues. Using professional judgement based on all of the information available, certain “suspect” data points were considered to be erroneous.

The data points removed represented approximately 3% of the total number of data points collected. At 8 of the 72 logger locations, a duplicate temperature logger was deployed. The temperatures recorded at each of the duplicate locations were compared and showed that the difference in the recorded temperatures was less than ±0.2°C approximately 95% of the time. Differences greater than ±1°C were found approximately 0.6% of the time and generally occurred when both loggers indicated a rapid change in water temperature.

### 3.3 Current Data

Current data collected at Port Darlington were provided by OPG after review by OPG technical staff and any suspect or erroneous data were removed. As such, no further review was required and the Port Darlington ADCP data.

The current data, presented as rose diagrams, collected near the DN site (CM01-15 and CM29-17) are provided in Appendix A. Preliminary current rose diagrams were generated to illustrate the general lake current conditions near the DN site. These data will be updated once the data collection for a full year is completed.

The current data provided in Figure 4.2.2-6 (and discussed in Section 4.2.2) are shown as the alongshore and offshore components to better visualize the actual current conditions (i.e., speed and direction) in order to consider potential effects of ambient currents on the measured lake temperatures.
4.0 DATA ANALYSIS

The following sections provide the analysis of current and temperature data collected during the 2011 Thermal and Current Monitoring Program.

4.1 Current Data

This section provides a preliminary analysis of the current data collected during the 2011 Thermal and Current Monitoring Program. Additional assessment will be provided once the remainder of the 2011/2012 data are collected.

The current rose analysis of the current directions for the Port Darlington ADCP, CM01-15 and CM29-17 are provided in Appendix A. From the current rose analysis, the following observations were made:

- At Port Darlington, the current direction is predominantly alongshore at all depths with the exception of the currents near the water surface. (The shoreline at Port Darlington is oriented at an angle of approximately 20 degrees counter-clockwise from the shoreline at the DN site.) At the surface, the current generally moves in an offshore direction. This indicates that the surface currents are influenced more by winds and that the currents at depth are influenced by the general lake wide circulation patterns.

- At CM01-15 (located approximately 2 km east of the DNGS diffuser), the current direction is predominantly to the west at all depths. The influence of wind at the surface is less noticeable than at the Port Darlington ADCP location.

- At CM29-17 (located south of the Mixing Zone), shows that the current directions near the surface (e.g. depths of 5 m or less) are predominantly to the south and occasionally to the west. However, at depth (e.g. deeper than 10 m) the currents are predominantly to the west. This suggests that the offshore momentum caused by the diffuser may be drawing lake water into the discharge plume from the bottom as well as the nearshore areas.

The current data presented in Appendix A and the observations provided above are preliminary and subject to change as a result of the additional assessment to be completed once all of the 2011/2012 data are collected and processed.

4.2 Temperature Data

This section provides an analysis of the temperature data collected during the 2011 Thermal and Current Monitoring Program. Complete time series graphs of the temperature data for each of the monitoring locations is provided in Appendix B. Appendix C provides time series plots of the 7-day rolling average temperatures for each of the monitoring locations.

The following sections provide specific analysis of the temperature data with respect to ambient water temperatures, thermal impacts at bottom locations and diffuser performance.
4.2.1 Ambient Conditions

Ambient monitoring locations provide a reference for water temperatures occurring in the study area under natural conditions. In the case of this assessment, the ambient monitoring locations were used:

- To define appropriate ambient water temperatures for the purpose of assessing the surface temperature increases within the DNGS thermal plume; and
- To define bottom water temperatures during the cold water period to assess potential thermal effects during the round whitefish spawning period.

Additional monitoring locations outside of the zone of influence of the DNGS thermal plume provided insight into the natural temperature variations that occur spatially and temporally in the lake during the warm water period. These locations provide information regarding the complex thermal regime (e.g., thermal stratification, upwelling events) in the offshore areas of Lake Ontario.

For the 1990-1996 “Darlington NGD - Lake Ontario Thermal Plume Study”, ambient temperatures were defined using the average bottom temperatures measured at the ambient locations (TD13-5/TD16-5) during the cold period (less than 4°C) and the average surface temperatures measured at the ambient locations (TD05-1/TD15-1) during the warm period (greater than 4°C) (Burchat and Romanchuk 1997). As mentioned in Section 2.1.1, the monitoring locations at TD15-1 and TD16-5 were located in an area that may be infilled for the proposed NND project and were replaced by DN15-1 and DN15-5 (located just east of TD15-1/TD16-5). For purposes of this assessment, temperatures measured at the new ambient locations are considered comparable to temperatures at TD15-1/TD16-5 since DN15-1/DN15-5 is located near TD15-1/TD16-5 (i.e., approximately 0.25 km east) in a similar water depth.

The temperature data collected at the historical ambient locations are shown on Figure 4.2.1-1. Figure 4.2.1-1 also shows the average ambient surface temperatures (TD05-1 and DN15-1), the average ambient bottom temperatures (TD13-5 and DN15-5), and the difference between the average ambient surface and average ambient bottom temperatures. Based on Figure 4.2.1-1, the following observations are made:

- The difference between the surface and bottom temperatures was generally less than 0.1°C between January and May 2011 (see upper graph on Figure 4.2.1-1). Differences as large as 1°C occurred infrequently once the ambient water temperatures increased to greater than 4°C near the end of April. This indicates that the water column remains well mixed to a depth of at least 5 m in the nearshore areas during the cool water period.
- The lower graph on Figure 4.2.1-1 shows that during the warmer water period (May to September) deviations between the surface and bottom water temperatures increase. Over this period, the average temperature difference between the surface and the bottom was approximately 1.8°C and frequently exceeded 5°C. This indicates that the water column is not well mixed during the warm water period.
- Upwelling events are observed on June 2, June 29, August 11, and September 15. During these upwelling events, conditions in Lake Ontario cause cooler water from deeper areas to rise to the surface resulting in a rapid decrease in the ambient water temperature at the surface.
Figure 4.2.1-2 compares the average ambient surface and bottom temperatures as well as the difference between the average ambient surface temperatures and offshore surface temperatures to temperature data collected at two offshore locations west and east of the DN site: DN14 and the Port Darlington ADCP (shown as PD-ADCP on Figure 2.1). Temperatures are measured at location DN14 at depths of 1, 5 m and bottom (13m) locations (DN14-1, DN14-5 and DN14-B, respectively). The Port Darlington ADCP (located east of the DN site, offshore of Port Darlington) records water temperature at a depth of approximately 15 m (nearly 3 m deeper than DN14-B).

Based on Figure 4.2.1-2, the following observations are made regarding thermal regime in Lake Ontario near the DN site:

- The upwelling events identified earlier at the ambient monitoring locations were also observed at all depths at DN14. More frequent upwelling events are observed at the bottom at DN14 (DN14-B) than at the surface (DN14-1); and

- The effect of upwelling events near the bottom at the Port Darlington ADCP are less pronounced than at the other locations shown on Figure 4.2.1-2.

Another control location near Port Granby (approximately 40 km east of the DN site) provides additional insight into the natural variability of water temperature in Lake Ontario. Temperature loggers were deployed at this location on June 10, 2011 to collect data at the surface (1-m depth), at mid-depth (5-m depth), and at the bottom (approximately 8-m depth). Given the distance between Port Granby and DNGS, the water temperatures measured at Port Granby may not be directly comparable to the temperatures measured closer to the DN site, especially on an hourly basis. However, the data collected at Port Granby were compared to the average ambient surface and bottom water temperatures on Figure 4.2.1-3. Based on Figure 4.2.1-3, the following observation is made regarding the thermal regime in Lake Ontario near the DN site compared to a location approximately 40 km away:

- Upwelling events were observed at Port Granby in parallel with the upwelling events observed near the DN site.

Conclusion

For the subsequent analysis of the surface thermal plume provided in Section 4.2.3, ambient temperature was defined using only the average ambient surface temperatures for the 2011 period of record which included both cold and warm water periods. For the warm water period, this is in agreement with the method employed by Burchat and Romanchuk (1997) for the “1990-1996 Darlington NGD - Lake Ontario Thermal Plume Study” and is considered appropriate since thermal stratification was observed during the warm water period. Burchat and Romanchuk (1997) used the average ambient bottom temperatures for the cold water periods (less than 4°C); however, only bottom temperature data were available during these periods in the 1990s. Since the water column is typically well mixed during the cold water period (i.e., the surface and bottom temperatures were generally less than 0.1°C between January and May 2011), it is appropriate to assess the surface thermal plume using the average ambient surface temperatures during both warm and cold water periods.
4.2.2 Temperatures at Bottom Locations (Sinking Plumes)

One of the objectives of the 2011 Thermal and Current Monitoring Program was to assess the potential thermal effects on VEC aquatic species. This was facilitated by the measurement of water temperatures at the bottom locations where spawning of round whitefish can potentially occur. The intention of this section is to evaluate if occurrences of the thermal plume contacting the lakebed can be detected and measured (i.e., if sinking plumes occur) and identify the locations, frequencies and durations of these events. These bottom temperature data are subsequently used in the Assessment of Temperature Effects on Round Whitefish (Chapter 5.0, Section 5.4.2).

The occurrence of thermal plume bottom contact may be related to the density difference between the thermal plume and the ambient water during the winter months (e.g., water is denser at 4°C than at 1°C) and/or certain ambient current conditions.

The data collected during the egg incubation period (January to March 2011) at all of the bottom locations are compared to the embryo survival criteria (discussed in Section 5.2) for:

- Offshore locations within the Mixing Zone characterized by depths greater than 10 m (shown on Figure 4.2.2-1);
- Offshore locations beyond the Mixing Zone characterized by depths greater than 10 m (shown on Figure 4.2.2-2);
- Nearshore locations within the Mixing Zone characterized by depths less than 10 m (shown on Figure 4.2.2-3);
- Shallow nearshore locations characterized by depths less than 10 m (shown on Figure 4.2.2-4); and
- Reference locations (shown on Figure 4.2.2-5).

Figures 4.2.2-1 through 4.2.2-5 also show the bottom water temperatures as an increase over the average bottom temperature. The average bottom temperature was calculated as the average of temperatures measured at all of the bottom locations with the exception of the Port Darlington ADCP and Port Granby locations to identify occurrences of potential sinking plumes. This approach was used to identify locations with bottom temperatures that differed relative to the average lake bottom conditions.

As seen in Figure 4.2.2-1, and compared to Figures 4.2.2-2 through 4.2.2-5, occurrences of elevated bottom temperatures were only measured at TD35-12 (located at the offshore end of the diffuser near the bottom) and were generally less than 4 hours in duration. These elevated bottom temperatures may be the results of one, or a combination of, the following factors: ambient currents corresponding to these events (e.g., current reversals, weak alongshore or offshore current components and/or strong onshore current components) that result in decreased advective transport and, therefore, decreased initial mixing and dilution; and density differences between the thermal plume and the ambient water.

The occurrence of elevated bottom temperatures at TD35-12 is compared to the alongshore and offshore current components at CM01-15 (located east of the DNGS diffuser, mid-way between the diffuser and ambient location DN15) and the Port Darlington ADCP in Figure 4.2.2-6. This figure indicates that the few infrequent strong onshore currents or current reversals may be a contributing factor to the short term occurrence of elevated
bottom temperatures at this one location. Figure 4.2.2-6 points to examples of strong onshore/alongshore currents, current reversals and weak/stagnant currents.

4.2.3 Diffuser Performance

Since DNGS became fully operational with four units in service in 1993, OPG used temperature monitoring data collected for the period of 1993 through 1995 to demonstrate the performance and effectiveness of the diffuser to mitigate potential thermal effects. For this period, the frequencies for a range of changes from ambient temperature were generated for various locations within and along the perimeter of the Mixing Zone. These frequency curves are provided in the Darlington Environmental Effects Report (DEER) (Ontario Hydro 1997).

In the DEER, the overall performance of the existing DNGS diffuser was evaluated at locations at the end of the diffuser and beyond: TD22-1 and TD25-8 (over the end of the diffuser, surface and 8-m depth, respectively) and TD32-1 and TD33-5 (offshore of the end of the diffuser at the edge of the Mixing Zone, surface and 5-m depth, respectively). Given the offshore orientation of the diffuser ports, these locations are all on the offshore side of the diffuser and are expected to typically be located within the thermal plume.

To evaluate the current diffuser performance relative to the historical diffuser performance, temperature change frequency curves for all of these locations were also generated using the temperature monitoring data collected in 2011 and compared with the DEER results. All of the temperature data recorded in 2011 and presented in this report were used to generate these curves for the locations at the end of the diffuser and beyond.

As discussed in Section 2.1.1, historically, ambient temperature was defined by temperatures measured at historical monitoring locations TD05-1, TD13-5, TD15-1 and TD16-5. Specifically, ambient temperatures were defined using the average bottom temperatures measured at the ambient locations (TD13-5/TD16-5) during the cold period (less than 4°C) and the average surface temperatures measured at the ambient locations (TD05-1/TD15-1) during the warm period (greater than 4°C) (Burchat and Romanchuk 1997). In 2011, TD15-1 and TD16-5 were replaced by location DN15-1/DN15-5, located just northeast of TD15-1/TD16-5 in a similar water depth (as discussed in Section 2.1.2). Temperatures measured at DN15-1/DN15-5 are considered comparable to temperatures at TD15-1/TD16-5 since DN15-1/DN15-5 is located near TD15-1/TD16-5 (i.e., approximately 0.25 km east) in a similar depth.

For the purposes of this analysis, ambient temperatures were defined as the average surface temperatures recorded at TD05-1 and DN15-1 for both the warm and cold periods. Since the water column is typically well mixed during the cold water period (i.e., the difference between the surface and bottom temperatures were generally less than 0.1°C between January and May 2011), variations between the results obtained using this method and the results obtained for the historical studies (Burchat and Romanchuk 1997 and Ontario Hydro 1997) are negligible.

Figure 4.2.3-1 shows the 2011 temperature change frequency curves compared to the DEER frequency curves for the locations at the end of the diffuser and beyond. The 2011 frequency curves agree well with the DEER frequency curves for the surface temperatures measured at the location at the edge of the Mixing Zone offshore of the diffuser (TD32-1) and the 8-m depth temperatures measured over the offshore end of the diffuser (TD25-8). However, the 2011 frequency curves for the temperatures measured near the surface at the location over the offshore end of the diffuser (TD22-1) and at the 5-m depth at the location at the edge of the
Mixing Zone offshore of the diffuser (TD33-5) are not as consistent with the DEER results as compared to the results for TD32-1 and TD25-8.

Figure 4.2.3-1 suggests that the temperature at location TD22-1 was within 2°C of the ambient temperature approximately 87% of the time in 2011 while this occurred approximately 95% of the time during the period of 1993 to 1995. Of note, the historical temperature records for TD22-1 exist only for the year 1993. A review of historical climate data recorded at the Environment Canada meteorological station located at the Trenton Airport (Trenton A station) indicated that the average air temperature for the period of January through August was over 1°C cooler in 1993 when compared to 2011. In addition, ambient lake water temperatures for the period from early February to early June were typically at least 1°C lower in 1993 than in 2011. Also, only 2 to 3 units were operating at DNGS in 1993 until mid-April. Conversely, DNGS was operating at full power (i.e., four units) for much of the 2011 period of record. As this location (TD22-1) is located over the diffuser, well within the Mixing Zone, it is not unexpected that temperature rises of 2°C above ambient will be observed more frequently than at the edge of the Mixing Zone.

The 2011 frequency curves for the temperatures measured at TD33-5 (at the Mixing Zone boundary) show an increase in the frequency in which temperature changes are below specific values when compared with the DEER results. Specifically, Figure 4.2.3-1 suggests that the temperature at location TD33-5 was within 2°C of the ambient temperature more often in 2011 than for the period of 1993 to 1995, i.e., approximately 95% of the time in 2011 as compared to approximately 87% of the time during the period of 1993 to 1995. Also, there is an increase in the frequency of negative temperature changes, which is likely attributed to lake thermal stratification and not diffuser performance.

The observations discussed above indicate that the DNGS diffuser has comparable performance to the DNGS operational period between 1993 and 1995.

Table 4.2.3-1 provides a summary of the diffuser performance over the 2011 monitoring period presented herein. The data presented in Table 4.2.3-1 were used to estimate the quartile (75th percentile) and maximum (95th percentile) areal extents of the thermal plume. The results are presented on Figure 4.2.3-2 (quartile extents) and Figure 4.2.3-3 (maximum extents). The results presented in these figures exclude the data collected at TD31-1 (between the nearshore end of the diffuser and the shoreline) due to a large data gap at this location (e.g., no data collected after May 2011). These figures represent the maximum distances from the diffuser where various temperature increases above ambient were observed over an 8-month period in 2011. The actual size of the thermal plumes at any point in time is a fraction of the total areas inside the contour lines shown on the figures.

Figure 4.2.3-2 shows that 75% of the time, the maximum temperature increase within the study area is 1.5°C and that the temperature increases at the edge the Mixing Zone are generally less than 1°C. The area contained within the 1°C contour line is approximately 0.7 km² and the area contained within the 1.5°C contour line is approximately 0.1 km².

95% of the time a thermal plume characterized by a 2.0°C increase above ambient temperature is contained within 2.0°C contour line shown in Figure 4.2.3-3. This area is approximately 1.8 km². This figure also shows that a 2.5°C increase above ambient temperature thermal plume is contained within a 0.3 km² area within the Mixing Zone 95% of the time.
It should be noted that these extents are representative of 2011 data collected over an 8-month period and may not be representative of the long term frequencies.

<table>
<thead>
<tr>
<th>Location</th>
<th>Water Depth (m)</th>
<th>Number of Data Points</th>
<th>Increase Over Ambient</th>
<th>Frequency of Exceedance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Average</td>
<td>75th Percentile</td>
</tr>
<tr>
<td>Inside Mixing Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD26-1</td>
<td>10</td>
<td>5,451</td>
<td>0.65</td>
<td>1.27</td>
</tr>
<tr>
<td>TD22-1</td>
<td>12</td>
<td>5,570</td>
<td>0.73</td>
<td>1.50</td>
</tr>
<tr>
<td>Edge of Mixing Zone (Clockwise from Nearshore – starting at TD30)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TD30-1</td>
<td>6</td>
<td>5,545</td>
<td>0.29</td>
<td>0.53</td>
</tr>
<tr>
<td>TD50-1</td>
<td>10</td>
<td>4,268</td>
<td>-0.09</td>
<td>0.31</td>
</tr>
<tr>
<td>TD53-1</td>
<td>15</td>
<td>3,764</td>
<td>0.30</td>
<td>0.89</td>
</tr>
<tr>
<td>TD32-1</td>
<td>14</td>
<td>2,926</td>
<td>0.20</td>
<td>0.92</td>
</tr>
<tr>
<td>TD43-1</td>
<td>10</td>
<td>5,736</td>
<td>0.31</td>
<td>0.66</td>
</tr>
<tr>
<td>TD40-1</td>
<td>8</td>
<td>5,645</td>
<td>0.24</td>
<td>0.50</td>
</tr>
<tr>
<td>Outside Mixing Zone (Clockwise from Nearshore – starting at DN01)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DN01-1</td>
<td>5</td>
<td>5,629</td>
<td>0.25</td>
<td>0.54</td>
</tr>
<tr>
<td>TD18-1</td>
<td>11</td>
<td>5,754</td>
<td>-0.06</td>
<td>0.37</td>
</tr>
<tr>
<td>DN05-1</td>
<td>15</td>
<td>5,754</td>
<td>0.10</td>
<td>0.63</td>
</tr>
<tr>
<td>DN07-1</td>
<td>18</td>
<td>5,754</td>
<td>0.06</td>
<td>0.69</td>
</tr>
<tr>
<td>DN09-1</td>
<td>18</td>
<td>5,754</td>
<td>0.03</td>
<td>0.72</td>
</tr>
<tr>
<td>DN08-1</td>
<td>14</td>
<td>4,412</td>
<td>0.35</td>
<td>0.78</td>
</tr>
<tr>
<td>DN06-1</td>
<td>12</td>
<td>5,744</td>
<td>0.21</td>
<td>0.52</td>
</tr>
<tr>
<td>DN04-1</td>
<td>7</td>
<td>4,215</td>
<td>0.11</td>
<td>0.36</td>
</tr>
<tr>
<td>DN02-1</td>
<td>4</td>
<td>5,633</td>
<td>0.35</td>
<td>0.64</td>
</tr>
</tbody>
</table>

In addition to the thermal discharges from DNGS, there are several other factors contributing to the frequency of 2°C temperature increase above ambient including natural spatial variation in ambient temperatures, upwelling events, and atmospheric heating and cooling at the surface. The influence of these factors can be seen at the ambient monitoring location near the DN site (Figure 4.2.1-1) and at the control location near Port Granby (Figure 4.2.1-3).
5.0 ASSESSMENT OF TEMPERATURE EFFECTS ON ROUND WHITEFISH

The assessment of temperature effects focuses on round whitefish since sensitive life stages are expected to be present in the area of the DNGS diffuser area beginning in late fall when adults move inshore to spawn. Previous studies (Golder and SENES 2009) indicate that spawning takes place in water depths of 5 to 10 m. Females deposit eggs on rocky substrates in late fall/early winter (typically during late November and into December) and the eggs develop over the winter, hatching in the early spring (late March into early April), at which time the larvae typically move inshore to feed. Young fish feed in the nearshore areas during the summer months, generally in the mid-depths, until the fall, at which time they begin to move offshore to deeper water (Scott and Crossman 1973). As a result, round whitefish are generally only resident in the area of the DNGS facility during the period when females are spawning in the late fall and while the eggs develop and hatch over winter.

The developing embryos are considered to be the life stages most sensitive to changes in temperature. High temperatures during embryo development can result in reduced survival of embryos, and while not directly affecting embryo survival, can also result in a reduction in development time. The latter may result in larvae hatching earlier in the spring, before suitable food resources are available.

As a result, the assessment considers two possible exposure scenarios: continuous (chronic) exposure to temperature increases, calculated as the 7-day moving average temperature, and the short term (acute) exposure assessed against the hourly maximum temperature at each monitoring location.

The 7-day moving average temperatures (i.e., Maximum Weekly Average Temperatures (MWAT)) denote exposures that would be expected on a continuous basis throughout the period of exposure (i.e., during that particular week), while the hourly maximum temperatures denote the maximum temperatures that fish could be exposed to for short periods of time within each weekly period. Since adverse effects are a function of both the dose (i.e., the exposure temperature) and the length of time a receptor is exposed, the assessment considers both short-term acute exposures through the assessment against hourly maximum temperatures, and long-term chronic exposures through assessment against the 7-day moving average temperatures. In the assessment, chronic exposure is considered throughout the embryo development stage. Acute exposures are considered with respect to the maximum temperature attained, the length of time temperatures were elevated above average temperatures, and the frequency with which the temperature increases occurred over the entire embryo development stage.

5.1 Assessment Approach

The effects of potential changes in water temperature are assessed on the basis of the life stages of round whitefish that are known to be present in the nearshore (i.e., <15m depths) through field studies conducted at the site. The assessment considers:

- The embryo development stage that will be present during the winter season (January through March);
- The optimum temperature for embryo development;
- The water depths at which round whitefish embryos are expected to be present during the winter season relative to the extent of the predicted temperature plume; and
The maximum temperature that could affect survival and embryo development, the frequency at which these occur and the potential for temperature increases to affect local populations.

The assessment is being conducted over a full year of measured temperatures, and thereby considers temperature changes through the different seasons. This assessment is based on the 7-day rolling average temperatures and the hourly maximum temperatures that are predicted to occur over a period of one week. These are compared to the temperature benchmarks for each species during each life stage that is known to be present.

This report presents the findings of the assessment of temperatures during the period January to April 2011.

The assessment is conducted through the following steps:

- Temperature thresholds for round whitefish life stages likely to be present during the period January through March are determined based on a review of existing studies;
- The potential for round whitefish life stages to be present in the area, and the extent of habitat utilization are assessed based on the existing field studies;
- The weekly average and hourly maximum temperatures recorded at the monitoring sites are considered with respect to the temperature benchmarks, and the potential for adverse effects on development of round whitefish embryos are described.

5.2 Temperature Benchmarks

The screening level assessment (Golder 2010) was conducted using limited thermal effects benchmarks from the available studies. The screening level assessment used data compiled by Wismer and Christie (1987) from a number of literature sources on temperature effects for the different life stages of the round whitefish. Wismer and Christie (1987) reported a temperature maximum for developing eggs (i.e., embryos) of 5°C during the period from January to March, with optimum temperatures for embryo development from 1°C to 5°C. Optimum temperature for egg hatching was reported as 2.2°C. The upper limit of 5°C reported by Wismer and Christie (1987) was used as the benchmark for assessing the effects of winter temperature changes on the survival of round whitefish eggs and larvae. To support the more detailed assessment, a literature review was conducted for additional data on thermal effects on round whitefish.

A search of the peer-reviewed literature found no additional studies examining thermal effects on round whitefish. Therefore, the development of a temperature benchmark was based on the detailed laboratory study by Griffiths (1980) that examined the effects of temperature changes on round whitefish embryo survival and development.

Griffiths conducted a series of experiments in which he subjected developing embryos to a change in temperature for 6 hours per day and then returned the embryos to baseline temperatures for 18 hours. During the study, embryos were maintained at baseline temperatures of 1, 4, 7 or 10°C, and were subjected to exposures to 1, 4, 7 or 10°C. Temperature increases occurred daily for the duration of the experiment, from fertilization to complete hatch, while control groups were maintained at a constant temperature of approximately
1.7 °C. Percent survival was recorded daily and stage of development was assessed twice weekly for warmer temperatures (7 and 10°C) and once weekly for cooler temperatures (1 and 4°C).

Griffiths (1980) established 19 stages of development of round whitefish embryos, from fertilization to complete hatch. Stages 1 to 9 are characterized by the formation of the blastula, followed by gastrulation (formation of germ layers) and epiboly (cell movement). At stage 9 the embryo has reached the free tail-bud stage and extends 2/3 of the distance around the curvature of the yolk. During stages 9 to 19 the eye pigment becomes visible, the pectoral fins are formed, circulation in the vitelline vein becomes visible and the stellate chromatophores form along the body and head. Stage 19 is defined by constant pectoral fin flutter. Stage 19 until complete hatch is characterized by eye movement and hatching.

Griffiths found that embryos were the most sensitive to temperature changes while undergoing fertilization to stage 9 of development and again during stage 19 to complete hatch. From stage 9 to stage 19, embryos were the most resilient and had the highest percent survival.

In the experiments, Griffiths noted that fertilized embryos exposed to a mean temperature of 1.69 ºC had a mean viable hatch of 88.21% and required 168 days to reach complete hatch (Table 5.2-1). In comparison, embryos exposed to a 3ºC increase in temperature (from 1ºC to 4ºC) for 6 h/day had a 4.01% decrease in viable hatch (to 84.20%) and a 20 day decrease in time required to complete hatch. When exposed to a 6ºC increase in temperature (from 1ºC to 7ºC), viable hatch decreased by 6.81% to 79.60%, and time required to reach complete hatch decreased by 42 days. Exposure to a constant temperature of 4ºC had a mean viable hatch of 84.75%, and required 122 days to reach complete hatch.

In the stages of development most sensitive to changes in temperature (fertilization to stage 9), fertilized embryos exposed to a constant temperature of 1ºC had 93.47% survival and required 41 days to reach stage 9 of development (Table 5.2-1). In comparison, embryos exposed to a 3ºC increase in temperature (from 1ºC to 4ºC) for 6 h/day had a 4.22% decrease (to 89.25%) in survival and a 4 day decrease in time required to reach stage 9 of development. When exposed to a 6ºC increase in temperature (from 1ºC to 7ºC), survival decreased by 6.89% (to 86.58%) and time required to reach stage 9 of development decreased by 11 days. A constant temperature of 4ºC had a 90.27% survival, and required 26 days to reach stage 9.

Griffiths also noted that the period from stage 19 to complete hatch was sensitive to changes in temperature. Embryos at stage 19 exposed to a constant temperature of 1ºC had 98.73% survival and required 51 days to reach complete hatch (Table 5.2-1 summarizes the data from Griffiths 1980). In comparison, embryos exposed to a 3ºC increase in temperature (from 1ºC to 4ºC) for 6 h/day had a 1.95% decrease (to 96.78%) in survival and a 2 day decrease in time required to reach complete hatch. When exposed to a 6ºC increase in temperature (from 1ºC to 7ºC), survival decreased by 4.53% (to 94.20%) and time required to reach stage 19 of development decreased by 10 days. A constant temperature of 4ºC had a 95.67% survival, and required 47 days to reach complete hatch. The data indicate that late stage embryos are less sensitive to temperature fluctuations than early stage (fertilization to stage 9) embryos and suggest that increases in temperature during early embryo development could have a greater effect on survival than temperature fluctuations during the final developmental stages, when embryos appear to be more resilient. Since temperatures in early spring are likely to fluctuate naturally, it is understandable that embryos would be more tolerant of temperature changes that occur in the late development stage.
Griffiths determined the thermal effects benchmark of 5°C based on the assumption that reduction of egg survival to 75% would place a substantial stress on the population. He also considered a hatch earlier than 30 days could mean a shortage of suitable zooplankton food and jeopardize fry survival. Griffiths noted that these values are arbitrary due to lack of research at the time. Data from their study show that at 5°C round whitefish eggs had a greater than 80% survival and a less than 30 days advance hatch. From these results, Griffiths (1980) conservatively concluded that there would be adequate survival of embryos (>75%) if continuous temperature increases (i.e., 24 hrs/day) were less than 3.5°C and periodic increases (i.e., 6 hrs/day) were less than 5°C.

As shown in Table 5.2-1, embryos exposed to a 3°C daily temperature increase (from 1°C to 4°C) experienced an overall reduction in survival of 4.01% compared to embryos exposed to a constant temperature of 1°C. Embryos exposed to a 6°C daily increase (from 1°C to 7°C) experienced a 8.61% decrease in survival. Neither temperature increase could be considered severe enough to affect the long term survival of the local population. Similarly, development time to hatch was reduced by 20 days for those embryos exposed to a 3°C daily increase, and 42 days when exposed to a 6°C daily increase. The latter is considered to potentially affect larval survival, since an early hatch could result in a lack of suitable food resources. Based on the data provided by Griffiths, an upper limit of 6°C is estimated, that would result in a 30 day decrease in embryo development time.

Based on the above benchmarks, and the benchmarks reported by Wismer and Christie (1987), the effects of temperature changes are therefore assessed against the following benchmarks:

- Optimum temperature range for egg survival – 1 to 5°C;
- Optimum temperature for egg hatching – 2.2°C;
- Optimum temperature for larval survival – 3°C;
- Upper range for embryo survival – 5°C, assuming continuous daily fluctuations throughout the embryo development stage;
- Upper range for larval survival post-hatch – 6°C, also assuming continuous daily fluctuations throughout the embryo development stage; and
- Sustained temperatures above 3.5°C during embryo development.

Use of these benchmarks to assess the effects of thermal exposure of round whitefish at DNGS assumes that the conditions under which they were developed would occur at the site. This assumes that embryos would be exposed to a regular increase in temperature for 6 hours each day, throughout the embryo development stage. If temperature increases at the site occur less frequently, then the effects would be moderated.
### Table 5.2-1: Mean Survival and Time Required to Complete Developmental Phase in Round Whitefish Exposed to Increases in Temperature

<table>
<thead>
<tr>
<th>Design</th>
<th>Mean Measured Temperature&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>Fertilization to Stage 9</th>
<th>Stage 9 to Stage 19</th>
<th>Stage 19 to Complete Hatch</th>
<th>Fertilization to Complete Hatch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base Temperature&lt;sup&gt;(°C for 18 h/day)&lt;/sup&gt;</td>
<td>Cycle Temperature&lt;sup&gt;(°C for 6 h/day)&lt;/sup&gt;</td>
<td>Base Temperature&lt;sup&gt;(°C for 18 h/day)&lt;/sup&gt;</td>
<td>Cycle Temperature&lt;sup&gt;(°C for 6 h/day)&lt;/sup&gt;</td>
<td>Time Required (days)</td>
</tr>
<tr>
<td>1</td>
<td>1.69</td>
<td>1.68</td>
<td>41</td>
<td>93.47</td>
<td>76</td>
</tr>
<tr>
<td>1</td>
<td>1.86</td>
<td>3.87</td>
<td>37</td>
<td>89.25</td>
<td>62</td>
</tr>
<tr>
<td>4</td>
<td>2.04</td>
<td>6.75</td>
<td>30</td>
<td>86.58</td>
<td>55</td>
</tr>
<tr>
<td>1</td>
<td>2.26</td>
<td>9.79</td>
<td>24</td>
<td>42.72</td>
<td>40</td>
</tr>
<tr>
<td>4</td>
<td>3.85</td>
<td>3.90</td>
<td>26</td>
<td>90.27</td>
<td>49</td>
</tr>
<tr>
<td>4</td>
<td>4.00</td>
<td>6.79</td>
<td>22</td>
<td>85.58</td>
<td>46</td>
</tr>
</tbody>
</table>

**Notes:**
- Data from Griffith 1980.
- Temperature exposures began 20-22 h after fertilization and were repeated for 6 h/day for the duration of the experiment (completion of hatch).
- (a) Measured temperatures displayed are averages from fertilization to complete hatch. Mean measured temperatures by developmental stage are reported in the source article.
5.3 Habitat Assessment

Round whitefish are predicted to be present in the area of the DNGS diffuser during late fall when adults move inshore to spawn. Spawning typically takes place in water depths of 5 to 10 m. Females deposit eggs on rocky substrates in late fall/early winter (typically during late November and into December). Suitable hard substrates (rocky outcrops or glacial tills) are present in the area of the diffuser, and as such round whitefish may use these areas for spawning. The eggs develop over the winter with hatching occurring in the early spring (late March into early April), at which time the larvae typically move inshore to feed. Young fish feed in the nearshore areas during the summer months, generally in the mid-depths, until the fall, at which time they begin to move offshore to deeper water (Scott and Crossman 1973).

The extent to which round whitefish use the nearshore habitat for spawning has been assessed through a number of studies beginning in the 1980’s. These have typically focused on assessment of early stage larvae, rather than eggs or embryos, simply due to the difficulty in collecting eggs or embryos.

Larval tow data collected since the 1980’s (Griffiths 1990; Griffiths 1992; SENES & Golder 2009), has shown that the majority of larvae can be found beginning at approximately the 5 m depth, with larval presence decreasing below the 10 m depth.

5.4 Thermal Effects Assessment

Historical and new monitoring locations around the DNGS site included in this assessment are shown on Figure 2.1. Round whitefish are predicted to be present in the diffuser area during late fall when adults move inshore to spawn. This assessment includes temperature monitoring data from mid January to April 30, 2011. December 2011 to May 2012 temperature monitoring data, corresponding to the time of spawning, will be reported once obtained and analysed.

Reference locations included the monitoring locations to the east of the DNGS diffuser (DN12-B, DN13-B and DN15-5) that were added in 2011, and two locations (TD13-5 and DN14-B) approximately 3.5 km to the west of the DNGS diffuser. The reference locations are located at a distance great enough from the existing DNGS diffuser that there should be no thermal effects due to diffuser operation.

Temperature measurements were made during the period January through March, with the following operational characteristics:

- January through to March 25 – all 4 units running at full power; and
- March 25 to May 19 – three units running at full power.

Therefore, the data used in the analysis are considered representative of temperature exposures that could occur under normal full operating conditions during the period when round whitefish embryos are present.
5.4.1 7-Day Rolling Average Temperature (Chronic) Assessment

The 7-day rolling average temperatures from the monitoring period of mid January to April 30, 2011 were compared to the benchmarks for embryo survival and larval survival post-hatch established in Section 5.2. These are considered separately under the following headings:

- Existing DNGS diffuser – includes the existing monitoring locations at the edge of the Mixing Zone, and new locations added in 2011; and
- Reference areas to the west and east of the DNGS diffuser, including the area of the proposed NND diffuser and the proposed embayment.

5.4.1.1 Existing DNGS Diffuser

Nearshore Locations <6 m Depth

During January and early February, temperatures at the inshore locations (depth <6 m) around the existing diffuser were below 1°C at all locations (Figure 5.4-2). The 7-day average temperatures reached 3°C on March 7, ten days earlier than those locations in the existing diffuser mixing area. The exception was location DN02-B where temperatures remained below 1°C for the duration of the monitoring period (until February 28). Locations inshore remained within the optimal range for egg survival of 1°C to 5°C from mid-February until early April and were generally below 2°C until early March. These inshore locations generally cooled down to lower temperatures in the winter and warmed up faster in the spring than deeper offshore locations, as indicated by the lower winter temperatures and the increase in temperature at TD31-B in March, where temperatures reached 4°C in mid-March. The 5°C benchmark for embryo survival was exceeded on April 14 at the inshore locations, but by this date most larvae would likely have hatched and moved inshore to feed. By the end of April, the 7-day average temperature reached the 6°C benchmark for larval survival post-hatch, well past the embryo development period.

Nearshore Locations within Mixing Zone Area 6-10 m Depth

Nearshore locations (depth 6 to 10 m) around the existing diffuser had a 7-day average temperature (Figure 5.4-3) within the optimal range for egg survival of 1°C to 5°C until April 11. Temperatures at these locations were below 2.5°C throughout the period from January to mid-March, and remained below 3°C until early April, when most eggs would likely have hatched. Temperatures reached the 6°C benchmark on April 28, well past the embryo development time.

Offshore Locations

In the existing diffuser area, the 7-day rolling average temperature (Figure 5.4-1) remained below 3°C until March 17, and then gradually increased throughout the month of April at all locations with the exception of TD35-12 (end of diffuser). While temperatures at TD35-12 followed the same general pattern as the other locations in the existing diffuser area, they were approximately 1°C warmer during the period monitored (January 30 to February 28, 2011). The 7-day average temperature dropped below 1°C at all locations between January and early February, with the exception of TD35-12. However, temperatures remained within the optimal range for egg survival of 1°C to 5°C from mid-February until early April. The benchmark of 5°C for embryo survival was not exceeded at any location until April 18, when all eggs would likely have hatched. The benchmark of 6°C for...
embryo development time that would not compromise larval survival post-hatch was not exceeded at any location until May. At that time the hatched larvae will have moved inshore to feed and are unlikely to be located in the diffuser area. None of the locations had sustained temperatures above 3.5°C during January through March, though temperatures at TD35-12 were above 3°C from approximately mid-February to early March.

The 7-day average temperatures at locations outside the Mixing Zone (depth 12 to 18 m) are shown in Figure 5.4-4. Bottom temperatures were slightly warmer than the inshore locations during January-February, likely as a result of the greater depths. While temperatures periodically dropped below 1°C until February 10, they ranged between 1°C and 3°C until March 31. From late March to mid-April temperatures gradually increased to reach 5°C by April 28. Temperatures did not exceed the benchmark of 6°C until early May.

5.4.1.2 Reference Locations

At the reference locations to the east of the DNGS diffuser, the 7-day average (Figure 5.4-5) remained below 3°C until March 18 at all locations. Temperatures at all locations to the east dropped below 1°C during January and early February and then remained within the optimal range for egg survival of 1°C to 5°C during the period of egg development and hatching (mid-February to early-April). Temperatures did not reach the 3.5°C threshold for sustained temperatures until the end of March, when larval hatch would likely be underway. Through late-March and early-April temperatures gradually increased until 7-day average reached the benchmarks of 5°C on April 10 and 6°C on April 24.

5.4.2 Maximum Hourly Temperatures (Acute) Assessment

Maximum hourly temperatures at the monitoring sites are shown on Figures 4.2.2-1 to 4.2.2-3. Temperatures are shown as the actual recorded temperatures and the change in temperature (Δt) over average bottom conditions (as defined in Section 4.2.2).

5.4.2.1 Existing DNGS Diffuser

Measured temperatures within the area of the existing DNGS diffuser are shown on Figure 4.2.2-1 to Figure 4.2.2-5.

Temperatures during the period January 23 to April 30, 2011 exceeded the 5°C benchmark at only one location, TD35-12, located near the lakeward end of the existing diffuser. This monitoring location is at the 11.25m depth, which is beyond the typical depths of 5m to 10m at which round whitefish eggs have historically been found.

Figure 5.4-6 shows the duration and maximum temperatures attained during each of the events shown in Figure 4.2.2-1. In total, 8 events occurred at TD35-12 between January 27, 2011 and March 2, 2011, when temperatures exceeded the 5°C benchmark (the temperature logger was lost after March 2). The longest event occurred on February 19, 2011, was 6 hours in duration and reached a maximum temperature of 6.47°C. The remaining events were shorter in duration, lasting between 1 and 5 hours, and attained maximum temperatures between 5°C and 6°C. Since Griffiths (1980) showed that over sustained temperature pulses that exceeded 5°C there was only a slight reduction in embryo survival, the isolated temperature increases that occurred at the
one location (TD35-12), are not likely to result in measurable effects on embryo survival or development, should embryos be present in the general area.

Figure 4.2.2-1 shows that a sustained exceedance of the 3.5°C benchmark of approximately 40 hours occurred at TD35-12 from February 15 through to February 19 which attained a maximum temperature of 4.75°C. A second occurrence was recorded from February 20 to February 21, and lasted approximately 35 hours and attained a maximum temperature of 4.23°C. A third occurrence was noted that began on February 24 and persisted intermittently until February 27 lasting approximately 40 hours in total and reaching a maximum temperature of 4.05°C (Figure 4.2.2-1).

Periodic exceedances of the 3.5°C benchmark occurred at DN10-B (10m depth) during February (Figure 4.2.2-3), but these were limited to isolated occurrences, and temperatures were generally below 3°C at these monitoring locations. The maximum temperature attained during these periodic exceedances was 3.88 °C on February 18, which lasted less than 6 hours.

Figure 4.2.2-2 (bottom figure) shows that temperature increases at the offshore locations in deeper waters also had periodic increases in bottom temperature during a short period in February (DN05-B, DN09-B). These were limited to the same period in February as the increase at DN10-B. Similar increases in temperatures occurred at other locations both within the Mixing Zone (TD34-B, TD45-B, TD55-B, Figure 4.2.2-1) and in the reference locations (DN13-B, DN14-B, Figure 4.2.2-5) as well as nearshore areas both in the Mixing Zone, and the reference areas (Figure 4.2.2-3). The increases appear to be due to a general event that occurred in the area at this time, and not related to operation of the diffuser. Griffiths noted that effects on embryo development could occur due to consistent exposure to temperatures above 3.5°C throughout the embryo development period. The intermittent increases in temperatures at TD35-12 are therefore unlikely to result in adverse effects on the developing embryos.

While isolated increases were noted at some monitoring locations in the latter half of March, these occurred during the later developmental stages of the embryos, when the data provided by Griffiths shows these would be most resilient to temperature changes.

Figures 4.2.2-1 to 4.2.2-5 show the temperature increases ($\Delta t$) over average bottom temperatures. The data show that there were no increases over the 5°C periodic temperature increase Griffiths determined would be the maximum increase that would not significantly affect embryo development. The maximum periodic increases occurred at TD35-12, and only on four occasions reached temperature increases that were slightly above 4°C. Figure 4.2.2-1 also shows that the 3.5°C increase for continuous exposure (i.e., over a 24 hour period) was not exceeded at any of the monitoring locations and that sustained (continuous) temperature increases over average conditions were limited to less than 2°C.

5.4.2.2 Reference Locations

Reference locations included monitoring locations DN12-B, DN13-B and DN15-B, to the east of the DNGS site and a minimum of 3 km east of the existing DNGS diffuser (Figure 2.1). An additional reference location, DN14-B was situated approximately 3.5 km to the west of the DNGS diffuser.

Bottom temperature at these locations (Figure 4.2.2-5) remained below 3.5°C throughout the period January through March 2011, and generally remained below 2°C though there was a general increase in temperatures
from February 17 to February 19, coinciding with the increase in temperatures at the other monitoring locations. There were no exceedances of the 5°C benchmark at any of the monitoring locations through to the end of March.

5.5 Conclusions

During the critical time of egg/embryo development and larval survival the 7-day moving average temperatures did not exceed the 5°C benchmark at any of the monitoring locations. At most locations temperatures were below 3°C until mid-March 2011. By the time temperatures reached 5°C in mid April, the larvae would have moved inshore to feed and would not be impacted by thermal effects in the diffuser areas. As well, there were no periods when sustained temperatures reached or exceeded 3.5°C, and no effects on embryo development would be likely.

The maximum hourly temperatures exceeded the 5°C benchmark only at one location, TD35-12. Since the exceedances were noted on only 8 occasions throughout the period from January to March, and did not exceed 6 hours in duration, the effects on embryo development are considered to be negligible.

The results from the Griffiths (1980) study showed that even when subjected to a 3°C increase in temperature for a 6 hour period daily throughout the entire embryo development period, there was only a 4% decrease in survival and a 20 day decrease in hatching time. The data collected at the monitoring locations show that these conditions did not occur at any of the majority of the monitoring locations, and that only at one location were there periodic exceedances of the 5°C benchmark, the longest of which persisted for a period of 6 hrs. Griffiths showed that under sustained daily temperature fluctuations of up to 6°C, there was only a decrease in embryo survival from 88.2% to 79.6%. Therefore, Griffiths tested embryo survival under conditions more conservative than actually occur at the site, and noted that the impacts would not have a significant effect on the round whitefish population. Conditions at the site showed substantially fewer temperature fluctuations than the conditions tested by Griffiths, and showed that effects on round whitefish embryo development are unlikely to occur.

There is potential concern that increased temperatures, while not directly affecting survival, could result in an acceleration of egg/embryo development and early hatching of larvae. Early hatching could have negative consequences if larvae hatch before there are sufficient food resources available to support larval growth and survival. Chronic exposure to an increase in temperature of 3°C (from 1°C to 4°C) was shown to decrease hatching time by 20 days (Griffiths 1980). Since the results showed that temperatures were within the optimal range for egg/embryo development and larval survival, there appears to be no risk that development would be accelerated to the point where food resources would not be available for the newly hatched larvae. As a result, when the larvae hatch, sufficient food resources are expected to be available as the larvae begin to move inshore to feed.

In summary, the 2011 data show that:

- Temperature changes (Δt) were less than the 5°C maximum recommended by Griffiths, and that temperature changes occurred infrequently at the one location, TD35-12, at the south end of the diffuser;
Temperature increases at TD35-12, were infrequent (8 occasions), and when these occurred during the period January to March, 2011 were limited to durations of 6 hours or less;

Periodic temperature increases at TD35-12 reached a maximum temperature of 6.47°C on one occasion, and were less than 5°C during the other temperature increases;

There was no indication of temperature changes (Δt) at locations adjacent to TD35-12, and sustained temperature increases were well below the 3.5°C limit recommended by Griffiths at all locations; and

The results indicate that at the temperatures measured during the 2011 monitoring program, there are no anticipated effects on round whitefish embryos due to operation of the diffuser and that the results support the conclusions in the EA.

Typically exposure would be considered on the basis of the temperature dose to which the embryos would be exposed, and the number of individuals likely affected in order to gauge the likely impact on local populations. While the studies conducted in the DNGS area show very low habitat utilization by round whitefish, the small changes in temperature, that did not reach benchmark levels that could affect embryo development or survival, preclude the need for assessing potential impacts on local populations. Since there is no potential for adverse effects, there are no predicted effects on local populations.
6.0 REFERENCES


U.S. Army Corps of Engineers (US ACE) 2011. Water Level Data for Lake Ontario 1918 to Present. USACE, Detroit District (www.lre.usace.army.mil/greatlakes/hh/greatlakeswaterlevels/)

Figure 2.4.1-1

HISTORICAL WATER LEVELS IN LAKE ONTARIO

- Monthly Average
- Seaway Construction
- Average 1970 - Present
- Trend (1970 to 2011)
Mean Annual Air Temperature (°C)

Year (January to December)

Trenton A Met Station Annual Average: Jan to Dec
Trenton A Met Station: Climatic Normal


1993 1996

Figure 2.4.2-1

HISTORICAL ANNUAL AIR TEMPERATURES AT TRENTON A MET STATION

Figure-3 of 23
Mean Air Temperature for January to April of each year (ºC)

Season (January thru April)

Trenton A Met Station Averages: Jan to Apr

Trenton A Met Station: Climatic Normal

Measured Temperature at Ambient Nearshore Locations (January to May)

Measured Temperature at Ambient Nearshore Locations (May to September)

Upwelling: June 2
Upwelling: June 29
Upwelling: Aug. 11
Upwelling: Sept. 11
Measured Temperature at Ambient Offshore Locations (January to May)

Measured Temperature at Ambient Offshore Locations (May to September)
Measured Temperature at Port Granby (May to September)

Temperature (°C)


-5 0 5 10 15 20 25 30

PG1-1 (1 m)  PG1-5 (5 m)  PG1-B (8 m)  Average Nearshore Surface  Average Nearshore Bottom  Nearshore Surface - Port Granby Surface
Measured Temperature at Bottom for Offshore Locations Within Mixing Zone

Temperature Increase over Average at Bottom for Offshore Locations Within Mixing Zone
Measured Temperature at Bottom for Offshore Locations Beyond Mixing Zone

Temperature Increase over Average at Bottom for Offshore Locations Beyond Mixing Zone
Figure 4.2.2-3

**Measured Temperature at Bottom for Nearshore Locations Within Mixing Zone**

- DN10-B (10.0 m)
- DN11-B (10.0 m)
- TD38-B (9.5 m)
- TD42-B (8.5 m)
- TD52-B (10.5 m)
- Average

**Temperature Increase over Average at Bottom for Nearshore Locations Within Mixing Zone**

- DN10-B (10.0 m)
- DN11-B (10.0 m)
- TD38-B (9.5 m)
- TD42-B (8.5 m)
- TD52-B (10.5 m)
Measured Temperature at Bottom for Shallow Nearshore Locations

Temperature (°C)

Temperature Increase over Average at Bottom for Shallow Nearshore Locations

Temperature (°C)
Figure 4.2.2-5

Measured Temperature at Bottom for Reference Locations

Temperature Increase over Average at Bottom for Reference Locations
Measured Temperature at Bottom for Offshore Locations Within Mixing Zone and Alongshore Current Component at CM01 and the Port Darlington ADCP

Current Reversals

Weak/Stationary Current

Strong Onshore Current

Temperature Criteria

CM01
Port Darlington ADCP

TD34-B (14.5 m)
TD35-12 (12.0 m)
TD45-B (10.0 m)
TD55-B (14.8 m)

Figure 4.2.2-6

Measured Temperature at Bottom for Offshore Locations Within Mixing Zone and Offshore Current Component at CM01 and the Port Darlington ADCP

Current Reversals

Weak/Stationary Current

Strong Onshore Current

Temperature Criteria

CM01
Port Darlington ADCP

TD34-B (14.5 m)
TD35-12 (12.0 m)
TD45-B (10.0 m)
TD55-B (14.8 m)
NOTE
LEGEND

- Monitoring Locations
- 75th Percentile Temperature Increase
- Channel
- Diffuser
- Mixing Zone

REFERENCE

Base Data - MNRF NPMIS, obtained 2004, CANMAP v2005.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2006
Datum: NAD 83 Projection: UTM Zone 17N

Figure 4.2.3-2

QUARTILE AREAL EXTENTS OF THERMAL PLUME

Project: DNGS REFURBISHMENT AND CONTINUED OPERATIONS PROJECT

Title: QUARTILE AREAL EXTENTS OF THERMAL PLUME

File: EB-2013-0321
Exhibit L
Schedule 12 LOW-009
Attachment 3
7-DAY MOVING AVERAGE TEMPERATURES AT OFFSHORE LOCATIONS INSIDE THE MIXING ZONE

**Figure 5.4-1**

**PROJECT NO.** 08-1112-0067
**SCALE AS SHOWN**
**REV. 0**

**DESIGN**
M. Dec. 2011

**CHECK**
G. Dec. 2011

**FILED**
2014-03-19

**Exhibit L**
Tab 4.9
Schedule 12 LOW-009
Attachment 3

**PROJECT**
DNGS Refurbishment and Continued Operations Project
Environmental Assessment

**TITLE**
7-DAY MOVING AVERAGE TEMPERATURES AT OFFSHORE LOCATIONS INSIDE THE MIXING ZONE

**DATE**
01/01/2011 to 05/31/2011

**ANALYSIS**
Graph shows temperature changes over time at offshore locations inside the mixing zone. Temperature values range from -1.00°C to 7.00°C.
Fig. 5.4-2 7-DAY MOVING AVERAGE TEMPERATURES AT INSHORE LOCATIONS <6 m DEPTH

*Figures 19-23 of 23*

**Exhibit L**
**Tab 4.9**
**Schedule 12 LOW-009**
**Attachment 3**
7-DAY MOVING AVERAGE TEMPERATURES AT NEARSHORE LOCATIONS AT 6-10 m DEPTHS

Figure 5.4-3
Fig. 5.4-4

7-DAY MOVING AVERAGE TEMPERATURES AT OFFSHORE LOCATIONS OUTSIDE THE MIXING ZONE AT >10 m DEPTHS

DATE TEMPERATURE
-0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00


Temperature (°C)

DN05-B
DN07-B
DN08-B
DN09-B
DN13-B
DN14-B
DESIGN
7-DAY MOVING AVERAGE TEMPERATURES AT REFERENCE LOCATIONS

FIGURE: 5.4-5

PROJECT: DNGS Refurbishment and Continued Operations Project
Environmental Assessment

TITLE
7-DAY MOVING AVERAGE TEMPERATURES AT REFERENCE LOCATIONS

DATE: Dec. 2011

Temperature (°C)

Date

0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
-1.00

DN13-B
DN14-B
DN15-5
TD13-5
OCCURRENCE AND DURATION OF TEMPERATURES
ABOVE 5° C THRESHOLD AT TD35-12

Figure-5.4-6

PROJECT TITLE
DNRS Refurbishment and Continued Operations Project
Environmental Assessment

Figure-23 of 23
APPENDIX A

Current Data
DIRECTION FREQUENCIES 2011: ADCP

[Graph showing direction frequencies for various ADCP systems]

ADCP-01, ADCP-02, ADCP-03, ADCP-04, ADCP-05, ADCP-06, ADCP-07, ADCP-08, ADCP-09, ADCP-10, ADCP-11, ADCP-12, ADCP-13.

Tab 4.9
Schedule 12 LOW-009
Attachment 3

Filed: 2014-03-19
EB-2013-0321
Exhibit L

A-1 of 3
APPENDIX B
Temperature Time Series Plots
MEASURED TEMPERATURE AT LOCATION: ADCP

Temperature (°C)

MEASURED TEMPERATURE AT LOCATION: CM01
MEASURED TEMPERATURE AT LOCATION: CM01

- Temperature (°C)

CM01-15 (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D1

Temperature (°C)

TD05-1 (15 Minute Data)  TD13-5 (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D2

Temperature (°C)

TD30-1 (15 Minute Data)  TD31-B (15 Minute Data)

MEASURED TEMPERATURE AT LOCATION: D3

Temperature (°C)

TD50-1 (15 Minute Data)  TD51-5 (15 Minute Data)  TD52-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D3

- TD50-1 (15 Minute Data)
- TD51-5 (15 Minute Data)
- TD52-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D3A

Temperature (°C)

DN16-1 (15 Minute Data)  DN16-5 (15 Minute Data)  DN16-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D4

TD53-1 (15 Minute Data)  
TD54-5 (15 Minute Data)  
TD55-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D4

- TD53-1 (15 Minute Data)
- TD54-5 (15 Minute Data)
- TD55-B (15 Minute Data)

Temperature (°C)

16-May-2011 to 28-Sep-2011
MEASURED TEMPERATURE AT LOCATION: D5

- TD32-1 (15 Minute Data)
- TD33-5 (15 Minute Data)
- TD34-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D5

Temperature (°C)

- TD32-1 (15 Minute Data)
- TD33-5 (15 Minute Data)
- TD34-B (15 Minute Data)
MEASUREMENT TEMPERATURE AT LOCATION: D6

[Graph showing temperature data over time from May 15, 2011, to September 28, 2011, with data points for TD43-1, TD43-1 QAQC, TD44-5, and TD45-B.]
MEASURED TEMPERATURE AT LOCATION: D7

Temperature (°C)

TD40-1 (15 Minute Data)  TD40-1 QAQC (15 Minute Data)  TD41-5 (15 Minute Data)  TD42-B (15 Minute Data)

MEASURED TEMPERATURE AT LOCATION: D9

Temperature (°C)

TD22-1 (15 Minute Data)  TD24-5 (15 Minute Data)  TD25-8 (15 Minute Data)  TD35-12 (15 Minute Data)


Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 3
MEASURED TEMPERATURE AT LOCATION: D10

Temperature (°C)


TD18-1 (15 Minute Data)  DN03-5 (15 Minute Data)  DN03-B (15 Minute Data)  DN03-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D11

Temperature (°C)

DN01-1 (15 Minute Data)  DN01-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D12

Temperature (°C)

DN02-1 (15 Minute Data)  DN02-B (15 Minute Data)


Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 3
MEASURED TEMPERATURE AT LOCATION: D13

- DN04-1 (15 Minute Data)
- DN04-B (15 Minute Data)
- DN04-B QAQC (15 Minute Data)

Temperature (°C)

MEASURED TEMPERATURE AT LOCATION: D15

- DN06-1 (15 Minute Data)
- DN06-5 (15 Minute Data)
- DN06-B (15 Minute Data)
- DN06-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D15

Temperature (°C)

- DN06-1 (15 Minute Data)
- DN06-5 (15 Minute Data)
- DN06-B (15 Minute Data)
- DN06-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D16
MEASURED TEMPERATURE AT LOCATION: D16

- DN07-1 (15 Minute Data)
- DN07-10 (15 Minute Data)
- DN07-5 (15 Minute Data)
- DN07-B (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D22

Temperature (°C)


0  5  10  15  20  25

DN13-1 (15 Minute Data)  DN13-5 (15 Minute Data)  DN13-B (15 Minute Data)  DN13-B QAQC (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D22

Temperature (°C)

- DN13-1 (15 Minute Data)
- DN13-5 (15 Minute Data)
- DN13-B (15 Minute Data)
- DN13-B QAQC (15 Minute Data)

Dates:
- 16-May-2011 to 28-Sep-2011
MEASURED TEMPERATURE AT LOCATION: D23

Temperature (°C)

MEASURED TEMPERATURE AT LOCATION: D24

Temperature (°C)

DN15-1 (15 Minute Data)  DN15-5 (15 Minute Data)
MEASURED TEMPERATURE AT LOCATION: D24

Temperature (°C)

DN15-1 (15 Minute Data)  DN15-5 (15 Minute Data)

MEASURED TEMPERATURE AT LOCATION: PG1
APPENDIX C

7 Day Averages
7 DAY ROLLING AVERAGE TEMPERATURE: ADCP
7 DAY ROLLING AVERAGE TEMPERATURE: CM01

Temperature (°C)

CM01-15

7 DAY ROLLING AVERAGE TEMPERATURE: CM29
7 DAY ROLLING AVERAGE TEMPERATURE: CM29
7 DAY ROLLING AVERAGE TEMPERATURE: D1

Temperature (°C)

TD05-1
TD13-5
7 DAY ROLLING AVERAGE TEMPERATURE: D2
7 DAY ROLLING AVERAGE TEMPERATURE: D2

Temperature (°C)

TD30-1  TD31-B

Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 3

C-10 of 66
7 DAY ROLLING AVERAGE TEMPERATURE: D5

Temperature (°C)


TD32-1  TD33  TD34-B
7 DAY ROLLING AVERAGE TEMPERATURE: D7
7 DAY ROLLING AVERAGE TEMPERATURE: D7

Temperature (°C)

TD40-1  TD40-1 QAQC  TD41-5  TD42-B


Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 3
7 DAY ROLLING AVERAGE TEMPERATURE: D8

Temperature (°C)

0 5 10 15 20 25


TD26-1  TD27-5  TD28  TD38-B
7 DAY ROLLING AVERAGE TEMPERATURE: D9

- TD22-1
- TD24-5
- TD25-8
- TD35-12

Temperature (°C)

7 DAY ROLLING AVERAGE TEMPERATURE: D9

Temperature (°C)

TD22-1  TD24-5  TD25-8  TD35-12
7 DAY ROLLING AVERAGE TEMPERATURE: D10

Temperature (°C)

7 DAY ROLLING AVERAGE TEMPERATURE: D11

Temperature (°C)

01-Jan-2011
16-Jan-2011
31-Jan-2011
15-Feb-2011
02-Mar-2011
17-Mar-2011
01-Apr-2011
16-Apr-2011
01-May-2011
16-May-2011

DN01-1
DN01-B
7 DAY ROLLING AVERAGE TEMPERATURE: D13

Temperature (°C)

DN04-1
DN04-B
DN04-B QAQC


C-32 of 66
7 DAY ROLLING AVERAGE TEMPERATURE: D14
7 DAY ROLLING AVERAGE TEMPERATURE: D15

Temperature (°C)
7 DAY ROLLING AVERAGE TEMPERATURE: D15

Temperature (°C)

7 DAY ROLLING AVERAGE TEMPERATURE: D17

- Temperature (°C)
- 7 DAY ROLLING AVERAGE TEMPERATURE: D17
- Temperature (°C)
- 7 DAY ROLLING AVERAGE TEMPERATURE: D17

**Graph Details:**
- **Axes:** X-axis: Dates from 16-May-2011 to 28-Sep-2011; Y-axis: Temperature (°C)
- **Lines:**
  - Blue: DN08-1
  - Light Blue: DN08-5
  - Green: DN08-10
  - Purple: DN08-B
  - Cyan Dashed: DN08-B QAQC

**Legend:**
- DN08-1
- DN08-5
- DN08-10
- DN08-B
- DN08-B QAQC

**時期和温度:**
- May 2011
- Jun 2011
- Jul 2011
- Aug 2011
- Sep 2011

**最終日:**
- 31 May 2011
- 30 Jun 2011
- 30 Jul 2011
- 29 Aug 2011
- 28 Sep 2011

**Note:**
- The graph shows the rolling average temperature for different locations and periods, with peaks and troughs indicating changes in temperature over time.
7 DAY ROLLING AVERAGE TEMPERATURE: D19

Temperature (°C)

7 DAY ROLLING AVERAGE TEMPERATURE: D20

Temperature (°C)

7 DAY ROLLING AVERAGE TEMPERATURE: D20

Temperature (°C)

0 5 10 15 20 25


DN11-B
7 DAY ROLLING AVERAGE TEMPERATURE: D21

Temperature (°C)

7 DAY ROLLING AVERAGE TEMPERATURE: D22

Temperature (°C)

7 DAY ROLLING AVERAGE TEMPERATURE: D22

Temperature (°C)

- DN13-1
- DN13-5
- DN13-B
- DN13-B QAQC

File: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 3
7 DAY ROLLING AVERAGE TEMPERATURE: D23

Temperature (°C)

7 DAY ROLLING AVERAGE TEMPERATURES: DN03-B

Average Maximum Temperature (°C)

Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 3
7 DAY ROLLING AVERAGE TEMPERATURES: TD38-B

<table>
<thead>
<tr>
<th>Year</th>
<th>Average</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Schedule 12 LOW-009
Attachment 3
7 DAY ROLLING AVERAGE TEMPERATURES: TD42-B

Average
Maximum

Temperature (°C)

Day of Year

Filed: 2014-03-19
EB-2013-0321
Exhibit L
Tab 4.9
Attachment 3
7 DAY ROLLING AVERAGE TEMPERATURES: TD45-B

<table>
<thead>
<tr>
<th>Year</th>
<th>Average</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>1991</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>1992</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>1993</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>1994</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1995</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1996</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2011</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
7 DAY ROLLING AVERAGE TEMPERATURES: TD52-B

- **1990**
- **1991**
- **1992**
- **1993**
- **1994**
- **1995**
- **1996**
- **2011**
- **Average**
- **Maximum**
At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.
PWU Interrogatory #005

Ref:
(a): Exh N1-1-1: Page18, Lines 10-13 and Lines 15-16:

Forecast OM&A expenses have increased for 2014 from $19.6M to $23.1M and for 2015 from $18.2M to $20.4M. The total increase in OM&A over the two years is $5.6M and is mainly due to the timing of the Operations Trainee Program, deferrals from 2013 and better defined cost estimates, partly offset by lower demolition and removal activities.

The in-service additions to rate base have increased for 2014 from $18.7M to $26.1M and for 2015 from $209.4M to $310.0M. The total increase for the two year period is $108.0M.

Page 19, Lines 1-3 states:
While OPG is seeking a finding of reasonability with respect to the updated test period capital expenditures, OPG is not seeking approvals of the higher levels of OM&A expense or in-service additions.

(b): Exh N1-1-1, Page 19 of 23, Lines 5-11

Separately, as a result of improved scope definition, the Fuel Handling Refurbishment and Balance of Plant contract strategies are currently under review; this review will be completed by December 15, 2013 and the contract strategy will be updated.

As part of the DRP’s annual review of its Program Management Plans, the plans are currently being updated and will be issued by December 15, 2013. These plans will reflect the latest information on how the DRP will be managed.

(c): Exh D2-2-. Darlington Refurbishment, Section 7.2 — Capital In-Service Additions, Page 22, Line 13- Page 28, Line 29


The Commission asked whether the Ea took into consideration the ISR and the Fukushima Lessons Learned. CNSC staff responded that the analysis conducted for the EA took into consideration the installation of safety enhancements identified in the ISR and Fukushima Lessons Learned, as this accurately reflects the post refurbishment operations of Darlington. A representative from OPG noted that four new Safety Improvement Opportunities (S10s) features, to be
completed before refurbishment, are the following:

- A containment filtered venting system;
- A third emergency power generator (a seismically qualified generator);
- Improvements to the power house steam venting system; and
- An emergency heat sink (an alternate and independent supply of water as an emergency heat sink).

**Issue Number: 4.9**

**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Project appropriate?

**Interrogatory**

**a)** Why is OPG not seeking approvals for the higher levels of OM&A expense or in-service additions in Ref (a)? What is OPG’s plan to recover these costs?

**b)** In Ref (b), has OPG filed the updated contract strategy and Program Management Plans? If yes, where in the evidence?

**c)** For each of the six facility and infrastructure projects in Ref (c), please provide specific descriptions of services to be delivered indicating how each project supports the operation of the existing units even before the start of refurbishment outage.

**d)** For each of the three safety improvement projects in Ref (c), please provide specific descriptions of services to be delivered indicating how each project supports the operation of the existing unit seven before the start of refurbishment outage.

**e)** As per Ref (c), page 23 of 33, the three safety improvement projects include the Containment Filter Venting System Project. Where in the evidence is this project described? What is the in-service date and cost of this project? Is OPG seeking to recover the cost in the test years?

**f)** Canadian Nuclear Safety Commission’s (“CNSC”) Reasons for Decision in respect of the Environmental Assessment Screening on the Proposal to Refurbish and Continue to Operate the Darlington GS also identified four new safety opportunities to be completed before refurbishment, including the provision of an alternate, independent supply of water as an Emergency Heat Sink. When will this project be completed and placed in-service? Has OPG included in-service capital additions in relation to the Energy Heat Sink project for 2014 and 2015 test years? If so, please provide a description of the project?

**Response**

**a)** Consistent with Ex N1-1-1, page 2, lines 14 - 16, OPG is not seeking to recover these amounts in the revised payment amounts and riders in order to minimize the impact on the proceeding schedule and to keep the Impact Statement to a manageable size.

**b)** OPG has not filed the updated contract strategy or Program Management Plans.
c) The following table summarizes the services to be delivered by the six facility and infrastructure projects and how each project supports the Darlington station before refurbishment:

<table>
<thead>
<tr>
<th>F&amp;IP Project</th>
<th>Description of Services to be delivered</th>
<th>How the project supports the operating units before refurbishment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Darlington Energy Complex</strong></td>
<td>Provide testing on new tooling and training on full scale mock-up for R&amp;FR work</td>
<td>No support to the Darlington station before Refurbishment. The R&amp;FR mock-up area will be used for training and testing in support of operations post refurbishment.</td>
</tr>
<tr>
<td></td>
<td>Provide warehousing of tooling and materials to be used in this training center</td>
<td>No support to the Darlington station before Refurbishment. The warehouse will be used to store tools and other inventory items post refurbishment.</td>
</tr>
<tr>
<td></td>
<td>House the DRP project management team</td>
<td>Improve communication and integration with the Darlington station</td>
</tr>
<tr>
<td></td>
<td>Provide a security in-processing centre</td>
<td>Alleviate the security processing burden and congestion for the Darlington station</td>
</tr>
<tr>
<td></td>
<td>House some Nuclear East Facilities staff and vehicles supporting the Darlington station</td>
<td>Alleviate the congestion for the Darlington station by relocating off-site; Reduce the travel/response time by remaining in close proximity while providing daily facilities services to the Darlington station</td>
</tr>
<tr>
<td></td>
<td>Provide a new Nuclear Information Centre that replaces the old on-site Information Centre, and house all associated Public Affairs staff</td>
<td>Continue to provide OPG nuclear generation information to the public while limiting public access to the site</td>
</tr>
<tr>
<td><strong>Water and Sewer</strong></td>
<td>Supply domestic water and fire water from the municipalities of Oshawa and Bowmanville to various station facilities</td>
<td>Ensure a reliable and safe supply with adequate capacity for both domestic water and fire protection requirements for the current operation of the plant. It addresses a long standing issue to have the water supplied from 2 sources as opposed to one that is in service today.</td>
</tr>
<tr>
<td></td>
<td>Send sewage directly to the municipality from a newly installed sanitary sewer line that will replace on-site Sewage Treatment Plant</td>
<td>Allow for the decommissioning of the existing deteriorating Sewage Treatment Plant that has achieved end of life. The new line is required to maintain current operation of the plant.</td>
</tr>
<tr>
<td><strong>Heavy Water Storage &amp; Drum Handling Facility</strong></td>
<td>Provide sufficient heavy water storage at the Darlington site for the heavy water from two units to meet DRP requirement</td>
<td>Enable more efficient utilization of the Darlington TRF by increasing the operational storage. This also facilitates the current TRF/Heavy Water Management Life Cycle Management Plan to 2055, thus reducing the risk of requiring a TRF refurbishment or construction of a new TRF facility</td>
</tr>
<tr>
<td></td>
<td>Provide additional permanent storage required to improve utilization of the Darlington TRF</td>
<td>Increase detritiation efforts and lower both tritium emissions and employee radiation exposure by improving the TRF efficiency</td>
</tr>
<tr>
<td></td>
<td>Provide a new Heavy Water Drum Handling, Cleaning, Testing and Storage Facility services to both Darlington and Pickering stations</td>
<td>Reduce large backlog of drums that has caused radiological and conventional safety concerns, injuries, and significant operational burden due to storing drums throughout the Heavy Water Management Building</td>
</tr>
<tr>
<td></td>
<td>Provide new consolidated office space for TRF staff</td>
<td>Rectify long standing problem of unconsolidated and non-standard TRF work locations with new offices; Improve communication, oversight and time in the field by relocating the managers to the central offices</td>
</tr>
</tbody>
</table>
d) The following provides specific descriptions of services to be delivered by the three safety improvement projects in Ref (c) and how each project supports the operation of the existing units even before the start of refurbishment outage.

<table>
<thead>
<tr>
<th>SIO Project</th>
<th>Description of Services to be delivered</th>
<th>How the project supports the operating units before refurbishment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powerhouse Steam Vending (&quot;PSVS&quot;)</td>
<td>PSVS modification will provide redundancy in the initiation logic for the Powerhouse Steam Venting system. This redundancy significantly reduces the risk of the PSVS failing under design basis accident conditions. This change reduces the risk from large main steamline break events.</td>
<td>These projects are regulatory commitments made in the DRP Environmental Assessment and increases safety margins of the running units.</td>
</tr>
<tr>
<td>Third Emergency Power Generator (&quot;EPG&quot;)</td>
<td>Addition of a third emergency power generator to provide Class II power to the station in case of loss of unit power. The addition of a third EPG improves the seismic robustness and overall reliability of the emergency power supply.</td>
<td></td>
</tr>
<tr>
<td>Containment Filtered Venting System (&quot;CFVS&quot;)</td>
<td>Containment Filtered Venting System (CFVS) provides a robust containment pressure relief pathway during and following beyond design basis events (BDBAs). The CFVS is designed to retain the radioactive materials that are released as a result of the containment pressure relief. This system ensures containment integrity throughout the extremely unlikely BDBAs.</td>
<td></td>
</tr>
</tbody>
</table>

e) The Containment Filter Venting System project is not described in the evidence, since originally it was not planned to come into service during the test period. The total cost for the Containment Filter Venting System project is forecast to be $39.0M, and to be placed
in-service in the fourth quarter of 2015. This project contributes to the increased in-service
additions in 2015 as noted in Ex. N1-T1-S1, page 18, lines 15 and 16. OPG is not seeking
approvals to recover the higher in-service additions in the test period as stated in Ex. N1-
T1-S1, page 19, lines 2 and 3.

f) Nuclear Safety identified to the CNSC in the Integrated Implementation Plan (“IIP”) that the
Emergency Heat Sink modification (“EHS”) would be installed prior to start of the first unit
refurbishment. The modification involves a piping connection from Emergency Service
Water to Heat Transport that is best completed during the Refurbishment outage. OPG will
be installing diesel fire pumps before the start of refurbishment creating an alternate flow
path to get water into the Primary Heat Transport (“PHT”) system, and, as a result the
EHS modification can be executed during the refurbishment. The project will be placed in-
service as part of the refurbishment project so there are no in-service capital additions
required during the 2014 and 2015 test period.
Ref: 4.9

**Issue:** Are the proposed test period in-service additions for the Darlington Refurbishment Project) appropriate?

**Interrogatory**

What is the status of all legal proceedings challenging the Joint Review Panel's report regarding the Darlington Refurbishment Project? What effect, if any, will legal challenges have on the proposed test year in-service dates of the Darlington Refurbishment Project.

**Response**

The legal proceeding challenging the decision of the Canadian Nuclear Safety Commission, not a Joint Review Panel, regarding the environmental assessment of the Darlington Refurbishment Project has reached the stage where all filings of the parties have been submitted to the Federal Court and a request made by the Applicants for the setting of a hearing date.

OPG cannot speculate with respect to the timing or results of the judicial review.
VECC Interrogatory #003

Ref: D2-2-1, page 27, Section 7.2.8

Issue Number: 4.9

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Project) appropriate?

Interrogatory

The referenced section refers to Emergency Power Generator (Third)

a) Please confirm that this generator is intended to provide electrical supply to the Darlington nuclear generating facility in the event of loss of external electrical supply. If unable to so confirm, please explain, indicating and fully describing the generation assets that are intended to provide electrical supply to the Pickering nuclear generating facility in the event of loss of external electrical supply.

b) Please confirm that the referenced generator will provide an electrical supply in the event of the loss of external electrical supply that will, among other things, provide electrical energy that will operate pumps used for cooling. If unable to so confirm, please indicate what other generating assets are used for cooling and describe these assets.

c) Please provide a description of other generating assets in-service that this generator is intended to complement in the event of an emergency. For example, please indicate whether the other generators diesel, in-line, 8 cylinders, whether they have been “turbocharged” or otherwise upgraded by or for OPG, whether they are inner cooled, the name of the supplier, whether they were new when acquired, when they went into service, and the historical purchase price.

d) Please provide a similar description for the referenced generator as was requested for existing generators in part c) above.

e) Have or will any of the emergency generators been “crash tested” to see if they can withstand going from stationary to full power under load in 10 seconds for an extended period of time? If not, please explain how they have been tested and how frequently they have been tested.

f) Have or will any of the emergency generators been tested while being monitored by an independent third party? If so, please provide details; if not, why not?

Response

a) & b) The two Emergency Power Generators (EPG1 and EPG2) at Darlington Nuclear are seismically qualified gas turbine generators which supply emergency power to a number of

Witness Panel: Darlington Refurbishment
loads, including the emergency water pumps which supply water to cool the reactor should external and standby electrical supply become unavailable. The Third Emergency Power Generator will be located on the Darlington site and will provide additional redundancy when either EPG1 or EPG2 is unavailable.

c) Darlington Nuclear has four gas turbine Standby Generators which provide the standby electrical power should external electrical supply become unavailable. These are Rolls Royce Olympus model SK30 rated for 26 MWe each. They were supplied by Pratt and Whitney Aircraft of Canada and Rolls Royce of Canada. The individual historical purchase costs associated with the gas turbine generators was approximately $39.6M and they were placed in-service in 1990.

d) EPG1 and EPG2 are Solar Turbine International Mars model 90 T10000 gas turbine generators rated at 6.8 MWe each and were purchased for $5.9M and placed in-service in 1990. The Third EPG project is in progress and a purchase order has not yet been issued for the supply of the gas turbine generator.

e) The design requirements for the Standby and Emergency Power Generator gas turbines do not require full load within 10 seconds. The Standby Generator design requirements are to complete nuclear safety equipment loading from stationary within four minutes. The requirement for the existing Emergency Power Generator is to be fully loaded from stationary within 140 seconds of a manual start. The third EPG project detailed design work will define the safety limits that determine the appropriate loading times. The requirement for the third EPG is expected to be similar to the existing EPGs. Routine testing of each Standby Generator is one hour operation every eight weeks. Routine Emergency Power Generator testing is 4 hours operation every 28 days.

f) The Canadian Nuclear Safety Commission conducts regulatory inspections of the standby generators and emergency power generators. The last inspection was conducted in September 2011.
Board Staff Interrogatory #051

Ref: Exh D2-2-1 page 23 & Attachment 8.-1

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

In Exh D2-2-1 OPG refers to the Darlington Energy Complex (“DEC”) while Attachment 8-1 is the business case for a project titled “Darlington Refurbishment Complex (DRC) at the Clarington Energy Center”. Are these one and the same?

Response

Yes. As the Darlington Energy Complex will house other OPG programs and services during and after the refurbishment period the name was changed to reflect this.
Board Staff Interrogatory #052

Ref: Exh D2-1-2 Section 3.1 page 2

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

OPG states that most projects to be undertaken in the test period are sustaining projects, or projects to sustain and/or improve plant reliability at both Darlington and Pickering. They include expenditures on systems and components approaching their end of life, or for which replacement parts are no longer readily available.

a) Are any of these projects directly or indirectly related to the DRP? If so please identify which ones and their total cost in 2014 and 2015.

b) Please describe the transition plan OPG has in place to ensure that there is ongoing coordination of the timing, approval and execution of sustaining and plant reliability projects with the DRP related investments.

c) Please provide examples of where a planned Darlington sustaining or reliability project has been deferred until after refurbishment has taken place.

Response

a) In the 2014 and 2015 Test Period there are no nuclear operations capital projects that OPG considers directly or indirectly related to the Darlington Refurbishment Project.

As part of the 2013 Darlington Scope Review, a portion of the Fuel Handling Reliability project scope was transferred to Darlington to be performed as part of the station’s Fuel Handling Reliability project (Ex. L-04.10-1 Staff-054). Fuel Handling reliability improvement projects are designed to address forced loss rate issues caused by inability to keep the reactor fuelled. Improved Fuel Handling reliability does, however, have a schedule risk management benefit for refurbishment defueling activities.

Also as part of the 2013 Darlington Scope Review approximately $180M of scope was identified that could be effectively performed post refurbishment using the normal station maintenance and project management processes. The Asset Investment Screening Committee (“AISC”) project prioritization and budgeting process will be used for all post refurbishment project requirements. As this scope is planned for execution post refurbishment there are no costs in 2014 and 2015. The $180M scope to be performed post refurbishment is included in the LUEC for the refurbishment business case.

b) The Darlington Refurbishment program includes a program scope review board as part of its managed system. This board reviews, approves, or rejects the major refurbishment scope.

Witness Panel: Nuclear Projects
The board consists of senior cross functional members and one of the three voting members includes the AISC Chair which provides alignment between nuclear operations portfolio projects and refurbishment scope. OPG plans to execute AISC projects based on station needs and give priority to the operating units during the refurbishment period. The refurbishment program scope review board will be used to identify and control any AISC projects that may need to be executed on a unit undergoing a refurbishment outage.

c) There are no examples of planned Darlington sustaining or reliability projects being deferred until after refurbishment has taken place.
Board Staff Interrogatory #053

Ref: Exh D2-1-2 section 1.0 & section 3 & Table

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

OPG states that “As part of its 2014-2016 Business Planning process, OPG is reassessing its 2015 project portfolio budget and anticipates increases in the project portfolio to address recent emerging requirements for new project expenditures” and that it “…intends to make capital investments associated with critical equipment at Darlington and Pickering in 2015 to meet regulatory requirements as well as improve ongoing and future reliability as Darlington units are taken offline for refurbishment.”

a) Please provide a brief description of the regulatory requirements underpinning these investments.

b) What will these aforementioned investments total for each of Darlington and Pickering and what amount, if any, is reflected in the 2015 rate base?

c) Are any or all of these costs reflected in OPG’s 2014-2016 Business Plan (filed with the Board on December 6, 2013) and/or updated DRP BCS (filed with the Board on February 6, 2014)?

d) Would these costs be incurred in 2015 if there were no DRP?

e) Will the unallocated portfolio budgets, of $128.0M in 2014 and $109.2M in 2015, fund these emerging needs? If not, please describe the assessment or needs review that OPG undertook/will undertake to determine that the unallocated portfolio budget is inadequate.

f) Are the unallocated portfolio budgets referenced in (e) reflected in 2014 or 2015 rate base?

Response

a) The regulatory requirements underpinning the investments in 2015 are mainly associated with Fukushima related projects to address CNSC Fukushima Action Items, Fire Code Compliance requirements in order to meet a new CSA standard mandated by the CNSC, Reactor Safety Upgrades and various Environmental projects.

b) For 2015, the new approved regulatory investments total approximately $28M for Darlington, approximately $21M for Pickering, and approximately $3M for Nuclear Support. However, additional regulatory investments are expected to be made and these will be funded from...
the “Unallocated” portion of the portfolio as per the Asset Investment Screening Committee (“AISC”) managed process. Rate base additions of $29M in Darlington, $10M in Pickering and $13M in Nuclear Support are forecast for 2015. These rate base additions would include expenditures in 2015 and from prior years. In addition, a portion of the “Unallocated” portfolio has been allocated to the 2015 rate base, associated with the expected additional regulatory investments.

c) All of the costs identified in b) are included in OPG’s 2014 - 2016 Business Plan.

d) The projects represent regulatory commitments required to ensure the safe operation of the Darlington station. As a result, the projects would likely proceed in 2015 even if the Darlington Refurbishment did not.

e) The “Unallocated” portion of the portfolio budget would be used to fund new requirements. In addition, the 2014 - 2016 Business Plan was increased to provide sufficient funding to execute emerging project work demands.

f) Yes. The Supplemental In-Service Forecast for 2014 and 2015 includes the “Unallocated” portfolio budget as described at Ex. D2-1-3, page 5.
Board Staff Interrogatory #54

Ref: Exh D2-2-1 Attachment 5 (Updated 2014-02-06) page 11

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

The BCS indicates the following. The second work area of Fuel Handling is the refurbishment of the Fuel Handling System. The work for the Fuel Handling System has been divided into 6 work packages. As part of the 2013 Darlington Scope Review, a portion of the scope has been transferred to the Darlington Station to be performed as part of the station’s Fuel Handling Reliability project. The balance of the scope will be awarded in late 2013 and early 2014.

Under which table in D2-1-3 and which Project number is the portion of the scope that has been transferred?

Response

Fuel Handling System station-owned projects are identified in Ex. D2-1-3, Table 2c (line 35 and 36) and Ex. D2-1-3, Table 5a (lines 1, 20, 38, 50 and 62).
**Board Staff Interrogatory #055**

Ref: Updated Exh D2-2-1 and Attachment 5 page 9

**Issue Number:** 4.10

**Issue:** Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

**Interrogatory**

The Updated Business Case Summary notes that OPG continues to discuss with the province the need for greater assurance of cost recovery and has suggested regulatory changes to facilitate this. Please describe the regulatory changes which OPG has recommended.

**Response**

OPG’s proposed changes to O. Reg. 53/05 are not relevant. The Updated Business Case Summary and the proposed changes referenced therein predate the current form of O. Reg. 53/05. It is only the current form of the O. Reg. 53/05, which was issued in November 2013 that has any bearing on the payment amounts for the test period.

Witness Panel: Overview, Regulatory Issues, Business Transformation
Board Staff Interrogatory #056

Ref: Exh D2-1-2 Table 1 & Exh D2-2-1 Table 1

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

Board staff prepared the table below for nuclear capital expenditures for the period 2010-2015.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations Capital</td>
<td>$178.3</td>
<td>$148.2</td>
<td>$161.4</td>
<td>$170.2</td>
<td>$196.3</td>
<td>$143.9</td>
<td>$998.3</td>
</tr>
<tr>
<td>Darlington Refurbishment Capital</td>
<td>$32.6</td>
<td>$91.0</td>
<td>$232.5</td>
<td>$529.8</td>
<td>$837.4</td>
<td>$631.8</td>
<td>$2,355.1</td>
</tr>
<tr>
<td>Total Nuclear Capital</td>
<td>$210.9</td>
<td>$239.2</td>
<td>$393.9</td>
<td>$700.0</td>
<td>$1,033.7</td>
<td>$775.7</td>
<td>$3,353.4</td>
</tr>
</tbody>
</table>

Based on the latest DRP business plan, what percentage of the DRP total capital expenditures is projected to have been spent by the end of 2015?

Response

The current high confidence estimate for the DRP, as included in Ex. D2-2-1, Attachment 5, page 2, is $12.9B including interest and escalation. This estimate includes both capital and OM&A expenditures.

The total capital expenditures projected to be spent in the Definition Phase by the end of 2015, as a percentage of the current high confidence estimate, is 18 per cent.

This includes expenditures related to regulatory approvals, engineering, planning and oversight, procurement of long lead materials, construction of facility and infrastructure projects, safety improvement projects, and the full scale reactor mockup.
**SEC Interrogatory #054**

Ref: D2-2-1/Updated/p.7

**Issue Number:** 4.10

**Issue:** Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

**Interrogatory**

Please provide a table showing, for each year 2010 through to the end of 2013 of the DRP, the actual and the current forecast amounts for:

(a) Retube and Feeder Replacement  
(b) Fuel Handling  
(c) Turbine Generators  
(d) Steam Generators  
(e) Facility and Infrastructure  
(f) Balance of Plant  
(g) Project Management and Administration  
(h) Other (define).

**Response**

The table below is a breakdown of actual costs for each year (2010 - 2013) of the DRP. The total in the table is $802M, $18M lower than the $820M reported in Ex. D2-2-1, Attachment 5 as 2013 actual costs are lower than forecast.

<table>
<thead>
<tr>
<th></th>
<th>$M (Millions)</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retube and Feeder Replacement</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>66</td>
<td>143</td>
</tr>
<tr>
<td>Fuel Handling</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Defueling</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Steam Generators</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Turbine Generators</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>Balance of Plant</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Islanding</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>System Shutdown</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Facilities &amp; Infrastructure (Note 1)</td>
<td>13</td>
<td>28</td>
<td>77</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Project Management and Support including Engineering and Regulatory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest</td>
<td>1</td>
<td>3</td>
<td>11</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>39</strong></td>
<td><strong>91</strong></td>
<td><strong>235</strong></td>
<td><strong>437</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Note 1:** 2010 was adjusted with $6M project costs that were transferred from Nuclear Portfolio to DRP F&IP after EB-2010-0008, to be consistent with D2-2-1 Attachment 5.
SEC Interrogatory #055

Ref: D2-2-1-Attachment 5 Updated

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

Please calculate the LUEC for the DRP under the following scenarios: $820 million life-to-date costs to the end of 2013 and each of: (a) $10 Billion total capital costs; (b) $11.5 billion total capital costs; (c) $12.5 billion total capital costs (2013$ including corporate overheads). Please provide all assumptions.

Response

a) As per Ex. L-04.7-1 Staff-038, the LUEC for a $10.0B capital cost project, including interest and future escalation in 2013 dollars is 8.2 cents/kWh.

b) The LUEC for a $11.5B capital cost project including interest and future escalation in 2013 dollars is 8.62 cents/kWh.

c) The LUEC for a $12.5B capital cost project including interest and future escalation in 2013 dollars is 8.93 cents/kWh.

Note in a, b, c above, the $10.0B, $11.5B, and $12.5B values quoted, are considered “overnight” dollars, i.e., excluding interest and future escalation. The LUECs provided above, include the cost of interest and escalation for the associated “overnight” amount. The LUECs, in all cases, are reported in 2013$ and include corporate overheads.

The post refurbishment costs and capacity factors assumed in parts a), b), and c) are consistent with the amounts included in Ex. D2-2-1, Attachment 5.
SEC Interrogatory #056

Ref: D2-2-1-Attachment 5 Updated/p.3

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

Please provide the assumptions and calculations for the estimate of 8.5 cents/kWh LUEC for Bruce Units 1 and 2.

Response

Please refer to the response to Board Staff Interrogatory #31, part d).
SEC Interrogatory #057

Ref: D2-2-1-Attachment 5 Updated/p.3

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

Please reconcile the figures shown on page 3 of the DRP Business Plan with Table 1 at D2-1-2/Table 1 Capital Expenditure Summary.

Response

The figures shown on page 3 of the DRP Business Case Summary (Ex. D2-2-1, Attachment 5) are based on the 2014 - 2016 Business Plan while the figures in the DRP Capital Expenditures Summary are based on the 2013 - 2015 Business Plan.

A breakdown by cost classification of the DRP Definition Phase cumulative Release 4c funds of $1,608M, as shown on Ex. D2-2-1 Attachment 5, page 3, and as per OPG’s 2014 – 2016 Business Plan, is provided below.

<table>
<thead>
<tr>
<th>$M</th>
<th>Cost Classification</th>
<th>2010-2012 Actual</th>
<th>2013 Forecast</th>
<th>2014 Plan</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2-2-1</td>
<td>Capital</td>
<td>361</td>
<td>448</td>
<td>765</td>
<td>1,574</td>
</tr>
<tr>
<td>Att. 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Page 3</td>
<td>OM&amp;A</td>
<td>4</td>
<td>7</td>
<td>23</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>365</td>
<td>454</td>
<td>788</td>
<td>1,608</td>
</tr>
</tbody>
</table>

Witness Panel: Darlington Refurbishment
**SEC Interrogatory #058**

**Ref:** D2-2-1-Attachment 5

**Issue Number:** 4.10

**Issue:** Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

**Interrogatory**

What is the cost of reconstruction of the Holt Bridge? Please describe the location of this bridge and the need for this project.

**Response**

The cost of the project will be $31M.

The new Holt Road interchange off Highway 401 will be located approximately 35 meters east of the existing Holt Road interchange ensuring that access to and from the Darlington site is maintained at all times.

The current interchange does not include a 401 westbound off-ramp to Holt Road and there is no eastbound access to the 401 from Holt Road. As a result, traffic accessing the Refurbishment project via Park Road access point, must exit the 401 at Courtice Road, if heading east, or Waverly, if heading west. Traffic heading west from Waverly along the South Service Road must then cross over the 401 off ramp at Holt Road resulting in significant delays entering and leaving the site.

Adding significant traffic congestion to the area including South Service Road and Baseline Road (North of the 401) will likely impact the relationship between OPG and the local community. Individuals will look for routes that will reduce their commuting time resulting in an increase in the use of side streets and residential roadways resulting in significant safety concerns.

It also must be recognized that Ontario's approved “Growth Plan for the Golden Horseshoe” forecasts an increase of approximately 430,000 people and 160,000 jobs by 2031 in the Region of Durham. The current plan is to widen the 401 through the area, which would likely result in bridge reconstruction, in 2028. OPG must complete this work prior to October 2016 to avoid significant wait times entering and exiting the site.
SEC Interrogatory #059

Ref: D2-2-1-Attachment 5 Updated/p.9

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

Please provide the CCA (component condition assessments) and their summary results.

Response

1,606 Component Condition Assessments ("CCA") were completed on 58 systems covered by the Integrated Safety Review. The component condition is identified as either very good, good, satisfactory, poor, or very poor.

Components in 1190 CCAs (74%) are assessed to be in very good or good condition, components in 363 CCAs (23%) are assessed to be in satisfactory condition, and components in 53 CCAs (3%) are assessed to be in poor or very poor condition.
SEC Interrogatory #060

Ref: D2-2-1-Attachment 5 Updated/p.9

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

Please explain what regulatory changes OPG has discussed with the Province to assure cost recovery of the DRP.

Response

Please see the response to Board Staff #55 (Ex. L-4.10-1 Staff 055).
SEC Interrogatory #061

Ref: D2-2-1-Attachment 5 Updated/p.17

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

Please provide the assumptions and summary analysis supporting the present values shown in Table 1 of the DRP Business Plan.

Response

The values in Table 1 are 2013 M$ (present value).

The modeling of the net present value benefit of a generation alternative requires a large number of assumptions regarding the costs of each alternative and the value of these alternatives to the system.

In Table 1, three schedule alternatives were analyzed and then compared relative to each other at different assumed achieved lives (prior to refurbishment) for the Darlington units. The three alternatives were:

- Alternative 1: 2016 Start with No Overlap of 1st and 2nd Units
- Alternative 2: 2016 Start with 1st and 2nd Units Overlapped
- Alternative 3: 2017 Start with 1st and 2nd Units Overlapped

For each of the above alternatives, the following costs and schedule assumptions were assessed:

- Changes to costs and schedule of the Darlington Refurbishment Project
- Changes to Darlington Station Base OM&A costs
- Changes to Darlington Station Planned Outage costs and schedules
- Changes to Darlington Station Project Expenditures
- Costs to enable specific alternatives (e.g. Fuel Channel Life Extension Project expenditures required to enable the “unlapped” schedule)

Note 1: Changes to the assumed refurbishment schedule affect timing of station base OM&A costs, the timing and duration of station planned outages and the timing of station projects expenditures).

The following table summarizes the changes in the above costs which were assessed for each of Alternatives 2 and 3 relative to Alternative 1, expressed in 2013$M (NPV)
The Fuel Channel Life Extension ("FCLE") Project has as its objective to gain high confidence in fitness-for-service of the Darlington fuel channels to 235,000 Effective Full Power Hours ("EFPH"). The costs used in the assessment applied the Darlington related portion of the FCLE project and related costs only to those alternatives (Alternatives 1 and 3) where the FCLE project was required to enable the alternative.

Changes to the Darlington Refurbishment Project schedule result in changes to energy profile from the Darlington units, thereby affecting the value of energy production and capacity based on the avoided cost of alternative generation (the system benefit or cost). These changes occur in the pre-refurbishment period (e.g., delayed schedule results in greater energy production in the pre-refurbishment period), during the refurbishment period (e.g., number of units overlapping; duration of refurbishment window), and the post-refurbishment period (e.g. delayed end of refurbishment translates into later energy production in the post refurbishment period).

The key assumptions which affect the calculation of the system benefit or cost include:

- The demand forecast
- The gas price forecast (affects the cost of gas-fired generation)
- The carbon price forecast
- The value of exports
- The amount of conservation/energy efficiency
- The amount of new generation such wind and solar.

Other assumptions are built into the detailed models used to do the assessment, including the manner in which generation is dispatched and the manner which various market rules affect the use of available generation.

The costs and system benefits are discounted to present value using a 7% discount rate.

Table 1 of Ex. D2-2-1, Attachment 5, page 17 represents the results of the three Alternatives compared against each other at four different assumptions regarding pre-refurbishment station life, i.e., 12 comparisons. The following table represents a summary of the analysis for the last column of Table 1 (i.e., the 235,000 EFPH column).
## Summary Analysis of 235,000 EFPH Column of Table 1, Ex. D2-2-1-Att 5(2013M$ PV)

<table>
<thead>
<tr>
<th>Factor</th>
<th>2016 Unlapped (Alt 1) vs. 2016 Lapped (Alt 2)</th>
<th>2016 Unlapped (Alt 1) vs. 2017 Lapped (Alt 3)</th>
<th>2017 Lapped (Alt 3) vs. 2016 Lapped (Alt 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refurbishment Costs</td>
<td>13</td>
<td>-101</td>
<td>114</td>
</tr>
<tr>
<td>Base OM&amp;A</td>
<td>-77</td>
<td>-20</td>
<td>-57</td>
</tr>
<tr>
<td>Outage OM&amp;A</td>
<td>11</td>
<td>43</td>
<td>-32</td>
</tr>
<tr>
<td>Projects</td>
<td>-41</td>
<td>-5</td>
<td>-36</td>
</tr>
<tr>
<td>Fuel Channel Life Extension Project &amp; related costs</td>
<td>-136</td>
<td>0</td>
<td>-136</td>
</tr>
<tr>
<td><strong>Cost Impact</strong></td>
<td><strong>-230</strong></td>
<td><strong>-83</strong></td>
<td><strong>-147</strong></td>
</tr>
<tr>
<td><strong>Energy &amp; Capacity Impacts</strong></td>
<td><strong>270</strong></td>
<td><strong>543</strong></td>
<td>-246</td>
</tr>
<tr>
<td>Total Pre-Tax Impact</td>
<td>40</td>
<td>460</td>
<td>-393</td>
</tr>
<tr>
<td><strong>Total Post Tax (75%)</strong></td>
<td><strong>30</strong></td>
<td><strong>345</strong></td>
<td><strong>-295</strong></td>
</tr>
</tbody>
</table>
SEC Interrogatory #062

Ref: D2-2-1-Attachment 5 Updated

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

Please reconcile the figures shown on page 3 of the DRP Business Plan with Table 1 at D2-1-2/Table 1 Capital Expenditure Summary

Response

Please see answer to L-4.10-17 SEC-057.
SEC Interrogatory #063

Ref: D2-2-1-Attachment 5 Updated/p39

Issue Number: 4.10

Issue: Are the proposed test period capital expenditures associated with the Darlington Refurbishment Project reasonable?

Interrogatory

Please also provide the analysis which supports the Darlington Units achieving 235,000 EFPH.

Response

The engineering analysis that will be required to determine if 235,000 EFPH can be achieved is described in the Fuel Channel Life Extension (“FCLE”) Project Business Case Summary (Ex. F2-3-3, Attachment 1, Tab 11). The FCLE Project is currently in progress.
Board Staff Interrogatory #057

Ref: Exh D2-2-1 section 6.0

Issue Number: 4.11

Issue: Are the commercial and contracting strategies used in the Darlington Refurbishment Project reasonable?

Interrogatory

The Commercial Strategy selected by OPG is a multi-prime contractor model in which there is more than one prime contractor working on the project.

a) Does OPG have experience in using a multi-prime contractor model to manage a large and complex project similar to what is planned for Darlington’s refurbishment? If so, for what major projects?
b) How are the risks associated with multi-prime contractor approach accounted for in the overall project cost?
c) Does OPG have a strategy at the prime-contractor level that deals with interface issues, potential conflicts and mitigating actions to resolve them?

Response

a) Although not of the same magnitude, OPG did use the same multi-prime contractor model on the Pickering Unit 1 Rehabilitation and the Pickering Unit 2 and 3 Safe Storage Projects. Both projects had complexities similar to the DRP.
b) OPG maintains a Risk Register for the entire project. As part of the calculation of project contingency, funding is identified should the risk materialize. These contingencies are included in the current overall project estimate.
c) OPG has a process underway to manage the integration of all contractor and OPG activities during the Definition Phase. A Coordination and Control schedule is used to manage interface requirements. Meetings to review the schedule and resolve issues happen as required but at a minimum of two times per month. During the Execution Phase the meetings will move to twice daily. Any issues not resolved through this process can be escalated to Steering Committees established with each contract for final resolution.
PWU Interrogatory #006

Ref:
(a): Exh.D2-2-1, page 15, lines 23-24:

The Commercial Strategy selected by OPG is a multi-prime contractor model in which there is more than one prime contractor working on the project.

Issue Number: 4.11
Issue: Are the commercial and contracting strategies used in the Darlington Refurbishment Project reasonable?

Interrogatory

a) In selecting the "multi-prime contractor model for the Darlington Refurbishment, did OPG undertake any "lessons learned" exercise with respect to the restart of two units at Pickering A and the refurbishment projects at Bruce Power A and Point Lepreau? If so, what lessons were learned from each of those refurbishments, and how did those lessons affect the decision to adopt the "multi-prime contractor model?"

Response

In parallel with the development of the Commercial Strategy, Bruce Power A and Pt. Lepreau refurbishment projects were visited and lessons learned from Pickering A reviewed. A number of key lessons learned related to accountability, integration, risk management, resource and skills availability, scheduling and cost management were identified.

The multi-prime contractor approach maintains the overall refurbishment accountability with OPG for the integration of all work while utilizing specific contractors to execute individual projects in the Engineer, Procure and Construct ("EPC") model. The model ensures that the best contractor is selected to execute a project. This process allows OPG to share the cost and schedule risk with the contractors where appropriate, identifies clear lines of accountability and delivers the required skills and resources to support the project.
SEC Interrogatory #064

Ref: D2-2-1/p.17

Issue Number: 4.11

Issue: Are the commercial and contracting strategies used in the Darlington Refurbishment Project reasonable?

Interrogatory

Explain how target pricing works.

Response

The target price is an estimate of the total cost to complete the work with upper and lower cost sharing bands. Within these bands OPG and the selected vendor will jointly share in cost over-runs or cost under-runs. OPG pays actual costs (based on negotiated allowed costs) plus a fixed fee which includes vendor profit and overhead. Vendors have meaningful fees at risk and have the ability to earn enhanced fees due to savings based on an agreed to formula. Vendors also have the ability to lose fees due to cost overruns based on an agreed to formula.
SEC Interrogatory #065

Ref: D2-2-1/p.20

Issue Number: 4.11

Issue: Are the commercial and contracting strategies used in the Darlington Refurbishment Project reasonable?

Interrogatory

For each of 2010 through 2013, what is the total amount of contracts that have been awarded to GEH-C? For each historical year what was that vendor’s cost overrun or underspending on each contract.

Response

Contracts are issued for a period greater than 1 year and therefore cannot be compared to actual costs on an annual basis. However, each project will carry a budget for the estimated annual amount to be spent in that year within the overall contract, as follows:

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Contracts Awarded (1)</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Contract $ Awarded</td>
<td>$0.1M</td>
<td>$2.0M</td>
<td>$1.2M</td>
<td>$32.0M</td>
<td>$35.3M</td>
</tr>
<tr>
<td>Requisition Cash Flows (B)</td>
<td>$0.05M</td>
<td>$2.05M</td>
<td>$1.2M</td>
<td>$3.9M</td>
<td>$7.2M</td>
</tr>
<tr>
<td>Actual Costs (A)</td>
<td>$0.02M</td>
<td>$1.7M</td>
<td>$0.8M</td>
<td>$2.6M</td>
<td>$5.2M</td>
</tr>
<tr>
<td>Cost Variance against requisition (A-B)</td>
<td>($0.03M)</td>
<td>($0.35M)</td>
<td>($0.4M)</td>
<td>($1.3M)</td>
<td>($2.0M)</td>
</tr>
</tbody>
</table>

Note 1: In the period, there were 5 Purchase Orders issued, 4 contained 1 line item each (total 4), 1 Purchase Order contained 5 line items (total 5) for a total of 9.

The vendor’s actual costs are below the contract cash flows for each historical year.
SEC Interrogatory #066

Ref: D2-2-1

Issue Number: 4.11

Issue: Are the commercial and contracting strategies used in the Darlington Refurbishment Project reasonable?

Interrogatory

For each of year of the DRP please show what percentage of the budget is sole sourced to each of SLN/Aecon, GEH-C and Alstom?

Response

There are two cases where the refurbishment project needed to procure equipment supply and services from the Original Equipment Manufacturer ("OEM"); GE Hitachi for the Fueling Machine work and Alstom for Technical Support and Equipment Supply for Turbine Generator work. These OEM’s were sourced as part of the competitive bidding process that took place at the time of the initial construction of Darlington. In these cases, the OEM is the sole supplier due to intellectual property constraints and the technical nature of the work or equipment supply of components manufactured by the OEM.

The work being performed by SLN/Aecon was competitively bid.

The total contract cash flows expressed as a percentage of the total DRP budget, Ex D2-2-1, Table 1, line 7, is summarized in the table below.

<table>
<thead>
<tr>
<th>$M</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total DRP Capital Budget</td>
<td>529.8</td>
<td>837.4</td>
<td>631.8</td>
</tr>
<tr>
<td>GEH-C</td>
<td>3.8</td>
<td>5.0</td>
<td>9.7</td>
</tr>
<tr>
<td>Alstom</td>
<td>27.4</td>
<td>15.9</td>
<td>28.7</td>
</tr>
<tr>
<td>Total Contracts</td>
<td>31.2</td>
<td>20.9</td>
<td>38.4</td>
</tr>
<tr>
<td>Percentage of Total DRP budget</td>
<td>5.9%</td>
<td>2.5%</td>
<td>6.1%</td>
</tr>
</tbody>
</table>


SEC Interrogatory #067

Ref: D2-2-1/p.23

Issue Number: 4.11

Issue: Are the commercial and contracting strategies used in the Darlington Refurbishment Project reasonable?

Interrogatory

Please provide information on the leased facilities that will be eliminated when the Darlington Energy Complex reverts to other uses after the DRP. Specifically, where are these facilities and what are is their current cost?

Response

The Darlington Energy Complex ("DEC") business case (Ex. D2-2-1, Attachment 8-1, page 20) stated that after the Darlington Refurbishment Project the DEC would allow the consolidation of leases and co-location of support staff, including Inspection and Maintenance ("IMS") staff, closer to the Darlington site. This plan has not changed.

IMS presently occupies 88k sq. ft. of leased office and warehouse space in three facilities in Durham with a current annual rent of $1.6 Million. OPG occupies another 635k sq. ft. of leased office and warehouse space in Durham.

Individual leased properties to be vacated have not been determined at this very early stage and any such plans would be commercially sensitive. However, given the amount of leased space, there is ample opportunity to consolidate office and warehouse space at the DEC. In addition, the DEC mock-up area could be used for ongoing training of OPG and potentially third party staff.

On an overall basis, using the total DEC usable area of 310k sq. ft. and a current average gross market rent of $20/sq.ft., a saving in lease costs of up to $6M/year could be realized by consolidating leased facilities at the DEC.
SEC Interrogatory #068

Ref: D2-2-1-Attachment 7/p.6

Issue Number: 4.11
Issue: Are the commercial and contracting strategies used in the Darlington Refurbishment Project reasonable?

Interrogatory

The Concentric Report identifies a major risk of OPG’s multi-prime contracting strategy being OPG’s retention of the role of managing prime contractor. They state “Ontario Power Generation’s coordination of the various work tasks will require extensive planning to prevent claims of delay or increased costs caused by Ontario Power Generation’s failure to adequately plan and coordinate the work or interference from another vendor.” Concentric goes on to state that OPG has limited experience in managing vendors. Please describe the steps OPG is taking to mitigate this risk.

Response

OPG has implemented an integrated tiered scheduling process, consistent with industry best practice, to manage the DRP. The Level 1 schedule establishes the key dates within the program, the Level 2 schedule is used to co-ordinate and control a number of vendor and OPG schedules related to a phase of the project, i.e., Definition Phase, or Unit 2 execution. The Level 3 schedule contains all of the details for a particular contractor or OPG department and their assigned scope of work.

Level 1: Program Master Schedule contains the highest level tasks for the entire DRP schedule; often referred to as a roadmap schedule, it outlines the start and end date of each refurbishment and the key activities within each phase of the Program. The schedule is managed and maintained by OPG only and is adjusted periodically based on input received in the Level 2 and Level 3 schedules.

Level 2: Program Coordination and Control Schedules, contain all Contractual Dates and all Work Packages for each phase of the DRP. It contains summary tasks for pieces of work assigned to contractors or different OPG groups that align with more detailed task breakdowns available in the Level 3 schedules.

Level 3: Project Detailed Production Schedules, owned by different contractors or departments within OPG. Schedules nominally contain tasks specific to a scope of work, with sequence logic and resources required to perform the work. Schedules contain summary tasks for grouping activities that can be linked to the same summary tasks available in the Level 2

During the contracting process OPG set the required standards for scheduling so that all vendors and OPG would be working off the same platform and to enable an integrated view of

Witness Panel: Darlington Refurbishment
the overall schedule. Each vendor’s detailed schedules are brought together in OPG’s system to
ensure alignment, integration and to identify gaps and issues at Level 2. The schedule includes
execution details, resource requirements, materials and support required from OPG to ensure
visibility of all project activities.

The schedule management process includes weekly face-to-face meetings between all vendors
and OPG to review the current schedule and 3 month look ahead. On a monthly basis the
vendors present their schedule status at the C&C Level 2 meeting attended by the
Refurbishment Executive team and key stakeholders.

In the execution phase of the project, activities will be managed at a lower level. The same
integrated schedule process will be used, however, meetings will move to twice daily and the
look ahead process will include a 6 shift and weekly as well as the 3 month view.

Monthly Executive Steering Committee meetings have also been implemented with each vendor
to ensure visibility and alignment across the vendors and OPG’s management teams.
Attendance at these meetings includes the Presidents and CEO’s, key executives and project
teams from both the vendors and OPG as well as key stakeholders. Monthly status reports as
well as project status, risks and opportunities are reviewed.

OPG Nuclear has decades of experience in managing multiple vendors working at our sites on
projects like: the vacuum building outages at Pickering and Darlington, the Safe Storage at
Pickering, the Return to Service Projects at Pickering and in the completion of billions of dollars
of project work across both sites. Although not to the magnitude of a Refurbishment Project,
they have provided us with the ability to successfully test processes like the C&C and Executive
Steering committees. These along with significant experience gained from benchmarking,
seconding to other projects and Industry Best Practices have allowed us to continually improve
the interactions between vendors and OPG. The processes will continue to evolve and improve
throughout the entire project life cycle.
Board Staff Interrogatory #058

Ref: Exh D2-1-2 and Updated D2-2-1 Attachment 5, Long-Term Energy Plan (December 2, 2013)

Issue Number: 4.12

Issue: Does OPG’s nuclear refurbishment process align appropriately with the principles stated in the Government of Ontario’s Long Term Energy Plan issued on December 2, 2013?

Interrogatory

On December 2, 2013 the Ministry of Energy released the Long Term Energy Plan ("LTEP") for the Province of Ontario. The LTEP noted that:

The nuclear refurbishment process will adhere to the following principles:
1. Minimize commercial risk on the part of ratepayers and government;
2. Mitigate reliability risks by developing contingency plans that include alternative supply options if contract and other objectives are at risk of non-fulfillment;
3. Entrench appropriate and realistic off-ramps and scoping;
4. Hold private sector operator accountable to the nuclear refurbishment schedule and price;
5. Require OPG to hold its contractors accountable to the nuclear refurbishment schedule and price;
6. Make site, project management, regulatory requirements and supply chain considerations, and cost and risk containment, the primary factors in developing the implementation plan; and
7. Take smaller initial steps to ensure there is opportunity to incorporate lessons learned from refurbishment including collaboration by operators.

On December 5, 2013 OPG filed an update to its evidence, including OPG’s 2014-2016 Business Plan (portions redacted) which was presented to its Board of Directors on November 14, 2013. On February 6, 2014 OPG filed an updated DRP Business Case Summary.

a) Is the 2014-2016 Business Plan consistent with all of the principles set out in the LTEP?
   i. If so, please demonstrate how the Business Plan puts each of the principles into action.
   ii. If not, please explain why OPG did not reflect these principles in the Business Plan.

b) Does the updated DRP Business Case Summary, including scope, cost schedule and project management approach, conform to the principles set out in the LTEP?
   i. If so, please demonstrate how the Business Plan puts each of the principles into action.
   ii. If not, please explain why OPG did not reflect these principles in the Updated Business Case Summary.
c) Please prepare a LUEC calculation which reflects the following scenario: at the completion of the refurbishment of Unit 2, actual refurbishment costs for Unit 2 are $0.7B in excess of budget. As a result, it is decided to cancel the refurbishment of Units 1, 3 and 4. What would the LUEC be for the production for a refurbished Unit 2 (i.e. all DRP costs recovered through only Unit 2 production)?

Response:

a) Although the Business Plan was issued prior to the Long Term Energy Plan ("LTEP"), OPG has assessed its submission against the principles identified in the LTEP and provides the following summary which illustrates the consistency of its plans with the LTEP. In relation to each of the LTEP principles, OPG has taken the following steps:

1. Minimize commercial risk on the part of ratepayers and government
   - Locking down project scope well in advance of starting construction;
   - Fully developing engineering and planning of the work so that it is 100% complete prior to the start of construction;
   - Building a full-scale mock-up of the DNGS reactor and vault that will be used for training and proving the tools needed for the removal and replacement of the reactor components;
   - Developing a release quality estimate ("RQE") in phases that incorporates a high-confidence budget and schedule for the work;
   - "Unlapping" Unit 2 from the subsequent units so that the focus can be on the planning and construction of a single unit and so that OPG can gain from the lessons learned in completing the work;
   - Utilizing target price contracts for the execution phase that is based on developing cooperation, transparency, and risk sharing with key vendors;
   - Utilizing fixed price contracts for certain execution phase scope that is well defined and where risk transfer to a third party is appropriate;
   - Negotiating various off-ramps and stages into contracts; and
   - Establishing a robust risk management process to directly identify and administer commercial risks.

2. Mitigate reliability risks by developing contingency plans that include alternative supply options if contract and other objectives are at risk of non-fulfillment
   - OPG’s decision to “unlap” Unit 2 from the other units’ refurbishments, which predated the LTEP, was intended to mitigate performance risk and to allow the DRP team to focus on one unit’s refurbishment at a time. If the first unit is not successful, off-ramps are in place; the second unit refurbishment will not commence until the first unit is successfully returned to service.
   - Risk assessment and appropriate contingency plans/back-out plans for each execution work package will be developed and included in the Release Quality Estimate.
   - OPG’s investment in the reactor mock-up will be used to perform full integration and commission testing of tools needed for refurbishment; lessons will be learned on the mock-up, not on the unit. The results of the mock-up testing will be incorporated into
the tooling performance guarantee, which sets the target schedule and price, with
the R&FR vendor

3. **Entrench appropriate and realistic off-ramps and scoping**
   - OPG has engaged in a deliberate process with numerous off-ramps for the definition
     phase including Board of Directors oversight and annual releases of funds.
   - Each contract has off-ramp provisions allowing OPG to terminate, with or without
     cause; OPG would be accountable to reimburse vendor for any reasonably incurred
     costs only.
   - Scope review process in place to minimize scope of work performed in
     Refurbishment period to things that must be done to extend life or can only be done
     in drained/defueled state.
   - OPG has fully examined the scope of the Unit 2 refurbishment project and optimized
     the work based on OPG’s regulatory commitments and/or on an analysis of the best
     time to perform the work.

4. **Hold Private sector operator accountable to the nuclear refurbishment schedule
   and price**
   - For OPG, please see item 5.

5. **Require OPG to hold its contractors accountable to the nuclear refurbishment
   schedule and price**
   - OPG, in implementing all of its contracts, is highly focussed on achieving value for
     money; there are incentives and/or disincentives related to achieving the cost and
     schedule set out in the contracts.
   - Contracts with major vendors are being developed and vetted utilizing a deliberate,
     staged and gated process with requirements for budget, schedule, scope, and risk
     identification at each gate.
   - Contracts have specific negotiated incentives and disincentives that are calculated
     toward promoting the contractor’s (and OPG’s) responsible management of the work.
   - OPG is implementing a detailed, integrated Level 3 schedule that will encompass all
     of the contractors’ and OPG’s work, as well as a rolled-up Level 2 Control and
     Coordination Schedule that is used as a higher level interfacing tool.
   - OPG has implemented cost control systems that are geared toward holding
     contractors accountable. These systems include earned value and budget controls
     through the gate process.
   - OPG performs analysis of all pricing and check estimates for contractors’ work.
     These estimates are provided by an independent vendor with experience in the
     industry.
   - OPG’s senior management has established separate regular steering committees
     with each of the major vendors’ executives which provide senior level leadership with
     a forum to discuss progress, potential and real issues impacting performance and
     commercial issues.
6. Make site, project management, regulatory requirements and supply chain considerations, and cost and risk containment, the primary factors in developing the implementation plan.

- OPG’s plan for the RQE assumes that all of the factors listed will be fully considered, planned, and budgeted in advance of execution of the work.
- Taking lessons from Pickering A, the DRP team has committed to completing the identification of all regulatory requirements well in advance of final design and construction.
- OPG has committed to the completion of the design and proving of the Retube and Feeder Replacement tools and completing procurement of all long lead materials one full year prior to the start of the first unit refurbishment.
- OPG has implemented, in accordance with Project Management Institute standards and Association for Advancement of Cost Engineering ("AACE") best practices, project controls and risk management programs and will continue to refine these tools as the outage nears.
- OPG has retained external oversight and engaged other corporate functions in providing input and assurance that the DRP team is meeting its commitments.

7. Take smaller initial steps to ensure there is opportunity to incorporate lessons learned from refurbishment including collaboration by operators.

- To fully incorporate lessons learned from the refurbishment of the first unit (Unit 2), the start of refurbishment work on the second unit (Unit 1) has been delayed until the completion of the first unit.
- OPG has filled key positions in its project management team with individuals with direct experience of prior CANDU refurbishments.
- OPG has contracted with SNC/Aecon, whose subsidiary CANDU Energy (formerly AECL) has been associated with each of the prior refurbishments.
- OPG and its contractors are studying lessons learned and OPEX from those prior projects and incorporating those into the DRP.
- OPG routinely collaborates with other CANDU operators directly and/or through the CANDU Owner’s Group. OPG has initiated further discussions with Bruce Power to determine additional areas for collaboration.

b) Please see response to item a)

c) While OPG believes that the scenario posed in this interrogatory to be highly unlikely, OPG has done a LUEC calculation which adds $0.7B to the amount OPG currently forecasts would be placed in-service at the completion of the Unit 2 refurbishment outage, and also eliminated further expenditures on Units 1, 3 and 4.

In developing this estimate, OPG has assumed no cost mitigation of the refurbishment project if it became evident that only Unit 2 would be completed. OPG has also utilized a range of assumptions about the costs of operations and support for a single unit in the post-refurbishment period. OPG would expect that losses of economies of scale would result in the operation and support costs of one unit to be more than one-fourth of the operating and support costs of the 4-unit Darlington Station. OPG has also not included in the calculation...
any energy and costs of operating the remaining 3 units to the normal ends of their current
(pre-refurbishment) lives.

The resultant LUEC ranges estimated for Unit 2 production only is in the order of 11 – 15
cents per kWh (2013$) over the life of Unit 2.
AMPCO Interrogatory #021

Ref: Government of Ontario’s Long Term Energy Plan (LTEP), Page 30

Issue Number: 4.12

Issue: Does OPG’s nuclear refurbishment process align appropriately with the principles stated in the Government of Ontario’s Long Term Energy Plan issued on December 2, 2013?

Interrogatory

Preamble: The LTEP indicates that the government will encourage the province’s two nuclear operators, Bruce Power and OPG to find ways of finding ratepayer savings through leveraging economies of scale in areas of refurbishment and operations. This could include arrangements with suppliers, procurement of materials, shared training, lessons learned, labour arrangements and asset management strategies.

a) Please demonstrate how OPG’s updated 2014-2016 Business Plan (Exhibit N1, Tab 1, Schedule 1) responds to the Government’s expectations.

Response

The Long Term Energy Plan was issued on December 2, 2013. OPG’s 2014 - 2016 Business Plan was approved by OPG’s Board of Director’s on November 14, 2014, prior to the issuance of the Long Term Energy Plan. OPG and Bruce Power collaborate in a number of ways.

- OPG and Bruce Power are collaborating through the CANDU Owners Group (“COG”) on joint initiatives to assess fuel channel degradation mechanisms and confirm fitness for service to current design life and to assess opportunities to extend the life of pressure tubes beyond the nominal design life (Reference Fuel Channel Life Extension project in Ex. L-04.7-1 Staff-033).

- OPG and Bruce Power are jointly negotiating a common Project Agreement with the Trade Unions focused on maximizing productivity and reducing costs.

- OPG and Bruce Power are jointly in discussion with the Trade Unions on shared on-boarding, security clearances, and training for Nuclear Worker Qualifications.

- OPG and Bruce Power take part in peer reviews in support of each other’s operations and project activities. For example, OPG Refurbishment Director of Operations & Maintenance was part of the WANO review for Bruce Unit 1 & 2; OPG seconded an employee to Bruce Power for two years to work on Bruce Unit 1 and 2 refurbishment.

- Refurbishment Operating Experience and lessons learned are shared by OPG, Bruce Power, and other CANDU owners through the COG Plant Refurbishment Working Group (“PRWG”).

Witness Panel: Darlington Refurbishment
OPG and Bruce Power have provided their unit refurbishment outage sequences to the OPA allowing the OPA to integrate the refurbishment schedules and assess the impacts on the Ontario power system to ensure a reliable supply of electricity is maintained during the refurbishment periods.

OPG has qualified a number of suppliers for the design and fabrication of specialty nuclear components; these suppliers would be qualified to supply other CANDU owners, including Brice Power.

Bruce Power and OPG exchange specialized engineering and other technical information to support resolution of common issues and pursue opportunities for improvements, including neutron over-power analysis, response to Fukushima, whole-site Probabilistic Risk Assessments, and intellectual property sharing agreement for specialized reactor inspection tools.

OPG provides a tritium removal service for Bruce Power CANDU units. These initiatives are built into OPG’s Business Plan in a number of ways:

OPG, Bruce Power, and other CANDU owners have cost sharing agreements for a number of these initiatives via the CANDU Owner’s Group. As an example, the Fuel Channel Life Management and Fuel Channel Life Extension initiatives have cost sharing agreements in place as the benefits of both projects would be shared by the Industry.

Actual initiatives, such as tritium removal services and specialty engineering arrangements are built into the cost and revenue streams of OPG’s Business Plan.

Results of these initiatives are incorporated into the business plan. The Fuel Channel Life Management and Fuel Channel Life Extension projects have been key inputs into the DRP schedule (per Ex. D2-2-1, Attachment 5, Table 1). Lessons learned and operating experiences have been implemented into the DRP planning assumptions.

Additional initiatives, such as outcomes of discussions with trade groups, results of Fuel Channel Life Extension, and additional lessons learned will be reflected in the release quality cost and schedule estimate (“RQE”) to be issued in October 2015.

For further information on how OPG adheres to the seven refurbishment principles in the Long Term Energy Plan, please see response to Ex. L-04 12-1 Staff-058.
Witness Panel: Darlington Refurbishment

CC Interrogatory #015

Ref:

Issue Number: 4.12

Issue: Does OPG’s nuclear refurbishment process align appropriately with the principles stated in the Government of Ontario’s Long Term Energy Plan issued on December 2, 2013?

Interrogatory

Please provide a detailed description of how OPG’s plans for nuclear refurbishment as provided in the updated evidence are aligned with the principles set out in The Government of Ontario’s LTEP.

Response

Please see response Ex. L-4.12-1 Staff-058 which provides a detailed description of how OPG’s plans for the Darlington Refurbishment Project (“DRP”) are aligned with the principles set out in the Government of Ontario’s Long Term Energy Plan.
ED Interrogatory #011

Ref: Ex. D2-2-1, Attachment 5, Updated 2014-02-06, page 2; and Ex. D2-2-1, pages 15 – 22.

Issue Number: 4.12

Issue: Does OPG’s nuclear refurbishment process align appropriately with the principles stated in the Government of Ontario’s Long Term Energy Plan issued on December 2, 2013?

Interrogatory

a) Please provide a break-out of management’s “high confidence” estimate of the total cost of the DRP, including capitalized interest, escalation and all other costs, in 2013$ and 2014$, according to the following categories: (i) RFR; (ii) Fuel Handling; (iii) Turbine-Generator; (iv) Steam Generators; and (v) Balance of Plant.

b) Please provide a breakout of the: (i) RFR; (ii) Fuel Handling; (iii) Turbine-Generator; (iv) Steam Generators; and (v) Balance of Plan costs according to: (A) contractor costs; and (B) non-contractor costs.

c) Please state the total cost of the DRP to OPG in 2013$ and 2014$ assuming the RFR, Fuel Handling, Turbine Generator; Steam Generators and Balance of Plan costs exceed budget by: (i) 50%; (ii) 100%; (iii) 150%; (iv) 200%; and (v) 250%. In each scenario, please also state: (i) the percentage of the contractors’ cost overruns that are passed on to OPG; and (ii) the DRP’s LUEC in 2013$ and 2014$.

Response

a) & b) The table below provides the requested break-out based on the amounts included in Ex. D2-2-1, Attachment 5. Interest and escalation are planned at the Program level and not at the individual project level and therefore have not been provided.
Notes:
1. 2013$ estimate based on Ex. D2-2-1, Attachment 5
2. 2014$ assumed 2% inflation

c) The DRP contracts are structured in a manner that allocates risk to the entity that is best able
to manage that risk. For example, the Retube and Feeder Replacement (“R&FR”) tooling
contract is fixed price, therefore, regardless of cost growth, OPG is protected. The R&FR
Execution work is target price with incentives for the contractor to lower costs. In a situation
where cost growth is significant, the contractor looses a portion of their fee as well as
overheads for additional costs incurred beyond the target price.

The table below provides the “high confidence” DRP cost under a range of contractor cost
over-run scenarios including the % of costs passed on to OPG and the impact on the DRP
LUEC for each scenario.
<table>
<thead>
<tr>
<th>Total DRP cost (P90)</th>
<th>% of Cost Passed to OPG</th>
<th>Impact on LUEC (P90)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013$ (Billion)</td>
<td>2014$B (Billion)</td>
</tr>
<tr>
<td>50%</td>
<td>10.0</td>
<td>10.2</td>
</tr>
<tr>
<td>100%</td>
<td>10.2</td>
<td>10.4</td>
</tr>
<tr>
<td>150%</td>
<td>11.1</td>
<td>11.3</td>
</tr>
<tr>
<td>200%</td>
<td>12.1</td>
<td>12.3</td>
</tr>
<tr>
<td>250%</td>
<td>13.1</td>
<td>13.3</td>
</tr>
</tbody>
</table>

Assumptions
1. Each project bundle has a variety of contracting strategies including Fixed Price, Target Price, Cost Plus, and Time and Material; the calculation of the “% of Costs Passed onto OPG” is based on these contract strategies.
2. This analysis assumes that the % of cost growth is spread evenly across all elements of the contract including fixed price, materials, and target price.
3. For each scenario, contingency, as reported in part a) and b) is reduced prior to incurring cost growth to the project; i.e. a 50% cost increase to the project decreases contingency and remains within the $10 Billion high confidence estimate.
4. OPG has maintained additional contingency and management reserve, i.e. only contingency distributed to the projects, in part a) and b) has been reduced due to cost overruns. Contingency and management reserve remains for other risks.
5. 2014$ assumed 2% inflation
ED Interrogatory #012

Ref: Ex. D2-2-1, Attachment 5, Updated 2014-02-06, page 2

Issue Number: 4.12

Issue: Does OPG’s nuclear refurbishment process align appropriately with the principles stated in the Government of Ontario’s Long Term Energy Plan issued on December 2, 2013?

Interrogatory

a) Please provide a break-out of management’s “high confidence” estimate of the total cost of the DRP in 2013$ and 2014$ according to: (i) Unit 2; and (ii) Units 1, 3 & 4.

b) Please provide management’s “high confidence” estimate of the total cost of the DRP to OPG in 2013$ and 2014$ assuming: (i) the Darlington Unit 2 refurbishment is completed in Q3 2019; and (ii) the remainder of the DRP is cancelled in Q3 2019. Please state the LUEC of the DRP in 2013$ and 2014$ under this scenario.

Response

a) A break-out of management’s “high confidence” estimate of the total cost of the DRP in 2013$ and 2014$ is provided below. This is based on information contained within Ex. D2-2-1, Attachment 5 and will be refined and finalized in October 2015 upon issuance of the Release Quality Estimate.

<table>
<thead>
<tr>
<th>Pre-requisite Projects</th>
<th>$2013</th>
<th>$2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>i.e. Facility and Infrastructure and Safety Improvement Opportunities</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Unit 2</td>
<td>3.7</td>
<td>3.8</td>
</tr>
<tr>
<td>- including Definition Phase Planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit 1</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Unit 3</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Unit 4</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>10.0</td>
<td>10.2</td>
</tr>
</tbody>
</table>

The amounts are in overnight dollars and exclude interest and escalation.

b) Please see OEB Staff Interrogatory # 58 (Ex. L-4.12-1 Staff-058).

Witness Panel: Darlington Refurbishment
ED Interrogatory #013

Ref: "The nuclear refurbishment process will adhere to the following principles….Mitigate reliability risks by developing contingency plans that include alternative supply options if contract and other objectives are at risk of non-fulfillment”. Long Term Energy Plan, page 29

Issue Number: 4.12
Issue: Does OPG’s nuclear refurbishment process align appropriately with the principles stated in the Government of Ontario’s Long Term Energy Plan issued on December 2, 2013?

Interrogatory

Please fully describe OPG’s alternative supply options (e.g., increased renewable and gas-fired generation from Ontario’s existing generating facilities, reduced electricity exports, increased electricity imports from Quebec, increased electricity imports from the U.S. [broken-out by fuel type]) and their forecast incremental costs if Darlington Unit 2 does not return to service on schedule. Please fully describe your input assumptions and justify your analysis.

Response

Darlington Unit 2 is scheduled to return to service in Q3 2019. If it is late, and there were no other adjustments to the nuclear schedule in the Long Term Energy Plan (“LTEP”), the ‘Planned Flexibility’ or Demand Response elements of LTEP would need to be increased.

The capacity options in the LTEP are indicated on page 16 of Module 3 posted on the OPA website at http://www.powerauthority.on.ca/power-planning/long-term-energy-plan-2013: clean imports, renegotiating expiring NUG contracts, additional demand response and additional conservation. There is also the option to convert Lambton and Nanticoke to gas. As described on page 46 of the LTEP, the Government will be reviewing the supply and demand picture annually and will respond as necessary if things don’t evolve as planned. Page 49 of Module 4 at the above website summarizes the OPA’s estimated costs in $/MWh for each resource in the plan including the Planned Flexibility.
ED Interrogatory #014

Ref: Appendix A of The Darlington Re-Build Consumer Protection Plan (attached)

Issue Number: 4.12

Issue: Does OPG’s nuclear refurbishment process align appropriately with the principles stated in the Government of Ontario’s Long Term Energy Plan issued on December 2, 2013?

Interrogatory

Appendix A of The Darlington Re-Build Consumer Protection Plan (attached) provides the original cost forecasts and the actual costs of Ontario’s nuclear projects. Does OPG dispute the accuracy of any of the facts provided in this Appendix? If “yes”, please state the facts that OPG disputes and provide OPG’s opinion as to the correct value(s).

Response

In response to EB-2013-0321, Decision and Order on Motions, dated May 16, 2014, OPG was asked to respond to the question “Does OPG have any basis/evidence to dispute the information contained in the Clean Air Alliance Report, Appendix A page 17, with respect to cost overruns?”

OPG has done a partial validation of the references cited in Appendix A, page 17, of the Clean Air Alliance Report. While OPG believes that the references are correctly cited, to the extent of its review, it is OPG’s opinion that in certain cases, the report fails to provide certain critical information that properly sets the context of the cost increases.

As an example, the report cites that in 1999 OPG estimated the total cost of returning the shutdown Pickering A Unit 1 to service would be $213 million. The reference further cites that the actual cost was 4.8 times higher at $1.016 billion. The reference fails to recognize that 1) the original estimate was made prior to detailed planning and completion of engineering, and 2) the project was approved by OPG’s Board of Director’s in July 2004 with a project estimate of $900 Million. The actual cost of the project was $1,016 Million, a 12.9% cost growth including project demobilization based on a decision not to restart Units 3 and 4.
PWU Interrogatory #007

Ref:

The reference lists seven principles which the nuclear refurbishment process will adhere to, including the following three principles:

1. Minimize commercial risk on the part of ratepayers and government;
2. Hold private sector operator accountable to the nuclear refurbishment schedule and price;
3. Require OPG to hold its contractors accountable to the nuclear refurbishment schedule and price;

Issue Number: 4.12
Issue: Does OPG’s nuclear refurbishment process align appropriately with the principles stated in the Government of Ontario’s Long Term Energy Plan issued on December 2, 2013?

Interrogatory

a) What implications, if any, does OPG expect the implementation of the three principles in the 2013 LTEP can have on the overall cost, schedule and feasibility of the Darlington refurbishment project?
b) Please identify the major changes made to OPG’s initial refurbishment plan as a result of the 2013 LTEP?

Response

Please see response Ex. L-4.12-1 Staff-058 which provides a detailed description of how OPG’s plans for the DRP are aligned with the principles set out in the Government of Ontario’s Long Term Energy Plan (“LTEP”). OPG has already built in the principles of LTEP into its current Business Case as provide in Ex. D2-2-1, Attachment 5 including the un-lapping of the first and second refurbishment units and has included “off-ramps” in the release strategy as well as within each contract.