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Title:

**DARLINGTON NGS PERIODIC SAFETY REVIEW SUMMARY REPORT**

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**DARLINGTON NGS PERIODIC SAFETY  
REVIEW SUMMARY REPORT****NK38-REP-03680-12010-R000**

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**Revision Summary**

<b>Revision Number</b>	<b>Date</b>	<b>Comments</b>
R000	2024-06-14	Summary of Periodic Safety Review issued for OPG acceptance.

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### Executive Summary

The current Darlington Nuclear Generating Station (NGS) Power Reactor Operating Licence is valid until November 2025. Ontario Power Generation (OPG) will be submitting a licence renewal application to support the continued operation of Darlington NGS beyond 2025. Two of the station's four nuclear reactors have been recently refurbished and returned to service. These are Units 2 and 3. Refurbishment has commenced on Units 1 and 4 and is expected to be completed in Q2 2025 and Q4 2026 respectively.

OPG has completed a Periodic Safety Review (PSR) of Darlington NGS to support the licence renewal and continued operation. A PSR is an internationally accepted method of evaluating the safety of an operating nuclear power plant against current standards and identifying practicable enhancements that would further increase safety.

This document is a summary of the Darlington PSR, referred to as D-PSR, which builds upon the review basis of earlier OPG Integrated Safety Review (ISR)/PSR work and other relevant assessments for OPG nuclear facilities. D-PSR comprises four major elements:

1. The D-PSR Basis Document, which has been reviewed and accepted by Canadian Nuclear Safety Commission (CNSC) staff.
2. A comprehensive assessment of the station for each of fifteen Safety Factors that cover plant design, operation, management, safety analysis, radiological impact on the environment and radiation protection.
3. A Global Assessment Report, which integrates information from the Safety Factor reviews, identifies practicable safety enhancements, and reaches a conclusion on the overall safety of the plant for the continued operating period.
4. An Integrated Implementation Plan, which translates the safety enhancements identified in the Global Assessment Report into specific actions with target completion dates.

The Global Assessment Report describes the current plant safety basis, including the plant design, management system, operating practices and the means by which personnel are qualified and trained to safely execute their responsibilities. This description accounts for the extensive safety enhancements, including equipment replacements and upgrades, that have been completed over the life of the station to date. The Global Assessment also describes the plant's multiple, overlapping barriers to the release of radioactivity to the environment. These multiple barriers result in extensive defence-in-depth for the plant. The assessment describes how the enhancements that will be implemented via the Integrated Implementation Plan will further strengthen safety and defence-in-depth.

The operating licence issued by the CNSC already requires Darlington NGS to meet many safety standards that are current and consistent with global best practice. Nevertheless, the Safety Factor phase of D-PSR assesses the plant design, processes, performance and management system against specific criteria and additional, modern safety standards that are not already identified as requirements in the operating licence. Differences where resolution has the potential to enhance safety are identified as "Gaps". The Global Assessment consolidates Gaps that are similar in nature or that are on the same topic into a series of Global Issues.

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The D-PSR identified 23 Global Issues. Ten of the Global Issues can be resolved in a practicable way to enhance the safety of the station, with a total of 35 potential safety enhancements, referred to as Resolution Statements, each of which describes an action or actions that resolve specific aspects of the associated Global Issue.

The Global Assessment identifies the other 13 Global Issues were either:

- Resolved subsequent to completion of the Safety Factor Reports so no further action is needed,
- Being addressed by ongoing activities outside of the D-PSR,
- Being resolved through Resolution Statements associated with another Global Issue,
- Have low safety significance and are addressed to the extent practicable, or
- Will be addressed through combinations of the above.

The Global Assessment includes a detailed assessment of the defence-in-depth of the station, considers the safety significance of the Global Issues and the safety benefits of the Resolution Statements, and performs an objective assessment which concludes that the station will be operated safely throughout the period of continued operation.

The Integrated Implementation Plan, which was produced in the final phase of the Periodic Safety Review, takes the Resolution Statements from the Global Assessment as input, and develops specific actions with planned completion dates for each.

Of the 35 Resolution Statements, 25 have been excluded from the D-PSR Integrated Implementation Plan because they are either already being tracked in the D-ISR Integrated Implementation Plan, covered by an existing action, or were completed following the finalization of the D-PSR Global Assessment Report. For the remaining 10 Resolution Statements, the Integrated Implementation Plan identifies a total of 17 specific actions, each with documented completion criteria. These actions are included in Appendix C. More than half of the actions will be completed by the end of 2024, and all actions are scheduled to be completed by the end of 2028. The safety of the plant is incrementally enhanced as each action in the Integrated Implementation Plan is completed.

Nine of the 10 Resolution Statements and 16 of the 17 specific actions in the Integrated Implementation Plan will support and enhance the station's fitness for service by aligning practices with the most current standards, completing assessments for additional components, and updating the Periodic Inspection Program (PIP) for the Tritium Removal Facility (TRF).

One of the 10 Resolution Statements and one of the 17 specific actions in the Integrated Implementation Plan will enhance the station's emergency management and fire protection by evaluating the benefit of revising existing governance to align with a newer National Building Code of Canada (NBCC) for future construction or modifications related to fire protection, occupant safety and accessibility.

A total of nineteen preliminary strengths were identified as part of the PSR process, as detailed in Table 5-1 below. These strengths were refined as part of the stakeholder review, resulting in twelve of these strengths being finalized in the GAR.

OPG has completed a Periodic Safety Review for Darlington NGS. The Periodic Safety Review has been performed consistent with Canadian regulatory requirements and accepted international practice. The Periodic Safety Review confirms the safety of the current plant and

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includes enhancements that will increase safety and strengthen defence-in-depth for continued operation. Actions are presently underway to implement these enhancements, which are being managed by the Integrated Implementation Plan. The Periodic Safety Review demonstrates that plant design, operation and practices will ensure continued safe operation.

D-PSR concludes that the current plant design, operation, processes and management system will ensure continued safe operation of the station both in the short term, and for operation to 2035. The Darlington NGS units will continue to be operated while assuring fitness for service of the structures, systems and components important to safety. OPG and the Darlington Station Leadership Team are committed to continual investment in the plant and focusing the organization to strive for continued improvement in the plant condition, operation and performance.

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### 1.0 INTRODUCTION

This report summarizes the PSR conducted in support of licence renewal and continued operation of Darlington NGS. This PSR builds upon the review basis of earlier OPG ISR/PSR work and other relevant assessments for OPG nuclear facilities. The work has been performed consistent with the requirements of CNSC REGDOC-2.3.3, *Periodic Safety Reviews* [R-1].

The objective of the D-PSR is to assess the design, condition and operation of Darlington NGS in support of continued safe operation for the period of D-PSR. The D-PSR will also determine if there are reasonable and practical enhancements that may be adopted to improve plant safety.

D-PSR was performed according to the D-PSR Basis Document [R-2]. The D-PSR Basis Document details the four PSR phases, the first of which is preparation of the Basis Document. The Basis Document establishes the scope and methodology for performing the D-PSR. The planning basis for D-PSR covers the period of operation of Darlington NGS units from November 2025 to November 2035.

The second phase is the Safety Factor Assessments. A Safety Factor is an aspect of safety to be assessed in a Periodic Safety Review. D-PSR assessed fifteen Safety Factors, listed in Table 1-1, which cover all aspects of plant design, operation, management, safety analysis, radiological impact on the environment and radiation protection. Each Safety Factor Report is comprised of assessments of review tasks per International Atomic Energy Agency (IAEA) Specific Safety Guide (SSG) No. 25, *Periodic Safety Review of Nuclear Power Plants* [R-3] and REGDOC-2.3.3 [R-1]. The D-PSR Basis Document further elaborates on these Review Tasks [R-2]. The Safety Factor Reports also document the results of the assessments of Darlington NGS against relevant modern Laws, Regulations, Codes and reviews the results of OPG Program effectiveness reviews, which includes audits and self-assessments.

The Safety Factor assessments also include a review of other sources of information that could provide useful information on the safety of continued operation, such as the Fukushima Action Items (FAIs) and open regulatory actions.

The Safety Factor reviews identify Strengths, Compliances, Gaps and Enhancement Opportunities (EOs). A Strength indicates that a safety requirement is exceeded. Compliance indicates that a safety requirement is met. A Gap indicates that a portion of the plant design or practices does not align with an element of a modern standard. An EO is where the plant or practice does not align with an optional requirement. Gaps and EOs are identified where the plant design or programs do not fully meet a review task or a safety significant element of a modern Law, Regulation, Code or Standard. Gaps and EOs may represent opportunities to further enhance safety over and above current requirements, and are the input to the next phase of D-PSR.

The third phase is the Global Assessment [R-4], which presents an assessment of the five levels of defence-in-depth, including consideration of other findings, such as Strengths and enhancements proposed through the Global Issue resolutions, in order to make a conclusion on the overall safety of continued operation of the plant. The Global Assessment also takes into account the results from the Safety Factor Reports. The Global Assessment consolidates

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similar Gaps and EOs into Global Issues and develops Resolution Statements for each Global Issue.

The fourth phase is the Integrated Implementation Plan (IIP) [R-5], which assembles the Global Issue Resolution Statements resulting from the Global Assessment and establishes explicit actions with corresponding schedules for implementation.

Section 2.0 of this report presents an overview of the methodology of the Periodic Safety Review; Section 3.0 presents a high-level view of the safety of Darlington NGS and identifies the major physical modifications that will or have been made to the station as part of the IIP to further enhance safety; Section 4.0 summarizes the review of the plant against modern expectations; Section 5.0 presents the assessment of acceptability of continued operation; Section 6.0 summarizes the IIP action groupings; and Section 7.0 presents the conclusion of the assessment of overall acceptability of operation of the plant.

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**Table 1-1: PSR Safety Factors**

<b>Safety Factor #</b>	<b>Topic</b>
1	Plant Design
2	Actual Condition of Structures, Systems and Components Important to Safety
3	Equipment Qualification (environmental and seismic)
4	Aging
5	Deterministic Safety Analysis
6	Probabilistic Safety Assessment
7	Hazard Analysis
8	Safety Performance
9	Use of Experience from Other Plants and Research Findings
10	Organization, the Management System and Safety Culture
11	Procedures
12	Human Factors
13	Emergency Planning
14	Radiological Impact on the Environment
15	Radiation Protection

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## 2.0 OVERVIEW OF THE PERIODIC SAFETY REVIEW PROCESS

The requirements for a Periodic Safety Review are defined in REGDOC-2.3.3 [R-1]. The specific process followed in D-PSR is described in the D-PSR Basis Document [R-2] and outlined below. The D-PSR Basis Document, along with other D-PSR deliverables discussed in this section, fulfills the requirements of REGDOC-2.3.3 [R-1].

Subsequent to acceptance of the D-PSR Basis Document by CNSC staff, the Safety Factor Reports were completed, as discussed in Section 1.0. The Safety Factor Reports presented the assessments of the review tasks for each Safety Factor, conformance with modern Laws, Regulations, Codes and Standards, and OPG Program effectiveness. In addition, the Safety Factor Reports included assessments of inputs from the following sources:

1. Darlington ISR results applicable to D-PSR,
2. Pickering PSR2 results applicable to D-PSR, which included programmatic components applicable to Darlington; and
3. OPG commitments to the CNSC and open CNSC action items.

The Gaps identified in the Safety Factor Reports provided input to the Global Assessment process, which consisted of the following main elements:

1. Consolidation of Gaps into Global Issues

Gaps with clear similarity in themes or topical areas were consolidated into a specific Global Issue.

2. Prioritization of the Global Issues

Each Global Issue was prioritized for its potential enhancement of nuclear safety. The prioritization process was comprised of deterministic and probabilistic considerations.

3. Development of Global Issue resolutions

Resolution Statements for Global Issues based on their safety significance.

4. Assessment of Defence-in-Depth

The adequacy of the provisions for defence-in-depth was confirmed by demonstrating that the Darlington NGS design and operation are aligned with the specific safety principles covered in IAEA Safety Report Series (SRS) No.46, *Assessment of Defence in Depth for Nuclear Power Plants* [R-6], taking into account the Strengths and Resolution Statements, and the impact of Acceptable Deviations.

The Global Assessment Report documented the results of the elements listed above and the assessment of overall acceptability.

The final phase of the Periodic Safety Review was the development of the IIP, which defined actions derived from the Resolution Statements to address the Global Issues identified in the Global Assessment. The IIP Actions included new initiatives as well as existing initiatives.

In addition to initial internal review by the Periodic Safety Review preparation teams, a number of targeted and overall reviews were performed during the Periodic Safety Review process.

These reviews were:

1. Review of the methodologies, Gaps, Global Issues, Resolution Statements, IIP Actions and overall conclusions by a third party Expert Panel.

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2. Review of the Periodic Safety Review reports by OPG Subject Matter Experts.
3. Review and approval of Global Issue Resolution Statements, the overall Global Assessment Report conclusions, and the IIP Actions and schedule by a Senior Management Scope Review Board.
4. Authorization of and a commitment to execute the IIP by the Senior Vice President for Darlington.

An action tracking and management system has been established for OPG and regulatory oversight, and an IIP process has been established to ensure that IIP Actions are completed according to the schedule in the IIP.

### 3.0 OVERALL PLANT PERFORMANCE

Safety Factor Reports provide assessments of the current state of the plant against modern expectations of programs and nuclear plant design. This section presents an overview of Darlington NGS's management system and organization, the plant's design, and an overview of current programs and processes to provide context for the Safety Factor reviews. In addition, the Global Assessment uses the current state of the programs and plant as a component in its assessment of the safety of continued operation of the plant.

#### 3.1 Management and Organization

Nuclear safety and security are core values at OPG. This is reflected in OPG Policy N-POL-0001, *Nuclear Safety & Security Policy* [R-7], which is endorsed by OPG's Board of Directors. The policy places nuclear safety and security as the overriding priority above that of cost, schedule and production. It requires that all employees conduct themselves in a manner consistent with the behaviour of a healthy nuclear safety culture. Such conduct requires that staff always consider how their everyday activities can impact the fundamental safety functions of the station.

OPG has established extensive programs and procedures and employs qualified staff to safely and effectively manage its nuclear plants. The programs and training were developed based on regulatory requirements, Canadian Standards Association (CSA) standards, IAEA Guides, World Association of Nuclear Operators (WANO) recommendations and nuclear industry best practices from around the world. As part of continuous improvement, the programs and training are kept up to date, based on audits, self-assessments, benchmarking, and ongoing use of industry operating experience (OPEX).

The existing corporate structure supports well-defined lines of responsibility throughout the organization. In particular, the appropriate functions are in place and adequately staffed to support and enhance nuclear safety at all levels of defence-in-depth.

Darlington NGS management is committed to continuously strengthen the safety culture within the Darlington NGS organization and safety culture is identified as a Strength for Darlington NGS.

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### 3.2 Plant Design Features

Darlington NGS was designed and built to high standards using the principles of defence-in-depth. The design includes a number of robust active and passive safety characteristics, as well as engineered and administrative safety features. These characteristics and features prevent accidents and mitigate accident progression should one occur.

#### 3.2.1 Major Modifications Since Initial Operation

Numerous improvement modifications have been made to Darlington NGS units since initial operation. These improvements reflect OPG's continuous improvement philosophy and bring the station into closer alignment with modern codes and standards. Furthermore, OPG's underlying philosophy regarding the application of defence-in-depth has focused on strengthening various layers of defence-in-depth at Darlington NGS, including these three initiatives:

- Darlington Life Extension;
- Safety Improvement Opportunities (SIOs); and
- Fukushima Project.

The Darlington Life Extension Project was undertaken to extend the life of the plant for 30 additional years of operation and involved a series of major component replacements, design modifications, inspection campaigns, and maintenance. The scope of this project included actions identified as part of the Environmental Assessment (EA) and D-ISR. An EA was conducted to assess the potential impacts of refurbishment and continued operation on the environment, including public safety and socio-economic considerations. Actions arising from the EA and the D-ISR were captured in the Darlington NGS IIP and are being tracked to completion in accordance with the IIP process.

The SIO Project was undertaken by OPG to identify practicable modifications which would reduce plant risk, the potential for public exposure to radiation and/or to address important regulatory issues.

Following the Fukushima event in 2011, OPG developed actions to enhance safety based on the lessons learned from the event. The key major modifications that have been made in response to the initiatives described above are as follows:

- **Shield Tank Overpressure Protection (STOP):** This modification enhances the relief capacity of the shield tank to prevent shield tank catastrophic failure from over-pressurization under severe Beyond Design Basis Accident (BDBA) conditions. The modification adds a rupture disc to provide overpressure relief for the shield tank on each unit.
- **Third Emergency Power Generator (EPG):** A third EPG has been designed and installed to withstand a seismic event more severe than the design basis earthquake (DBE) for which the existing two EPGs are designed, and to increase emergency power reliability when one EPG is not available.

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- **Emergency Heat Sink (EHS):** EHS allows for direct Emergency Service Water (ESW) inventory addition to the Heat Transport System (HTS). This SIO improves mitigating capability for a low frequency event of an in-core loss-of-coolant accident (LOCA) with Loss of Emergency Coolant Injection (LOECI) and BDBAs.
- **Auxiliary Shutdown Cooling (ASDC):** This modification provides two additional Shutdown Cooling (SDC) pumps to the existing SDC System. These two additional pumps provide additional diversity, independence, redundancy and physical separation for common mode failures during outages.
- **Containment Filtered Venting System (CFVS):** Following certain severe accidents, there is postulated to be a significant challenge to containment envelope integrity due to pressure exceeding design limits. The CFVS provides a means of relieving the containment pressure while minimizing radioactivity release. The system is capable of operation under severe conditions, including a complete loss of power.
- **Auxiliary Service Water (ASW) Load Shedding:** Automatic ASW load shedding has been installed to improve firewater margin and provides a connection point for the Fukushima Emergency Mitigating Equipment (EME) pumps to supply emergency water to ESW.
- **Powerhouse Steam Venting System (PSVS) enhancements:** PSVS that is an important system to protect plant systems following a steam line break. Enhancements to improve redundancy and reliability of the system have been implemented.
- **Modified 37-Element (37M) Fuel:** The 37M fuel design was introduced to enhance heat transfer along the centre of the fuel bundle and improve safety margins. Compared to the original design, the 37M fuel features a smaller element diameter, a thinner sheath to maintain collapsibility and higher space pads to compensate for the smaller diameter.
- **Replacement of fuel channels, calandria tubes and feeders:** The refurbishment project has or will remove and replace all of the fuel channels, calandria tubes and feeder portions.
- **Passive Autocatalytic Recombiners (PARs):** PARs have been installed to effectively mitigate hydrogen in the long term under accident conditions. PARs operate passively to reduce hydrogen concentration inside containment and provide an additional means of mitigating potential containment flammability challenges for BDBAs, particularly in events where the hydrogen igniters are not operational.
- **Column Line 11 Wall Enhancements:** Originally designed and constructed as a tornado/rail line blast wall, Column Line 11 runs East-West and forms the boundary between the Reactor Auxiliary Bay (RAB) and the Turbine Auxiliary Bay (TAB). It acts as an environmental barrier and can protect equipment south of it from Secondary Side Line Breaks (SSLBs) in the TAB, and equipment north of it from SSLBs in the RAB. Modifications have been implemented to make Column Line 11 a steam barrier to protect critical equipment located within the RAB from an SSLB in the TAB.
- **Fire Protection Upgrades:** A number of modifications have been installed or are in-progress to address findings from the code related gaps from the D-ISR. Examples of these upgrades include changes to the fire alarm system to allow transfer of the fire alarm to the Secondary Control Area, installation of fire dampers and fire doors, and Class II power supply to emergency lighting in the Unit 0 transfer chamber.

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In summary, a significant number of modifications have been implemented at Darlington NGS in support of continued operations and to align with current industry best practices.

### 3.3 Programs and Processes

Darlington NGS is operated and maintained in accordance with current nuclear industry codes and standards consistent with regulatory and safety requirements and industry best practice. Normal plant operation is controlled by detailed, validated, and formally approved procedures. The programs comprising the Nuclear Management System are aligned with modern industry best practice as evidenced by the few D-PSR Gaps identified in the related Safety Factor Reports, and they typically support multiple levels of defence-in-depth. Some of the key programs are listed and summarized below:

- **Equipment Reliability:** This program defines the requirements for establishing and maintaining optimum levels of reliability for components important to nuclear safety, production, and environmental protection. Reliable performance of components means very low numbers of component failures, degraded equipment condition is minimized, and redundancy is maintained on key systems.

Implementation of the Equipment Reliability Program at Darlington NGS is a station priority, and OPG continues to focus on improving the program to achieve safe, reliable, and economic production.

- **Environmental Qualification (EQ):** This program establishes an integrated and comprehensive set of requirements that provides assurance that essential equipment can perform as required if exposed to harsh Design Basis Accident (DBA) conditions, and that this capability is preserved over the life of the plant.

Under this program, there is a requirement for the EQ of Group 1 and Group 2 systems allowing them to be available for all SSLBs except for those of low frequency. This requirement exceeds modern requirements for the EQ of structures, systems, and components (SSCs).

- **Risk and Reliability Program:** This program establishes a framework for the development and use of Probabilistic Safety Assessment (PSA) as a means to manage radiological risks from nuclear accidents and to contribute to safe operation of the reactors.

OPG recently completed the most recent update of the Darlington Probabilistic Safety Assessment (referred to as "DARA"), which is comprised of several distinct elements covering such hazards as internal events (e.g., steam line break, loss of coolant accidents), seismic events, internal fires, internal flooding, and high winds. The use of the DARA study helped identify plant design changes, some of which have now been installed and have resulted in significant benefits to nuclear safety and reduced risk to the public.

### 3.4 Continuous Improvement

The continuous improvement process through which OPG strives to improve the safety and performance of its nuclear power plants is longstanding, ongoing, and covers all aspects of operation. Current performance is compared to management expectations, industry standards

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of excellence, internal and external OPEX, and regulatory requirements to identify areas with opportunities for improvement, prepare action plans and incorporate enhancements.

Established programs and processes are used to identify and address areas for improvement. OPG participates with industry partners in developing new or revised codes and standards, in research and development activities, in the application of emerging technologies, and in the exchange of OPEX. This is done through membership in organizations such as WANO, Institute of Nuclear Power Operations (INPO), the CANDU Owners Group, the CSA and the Electric Power Research Institute (EPRI).

The following sections describe some of the more significant areas of ongoing improvement.

### 3.4.1 Fukushima Operating Experience

Following the March 2011 earthquake in Japan, the safety systems at the Fukushima Daiichi Nuclear Power Plant operated as designed and the reactors were automatically shut down. However, the tsunami that followed disabled power to critical support systems.

OPG acted promptly to understand what had happened at Fukushima Daiichi and confirmed that the OPG nuclear fleet remained safe for continued operation. OPG has completed additional assessments including those requested by the CNSC to review the impact of a similar event (that is, an event resulting in a total loss of all AC power, subsequently resulting in a total loss of heat sinks) at OPG stations. Enhancements to provisions to maintain or re-establish the Control, Cool, Contain and Monitor safety functions were assessed to determine those that are most practical to implement and also meet specified requirements. Several enhancements have been implemented and additional ones are being implemented. These include the use of EME and Severe Accident Management Guidelines (SAMG). Emergency response planning is also undertaken, and emergency drills are run on a periodic basis to ensure staff are prepared to respond as required.

The latest Darlington PSA study credits the use of EME installed as part of the lessons learned from Fukushima and shows that the risk of severe core damage and large release has significantly decreased.

A Mutual Aid Agreement for Nuclear Emergency Support is in place with all Canadian nuclear utilities to provide support in the event of an emergency.

OPG continues to have a strong presence in international forums and with all operators of Canadian nuclear generating stations to ensure that any further lessons learned from the Fukushima accident are assessed for Darlington NGS.

### 3.4.2 Radiation Protection Initiatives

Consistent with the policy of continuous improvement, OPG identifies and implements strategic improvement initiatives which would further reduce radiation exposures, to ensure that doses will be As Low As Reasonably Achievable (ALARA) during continued operation. These strategic initiatives include radiation source elimination, shielding and worker protection. Darlington NGS has been recognized by external organizations for the strength of its ALARA program performance and received the Information Systems on Occupational Exposure (ISOE) World Class ALARA Performance Award in 2008. In the 2019 Regulatory Oversight Report for

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Canadian Nuclear Power Plants, the CNSC concluded that Darlington NGS exceeded expectations for the application of ALARA.

#### 4.0 RESULTS OF THE SAFETY FACTOR REVIEW AND GAP EVALUATION

As discussed in Sections 1.0 and 2.0, the assessments presented in the Safety Factor Reports determine if the intent of the review tasks is met and whether the current state of the plant design and operation conforms with the safety-significant elements of modern Laws, Regulations, Codes, and Standards.

A number of Gaps and EOs were identified in the Safety Factor Reports. However, none of the fifteen Safety Factor Reports identified any fundamental safety issues. Overall, OPG has effective programs and processes in place for continued safe operation of the Darlington NGS.

As noted in Section 2.0, Gaps and EOs with similar themes or topical areas are consolidated into a specific Global Issue. For example, governance issues, where their resolution would require modification to OPG governance documentation, are grouped into a single Global Issue. For Gaps and EOs related to the implementation or effectiveness of governance, but where the governance itself is adequate, a distinct Global Issue for Governance Implementation/Effectiveness Issues is identified. The consolidation of Gaps and EOs also considers the expected differences between the level of safety significance of Gaps and EOs and their resolutions.

The Global Issues resulting from the consolidation of Gaps and EOs and for which Resolution Statements are developed are listed in [Appendix C](#). Resolutions are not developed for Global Issues that have low safety significance and are addressed to the extent practicable, so these Global Issues are not listed in [Appendix C](#). Other Global Issues are also not listed in [Appendix C](#) because the resolutions are either already being tracked in the D-ISR IIP, covered by an existing action, or were completed following the finalization of the D-PSR GAR. [Appendix C](#) shows the Resolution Statement(s) and IIP Action(s) associated with each Global Issue listed.

The CNSC uses a Safety and Control Area (SCA) framework to assess licensee conformance with regulatory requirements and expectations. The 14 SCAs cover all facility programs. [Appendix A](#) shows how the Global Issues for which there are Resolution Statements align with the 14 SCAs.

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### 5.0 ASSESSMENT OF OVERALL ACCEPTABILITY OF CONTINUED OPERATION

Overall acceptability of the operation of the plant for the continued operating period is evaluated on the basis of a balanced view of all D-PSR results. The evaluation considers enhancements associated with the Global Issue Resolution Statements, Strengths, Acceptable Deviations, and the assessment of defence-in-depth. Global Issues have been discussed in Section 4.0 above; Strengths, Acceptable Deviations, and the Defence-in-Depth Assessment are discussed in this section.

#### 5.1 Strengths Identified in D-PSR

The Darlington NGS Strengths are used in the Global Assessment as indicators of alignment with modern codes, standards, and practices, and in the development of Resolution Statements for Global Issues. They are also used in the Defence-in-Depth Assessment described in Section 5.2 to demonstrate fulfillment of the safety requirements of defence-in-depth.

REGDOC-2.3.3 [R-1] defines strengths as current practices that are “equivalent to or better than those established in modern codes and standards, practices”. Positive findings in D-PSR are identified as possible strengths if there is clear evidence that Darlington NGS and/or OPG programs are equivalent to or surpass the provisions of modern requirements and practices or review task objectives.

Strengths were identified from the following:

- Safety Factor Reports
- Codes and Standards Assessments
- Independent Third Party Assessments

A total of nineteen preliminary strengths were identified as part of the PSR process, as detailed in Table 5-1 below. These strengths were refined as part of the stakeholder review, resulting in twelve of these strengths being finalized in the GAR.

These twelve strengths are identified in [Appendix B](#), which also shows the levels of defence-in-depth supported by each Strength.

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**Table 5-1: Strengths Identified During the PSR Process**

Strength Title and Description
<p><b>Darlington NGS Effectiveness of Configuration Management</b></p> <p>The effectiveness of configuration management practices at Darlington NGS represent a D-PSR strength in terms of the ability to maintain the adequacy of station design documentation in the future. Specific observations which support this conclusion are the CSA N286.10-16 compliance review and self-assessments that indicate the Engineering Change Control Program and Design Management Program have effectively managed systems controls and are consistent with industry-best practices.</p>
<p><b>Modifications to Reduce Plant Risk and Strengthen Defence in Depth</b></p> <p>The SIO project resulted in recommendations to implement a suite of modifications to reduce plant risk and strengthen defence in depth. One of the recommendations from the SIO Project was the installation of new ASDC pumps in each unit. This modification represents a significant improvement to Level 2 and 3 defence in depth as the ASDC pumps provide an additional barrier to protect against challenges to the backup heat sink in the SDC Odd/SDC Even configuration. The installation of the ASDC pumps during the unit refurbishment outages at Darlington NGS represents a D-PSR strength.</p>
<p><b>Installation of a CFVS for BDBAs Mitigation</b></p> <p>The CFVS is an engineering filtered venting pathway designed specifically for BDBAs involving elevated containment pressures.</p> <p>The installation of CFVS represents a significant modification implemented after D-ISR which provides significant benefits in terms of minimizing on-site and off-site radiological doses during the BDBA response. This is because an underlying principle of the operating strategy is to maximize the time prior to placing CFVS into service in order to minimize on-site and off-site radiological doses.</p> <p>The CFVS operating strategy demonstrates that CFVS would not be required within 24 hours of the initiating event. This exceeds the requirements contained in Section 8.6.12 of CNSC REGDOC-2.5.2, "Design of Reactor Facilities: Nuclear Power Plants" and represents a D-PSR strength.</p>
<p><b>BDBA Guidance Exceeds Requirements</b></p> <p>As part of the BDBA Program, a framework has been established for managing the availability of systems which perform BDBA functions. Key features of this framework are guidelines that:</p> <ul style="list-style-type: none"> <li>• identify functional requirements for systems.</li> <li>• provide a means of managing the response to potential operability issues related to the BDBA response.</li> </ul> <p>The formalized guidance exceeds the requirements specified in CSA N290.16-16, "Requirements for Beyond Design Basis Accidents" and represents a D-PSR strength.</p>

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Strength Title and Description
<p><b>Pressure Boundary Program Effectiveness</b></p> <p>Based on an assessment of programmatic audits and self-assessment results, there is a strength related to the effectiveness of the Pressure Boundary Program. Specifically, this strength reflects the conclusions of multiple, independent audits and self-assessments which determined that the Pressure Boundary Program is consistent with industry best practices and has effective managed system controls. Relevant audits and self-assessments involved are listed below:</p> <ul style="list-style-type: none"> <li>• Independent review of OPG Nuclear Pressure Boundary Quality Program by the ANRIC Evaluation Team;</li> <li>• Performance Based Audit by the OPG Nuclear Oversight of the Pressure Boundary Program in October 2020; and</li> <li>• CNSC Type II Compliance Inspection of the Pressure Boundary Program which was performed in March 2017.</li> </ul>
<p><b>State-of-the-art Reactor Mock-up and Rehearsal Facilities</b></p> <p>The Darlington Energy Centre (DEC) building includes a new state-of-the-art training facility with a full-scale mock-up of the inside of a reactor, plus a tooling and testing facility to allow for the design and development of tools and processes needed for the refurbishment project. The DEC also houses multiple other mock-up models (e.g., end fitting arrays) and specialized tools being used during removal and replacement of pressure tubes, calandria tubes, the feeder pipes in the reactor. The ability to perform maintenance activity rehearsals on a full-scale facility mitigates the potential for in-reactor discovery issues, maintenance errors, and it facilitates planning for radiological dose minimization.</p> <p>This reactor mock-up and rehearsal facilities exceeds the objectives of Review Task #2 [of Safety Factor 2] and is first-of-kind maintenance facility for CANDU reactors. This is considered a D-PSR Strength for Darlington NGS.</p>
<p><b>Seismic Qualification program</b></p> <p>The seismic qualification program at OPG provides framework for activities related to the requirements for seismic design and qualification of DNGS in accordance with the CSA N289 series of standards. The Law, Regulation, Code and Standard (LRCS) reviews have demonstrated that DNGS is fully compliant with the modern editions of the standards and exceeds the seismic requirements in the design basis and the licensing basis which is the 2008 version of CSA N289.1. Further, the DNGS applies a lower frequency Margin Design Earthquake (MDE) for new modifications, which exceeds the amplitude used for the Design Basis Earthquake. The extent of seismic qualification at DNGS and the fact that Darlington is fully compliant with the modern editions of the CSA N289 series of standards, is a D-PSR strength.</p>
<p><b>EQ of Group 1 and Group 2 systems</b></p> <p>The EQ of DNGS Group 1 and Group 2 systems provides redundancy and diversity. The requirement for EQ of Group 1 and Group 2 system mitigating capability is unique to the DNGS design and licensing basis and exceeds modern requirements for the EQ of SSCs. This requirement has resulted in an extensive set of EQ'd systems. This qualification combined with the extent of activities relating to the preservation and maintenance of EQ result in EQ of being a D-PSR strength.</p>

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Strength Title and Description
<p><b>Performance of Chemistry Program</b></p> <p>OPG has consistently performed well and has continually raised internal targets to progress towards achieving nuclear excellence for Chemistry Control. The strong performance of CNSC Chemistry Index (CI) and Chemistry Compliance Index (CCI) for Chemistry Program for a number of years is identified as a D-PSR strength.</p>
<p><b>Acceptance of PSA Methodologies</b></p> <p>OPG has prepared and updated a suite of PSA Guides to describe the methodologies for different PSA elements and obtained CNSC acceptance of the methodologies prior to completion of the analysis. A series of detailed PSA reports have been created to document the analyses.</p>
<p><b>PSA Modelling of Plant Configurations Prior to Refurbishment</b></p> <p>The PSA elements included sensitivity cases to assess other station configurations, including assessment of a pre-refurbishment model unit, and assessment of all four units in the post-refurbishment configuration. This modelling of the different refurbishment configurations in the 2020 PSA study is a D-PSR strength.</p>
<p><b>Use of the PSA to Identify Potential Design Changes for Risk Reduction</b></p> <p>The risk assessment study was used to identify potential plant design changes (e.g., refurbishment related Safety Improvement Opportunities) that would lead to a decrease in the nuclear safety risk.</p>
<p><b>Assessment of Internal and External Hazards</b></p> <p>The systematic identification of internal and external hazards as prescribed in the current licence exceeds that of newer requirements and those in this review task. Further, the current application of a comprehensive suite of screening guides systematically establishes the basis for screening-in or -out initiating events and combinations of events represents a D-PSR Strength.</p>
<p><b>Development and Implementation of New OPEX Database</b></p> <p>OPG has recently developed and released a new OPEX database to facilitate the distribution of external OPEX from COG to departmental OPEX Single Points of Contact (SPOCs), management of OPEX reviews, and documentation of initial assessments or dispositions from site departments. The OPEX database also provides a readily available repository of all previous external OPEX and site reviews/responses to new OPEX with searching capabilities. This database provides various dashboards to present OPEX related information at a glance. Several OPEX health metrics are also monitored and tracked through the OPEX database. The new database has improved functionality and user interface, reducing the potential for relevant OPEX to be missed or not effectively actioned upon.</p> <p>The development and implementation of the OPG OPEX database to readily capture/access OPEX related information in a single repository demonstrates an innovative use of advanced IT tools to facilitate improvements for OPEX management. With the identified efficiencies and notable improvements in the OPEX database, the OPEX database represents the use of industry best practices in the sending and receiving of OPEX from other nuclear power plants. This exceeds the requirements of the Review Task and is considered to be a D-PSR strength.</p>

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Strength Title and Description
<p><b>Nuclear Safety and Security Culture Monitoring Panel (NSSCMP)</b></p> <p>The NSSCMP reviews Nuclear Safety and Security Culture trends and potential issues that could impact Nuclear Safety and Security Culture health and ensure issues are appropriately addressed. The processes are aligned with the NSSCMP requirements outlined in Nuclear Energy Institute guidance for fostering a strong nuclear safety culture. The use of NSSCMPs is considered to be a D-PSR strength as it exceeds the requirements of CNSC REGDOC-2.1.2 and further promotes meaningful conversations and the spread of lessons learned amongst station leaders to ensure any emergent issues that could impact nuclear safety culture are addressed.</p>
<p><b>Resilience Training for Accident Management</b></p> <p>The OPG training element relating to resilience training for accident management is identified as a strength relating to Review Task #4 [of Safety Factor 13]. The purpose of this training is to facilitate improved decision-making capabilities of authorized staff and key roles in the Emergency Response Organization (ERO) when faced with increased levels of stress that could be anticipated during Design Basis and Beyond Design Basis Accidents, including multi-unit accidents. This training has been provided to personnel with key roles in emergency response (i.e., Shift Manager, Emergency Response Director, and Emergency Response Manager). This resiliency training to emergency responders is beyond that required for regulatory and licensing requirements. This represents a D-PSR strength for the OPG Emergency Preparedness Program in responding and adapting successfully to extreme events. The provision of this training exceeds the objective of Review Task #4 and is considered to be a best practice.</p>
<p><b>Management of EITER</b></p> <p>The OPG and Darlington programs relating to the management of EITER is a strength. With high levels of equipment reliability, this demonstrates that the management of EITER is effective within the Consolidated Nuclear Emergency Plan (CNEP) and is consistent with industry best-practices. Further, the management of the EITER program has been recognized as an industry strength. Therefore, this exceeds the objective of the Review Task in confirming the adequacy of on-site equipment for emergencies and is recognized as a D-PSR strength.</p>
<p><b>Implementation of Phase 2 EME</b></p> <p>The implementation of Phase 2 EME provides defence-in-depth for scenarios where efforts to recover Emergency Power Supply (EPS) are unsuccessful; this is a strength relating to Review Task #10. The robustness of the EPGs and the EPS system as a whole has been demonstrated for Beyond Design Basis Events. This includes a combination of analysis activities (e.g., survivability assessments for Review Level Conditions (RLC) associated with various external hazards) and design modifications (e.g., hardening EPS and installation of a third EPG qualified for RLC and Margin Design Earthquake). As a result, there is reasonable confidence that emergency response actions which attempt to restore EPS will be successful for a wide range of external events. In the event that actions to recover EPS are unsuccessful, Phase 2 EME is deployed as part of the longer-term emergency response. The defence-in-depth afforded by Phase 2 EME in terms of facilitating unit(s) stabilization and recovery exceeds requirements and is a D-PSR strength.</p>

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Strength Title and Description
<p><b>Performance of radiation exposures ALARA Program</b></p> <p>DNGS has been recognized by external organizations for the strength of its ALARA program performance and received the ISOE World Class ALARA Performance Award in 2008. In the 2019 Regulatory Oversight Report for Canadian Nuclear Power Plants, the CNSC concluded that DNGS exceeded expectations for the application of ALARA. DNGS ALARA performance is identified as a D-PSR strength.</p>

## 5.2 Defence-in-Depth

Defence-in-depth is a comprehensive approach to safety. It establishes five levels, each designed to prevent an accident from occurring, to mitigate an accident should one occur, or to prevent an accident from degrading to a more serious event. The general objective of defence-in-depth is to ensure that a single equipment or human failure at one level of the five levels of defence, and even a combination of failures at one level of defence, would not jeopardize the integrity of subsequent levels. In this way, defence-in-depth provides multiple, redundant safety provisions for the protection of the public and the environment.

The approach taken in this assessment was based on IAEA SRS-46 [R-6]. The approach analyzed the five independent levels of defence. All levels of defence-in-depth rely on multiple barriers of protection to prevent or limit equipment failures or human errors and mitigate the consequences should these failures or errors occur. The intent of the review was to confirm that, for each of the five levels of defence, the barriers will be effective for the period of continued operation.

The scope considered the following elements of D-PSR:

- The Strengths that have been identified in the D-PSR process, and how they support the baseline plant meeting the requirements of defence-in-depth.
- The positive impact on defence-in-depth of the proposed enhancements associated with the Global Issue Resolution Statements.
- Confirmation that Acceptable Deviations do not have a significant adverse effect on defence-in-depth, either individually or in aggregate.

The results of the assessment for the five levels of defence-in-depth are summarized below.

### Level 1 – Prevention of abnormal operation and failures

The objective of the first level of defence is to prevent deviations from normal operation, and to prevent failures of SSCs important to safety. A strong Level 1 defence requires a conservative design and high-quality construction and operation. This is particularly important for the physical barriers between the fuel and the environment.

The assessment has confirmed that effective Level 1 barriers are ensured through the original conservative design supplemented by design improvements implemented since initial operation (some of which are discussed in Section 3.2), comprehensive programs in place, including effective operating and maintenance programs to ensure continued fitness for service and operation within the design basis, and ongoing continuous improvements based on national and international OPEX and evolving regulatory

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requirements. Given the focus and priority placed on addressing new requirements in modern codes and standards and the processes in place to address equipment condition, the first level of defence will continue to be strong and effective for Darlington NGS.

### Level 2 – Control of abnormal operation and detection of failures

The objective of the second level of defence is to detect and intercept deviations from normal operating conditions, in order to prevent Anticipated Operational Occurrences (AOOs) from escalating to accident conditions. A strong Level 2 defence requires control of plant behaviour using both inherent and engineered design features including both protective systems and surveillance features.

The Level 2 defence-in-depth design features at Darlington NGS include the Reactor Regulating System and plant process control systems. These components are all coordinated to monitor and control total reactor power and reactor flux shape, and to monitor important plant parameters so that reactor power can be reduced via reactor power setback or stepback, if any parameter is beyond its setpoint and to avoid the need for special safety system action. Reactor control in Darlington NGS has a high degree of immunity to process upsets and measurement failures due to extensive redundancy in control devices and process measurements.

The Safe Operating Envelope (SOE) defines the set of limits and conditions within which the plant shall be operated to ensure conformance with the safety analysis basis. The SOE limits and conditions are mapped into operating constraints in station documentation and compliance with the SOE ensures that the plant is operated safely within its licensing basis, such that time spent operating outside the SOE is detected in a timely manner and appropriate actions are taken to ensure a timely return back within the SOE.

The assessment of defence-in-depth Level 2 concludes that the provisions in place are mature and robust. Implementation of measures to ensure compliance with modern requirements for inspections and maintenance, and improvements to the Deterministic Safety Analysis (DSA) and PSA will further enhance the Level 2 barrier at Darlington NGS.

### Level 3 – Control of accidents within the design basis

The objective of the third level of defence is to minimize the consequences of accidents by providing inherent safety features, fail-safe design, additional equipment and mitigating procedures. A strong Level 3 defence is evidenced by the design and robustness of engineered safety features coupled with correspondingly robust operating procedures.

Darlington NGS has four special safety systems that limit consequential fission product releases to the public following any DBA and multiple heat removal systems of adequate capacity to ensure that heat generated in the fuel is transferred to the atmosphere or the lake under normal operating, shutdown/outage, and DBA conditions. The reactors are equipped with multiple sources of electrical power to ensure that controls and equipment important to safe operation are available.

The Darlington NGS Safety Report [R-8] contains analyses demonstrating the effectiveness of the Special Safety Systems and other Systems Important to Safety.

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Effectiveness is ultimately demonstrated by the safety analyses showing that public dose meets the applicable regulatory limits for the full range of accidents considered in the design.

The review confirms that the Darlington NGS has strong Level 3 barriers, due to the high quality of the design, which include extensive mitigating provisions and comprehensive accident management procedures. A robust set of safety analyses and assessments, which will be further enhanced through the implementation of CNSC REGDOC-2.4.1 and best practices from CSA N290.17-17, demonstrate the adequacy of this level of defence-in-depth.

### Level 4 – Control of severe plant conditions

The objective of the fourth level of defence is to ensure that radioactive releases caused by BDBAs including severe accidents are kept as low as practicable. A strong Level 4 defence requires a robust containment design, as well as strong complementary design features and accident management strategies to prevent accident progression and mitigate the consequences of Design Extension Conditions.

Several complementary design features for BDBAs have been fully implemented at Darlington NGS since its initial construction. CFVS provides protection of containment against the potential of slow over-pressurization failure while reducing radioactive release to the atmosphere in the event of a BDBA. The effectiveness of CFVS is enhanced by the STOP modification. The Hydrogen Ignition System provides a means to safely combine any hydrogen (or deuterium) gases generated in containment following postulated events. PARs provide an additional means of mitigating potential containment flammability challenges for BDBAs, particularly in events where the Hydrogen Ignition System is not operational. The implementation of EME provides another key line of defence for BDBAs.

OPG has a mature emergency response infrastructure in place, and dedicated and qualified emergency response personnel and EITER are maintained at all times.

The measures considered at the first three levels of defence-in-depth will ensure maintenance of the structural integrity of the core and limit potential radiation hazards for members of the public. The D-PSR assessments and review of safety principles demonstrate that additional design features and procedural provisions are in place and adequate to address severe accident conditions.

A significant number of improvements have been implemented since initial operation specifically to reinforce Level 4 defence-in-depth. Nonetheless, OPG, as a learning and continuous improvement organization, continues to evaluate industry OPEX, best practices and recommendations in order to identify opportunities for improving their accident management capabilities.

### Level 5 – Mitigation of radiological consequences

The objective of the fifth level of defence is to mitigate the radiological consequences of potential releases of radioactive materials. A strong Level 5 defence is evidenced by a robust emergency response program consisting of adequately equipped emergency support facilities and plans for on-site and off-site emergency response.

OPG has extensive plans and procedures in place to ensure capability and readiness to respond to a nuclear emergency, with the support of a coordinated effort from various

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response organizations. The implementation of SAMG, post-accident monitoring capability, installation of CFVS, and implementation of OPEX from Fukushima have also significantly improved the existing robust barriers for the Level 5 defence-in-depth.

In conclusion, a review of the five levels of defence performed in support of the Global Assessment has confirmed that Darlington NGS meets the defence-in-depth requirements, as a robust set of barriers is in place for the five levels of defence. The adequacy of these provisions has been confirmed by the comprehensive PSAs. No additional Gaps or improvements required beyond those being addressed by the Global Issue Resolution Statements were identified. The levels of defence will be further strengthened as the planned safety improvements are implemented.

### 5.3 Acceptable Deviations

An assessment was performed to determine if Gaps that were not individually significant could become more significant when their collective effect was considered. The interaction assessment focused on the Gaps that were categorized as Acceptable Deviations. The results of this assessment concluded that the aggregate impact of Acceptable Deviations on the associated safety principles related to all levels of defence-in-depth is very low and there are no additional D-PSR Issues resulting from this assessment.

### 6.0 THE INTEGRATED IMPLEMENTATION PLAN

As discussed in Section 2.0, the IIP is completed in the final phase of the Periodic Safety Review process and defines the actions derived from the Resolution Statements to address the Global Issues identified in the Global Assessment [R-4].

The Global Assessment identified 23 Global Issues. Dispositions of 13 of these Global Issues were categorized in the Global Assessment as follows and thus Resolution Statements are not required:

- The Global Issue is either resolved subsequent to completion of the Safety Factor Reports so no further action is needed, or
- The Global Issue is being addressed by ongoing activities outside of the D-PSR process, or
- The Global Issue will be resolved through Resolution Statements associated with another Global Issue, or
- The Global Issue has low safety significance and is addressed to the extent practicable, or
- The Global Issue will be addressed through combinations of the above.

The Global Assessment identified 35 Resolution Statements for the remaining 10 Global Issues. Of the 35 Resolution Statements, 25 have been excluded from the D-PSR Integrated Implementation Plan because they are either already being tracked in the D-ISR Integrated Implementation Plan, covered by an existing action, or were completed following the finalization of the D-PSR Global Assessment Report. Specific actions to enhance safety were prepared in

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the IIP for the remaining 10 Resolution Statements, resulting in 17 IIP Actions. These 17 IIP Actions may be grouped as follows:

- 16 specific actions will support the station's fitness for service by ensuring compliance with relevant standards, completing assessments for unmapped components, revising the PIP for TRF structures and inspecting TRF structures per the updated PIP.
- One specific action will support the station's emergency management and fire protection by evaluating the benefit of revising existing governance to align with the NBCC for future construction or modifications related to fire protection, occupant safety and accessibility.

More than half of these actions are scheduled in the IIP to be completed by the end of 2024, and all actions are currently scheduled to be completed by the end of 2028. The IIP Actions are shown in [Appendix C](#).

## 7.0 CONCLUSIONS OF THE D-PSR

### 7.1 D-PSR Review and Acceptance by the CNSC

According to CNSC REGDOC-2.3.3 [R-1], the reports produced in each phase of a Periodic Safety Review must be submitted to the CNSC. In particular, CNSC staff confirms that the D-PSR Basis Document is acceptable, reviews the Safety Factor Reports and the Global Assessment Report, and confirms that the IIP is acceptable.

The CNSC accepted the D-PSR Basis Document [R-2]. The D-PSR Safety Factor Reports were submitted to the CNSC. CNSC staff reviewed the reports and their comments have been taken into account in the subsequent elements of D-PSR, including the identification of additional Gaps. The Global Assessment Report [R-4] was submitted to the CNSC. CNSC staff reviewed the Global Assessment Report and their comments have been taken into account in the IIP. The IIP [R-5] was submitted to CNSC staff, who confirmed that it fulfills regulatory requirements, meets CNSC staff expectations and is acceptable [R-9].

### 7.2 Conclusion of the Assessment of Overall Acceptability of Operation of the Plant

The PSR demonstrates that Darlington NGS will operate safely during the continued operating period. Activities that will further enhance safe plant operation are planned or in progress. The justification for this conclusion is based on the following:

Current Plant State:

- i) OPG has comprehensive programs in place to ensure the condition of SSCs important to safety at Darlington NGS is well understood, to assess the level of fitness for service, and to effectively take action to maintain good plant condition. This has led to continuous improvement in the condition of the plant, and plant performance.
- ii) OPG has made significant improvements to the Darlington plant design and processes. The plant design enhancements, discussed in Section 3.2, together with the process enhancements, closely align the plant with safety-significant requirements of modern codes and standards (which in some cases are beyond current requirements), and

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enhance defence-in-depth. In particular, enhancements made in response to the 2011 Fukushima accident have reduced, and will further reduce, the risk associated with BDBAs.

- iii) The design and operation of the plant meet the current deterministic safety analysis dose limits, and processes are in place to ensure the safety analysis accounts for any additional aging effects associated with continued operation. The Probabilistic Safety Assessment shows that the OPG risk-based Safety Goals for Core Damage Frequency and Large Release Frequency are met.
- iv) Radiological dose performance and environmental impact performance are significantly better than regulatory limits. Programs are in place to ensure the ongoing effectiveness of the radiological protection of workers, the public and the environment.

#### Results of the PSR:

- i) The Global Assessment identified 12 Strengths (refer to Section 5.1), indicating that Darlington NGS is well aligned with modern codes, standards and best practices in key areas.
- ii) The Global Assessment identifies 23 Global Issues. Resolution Statements for Global Issues were developed, and many are in progress to further enhance safety. Most of the Resolution Statement actions reflect existing work programs and plans at the station. In particular, for the Global Issues of highest safety significance (e.g., Fitness for Service Assessments to cover the operating period), OPG is already actively working on addressing the Global Issues for the operating period to the end of 2035. One Global Issue, which is related to the replacements of the Heat Transport System Liquid Relief Valves, was assessed as having a high impact on nuclear safety and assigned Safety Significance Level 1. OPG was already fully aware of the need to complete the replacement of these valves and there are open actions associated with the D-ISR IIP to track the replacement of these valves to completion. None of the Global Issues identify an immediate safety concern that requires additional planned or urgent action to be taken outside of the PSR process. Specific IIP Actions in the Integrated Implementation Plan have been identified to address the Global Issues.
- iii) The assessment of Acceptable Deviations confirms there is no impact on the conclusion of the Global Assessment, either individually or in aggregate.
- iv) The assessment of defence-in-depth of the plant includes a detailed review and confirmation of the adequacy of the provisions for each level of defence. This is based on an assessment of how the related safety principles for each level of defence-in-depth are met, taking into account the plant design, the ongoing operations and maintenance activities at the plant, the identified Strengths, as well as the proposed enhancements identified in the Global Assessment process and that will be implemented through the IIP. The assessment also accounts for the aggregate effect of Acceptable Deviations. The Defence-in-Depth Assessment shows that Darlington NGS units design and operation have adequate and effective barriers in all levels of defence-in-depth.
- v) The IIP comprises a total of 17 specific actions, which will address 10 Global Assessment Resolution Statements. More than half of the specific actions in the IIP are planned for completion by the end of 2024, and all are planned for completion by the end of 2028.

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- vi) OPG’s organizational structure and management system provides the requisite processes, tools, resources and oversight that will ensure continued safe operation of the plant.

In summary, the current plant design, operation, processes and management system will ensure continued safe operation of Darlington. Completion of the actions identified in the IIP will further enhance safety. OPG and the Darlington Station Leadership Team are committed to investing in the plant, and focusing the organization to strive for continued improvement in the plant condition, operation and performance.

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### 8.0 ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
AOO	Anticipated Operational Occurrence
ASDC	Auxiliary Shutdown Cooling
ASME	American Society of Mechanical Engineers
ASW	Auxiliary Service Water
BDBA	Beyond Design Basis Accident
BOP	Balance of Plant
CANDU	CANada Deuterium Uranium
CANUTEC	Canadian Transport Emergency Centre
CCI	Chemistry Compliance Index
CFVS	Containment Filtered Venting System
CI	Chemistry Index
CNEP	Consolidated Nuclear Emergency Plan
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association
CT	Calandria Tube
DARA	Darlington Probabilistic Safety Assessment
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DEC	Darlington Energy Centre
DNGS	Darlington Nuclear Generating Station
D-PSR	Darlington Periodic Safety Review
DSA	Deterministic Safety Analysis
EA	Environmental Assessment
EHS	Emergency Heat Sink
EITER	Equipment Important to Emergency Response
EME	Emergency Mitigating Equipment
EO	Enhancement Opportunity
EPG	Emergency Power Generator
EPRI	Electric Power Research Institute
EPS	Emergency Power Supply
EQ	Environmental Qualification

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ERO	Emergency Response Organization
ESW	Emergency Service Water
FAI	Fukushima Action Item
FFS	Fitness for Service
GAR	Global Assessment Report
GI	Global Issue
HTS	Heat Transport System
IAEA	International Atomic Energy Agency
IAM	Integrated Aging Management
IIP	Integrated Implementation Plan
INPO	Institute of Nuclear Power Operations
ISOE	Information Systems on Occupational Exposure
ISR	Integrated Safety Review
LCMP	Life Cycle Management Plan
LOCA	Loss of Coolant Accident
LOECI	Loss of Emergency Coolant Injection
LRCS	Law, Regulation, Code, and Standard
MDE	Margin Design Earthquake
MECP	Ministry of Environment, Conservation and Parks
NBCC	National Building Code of Canada
NGS	Nuclear Generating Station
NPP	Nuclear Power Plant
NSSCMP	Nuclear Safety and Security Culture Monitoring Panel
NWM	Nuclear Waste Management
OPEX	Operating Experience
OPG	Ontario Power Generation
PAR	Passive Autocatalytic Recombiner
PIP	Periodic Inspection Program
PSA	Probabilistic Safety Assessment
PSR	Periodic Safety Review
PSR2	Periodic Safety Review 2
PSVS	Powerhouse Steam Venting System
RAB	Reactor Auxiliary Bay

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REGDOC	Regulatory Document
RLC	Review Level Condition
RS	Resolution Statement
SAMG	Severe Accident Management Guidelines
SCA	Safety and Control Area
SDC	Shutdown Cooling
SF	Safety Factor
SIO	Safety Improvement Opportunity
SOE	Safe Operating Envelope
SPOC	Single Point of Contact
SRS	Safety Report Series
SSCs	Structures, Systems and Components
SSG	Specific Safety Guide
SSLB	Secondary Side Line Break
STOP	Shield Tank Overpressure Protection
TAB	Turbine Auxiliary Bay
TRF	Tritium Removal Facility
WANO	World Association of Nuclear Operators

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### 9.0 REFERENCES

- [R-1] CNSC Regulatory Document, "Periodic Safety Reviews", REGDOC-2.3.3, April 2015.
- [R-2] OPG Report, "DNGS Periodic Safety Review Basis Document", NK38-REP-03680-11844 R002, February 03, 2021.
- [R-3] IAEA Specific Safety Guide, "Periodic Safety Review of Nuclear Power Plants", SSG-25, March 2013.
- [R-4] OPG Report, "Darlington NGS Periodic Safety Review (D-PSR): Global Assessment Report", NK38-REP-03680-11938 R000, December 08, 2022.
- [R-5] OPG Report, "Darlington NGS Periodic Safety Review (D-PSR): Integrated Implementation Plan", NK38-REP-03680-11940 R000, August 24, 2023.
- [R-6] IAEA Report, "Assessment of Defence in Depth for Nuclear Power Plants", Safety Report Series No. 46, February 2005.
- [R-7] OPG Policy, "Nuclear Safety & Security Policy", N-POL-0001-R004, May 13, 2020.
- [R-8] OPG Safety Report, "Darlington Nuclear 1-4 Safety Report: Part 3 - Accident Analysis", NK38-SR-03500-10002 R005, October 30, 2017.
- [R-9] CNSC Correspondence, "Darlington NGS – Periodic Safety Review (D-PSR) – CNSC Staff Acceptance of the Integrated Implementation Plan (IIP)", e-Doc 7248767, OPG File No. NK38-CORR-00531-25314 R000, March 25, 2024.
- [R-10] CNSC Report, Regulatory Oversight Report for Canadian Nuclear Power Plants: 2018, 2019, 2020, 2021, 2022.

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**Appendix A: D-PSR Results by CNSC Safety and Control Area**

REGDOC-2.3.3 [R-1] specifies that PSRs be comprised of the assessments of 15 Safety Factors, which are identical to the 14 Safety Factors specified in the IAEA's guidance, SSG-25 [R-3], plus Radiation Protection. The CNSC evaluates and reports nuclear power plant safety performance according to 14 SCAs to confirm that licensees meet expectations for the provision of measures to protect health, safety and the environment and with respect to Canada's international obligations. Although the Safety Factors and the SCAs are not the same, there are significant similarities. The D-PSR Global Issues are presented in this appendix in the context of the Safety and Control Areas to facilitate understanding of how the D-PSR results will support and enhance performance in each of the SCAs.

Table A-1 lists the SCAs in the first column and the Safety Factors in the column headings in the first row. A check mark in a cell indicates that the Safety Factor correlates partially or totally to the SCA. In many cases, several Safety Factors are related to a single SCA, and some Safety Factors are relevant to multiple SCAs. Shading in a row indicates that the SCA is not within the scope of the Periodic Safety Review.

The table indicates that the emphasis of a Periodic Safety Review is on reactor safety, including design, operating programs and performance, safety analysis, radiation protection and impact on the environment. Licensee programs that are not directly related to reactor safety, such as security, safeguards, etc., are subject to regulatory oversight outside of the Periodic Safety Review process.

This appendix states the purpose of each SCA, identifies the Safety Factors applicable to each SCA and summarizes the findings of D-PSR for each SCA. [Appendix C](#) provides a list of the Global Issues, Resolution Statements, and IIP Actions and identifies the associated SCA.

The CNSC publishes an annual regulatory oversight report, organized by SCA, which provides the CNSC's assessment of the nuclear power industry's safety performance. Each SCA discussion in this section includes the CNSC's rating of Darlington NGS's safety performance for that SCA from the reports of the last five years as an indicator of future safety performance. This is followed by a summary of D-PSR results indicating Darlington NGS's conformance with modern requirements and expectations, which has a direct bearing on continued operation.

The CNSC has assessed Darlington Nuclear Generating Station's overall performance as satisfactory or fully satisfactory over the last five years [R-10].



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## A.1 Management System

The Management System SCA covers the framework that establishes the processes and programs required to ensure an organization achieves its safety objectives, continuously monitors its performance against these objectives, and fosters a healthy safety culture.

D-PSR addressed specific aspects of the Management System SCA in the Use of Experience from Other Nuclear Power Plants and Research Findings, Organization, Management System, and Safety Culture, Procedures, and Human Factors Safety Factors. In addition to the review tasks associated with these Safety Factors, OPG programs and modern codes and standards related to the Management System subject area were assessed.

The assessment of the Organization, Management System, and Safety Culture Safety Factor states that the review has confirmed that the Darlington NGS organization, management system and safety culture are adequate and effective for ensuring safe operation of the plant.

The assessment of the Procedures Safety Factor states that the review has confirmed that the Darlington NGS processes for managing, implementing and adhering to operating procedures and for maintaining compliance with operational limits and requirements are adequate and effective and ensure plant safety.

Global Issues against the Safety Factors related to the Management SCA were identified however the Global Issues were either resolved, are being addressed by activities outside of D-PSR, will be resolved through Resolution Statements associated with another Global Issue, or have low safety significance, thus there are no Global Issues listed in [Appendix C](#) that are associated with the Management System SCA.

The CNSC has consistently assessed the Management System SCA as satisfactory over the last five years [R-10]. The positive results of D-PSR related to this SCA, including Strengths shown in [Appendix B](#),

- SF9-S1, Development and implementation of new OPEX database, and
- SF10-S1, Use of Nuclear Safety and Security Culture Monitoring Panel reviews,

indicate that this will apply for continued operation.

## A.2 Human Performance Management

The Human Performance Management SCA covers activities that enable effective human performance through the development and implementation of processes that ensure that licensees have sufficient staff in all relevant job areas with the necessary knowledge, skills, procedures and tools in place to safely carry out their duties.

D-PSR addressed specific aspects of human performance in the Organization, Management System, and Safety Culture, Procedures, and Human Factors Safety Factors.

The assessment of the Human Factors Safety Factor states that the review has confirmed, by assessment against the current licensing basis and applicable standards, requirements, and practices, that the design of Darlington and its documentation is adequate.

Global Issues against the Safety Factors related to the Human Performance Management SCA were identified however the Global Issues were either resolved, are being addressed by

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activities outside of D-PSR, will be resolved through Resolution Statements associated with another Global Issue, or have low safety significance and are addressed to the extent practicable, thus there are no Global Issues listed in [Appendix C](#) that are associated with the Human Performance Management SCA.

The CNSC has consistently assessed the Human Performance Management SCA as satisfactory over the last five years [R-10]. The positive results of D-PSR related to this SCA, including the Strength shown in [Appendix B](#),

- SF10-S1, Use of Nuclear Safety and Security Culture Monitoring Panel reviews, indicate that this will apply for continued operation.

### A.3 Operating Performance

The Operating Performance SCA includes an overall review of the conduct of the licensed activities and the activities that enable effective performance.

D-PSR addressed specific aspects of the Operating Performance SCA in the Safety Performance, Use of Experience from Other Plants and of Research Findings, Organization, Management System, and Safety Culture, and Procedures Safety Factors.

The assessment of the Safety Performance Safety Factor states that the review has confirmed, through an assessment of the safety performance of Darlington NGS (DNGS) and its trends from records of operating experience, that OPG is effectively monitoring and ensuring safe operation of the plant.

The assessment of the Use of Experience from Other Nuclear Power Plants and Research Findings Safety Factor states that the review has confirmed that the processes for feedback of experience from nuclear operations and research that are used to evaluate practicable safety improvements are acceptable.

Global Issues against the Safety Factors related to the Operating Performance SCA were identified however the Global Issues were either resolved, are being addressed by activities outside of D-PSR, will be resolved through Resolution Statements associated with another Global Issue, or have low safety significance and are addressed to the extent practicable, thus there are no Global Issues listed in [Appendix C](#) that are related to the Operating Performance SCA.

The CNSC has consistently assessed the Operating Performance SCA as satisfactory or fully satisfactory over the last five years [R-10]. The positive results of D-PSR related to this SCA, including Strengths shown in [Appendix B](#),

- SF9-S1, Development and implementation of new OPEX database, and
- SF10-S1, Use of Nuclear Safety and Security Culture Monitoring Panel reviews, indicate that this will apply for continued operation.

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## A.4 Safety Analysis

The Safety Analysis SCA pertains to maintaining the safety analysis that supports the overall safety case for the facility. Safety analysis is a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility and considers the effectiveness of preventive measures and strategies in reducing the effects of such hazards.

D-PSR addressed specific aspects of the Safety Analysis SCA in the Deterministic Safety Analysis, Probabilistic Safety Assessment, and Hazard Analysis Safety Factors.

The assessment in the Deterministic Safety Analysis Safety Factor Report states that the review has confirmed, by assessment against the current licensing basis and applicable standards, requirements and practices, that the design of Darlington NGS and its documentation is adequate.

The assessment in the Probabilistic Safety Assessment Safety Factor Report states that the PSA programs and procedures at OPG and implemented at Darlington NGS are comprehensive, resulting in a systematic and disciplined approach to identifying, prioritizing, and addressing any PSA related issues. The OPG PSA methodology and latest Darlington PSA study is compliant with the current licence requirements.

The assessment in the Hazard Analysis Safety Factor Report states that the review has confirmed, by assessment against the current licensing basis and applicable standards, requirements and practices, that the design of Darlington NGS and its documentation is adequate.

Global Issues against the Safety Factors related to the Safety Analysis SCA were identified however the Global Issues were either resolved, are being addressed by activities outside of D-PSR, will be resolved through Resolution Statements associated with another Global Issue, or have low safety significance and are addressed to the extent practicable, thus there are no Global Issues listed in [Appendix C](#) that are related to the Safety Analysis SCA.

The CNSC has consistently assessed the Safety Analysis SCA as satisfactory or fully satisfactory over the last five years [R-10]. The positive results of D-PSR related to this SCA, including the Strength shown in [Appendix B](#),

- SF6-1, Use of DARA study to identify potential plant design changes for risk reduction, indicate that this will apply for continued operation.

## A.5 Physical Design

The Physical Design SCA relates to activities that affect the ability of structures, systems and components to meet and maintain their design basis, given new information arising over time and taking changes in the external environment into account.

D-PSR addressed specific aspects of the Physical Design SCA in the review of Plant Design, Actual Condition of SSCs Important to Safety, Equipment Qualification, and Aging Safety Factors. The majority of review tasks for the Actual Condition of SSCs Important to Safety and Aging Safety Factors are relevant to the Fitness for Service SCA, so these aspects are discussed in Section A.6 below.

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The Plant Design Safety Factor Report states that the review has confirmed, by assessment against the current licensing basis and applicable standards, requirements and practices, that the design of Darlington NGS and its documentation are adequate.

The Equipment Qualification Safety Factor Report states that the review has confirmed that Darlington NGS has effective programs and procedures to ensure equipment important to safety is qualified to perform its designated safety function throughout its installed service life.

Global Issues against the Safety Factors related to the Physical Design SCA were identified however the Global Issues were either resolved, are being addressed by activities outside of D-PSR, will be resolved through Resolution Statements associated with another Global Issue, or have low safety significance and are addressed to the extent practicable, thus there are no Global Issues listed in [Appendix C](#) that are related to the Physical Design SCA.

The CNSC has consistently assessed the Physical Design SCA as satisfactory over the last five years [R-10]. The positive results of D-PSR related to this SCA, including Strengths shown in [Appendix B](#),

- SF1-S1, Installation of CFVS,
- SF2-S1, State-of-the-art reactor mock-up and rehearsal facilities at the Darlington Energy Centre,
- SF3-S1, Seismic Qualification program,
- SF3-S2, Environmental qualification of Group 1 and Group 2 systems, and
- SF4-S1, Performance of Chemistry Program,

indicate that this will apply for continued operation.

### A.6 Fitness for Service

The Fitness for Service SCA covers activities that affect the physical condition of structures, systems and components to ensure that they remain effective over time. This includes programs that ensure all equipment is available to perform its intended design function when called upon to do so.

D-PSR addressed specific aspects of the Fitness for Service SCA in the review of Actual Condition of SSCs Important to Safety, Equipment Qualification, and Aging Safety Factors. The conclusions of the review of the Equipment Qualification Safety Factor are provided in Section A.5 above. The results of the Safety Factor Reports on Actual Condition of SSCs Important to Safety and Aging are discussed under this SCA.

OPG manages the aging and obsolescence of SSCs through the Integrated Aging Management (IAM) Program. The IAM Program is consistent with best industry practices and ensures the safe long term operation of the station.

The IAM Program establishes an integrated set of activities that ensure:

- The long term health of SSCs,
- The high operational reliability of equipment, and
- The safety and operating margins are monitored and maintained.

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The condition of Major Components, consisting of Fuel Channels, Feeders, Steam Generators, and Reactor Components and Structures is managed by rigorous Life Cycle Management Plans (LCMPs) stipulated by the IAM Program.

The Safety Factor Report on Actual Condition of SSCs Important to Safety states that the review has confirmed the actual condition of SSCs important to safety is adequate for them to meet their design requirements.

The Aging Safety Factor Report states that the review has confirmed that aging at Darlington NGS is being effectively managed so that required safety functions are maintained, and an effective Aging Management Program is in place for future plant operation.

Five Global Issues related to the Fitness for Service SCA are listed in [Appendix C](#) and summarized as follows:

- GI-11: The Resolution Statements for GI-11 propose developing accepted methodologies to perform uncertainty analyses in probabilistic evaluations for pressure tubes and combine allowable failure frequencies from different degradation mechanisms.
- GI-12: The Resolution Statement for GI-12 proposes completing element selection of Balance of Plant (BOP) systems, additional assessments and program scope adjustments. It also proposes submitting a transition plan to the CNSC describing the strategy for program implementation and establishing regulatory commitments and internal actions once CNSC concurrence is obtained.
- GI-15: The Resolution Statements for GI-15 propose developing a transition plan for DNGS complying with mandatory and non-mandatory clauses of CSA N290.9-19 and developing a strategy to confirm compliance with the new requirements of CSA N290.9 Clause 4.2.6.
- GI-16: The Resolution Statement for GI-16 proposes implementing N-PROC-MA-0066 R006 for in-service examination of concrete containment to comply with CSA N287.7-17.
- GI-21: The Resolution Statement for GI-21 proposes completing scoping, screening, and condition assessments for unmapped components in D-PSR scope, performing inspections of the TRF structures per the PIP and revising the PIP to reflect additional knowledge obtained since the PIP was issued in 2014 to ensure that scope of inspection activities covers the full scope of structures in the various buildings addressed in this PIP.

The CNSC has consistently assessed the Fitness for Service SCA as satisfactory over the last five years [R-10]. The positive results of D-PSR related to this SCA, including Strengths shown in [Appendix B](#),

- SF2-S1, State-of-the-art reactor mock-up and rehearsal facilities at the Darlington Energy Centre,
- SF3-S1, Seismic Qualification program,
- SF3-S2, Environmental qualification of Group 1 and Group 2 systems, and
- SF4-S1, Performance of Chemistry Program,

and the enhancements to safety through resolution of the Global Issues, indicate that this will apply for continued operation.

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## A.7 Radiation Protection

The Radiation Protection SCA covers the implementation of a radiation protection program in accordance with the Radiation Protection Regulations. This program must ensure that contamination and radiation doses received are monitored and controlled and maintained ALARA.

D-PSR addressed specific aspects of the Radiation Protection SCA in the Plant Design, Safety Performance, Organization, Management, and Safety Culture, Procedures, Human Factors, Emergency Planning, and Radiation Protection Safety Factor Reports.

The Radiation Protection Safety Factor Report states that the review has confirmed that Radiation Protection has been adequately accounted for in the design and operation of DNGS, that Radiation Protection provisions (including design and equipment) provide adequate protection of person from the harmful effects of radiation, and ensure that contamination and radiation exposures and doses to persons are monitored and controlled, and maintained ALARA.

Global Issues against the Safety Factors related to the Radiation Protection SCA were identified however the Global Issues were either resolved, are being addressed by activities outside of D-PSR, will be resolved through Resolution Statements associated with another Global Issue, or have low safety significance and are addressed to the extent practicable, thus there are no Global Issues listed in [Appendix C](#) that are related to the Radiation Protection SCA.

The CNSC has consistently assessed the Radiation Protection SCA as satisfactory or fully satisfactory over the last five years [R-10]. The positive results of D-PSR related to this SCA, including Strengths shown in [Appendix B](#),

- SF10-S1, Use of Nuclear Safety and Security Culture Monitoring Panel reviews, and
- SF15-S1, Performance of ALARA Program,

indicate that this will apply for continued operation.

## A.8 Conventional Health and Safety

The Conventional Health and Safety SCA covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.

The Conventional Health and Safety SCA was addressed in the D-PSR review of the Organization, Management System, and Safety Culture, Procedures, and Human Factors Safety Factors.

The Organization, Management System, and Safety Culture Safety Factor Report confirmed that an adequate safety policy is in place to ensure safety takes precedence over production. Pre-Job Briefings and Safe Work Plans are performed and provide an opportunity for the briefer and the team performing the task to review and discuss safety hazards and steps to decrease or eliminate hazards.

The Human Factors Safety Factor Report confirmed that effective pre-job briefs assist in the safe and efficient planning preparation and execution of plant activities and include the identification of conventional safety hazards and effective defences against these risks such as work practices, procedures, oversight, event free tools and physical barriers.

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Global Issues against the Safety Factors related to the Conventional Health and Safety SCA were identified however the Global Issues were either resolved, are being addressed by activities outside of D-PSR, will be resolved through Resolution Statements associated with another Global Issue, or have low safety significance and are addressed to the extent practicable, thus there are no Global Issues listed in [Appendix C](#) that are related to the Conventional Health and Safety SCA.

The CNSC has consistently assessed the Conventional Health and Safety SCA as satisfactory over the last five years [R-10]. The positive results of D-PSR related to this SCA, including the Strength shown in [Appendix B](#),

- SF10-S1, Use of Nuclear Safety and Security Culture Monitoring Panel reviews, and indicate that this will apply for continued operation.

### A.9 Environmental Protection

The Environmental Protection SCA covers programs that identify, control and monitor all releases of radioactive and hazardous substances and effects on the environment from facilities or as the result of licensed activities.

The D-PSR review of the Safety Performance, Organization, Management, and Safety Culture, and Radiological Impact on the Environment Safety Factors confirmed that the Darlington NGS operating organization has an adequate program for the surveillance of the radiological and non-radiological impacts of the station on the environment.

The Radiological Impact on the Environment Safety Factor Report states that the review has confirmed that the design of Darlington NGS and its documentation is adequate as it relates to Safety Factor 14, with some gaps in effectiveness, against the requirements of LRCSs and related to an open regulatory action to be addressed.

Global Issues against the Safety Factors related to the Environmental Protection SCA were identified however the Global Issues were either resolved, are being addressed by activities outside of D-PSR, will be resolved through Resolution Statements associated with another Global Issue, or have low safety significance and are addressed to the extent practicable, thus there are no Global Issues listed in [Appendix C](#) that are related to the Environmental Protection SCA.

The CNSC has consistently assessed the Environmental Protection SCA as satisfactory over the last five years [R-10]. The positive results of D-PSR related to this SCA and the enhancements to safety through resolution of the open regulatory action indicate that this will apply for continued operation.

### A.10 Emergency Management and Fire Protection

The Emergency Management and Fire Protection SCA covers emergency plans and emergency preparedness programs that exist for emergencies and for non-routine conditions including any results of exercise participation.

The Emergency Management and Fire Protection SCA was addressed in the D-PSR review of the Hazard Analysis and Emergency Planning Safety Factors. The Emergency Planning Safety

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Factor Report includes the fire response assessment results while fire protection operations, design and analysis are discussed and rated in the appropriate SCA of operating performance, safety analysis or physical design.

The Emergency Planning Safety Factor Report states that the review has confirmed that Darlington NGS has effective plans, staff, facilities and equipment for dealing with emergencies and arrangements have been adequately coordinated with local and national system and are regularly exercised.

There is one Global Issue listed in [Appendix C](#) (GI-5) that originates from a Plant Design Safety Factor gap but relates to the Emergency Management and Fire Protection SCA. The Resolution Statement for GI-5 proposes evaluating the benefit of formally using NBCC 2015 for future construction or modifications related to fire protection, occupant safety, and accessibility and developing a strategy if judged beneficial.

The CNSC has consistently assessed the Emergency Management and Fire Protection SCA as satisfactory over the last five years [R-10]. The positive results of D-PSR related to this SCA, including Strengths shown in [Appendix B](#),

- SF13-S1, Provision of resilience training for accident management,
- SF13-S2, Management of the Equipment Important to Emergency Response program, and
- SF13-S3, Implementation of Phase 2 Emergency Mitigating Equipment,

and the enhancements to safety through resolution of the Global Issue, indicate that this will apply for continued operation.

## A.11 Waste Management

The Waste Management SCA covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility to a separate waste management facility. This also covers the planning for decommissioning.

The Waste Management SCA was addressed in the D-PSR review of the Safety Performance, Organization, Management, and Safety Culture and Radiological Impact on the Environment Safety Factors.

The Safety Performance Safety Factor Report identified that waste specific Nuclear Waste Management (NWM) governance is implemented for waste acceptance to ensure that all waste received and managed by NWM facilities is in accordance with the facility licensing basis and applicable standards. Records of the amount of low and intermediate-level radioactive solid waste generated are documented in quarterly reports and issued to the CNSC per REGDOC-3.1.1 requirements. Additionally, records of non-radioactive hazardous chemical waste shipments are sent to the Ontario Ministry of Environment, Conservation and Parks (MECP) and stored by DNGS for a minimum of 2 years as required by provincial regulation.

The Radiological Impact on the Environment Safety Factor Report identified that the waste classification process did not include instruction regarding management of supporting documentation or the requirement to perform an annual review of waste classifications performed at DNGS and the Management of Waste and Other Environmentally Regulated Materials standard did not indicate where the accountability lies, within OPG, for updating the

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Canadian Transport Emergency Centre (CANUTEC) registration each year. However, the necessary corrective actions were implemented to address these issues.

Global Issues against the Safety Factors related to the Waste Management SCA were identified however the Global Issues were either resolved, are being addressed by activities outside of D-PSR, will be resolved through Resolution Statements associated with another Global Issue, or have low safety significance and are addressed to the extent practicable, thus there are no Global Issues listed in [Appendix C](#) that are related to the Waste Management SCA.

The CNSC has consistently assessed the Waste Management SCA as satisfactory over the last five years [R-10].

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**Appendix B: Strengths Used in the Defence-in-Depth Assessment**

Strength ID	Strength Title and Description	Defence-in-Depth Level
SF1-S1	<p><b>Installation of a CFVS for BDBAs Mitigation</b></p> <p>The CFVS is an engineering filtered venting pathway designed specifically for BDBAs involving elevated containment pressures.</p> <p>The installation of CFVS represents a significant modification implemented after D-ISR which provides significant benefits in terms of minimizing on-site and off-site radiological doses during the BDBA response. This is because an underlying principle of the operating strategy is to maximize the time prior to placing CFVS into service in order to minimize on-site and off-site radiological doses.</p> <p>The CFVS operating strategy demonstrates that CFVS would not be required within 24 hours of the initiating event. This exceeds the requirements contained in Section 8.6.12 of CNSC REGDOC-2.5.2, "Design of Reactor Facilities: Nuclear Power Plants" and represents a D-PSR strength.</p>	4, 5
SF2-S1	<p><b>State-of-the-art Reactor Mock-up and Rehearsal Facilities</b></p> <p>The DEC building includes a new state-of-the-art training facility with a full-scale mock-up of the inside of a reactor, plus a tooling and testing facility to allow for the design and development of tools and processes needed for the refurbishment project. The DEC also houses multiple other mock-up models (e.g., end fitting arrays) and specialized tools being used during removal and replacement of pressure tubes, calandria tubes, the feeder pipes in the reactor. The ability to perform maintenance activity rehearsals on a full-scale facility mitigates the potential for in-reactor discovery issues, maintenance errors, and it facilitates planning for radiological dose minimization.</p> <p>This reactor mock-up and rehearsal facilities exceeds the objectives of Review Task #2 [of Safety Factor 2] and is first-of-kind maintenance facility for CANDU reactors. This is considered a D-PSR Strength for Darlington NGS.</p>	1, 2

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Strength ID	Strength Title and Description	Defence-in-Depth Level
SF3-S1	<p><b>Seismic Qualification program</b></p> <p>The seismic qualification program at OPG provides framework for activities related to the requirements for seismic design and qualification of DNGS in accordance with the CSA N289 series of standards. The LRCS reviews have demonstrated that DNGS is fully compliant with the modern editions of the standards and exceeds the seismic requirements in the design basis and the licensing basis which is the 2008 version of CSA N289.1. Further, the DNGS applies a lower frequency MDE for new modifications, which exceeds the amplitude used for the Design Basis Earthquake. The extent of seismic qualification at DNGS and the fact that Darlington is fully compliant with the modern editions of the CSA N289 series of standards, is a D-PSR strength.</p>	2, 3
SF3-S2	<p><b>EQ of Group 1 and Group 2 systems</b></p> <p>The EQ of DNGS Group 1 and Group 2 systems provides redundancy and diversity. The requirement for EQ of Group 1 and Group 2 system mitigating capability is unique to the DNGS design and licensing basis and exceeds modern requirements for the EQ of SSCs. This requirement has resulted in an extensive set of EQ'd systems. This qualification combined with the extent of activities relating to the preservation and maintenance of EQ result in EQ of being a D-PSR strength.</p>	2, 3
SF4-S1	<p><b>Performance of Chemistry Program</b></p> <p>OPG has consistently performed well and has continually raised internal targets to progress towards achieving nuclear excellence for Chemistry Control. The strong performance of CNSC CI and CCI for Chemistry Program for a number of years is identified as a D-PSR strength.</p>	1
SF6-S1	<p><b>Use of the PSA to Identify Potential Design Changes for Risk Reduction</b></p> <p>The risk assessment study was used to identify potential plant design changes (e.g., refurbishment related Safety Improvement Opportunities) that would lead to a decrease in the nuclear safety risk.</p>	1, 2, 3, 4

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Strength ID	Strength Title and Description	Defence-in-Depth Level
SF9-S1	<p><b>Development and Implementation of New OPEX Database</b></p> <p>OPG has recently developed and released a new OPEX database to facilitate the distribution of external OPEX from COG to departmental OPEX SPOCs, management of OPEX reviews, and documentation of initial assessments or dispositions from site departments. The OPEX database also provides a readily available repository of all previous external OPEX and site reviews/responses to new OPEX with searching capabilities. This database provides various dashboards to present OPEX related information at a glance. Several OPEX health metrics are also monitored and tracked through the OPEX database. The new database has improved functionality and user interface, reducing the potential for relevant OPEX to be missed or not effectively actioned upon.</p> <p>The development and implementation of the OPG OPEX database to readily capture/access OPEX related information in a single repository demonstrates an innovative use of advanced IT tools to facilitate improvements for OPEX management. With the identified efficiencies and notable improvements in the OPEX database, the OPEX database represents the use of industry best practices in the sending and receiving of OPEX from other nuclear power plants. This exceeds the requirements of the Review Task and is considered to be a D-PSR strength.</p>	1, 2, 3, 4
SF10-S1	<p><b>Nuclear Safety and Security Culture Monitoring Panel</b></p> <p>The NSSCMP reviews Nuclear Safety and Security Culture trends and potential issues that could impact Nuclear Safety and Security Culture health and ensure issues are appropriately addressed. The processes are aligned with the NSSCMP requirements outlined in Nuclear Energy Institute guidance for fostering a strong nuclear safety culture. The use of NSSCMPs is considered to be a D-PSR strength as it exceeds the requirements of CNSC REGDOC-2.1.2 and further promotes meaningful conversations and the spread of lessons learned amongst station leaders to ensure any emergent issues that could impact nuclear safety culture are addressed.</p>	1, 2, 3, 4

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Strength ID	Strength Title and Description	Defence-in-Depth Level
SF13-S1	<p><b>Resilience Training for Accident Management</b></p> <p>The OPG training element relating to resilience training for accident management is identified as a strength relating to Review Task #4 [of Safety Factor 13]. The purpose of this training is to facilitate improved decision-making capabilities of authorized staff and key roles in the ERO when faced with increased levels of stress that could be anticipated during Design Basis and Beyond Design Basis Accidents, including multi-unit accidents. This training has been provided to personnel with key roles in emergency response (i.e., Shift Manager, Emergency Response Director, and Emergency Response Manager). This resiliency training to emergency responders is beyond that required for regulatory and licensing requirements. This represents a D-PSR strength for the OPG Emergency Preparedness Program in responding and adapting successfully to extreme events. The provision of this training exceeds the objective of Review Task #4 and is considered to be a best practice.</p>	4
SF13-S2	<p><b>Management of EITER</b></p> <p>The OPG and Darlington programs relating to the management of EITER is a strength. With high levels of equipment reliability, this demonstrates that the management of EITER is effective within the Consolidated Nuclear Emergency Plan (CNEP) and is consistent with industry best-practices. Further, the management of the EITER program has been recognized as an industry strength. Therefore, this exceeds the objective of the Review Task in confirming the adequacy of on-site equipment for emergencies and is recognized as a D-PSR strength.</p>	3, 4
SF13-S3	<p><b>Implementation of Phase 2 EME</b></p> <p>The implementation of Phase 2 EME provides defence-in-depth for scenarios where efforts to recover EPS are unsuccessful; this is a strength relating to Review Task #10. The robustness of the EPGs and the EPS system as a whole has been demonstrated for Beyond Design Basis Events. This includes a combination of analysis activities (e.g., survivability assessments for RLCs associated with various external hazards) and design modifications (e.g., hardening EPS and installation of a third EPG qualified for RLC and Margin Design Earthquake). As a result, there is reasonable confidence that emergency response actions which attempt to restore EPS will be successful for a wide range of external events. In the event that actions to recover EPS are unsuccessful, Phase 2 EME is deployed as part of the longer-term emergency response. The defence-in-depth afforded by Phase 2 EME in terms of facilitating unit(s) stabilization and recovery exceeds requirements and is a D-PSR strength.</p>	4, 5

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Strength ID	Strength Title and Description	Defence-in-Depth Level
SF15-S1	<p><b>Performance of radiation exposures ALARA Program</b></p> <p>DNGS has been recognized by external organizations for the strength of its ALARA program performance and received the ISOE World Class ALARA Performance Award in 2008. In the 2019 Regulatory Oversight Report for Canadian Nuclear Power Plants, the CNSC concluded that DNGS exceeded expectations for the application of ALARA. DNGS ALARA performance is identified as a D-PSR strength.</p>	1, 2, 3, 4

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**Appendix C: Global Issue and IIP Actions Summaries**

Global Issue	Global Issue Title	Resolution Statements & IIP Actions	CNSC Safety & Control Area	Defence-in-Depth Level
GI-05	NBCC – National Building Code of Canada	<p><b>Resolution Statement:</b> Evaluate the benefit of formally using NBCC 2015 for future construction or modifications related to fire protection, occupant safety, and accessibility and, if judged beneficial, a strategy should be developed to ensure alignment with the requirements of NBCC 2015 Part 3.</p> <p><b>IIP Action:</b> Review, evaluate, and revise existing governance, as required, to include use of NBCC 2015 Part 3 for future construction or modifications related to fire protection, occupant safety, and accessibility.</p>	10 – Emergency Management and Fire Protection (A.10)	2, 3
GI-11	CSA N285.8 – Technical Requirements for In-Service Evaluation of Zirconium Alloy Pressure Tubes in CANDU Reactors	<p><b>Resolution Statement:</b> Develop and submit an implementation plan for developing inputs to satisfy the methodology in the Non-Mandatory Annex G of CSA N285.8-15 (Update No. 1) to perform uncertainty analyses in probabilistic evaluations where the threshold requirement is met per CSA N285.8.</p> <p><b>IIP Action:</b> Develop implementation plan for developing inputs to satisfy the methodology in the Non-Mandatory Annex G of CSA N285.8-15 (Update No. 1) for performing uncertainty analyses in probabilistic evaluations where the threshold is met and OPG to submit the implementation plan to the CNSC.</p> <p><b>Resolution Statement:</b> Develop and submit an implementation plan for developing inputs to satisfy the methodology for combining allowable failure frequencies from different degradation mechanisms per Clause 7.3.1.2 of CSA N285.8-15 (Update No. 1).</p> <p><b>IIP Action:</b> Revise/issue a compliance plan providing for the means by which OPG will comply with Clause 7.3.1.2 of CSA N285.8 (Update No.1). The approach to compliance with CSA Clause 7.3.1.2 will be provided for in OPG's CSA N285.8 compliance plan that addresses current and future actions pursuant to core assessment compliance with the latest revision of the CSA N285.8 standard.</p>	06 – Fitness for Service (A.6)	2, 3

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Global Issue	Global Issue Title	Resolution Statements & IIP Actions	CNSC Safety & Control Area	Defence-in-Depth Level
GI-12	CSA N285.7 Periodic Inspection Program	<p><b>Resolution Statement:</b> Complete final element selection of all pre-screened Balance of Plant (BOP) systems, additional assessments (where necessary) and program scope adjustments. Submit a transition plan to the CNSC describing the strategy for program implementation. Once CNSC concurrence is obtained with the transition plan, establish regulatory commitments and internal actions to track the following steps for program implementation:</p> <ol style="list-style-type: none"> <li>1. Preparation of program documentation such as PIP Plans, PIP Databases, PIP Schedules, and required governance.</li> <li>2. Preparation of new CSA N285.7 compliance inspection procedures and/or updates to existing inspection procedures to include CSA N285.7.</li> <li>3. Revision of affected OPG governance and other documents to include CSA N285.7 requirements where necessary.</li> <li>4. Receipt of necessary regulatory acceptance, approval, and concurrence of the final PIP and supporting documentation; and</li> <li>5. Commencement of periodic inspections.</li> </ol> <p>Once done, this will facilitate compliance with the CSA N285.7 standard.</p> <p><b>IIP Actions:</b></p> <ol style="list-style-type: none"> <li>1. Strategy and Support Department to provide the Nuclear Regulatory Affairs with CNSC package to submit OPG's transition plan identifying the compliance date and describing the plan and key transition dates for full implementation of the 2021 edition of CSA Standard N285.7 in Darlington NGS.</li> <li>2. OPG to submit transition plan to CNSC identifying the compliance date and describing the plan and key transition dates for full implementation of the 2021 edition of CSA Standard N285.7 in Darlington NGS.</li> </ol>	06 – Fitness for Service (A.6)	1, 2, 3

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GI-15	CSA N290.9 – Reliability and Maintenance Programs for Nuclear Power Plants	<p><b>Resolution Statement:</b> CSA N290.9-19 introduces new requirements for reliability and maintenance activities that are not explicitly reflected in relevant OPG governance. Develop a transition plan for DNGS complying with mandatory clauses of CSA N290.9-19. The transition plan will address the approach to be followed to demonstrate compliance with Clauses 4.1.1, 4.2.5, 6.3.3, 6.3.7, 6.3.9, 6.5.2, 6.5.4, 6.5.10, 6.5.11, and 8.5 of CSA N290.9-19.</p> <p><b>IIP Action:</b> Evaluate and incorporate new requirements for reliability and maintenance activities into OPG governance, as required, to demonstrate compliance with Clauses 4.1.1, 4.2.5, 6.3.3, 6.3.7, 6.3.9, 6.5.2, 6.5.4, 6.5.10, 6.5.11, and 8.5 of CSA N290.9-19.</p>	06 – Fitness for Service (A.6)	2, 3
		<p><b>Resolution Statement:</b> Develop a strategy to confirm compliance with the new requirements of CSA N290.9 Clause 4.2.6 for monitoring function reliability. Strategy to include implementation and governance update as required.</p> <p><b>IIP Actions:</b></p> <ol style="list-style-type: none"> <li>1. Develop a strategy to confirm compliance with the new requirements of Clause 4.2.6 of CSA N290.9 for monitoring function reliability.</li> <li>2. Evaluate and incorporate the requirements for reliability and maintenance activities into OPG governance, as required, to demonstrate compliance with Clause 4.2.6 of CSA N290.9.</li> </ol>	06 – Fitness for Service (A.6)	2, 3
		<p><b>Resolution Statement:</b> CSA N290.9-19 introduces new, non-mandatory requirements for reliability and maintenance activities that are not explicitly reflected in relevant OPG governance. Develop a transition plan for DNGS complying with non-mandatory clauses of CSA N290.9-19. The transition plan will address the approach that will be followed to demonstrate compliance with Clauses 5.4.5, 6.4.3, 6.4.6, and 6.5.13 of CSA N290.9-19, recognizing that the method of compliance with these clauses needs to consider whether the required activities are practical to implement.</p>	06 – Fitness for Service (A.6)	2, 3

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Global Issue	Global Issue Title	Resolution Statements & IIP Actions	CNSC Safety & Control Area	Defence-in-Depth Level
GI-16	Governance Issues	<p><b>IIP Action:</b> Evaluate and incorporate new non-mandatory requirements for reliability and maintenance activities into OPG governance, where the required activities are practical to implement, to demonstrate compliance with Clauses 5.4.5, 6.4.3, 6.4.6, and 6.5.13 of CSA N290.9-19.</p> <p><b>Resolution Statement:</b> Implement N-PROC-MA-0066 R006, and update implementing documentation as applicable, for in-service examination of concrete containment at Darlington to comply with CSA N287.7-17.</p> <p><b>IIP Actions:</b></p> <ol style="list-style-type: none"> <li>1. Review and update the Reactor Building, Containment and Vacuum Building PIPs for compliance with CSA N287.7-17.</li> <li>2. Review and update post tensioning inspections per CSA N287.7-17.</li> <li>3. Review and update leakage rate documents per CSA N287.7-17.</li> <li>4. OPG to submit transition documents to the CNSC.</li> </ol>	06 – Fitness for Service (A.6)	1, 2, 3
GI-21	Aging Management	<p><b>Resolution Statement:</b> Complete scoping, screening, and condition assessments for unmapped components in D-PSR scope.</p> <p><b>IIP Actions:</b></p> <ol style="list-style-type: none"> <li>1. Conduct a gap assessment to scoping and screening of the “unmapped” components to define new and revised commodity groups and determine which of them warrant detailed Condition Assessments.</li> <li>2. Perform condition assessments for the selected commodity groups of components which warrant detailed condition assessments as identified in the gap assessment.</li> </ol> <p><b>Resolution Statement:</b> Perform inspections of the TRF structures as per the TRF Structures PIP. Revise the TRF Structures PIP to reflect additional knowledge obtained since the PIP was issued in 2014 to ensure that the scope of inspection</p>	06 – Fitness for Service (A.6)	1, 2

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Global Issue	Global Issue Title	Resolution Statements & IIP Actions	CNSC Safety & Control Area	Defence-in-Depth Level
		<p>activities covers the full scope of structures in the various buildings addressed in this PIP.</p> <p><b>IIP Actions:</b></p> <ol style="list-style-type: none"> <li>1. Review, evaluate, and update the TRF Structures PIP to include additional inspection scope for all applicable TRF structures, as required.</li> <li>2. Perform inspection of the TRF structures.</li> </ol>		