ONTARIO POWER GENERATION

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OPG Proprietary

May 30, 2024

CD# NK38-CORR-00531-25450 P

Ms. C. Salmon
Commission Registrar
Canadian Nuclear Safety Commission
P.O. Box 1046
280 Slater Street
Ottawa, Ontario, K1P 5S9

Dear Ms. C. Salmon:

Darlington NGS – Application for Renewal of the Darlington Nuclear Generating Station Power Reactor Operating Licence 13.03/2025

The purpose of this letter is to submit to the Canadian Nuclear Safety Commission (CNSC) Ontario Power Generation Inc.'s (OPG) application for renewal of the Darlington Nuclear Generating Station (NGS) Power Reactor Operating Licence, PROL 13.03/2025, which expires on November 30, 2025.

OPG requests a 30-year licence renewal from December 1, 2025 to November 30, 2055.

OPG is an Ontario-based electricity generation company whose principal business is the generation and sale of electricity in Ontario. OPG head office is located at 700 University Avenue, Toronto, Ontario, M5G 1X6.

The management and control of operation of the Darlington NGS and the nuclear substances, prescribed equipment, and associated prescribed information, are the overall responsibility of Mr. Allan Grace, Senior Vice-President.

The Darlington NGS facility consists of four nuclear reactors designed, constructed and operated primarily to produce electrical power. Darlington NGS also includes the Tritium Removal Facility (TRF) housed within the Heavy Water Management Building. The TRF is designed, constructed, and operated to reduce the tritium levels in heavy water inventories.

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In 2016, Darlington commenced station refurbishment activities consisting of the replacement, upgrades and the rehabilitation of critical components, which will allow for safe and reliable station operation through 2055. The Refurbishment Project is more than two-thirds complete in its 10-year execution phase, realizing strong safety, quality and schedule performance. Units 2 and 3 were successfully refurbished and returned to service and are operating at full capacity. Units 1 and 4 refurbishments are continuing with a targeted returned to service in Q2 of 2025 (prior to licence renewal) and Q3 of 2026, respectively.

This licence renewal application has been prepared in accordance with the requirements of the *Nuclear Safety and Control Act* and the associated Regulations. This submission is also being made as per the requirements and guidance in Regulatory Document REGDOC-1.1.3, *Licence Application Guide: Licence to Operate a Nuclear Power Plant* and in accordance with the additional instructions provided by CNSC staff in Reference 1.

In Reference 1, CNSC staff also requested, for identified Canadian Standards Association (CSA) standards and CNSC REGDOCs, that OPG provide implementation plans or justification for the CSA standards or REGDOCs to be used as guidance in the Darlington Licence Conditions Handbook. OPG provided this information in Reference 2.

For ease of use, Attachment 1 provides a *"Licence Renewal Application Matrix – Applicable Regulations",* to assist CNSC staff in locating specific information within the application.

Attachment 2 provides the *"Darlington Nuclear Generating Station Power Reactor Operating Licence Renewal Application"* describing the 14 Safety and Control Areas, facility-specific information, additional matters of regulatory interest, OPG's programs, station performance during the current licence period and planned improvements.

The information provided within this licence application demonstrates that OPG is qualified to carry on the licensed activities to operate a Class I nuclear facility and makes adequate provisions to protect the health, safety and security of persons and the environment, and maintain national security and measures required to implement international obligations.

OPG is committed to the safe and reliable operation of the Darlington NGS and continues to meet the requirements of the *Nuclear Safety and Control Act* and the associated Regulations.

Should you require any further information, please contact Ms. Aditi Bhardwaj, Senior Manager, Darlington Regulatory Affairs, at 289-387-2110.

Sincerely,

Allan Grace
Senior Vice President
Darlington Nuclear
Ontario Power Generation Inc.

Attach.

cc: CNSC Site Supervisor – Darlington
A. Viktorov - Ottawa
A. Baig - Ottawa
forms-formulaires@cnsc-ccsn.gc.ca
registry-greffe@cnsc-ccsn.gc.ca

References:

1. CNSC Letter, A. Mathai to R. Geofroy, “Application Requirements for Renewal of the Darlington Nuclear Generating Station Power Reactor Operating Licence”, April 10, 2024, e-Doc# 7058965, CD# NK38-CORR-00531-24688.

2. OPG Letter, A. Grace to A. Mathai, “Response to CNSC Staff’s Request for Implementation Plans or Justification for Identified Documents to be Guidance in the Darlington Licence Conditions Handbook”, March 19, 2024, CD# NK38-CORR-00531-25234.

ATTACHMENT 1

OPG letter, A. Grace to C. Salmon, “Darlington NGS: Application for Renewal of the Darlington Nuclear Generating Station Power Reactor Operating Licence 13.03/2025”

CD# NK38-CORR-00531-25450 P

Licence Renewal Application Matrix – Application Regulations

(6 pages)

Attachment 1

Table 1: Licence Renewal Application Matrix – Applicable Regulations

NOTE: Unless otherwise specified, all sections cross-referenced below refer to Attachment 2.

Section	Regulatory Requirement	Location in Submission
General Nuclear Safety and Control Regulations		
LICENCES - General Application Requirements		
3 (1)	An application for a licence shall contain the following information: (a) the applicant's name and business address;	Cover letter
	(b) the activity to be licensed and its purpose;	Appendix C
	(c) the name, maximum quantity and form of any nuclear substance to be encompassed by the licence;	Appendix C
	(d) a description of any nuclear facility, prescribed equipment or prescribed information to be encompassed by the licence;	Section 1.1
	(e) the proposed measures to ensure compliance with the *Radiation Protection Regulations*, the *Nuclear Security Regulations* and the *Packaging and Transport of Nuclear Substances Regulations, 2015*	Sections 2.7, 2.12 and 2.14
	(f) any proposed action level for the purpose of section 6 of the *Radiation Protection Regulations*;	Sections 2.7 and 2.9
	(g) the proposed measures to control access to the site of the activity to be licensed and the nuclear substance, prescribed equipment or prescribed information;	Section 2.12
	(h) the proposed measures to prevent loss or illegal use, possession or removal of the nuclear substance, prescribed equipment or prescribed information;	Sections 2.12 and 2.13
	(i) a description and the results of any test, analysis or calculation performed to substantiate the information included in the application;	Section 1.1 and 2.4
	(j) the name, quantity, form, origin and volume of any radioactive waste or hazardous waste that may result from the activity to be licensed, including waste that may be stored, managed, processed or disposed of at the site of the activity to be licensed, and the proposed method for managing and disposing of that waste;	Section 2.11, Appendix C and Appendix D
	(k) the applicant's organizational management structure insofar as it may bear on the applicant's compliance with the Act and the	Section 2.1

Section	Regulatory Requirement	Location in Submission
	regulations made under the Act, including the internal allocation of functions, responsibilities and authority;	
	(l) a description of any proposed financial guarantee relating to the activity to be licensed; and	Section 4.3
	(m) any other information required by the Act or the regulations made under the Act for the activity to be licensed and the nuclear substance, nuclear facility, prescribed equipment or prescribed information to be encompassed by the licence.	Throughout
3 (1.1)	The Commission or a designated officer authorized under paragraph 37(2)(c) of the Act, may require any other information that is necessary to enable the Commission or the designated officer to determine whether the applicant (a) is qualified to carry on the activity to be licensed; or	See Table 2 in this Attachment 1.
	(b) will, in carrying on that activity, make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed.	Sections 2.7, 2.8, 2.9, 2.10, 2.12, 2.13
LICENCES – Application for Renewal of Licence		
5	An application for the renewal of a licence shall contain (a) the information required to be contained in an application for that licence by the applicable regulations made under the Act; and	Throughout
	(b) a statement identifying the changes in the information that was previously submitted.	Throughout
OBLIGATIONS – Representatives of Applicants and Licensees		
15	Every applicant for a licence and every licensee shall notify the Commission of (a) the persons who have authority to act for them in their dealings with the Commission;	OPG Letter “OPG – Persons Authorized to Act on Behalf of OPG in Dealings with the CNSC and Senior Leadership Positions with Responsibility for Safety”, March 25, 2024, N-CORR-00631-23968.
	(b) the names and position titles of the persons who are responsible for the management and control of the licensed activity and the nuclear substance, nuclear facility, prescribed	Cover letter; also OPG Letter “OPG – Persons Authorized to Act

Section	Regulatory Requirement	Location in Submission
	equipment, or prescribed information encompassed by the licence; and	on Behalf of OPG in Dealings with the CNSC and Senior Leadership Positions with Responsibility for Safety", March 25, 2024, N-CORR-00631-23968.
	(c) any change in the information referred to in paragraphs (a) and (b), within 15 days after the change occurs.	OPG will continue to provide the required information.
Class I Nuclear Facilities Regulations		
LICENCE APPLICATIONS – General Requirements		
3	An application for a licence in respect of a Class I nuclear facility, other than a licence to abandon, shall contain the following information in addition to the information required by section 3 of the *General Nuclear Safety and Control Regulations*: (a) a description of the site of the activity to be licensed, including the location of any exclusion zone and any structures within that zone;	Section 1.1
	(b) plans showing the location, perimeter, areas, structures and systems of the nuclear facility;	Section 1.1
	(c) evidence that the applicant is the owner of the site or has authority from the owner of the site to carry on the activity to be licensed;	Section 1.1
	(d) the proposed management system for the activity to be licensed, including measures to promote and support safety culture;	Section 2.1
	(d.1) the proposed human performance program for the activity to be licensed, including measures to ensure workers' fitness for duty.	Section 2.2
	(e) The name, form, characteristics and quantity of any hazardous substances that may be on the site while the activity to be licensed is carried on;	Appendix D
	(f) the proposed worker health and safety policies and procedures;	Section 2.8
	(g) the proposed environmental protection policies and procedures;	Section 2.9
	(h) the proposed effluent and environmental monitoring programs;	Section 2.9
	(i) if the application is in respect of a nuclear facility referred to in a paragraph 2(b) of the Nuclear Security Regulations, the information required by section 3 of those Regulations;	Section 2.12
	(j) the proposed program to inform persons living in the vicinity of the site of the general nature and characteristics of the anticipated effects	Section 4.4

Section	Regulatory Requirement	Location in Submission
	on the environment and the health and safety of persons that may result from the activity to be licensed; and	
	(k) the proposed plan for the decommissioning of the nuclear facility or of the site.	Section 2.11
LICENCE APPLICATIONS – Licence to Operate		
6	An application for a licence to operate a Class I nuclear facility shall contain the following information in addition to the information required by section 3: (a) a description of the structures at the nuclear facility, including their design and their design operating conditions;	Sections 1.1 and 2.5
	(b) a description of the systems and equipment at the nuclear facility, including their design and their design operating conditions;	Section 2.5
	(c) a final safety analysis report demonstrating the adequacy of the design of the nuclear facility;	Section 2.4
	(d) the proposed measures, policies, methods and procedures for operating and maintaining the nuclear facility;	Sections 2.3, 2.6
	(e) the proposed procedures for handling, storing, loading and transporting nuclear substances and hazardous substances;	Sections 2.5, 2.6, 2.11, 2.14
	(f) the proposed measures to facilitate Canada's compliance with any applicable safeguards agreement;	Section 2.13
	(g) the proposed commissioning program for the systems and equipment that will be used at the nuclear facility;	Section 3.2
	(h) the effects on the environment and the health and safety of persons that may result from the operation and decommissioning of the nuclear facility, and the measures that will be taken to prevent or mitigate those effects;	Sections 2.7, 2.8, 2.9, 2.11
	(i) the proposed location of points of release, the proposed maximum quantities and concentrations, and the anticipated volume and flow rate of releases of nuclear substances and hazardous substances into the environment, including their physical, chemical and radiological characteristics;	Section 2.9
	(j) the proposed measures to control releases of nuclear substances and hazardous substances into the environment;	Section 2.9
	(k) the proposed measures to prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances on the	Section 2.10

Section	Regulatory Requirement	Location in Submission
	environment, the health and safety of persons and the maintenance of national security, including measures to (i) assist off-site authorities in planning and preparing to limit the effects of an accidental release, (ii) notify off-site authorities of an accidental release or the imminence of an accidental release, (iii) report information to off-site authorities during and after an accidental release, (iv) assist off-site authorities in dealing with the effects of an accidental release, and (v) test the implementation of the measures to prevent or mitigate the effects of an accidental release;	
	(l) the proposed measures to prevent acts of sabotage or attempted sabotage at the nuclear facility, including measures to alert the licensee to such acts;	Section 2.12
	(m) the proposed responsibilities of and qualification requirements and training program for workers, including the procedures for the requalification of workers; and	Section 2.2
	(n) the results that have been achieved in implementing the program for recruiting, training and qualifying workers in respect of the operation and maintenance of the nuclear facility.	Section 2.2
Nuclear Security Regulations		
LICENCE APPLICATION – Licence in Respect of Category I or II Nuclear Material or a Nuclear Facility		
3	An application for a licence in respect of Category I or II nuclear material, other than a licence to transport, and an application for a licence in respect of a nuclear facility referred to in paragraph 2(b) shall contain the following information in addition to the information required by section 3 of the *Nuclear Substances and Radiation Devices Regulations* or sections 3 to 8 of the *Class I Nuclear Facilities Regulations*, as applicable: (a) a copy of the arrangements referred to in section 35;	Section 2.12
	(b) the site plan referred to in section 16;	Sections 1.1 and 2.5
	(c) a description of the proposed security equipment, systems and procedures;	Section 2.12

Section	Regulatory Requirement	Location in Submission
	(d) a description of the proposed on-site and off-site communications equipment, systems and procedures;	Section 2.12
	(e) a description of the proposed structure and organization of the nuclear security officer service, including the duties, responsibilities and training of nuclear security officers;	Section 2.12
	(f) the proposed plan and procedures to assess and respond to breaches of security; and	Section 2.12
	(g) the current threat and risk assessment.	Section 2.12

Table 2: Licence Application Matrix – Additional Matters of Regulatory Interested Identified by CNSC

No.	Item	Location in Submission
1	Environmental assessment	Section 2.9 and 4.1
2	Indigenous engagement	Section 4.2
3	Cost recovery	Section 4.3
4	Financial guarantees	Section 4.3
5	Improvement plans and significant future activities	Section 1.5
6	Licensee public information program	Section 4.4
7	Nuclear Liability insurance	Section 4.3

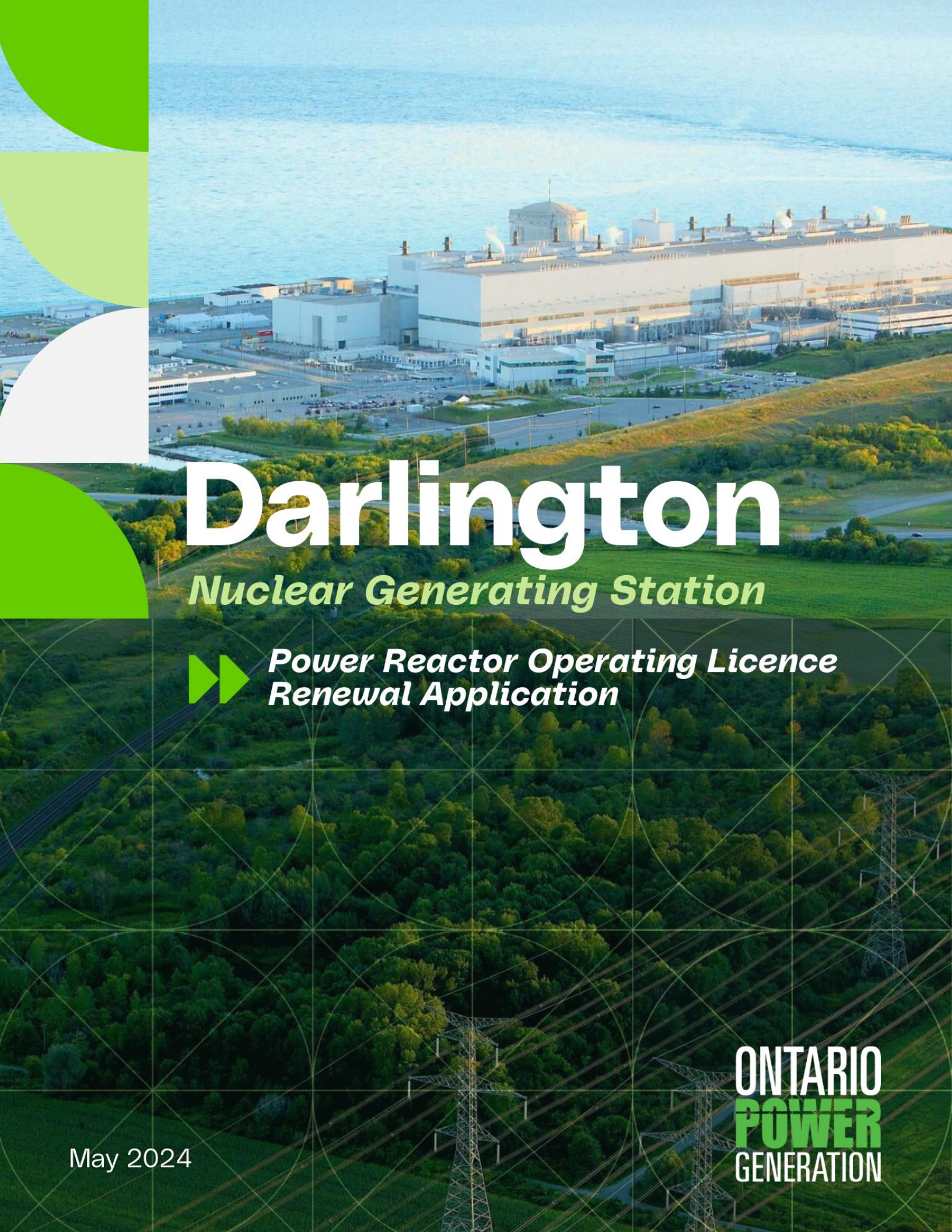
ATTACHMENT 2

OPG letter, A. Grace to C. Salmon, “Darlington NGS: Application for Renewal of the Darlington Nuclear Generating Station Power Reactor Operating Licence 13.03/2025”

CD# NK38-CORR-00531-25450 P

Darlington Nuclear Generating Station Power Reactor Operating Licence Renewal Application

(320 pages)



Darlington

Nuclear Generating Station

Power Reactor Operating Licence Renewal Application

May 2024

ONTARIO POWER GENERATION

Land Acknowledgement

The lands and waters on which the Darlington Nuclear Generating Station (NGS) is situated are the treaty and traditional territory of the Michi Saagiig and Chippewa Nations, collectively known as the Williams Treaties First Nations.

Darlington NGS is within the territory of the Gunshot Treaty and the Williams Treaties of 1923. These Treaty Rights were reaffirmed in 2018 in a settlement with Canada and the Province of Ontario.

Ontario Power Generation Inc. (OPG) respectfully acknowledges that the Williams Treaties First Nations are the Rights holders, stewards, and caretakers of these lands and the waters that touch them, and that they continue to ensure their health and integrity for generations to come.

As a company, OPG remains committed to developing positive and mutually beneficial relationships with the Williams Treaties First Nations.

Executive Summary

Ontario Power Generation Inc. (OPG) requests authorization from the Canadian Nuclear Safety Commission (CNSC) for renewal of the Darlington Nuclear Generating Station (NGS) Power Reactor Operating Licence (PROL) 13.03/2025 for a 30-year licence term from December 1, 2025 to November 30, 2055.

This application demonstrates that OPG will continue to safely operate the Darlington NGS while meeting the requirements of the *Nuclear Safety and Control Act* (NSCA) and associated Regulations. OPG will continue its licensed activities and make adequate provisions to protect the health, safety and security of persons and the environment, and maintain national security and measures required to implement international obligations.

Darlington NGS is a top quartile performing nuclear power plant, with more than three decades of experience operating experience. OPG has a strong reputation for safe and reliable operations and has earned community support and trust in the communities in which we operate. The requested 30-year licence timeline coincides with station operational objectives achieved through our refurbishment of the Darlington NGS units.

OPG values the relationships it has built with Indigenous Nations and communities, our stakeholders and members of the public, and is committed to continued collaboration and engagement regarding ongoing operations to support a cleaner environment while meeting the electricity needs of the province of Ontario.

To ensure Indigenous Nations and communities, stakeholders and members of the public have opportunities to engage with the Commission regarding Darlington NGS operations over a 30-year licence term, OPG welcomes opportunities to address both in-person (oral) and written interventions at any future Commission proceeding concerning Darlington NGS, such as Regulatory Oversight Report (ROR) reviews and licence amendment requests.

Safety and Control Areas

This licence renewal application provides the information required to demonstrate that OPG meets or exceeds the applicable requirements of the NSCA and the associated Regulations.

The application is structured in accordance with the CNSC Safety and Control Areas (SCAs). To ensure that licensees in Canada meet all of their regulatory requirements and expectations, the CNSC assess how well licensees are complying with these requirements. The CNSC base their evaluations on 14 SCAs, broadly sorted into three functional areas: Management, Facility and Equipment, and Core Controls and Processes.

This application highlights strengths and achievements in each SCA and updates information since the last licence application, including improvements made or planned, to support operation through the end of the requested licence term.

Darlington Refurbishment

The Darlington NGS Refurbishment Project is one of Canada's largest clean energy infrastructure projects consisting of the replacement of life-limiting critical components, the completion of upgrades to meet applicable regulatory requirements, and the rehabilitation of components. This project allows for safe and reliable plant operation through 2055.

In the final quarter of 2023, several major milestones of the Refurbishment Project were completed, including Unit 1 reactor reassembly and the continuation of Unit 4 refurbishment execution including the beginning of reactor disassembly – the final unit at Darlington NGS to do so. The full Darlington NGS Refurbishment Project is more than two-thirds complete in its 10-year execution phase, realizing strong safety, quality and schedule performance. Darlington NGS Units 2 and 3, each successfully refurbished and previously returned to service in June 2020 and July 2023 respectively; are operating at full capacity.

The refurbishment of Units 1 and 4 are forecasted to be returned to service in Q2 of 2025 (prior to licence renewal) and Q3 of 2026 respectively.

Tritium Removal Facility

The Darlington NGS Tritium Removal Facility (TRF) supports maintaining low tritium levels at all Ontario Canada Deuterium Uranium reactors. The TRF has removed over 157 million Curies (5.8e+18 Bq) of reactor heavy water tritium from these facilities since 2015.

Reliability improvements and life cycle management activities will be incorporated into each of a number of planned TRF outages to ensure the facility will support operation of the Darlington NGS through the next 30 years.

Station Safety and Reliability

During the current licence term, Darlington NGS continued to demonstrate strong safety performance. OPG has received the Electricity Canada President's Award of Excellence for Employee Safety – Generation, 9 times in the last 10 years. The award recognizes OPG's achievement of being in the top quartile for both total recordable injury frequency and lost time injury severity rates.

Station reliability has remained strong due to investments and improvements made over the current licensing period. Significant improvements were achieved in Fuel Handling Reliability, Work Protection and Equipment Reliability.

Some accomplishments that contributed to safety and reliability since 2015 include the implementation of new emergency mitigating equipment and connection points, a containment filtered venting system, two auxiliary shutdown cooling pump installations, establishment of the monitoring & diagnostics centre as well as installation of a third Emergency Power Generator (EPG) and replacement of the existing two EPGs.

Through ongoing investments, innovations and the efforts of our employees, Darlington NGS is exhibiting strong safety and operational performance. This track record is a testament to the diligence and passion for excellence that all personnel are committed to on a daily basis in support of the safe and reliable operation of the station. Every day we demonstrate safety through our operations. This is supported by on site CNSC personnel who ensure that we meet

rigorous requirements and standards. Public and environmental safety is more than a top priority; it is part of who we are.

Darlington NGS continues to operate safely as evidenced by CNSC assessments of findings from compliance verification activities in each of the 14 CNSC SCAs. These ongoing assessments support the fact that Darlington NGS made adequate provisions for the protection of the health, safety and security of persons and the environment during this licensing period.

Periodic Safety Review

In support of continued long-term operation, and as required by the current Darlington NGS licence, a Periodic Safety Review (PSR) was completed to confirm the design, condition and operation of the Darlington NGS supports continuing commercial operation from 2025 to 2035.

Per the PSR process, OPG submitted a PSR basis document, safety factor reports, a global assessment report and an Integrated Implementation Plan (IIP) for the implementation of safety enhancements. The Darlington NGS PSR-IIP required by the current licence and to support this licence renewal, was accepted by the CNSC in Q1 2024.

During the proposed 30-year licence term, OPG will perform PSR and associated IIP updates at an approximate 10-year frequency.

Isotopes

OPG plans to utilize Darlington NGS reactors to support the commercial production of medical and industrial isotopes, such as Cobalt-60 (Co-60), Molybdenum-99 (Mo-99) and Yttrium-90 (Y-90).

OPG has been producing Co-60, a critical isotope used in medical device sterilization and in food production, at Pickering NGS for decades. Pending regulatory approvals, OPG is planning to expand its Co-60 production capability using all four Darlington NGS units, easing the current shortages of Co-60 in the global market.

OPG and its strategic partners, are planning to harvest Mo-99, using a first-of-a-kind Target Delivery System (TDS), in Darlington NGS Unit 2. This TDS system allows for target capsules to be inserted into the reactor core for irradiation to safely produce medical isotopes. These isotopes are used in more than 40 million medical procedures each year, helping to detect illnesses like cancer and heart disease.

Additionally, pending regulatory approvals, the TDS on Darlington NGS Unit 2 will be used to irradiate Yttrium-89 (Y-89) target capsules to produce Y-90, a widely used medical isotope around the world in non-invasive treatments to destroy cancer cells and shrink tumours.

With advancements in medical and industrial sectors, OPG is investing in innovative technologies to expand isotope production capabilities into valuable resources that benefit our society.

Equity Diversity & Inclusion

OPG prides itself in being a leader. Whether it be in safety, operations, project execution, or innovation, OPG strives to be anything but average on its journey to a net-zero future.

Being a leader starts with building a diverse and inclusive workforce, one that is reflective of the people of Ontario. To this end, in 2021, OPG launched a 10-year Equity, Diversity, and Inclusion (ED&I) strategy to guide the journey towards ED&I excellence. The ED&I strategy is organized into focus areas that will drive the strategy, attract, retain, and connect with workers and listen to and serve the community. Numerous initiatives and strategies have been identified across the company that will help advance the priorities of the focus areas. A few recent examples include:

- Completion of employment systems review of policies, practices and employee experiences to identify systemic barriers to equity.
- Giving leaders metrics and tools for more equitable succession planning.
- Identification and support of education programs (e.g. Skills Ontario, First Robotics).

Through our ED&I strategy, OPG is committed to becoming a global ED&I best practice leader by 2030.

In March 2023, OPG was named one of Canada's Best Diversity Employers. Half of OPG's executive leadership is comprised of individuals belonging to designated groups, including women and racialized people.

Climate Change

OPG is driving to be a net-zero company by 2040, and to act as a catalyst for a net-zero carbon economy by 2050.

In 2020, OPG released its first-ever climate change plan. The four-phase action plan contains ambitious goals that guide the promise to be a catalyst for efficient, economy-wide decarbonization and economic renewal, while protecting the environment. The plan commits to:

- Add clean power.
- Continue to invest in all generating asset-based climate vulnerabilities.
- Innovate through new technology investments such as Small Modular Reactors (SMRs).
- Continue to lead decarbonization in Ontario and share expertise.

Nuclear power is essential in attaining greenhouse gas emission reduction targets. Having analyzed the electricity and energy needs of Ontario, the Independent Electricity System Operator has concluded that a mix of technologies, including nuclear, will be needed in Ontario.

The Darlington NGS plays a significant role in our climate change plans via the Refurbishment Project, currently underway, and the investment in the plan for new SMRs at the Darlington NGS site.

Indigenous Engagement

OPG acknowledges the Aboriginal and/or Treaty rights of Indigenous Nations and communities as recognized in the Constitution Act, 1982 and regularly undertakes engagement with Indigenous Nations and communities with established Aboriginal and/or Treaty rights proximate to the site. OPG also engages with Indigenous Nations and communities that express interest in its sites and operations.

OPG is committed to engaging with Indigenous Nations and communities regarding nuclear operations. OPG recognises that meaningful engagement begins with relationship-building, the establishment of trust and is committed to respect, openness and transparency in building these relationships. In the context of this specific application, OPG is committed to building an engagement plan with Indigenous Nations and communities to increase collaboration and deepen engagement with respect to the Darlington NGS. OPG's intent is to develop a framework for both the licence renewal application process as well as ongoing engagement after a licensing decision is made. OPG is steadfast in its commitment to supporting meaningful engagement during and after the licencing application process, and will work in collaboration with Indigenous Nations and communities to build the engagement plans.

OPG's Indigenous Relations Policy provides a framework for engaging with Indigenous peoples and providing support for community programs and initiatives while respecting Aboriginal and/or Treaty rights which are recognized and affirmed under s. 35 of Constitution Act, 1982. Some initiatives include:

- OPG has established several Framework Agreements with Indigenous Nations and communities to support regular engagement.
- Invitations provided to several Indigenous Nations and communities to engage on this licence renewal application.
- Ongoing meetings with Indigenous Nations and communities to discuss station operations and performance and other priority topics from the communities.
- All the local Indigenous Nations and communities are invited to participate in the Canadian Centre for Nuclear Sustainability and its Indigenous Advisory Council.
- Creation and participation in the Indigenous Opportunities Network, an OPG community-centred program aimed to increase the representation of Indigenous workers at OPG and within the broader energy sector.

OPG is committed to taking concrete and measurable actions to advance reconciliation with Indigenous peoples and to regularly report on the company's activities and progress in achieving established goals. In the fall of 2021, OPG launched its Reconciliation Action Plan (RAP). The RAP is a public document that serves as a roadmap to reconciliation and the 2021 edition included many specific actions and commitments with clear deliverables and timelines spanning between 2022 and 2031.

An annual RAP report was published in the fall of 2022 noting that the first-year goals were achieved. The RAP will be updated in Q2 2024 and will include reporting of 2023 results along with many new commitments developed through internal discussions and input from Indigenous Nations, communities, and businesses.

OPG's employees remain committed to advancing our Reconciliation journey. We will continue to listen, learn, and build momentum to meet our ambitious goals.

Public Engagement and Communications

OPG values the relationships it has with local communities, the public and all of its stakeholders. OPG fosters open and ongoing communications through a comprehensive public outreach program (Public Information and Disclosure Protocol).

The program ensures public communications are informative, timely and accurate; and material information is disclosed in accordance with applicable legal and regulatory requirements. Information is communicated in a number of ways based on audience identification, their interests, perception of risk; and their preferred means of communication. This ensures clear understanding of nuclear operations, activities and projects to allow the public to make informed objective decisions through readily accessible information, open dialogue and opportunities to have concerns addressed.

OPG's relationship with the local community remains strong due to ongoing open engagement and sustainable partnerships with Indigenous Nations and communities, and community stakeholders. Community stakeholders include, government, media, business leaders, educational institutions, interest groups, and community organizations.

Conclusion

In summary, this licence renewal application contains sufficient information to demonstrate that OPG meets all the requirements of the NSCA and associated Regulations and demonstrates that OPG:

- Is qualified to carry on the activities to be licensed; and,
- Will, in carrying on that activity, make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed.

OPG has demonstrated strong safety and reliability performance at the Darlington NGS during the current licence term resulting in many significant achievements. With the improvements and future activities planned as outlined in this application, OPG is confident the Darlington NGS can continue to operate safely and reliably through 2055.

OPG is committed in their support of continued, meaningful dialogue with Indigenous Nations and communities and members of the public, during the requested licence term to ensure concerns are addressed.

OPG therefore requests the CNSC to authorize the renewal of the Darlington NGS PROL for a 30-year term from December 1, 2025 to November 30, 2055.

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1.0 Darlington NGS Licence Renewal – Introduction

Ontario Power Generation Inc. (OPG) is responsible for approximately half of the electricity generation in the province of Ontario and operates two nuclear generating stations in the province. Darlington Nuclear Generating Station (NGS) is a four-unit facility responsible for generating over 20 percent of Ontario's electricity needs, which is enough energy to power two million homes. Darlington NGS also includes the Tritium Removal Facility (TRF), which reduces the tritium levels in heavy water inventories.

OPG is applying to the Canadian Nuclear Safety Commission (CNSC) for renewal of the Darlington NGS Power Reactor Operating Licence (PROL) 13.03/2025 which expires on November 30, 2025. OPG is requesting a 30-year licence term of the Darlington NGS PROL from December 1, 2025 to November 30, 2055. This licence renewal application has been prepared in accordance with the requirements of the *Nuclear Safety and Control Act* (NSCA) and its associated Regulations. The application has also applied the requirements and guidance contained in CNSC regulatory document REGDOC-1.1.3, *Licence Application Guide: Licence to Operate a Nuclear Power Plant*. OPG will continue to carry on the licensed activities and make adequate provisions to protect the health, safety and security of persons and the environment, and maintain national security and measures required to implement international obligations.

Since its start of commercial operation in 1990, Darlington NGS has proven to be a safe, reliable and important source of energy for the province of Ontario while meeting the constant and growing energy needs. The dedicated team of professionals who operate and maintain the station have consistently demonstrated their commitment to safety and excellent performance.

Our reactors do more than generate electricity. Darlington NGS reactors are utilized to support the radioisotope industry in both the medical and food safety fields. The predictable and reliable nature of our reactors enables dependable supply chains for isotope markets and provides opportunity to expand offerings to new isotope markets. OPG's request for a 30-year licence term is based on the following:

- **Experience:** OPG has more than five decades of experience operating nuclear generating stations safely and reliably. OPG's team of nuclear professionals have been operating Darlington NGS safely and reliably since 1990.
- **Proven Technology:** The Canada Deuterium Uranium (CANDU) reactor is a robust technology with multiple safety features, including redundant systems and passive safety mechanisms. CANDU reactors have a strong track record of reliability, with many units operating safely and consistently for decades.
- **Operational and Project Excellence:** Darlington NGS undergoes an international World Association of Nuclear Operators (WANO) peer review every two years and is recognized as a top-performing nuclear power plants in the world. Darlington NGS continues to be seen as operating to the highest levels of operational safety and reliability. In 2016, after years of detailed planning and preparation, OPG's team of project partners, industry experts, energy professionals, and skilled tradespeople successfully commenced refurbishment of the first of four Darlington NGS reactors. The Darlington NGS refurbishment of the units, through major component replacements, inspection, and modifications to improve the plant, will enable OPG to continue safe and reliable operation through a 30-year licence term. The refurbishment of Units 2 and 3 is

complete, and Units 1 and 4 are currently in progress with completion expected by the end of 2026.

- **Accepted Industry Practice:** The concept of a 30+ year licence is common in the international community. Several nuclear power generating stations around the world have 30+ years to indefinite licence terms.
- **Periodic Safety Review:** A Periodic Safety Review (PSR) is a systematic and comprehensive review performed by licensees at approximately 10-year intervals of the design, condition and operation of the facility against modern codes and standards. PSRs are conducted in accordance with REGDOC-2.3.3, *Periodic Safety Reviews* and typically require 2 to 3 years to complete. The PSR results are used to determine reasonable and practical improvements and enhancements to ensure continued safe operation until the next PSR. The identified safety improvements and schedule for their completion are documented in an Integrated Implementation Plan (IIP) and submitted to the CNSC for acceptance.
- **Regulatory Oversight:** The CNSC's continuous oversight of compliance and safety performance at Darlington NGS is independent of licence length and includes provisions such as:
    - **Reporting:** REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* requires licensees to submit quarterly and annual reports on various subjects and provides requirements related to the submission of other important reports (such as updates to the safety analysis report and proposed decommissioning plan), that are reviewed by the CNSC. Under REGDOC-3.1.1, licensees are also required to report any unplanned situations and events to the CNSC.
    - **Compliance Verification:** The CNSC conducts regular inspections and evaluations to verify licensees are complying with the licensing basis and other conditions as specified within the station's operating licence. Inspections are carried out by permanent onsite CNSC Inspectors with assistance from CNSC Head Office staff. Compliance verification activities enable the CNSC to provide assurances of the continuing compliance and safety performance of licensees.
    - **Enforcement:** The CNSC uses a graduated approach to enforcement to encourage compliance. When a non-compliance is identified, the CNSC determines the appropriate enforcement action based on the safety significance and other factors, such as whether the non-compliance is systemic or repeated. Enforcement tools range from informal discussions to orders under the NSCA, administrative monetary penalties and legal prosecution. In addition, the CNSC Commission under Section 25 of the NSCA, irrespective of the duration of a licence, can amend, suspend in whole or in part, or revoke a licence at any time, on its own initiative.
    - **Regular Assessment of Compliance and Performance:** the CNSC provides summary assessments to the public and CNSC Commission on the overall state of Canadian nuclear power plant compliance and safety performance in reports such as the annual Regulatory Oversight Report (ROR). The ROR also includes discussions on emerging regulatory issues pertaining to the industry at large and to each licensed station. The ROR is presented in an annual public CNSC Commission meeting where Indigenous Nations and communities and members of the public may observe the meeting and formally participate as intervenors.

- **Environmental Protection Reviews:** the CNSC conducts periodic Environmental Protection Reviews (EPR) to evaluate how effectively a licensee is protecting human health and the environment in its community. The EPR considers the results of CNSC compliance and technical assessment activities as well as results from the CNSC Independent Environmental Monitoring Program and other independent verification activities. EPR reports are made available through the CNSC's website and on the open government portal.

OPG is committed to building and growing long-term, mutually beneficial working relationships with Indigenous Nations and communities regarding nuclear operations and future projects. Our relationships are developed on a foundation of respect for the rights of Indigenous Nations and our goal is to build and preserve openness, transparency, and trust. OPG is committed to building engagement plans with Indigenous Nations and communities for both the licence renewal application process as well as ongoing engagement after a licensing decision is made. OPG is steadfast in its commitment to supporting meaningful engagement during and after the licencing application process and will work in collaboration with Indigenous Nations and communities to build the engagement plans.

OPG believes in open and transparent communication in a timely manner to maintain positive and supportive relationships, and confidence of key stakeholders and the local community who have an interest in the operation and management of the station. OPG's community relations and public information program has been recognized as a strength by national and international utility peers and OPG strives to make a difference to help improve the well-being of its host communities through quality programming and environmental partnerships and programs.

OPG recognizes that Indigenous Nations and communities and members of the public appreciate the opportunity to engage directly with the Commission on matters of interest related to Darlington NGS. OPG values intervenor perspectives and welcomes opportunities to address both in-person (oral) and written interventions at any future Commission proceeding concerning Darlington NGS, e.g., ROR reviews and licence amendment requests.

This application for licence renewal provides the licensing basis for renewal of the Darlington NGS PROL, including any changes and updates to the information previously provided in References 1.0-1 and 1.0-2. In support of this application for renewal of the Darlington NGS PROL, OPG has submitted information in Reference 1.0-3 on implementation plans for Canadian Standards Association standards and CNSC regulatory documents identified by the CNSC for potential inclusion in Darlington NGS's Licence Conditions Handbook.

1.1 Site Description and Ownership

Located in the traditional territory of the Michi Saagiig and in the Municipality of Clarington in Durham Region (70 km east of Toronto), Ontario, OPG's Darlington NGS is a facility comprised of four CANDU pressurized heavy water reactors. Darlington NGS has a net generating capacity of 3,524 MW.

Darlington NGS's location and the location of the exclusion zone and structures within the zone are found in the following drawings:

i. Ontario Hydro layout drawing NK38-D0H-10220-1001, Rev 10, February 2015;

ii. Ontario Hydro layout drawing NK38-D0H-10220-1002, Rev 4, March 1982; and,

iii. Darlington NGS-A Plant Survey LO4254-DZS-10162-0531, June 7, 1999.

The Darlington NGS safety report provides detailed and extensive information on the facility and the systems, structures, and component design. This information can be found in Parts 1 and 2 of the safety report.

The Darlington NGS site is owned by OPG, which is owned by the Province of Ontario; the title/deed is available upon request.

1.2 Our People

At OPG, we are growing stronger every day because of the mix of talents and skills our increasingly diverse team of employees bring to the organization. OPG values the importance of a diverse, engaged workforce and we are proud to be an equal opportunity employer that actively seeks applicants from a variety of diverse backgrounds.

In 2021, OPG launched its first ever Equity, Diversity and Inclusion (ED&I) strategy; a 10-year strategy to become a global leader in ED&I best practices. This ambitious strategy identifies nearly 100 initiatives and 15 strategic priorities to be carried out across the enterprise by 2030, including:

- Establishing anti-racism training for all OPG employees (achieved in 2023).
- Providing five million dollars in funding over 10-years to post-secondary programs to graduate and recruit students from historically under-represented communities.
- Partnering with the BlackNorth Initiative to launch a nationwide science, technology, engineering and mathematics recruitment platform to connect BlackNorth candidates with internship, mentorship and career opportunities across the sector.

- OPG's Indigenous Opportunities Network (ION) program, which is a collaboration between OPG, the Electrical Power Systems Construction Association, Kagita Mikam Aboriginal Employment and Training, and unions/vendors engaged on the Darlington Refurbishment Project. Since launching the program in 2018, 125 ION participants have been placed.
- OPG's 2021 Reconciliation Action Plan (RAP), which includes three commitments, such as providing resources to all OPG employees to increase knowledge, understanding, and learning of Indigenous culture under its "People" pillar. The People pillar was established to create an engaged and inclusive workforce that reflects the broad diversity of Indigenous communities and peoples across the company.

Notably, in 2022 OPG made history with an all-women led crew of CNSC-licenced Control Room Shift Supervisors and Shift Managers at the Pickering NGS. OPG's employees are helping us drive our ED&I strategy forward and fostering a more inclusive workplace by getting involved and increasing awareness through numerous employee resource groups including the Abilities Alliance, Indigenous Circle, PRIDE Group, Racial Equality, and Women's Employee Resource Group. Employees have access to additional learning opportunities through various groups and partnerships including Women in Nuclear, the Canadian Centre for Diversity and Inclusion, and Pride at Work Canada.

These initiatives and more have led to OPG being named one of Canada's Best Diversity Employers in 2023, an award that recognizes employers across Canada for exceptional workplace ED&I programs.

1.3 Station Performance

Throughout the licence term, Darlington NGS has continued to maintain a strong performance record that demonstrates OPG's on-going commitment to produce reliable, clean energy while protecting the public, the environment and our staff.

Darlington NGS has had no lost time or work restricted injuries since 2019, and continues to be in the top quartile for Canadian Electricity Association Group I members for Total Recordable Injury Frequency/All Injury Rate. In the last 10-years, OPG has been awarded the Electricity Canada President's Award for Excellence in Employee Safety 9 times for its corporate-wide performance.

On February 4, 2021, Unit 1 achieved a world record of 1,106 days of continuous operation. This accomplishment highlights the effectiveness of the preventive maintenance programs and strong human performance that contribute to overall station reliability.

Throughout the licence term, collective and individual doses were managed well below administrative and regulatory dose limits. This was due to a number of factors including strong equipment reliability, reduced radiological source term following unit refurbishment, low unit forced loss rate and implementation of dose reduction initiatives.

Additionally, the 2020 Darlington NGS Environmental Risk Assessment concluded that the Darlington NGS site is operated in a manner that is protective of human and ecological receptors residing in the surrounding area. Environmental emissions to air and water were typically well below 1% of the Derived Release Limits. Similarly, dose to the public from operation of the Darlington NGS site continued to be a very small fraction of both the annual

regulatory dose limit and the annual natural background radiation in the area. Tritium concentrations in groundwater were also consistently low, indicating that the potential for adverse impacts to off-site groundwater quality from the Darlington NGS site is low to negligible.

The Darlington Periodic Safety Review (D-PSR) identified 12 strengths in a wide range of areas where Darlington NGS exceeds modern requirements. The identification of these strengths is consistent with results from recent trends of key plant performance indicators which demonstrate that Darlington NGS has been operated in a safe and reliable manner. The D-PSR also concluded the current plant design, operation, processes and management system will ensure continued safe operation of the station. The implementation of enhancements identified through the CNSC accepted IIP will support and enhance the high standard of safe operation until the next PSR.

Darlington NGS hosted several WANO peer reviews over the licence term that focused on the safe and reliable operation of the station. The results of the evaluations show that Darlington continues to be seen as operating to the highest levels of operational safety and reliability.

OPG continues to invest in Darlington NGS to ensure the station's ongoing safe and reliable operations and to position it for industry-leading operating and cost performance in the longer term. In addition to the ongoing refurbishment of the station's generating units, investments in life cycle and aging management projects, facility upgrades, and work in support of regulatory commitments are included.

Achievements and Initiatives During Current Licence Term

Strong performance of the Darlington NGS is the result of a robust design, solid engineering, operations and maintenance programs and processes that incorporate continuous improvement, and an organization that is committed to safety as a core value and overriding priority. Continuous evaluation of Darlington NGS's performance is what helps the station validate its strengths and areas for improvement; as well as ensuring the station consistently demonstrates the *"Staying on Top – Advancing a Culture of Continuous Improvement"* Institute of Nuclear Power Operations values. *"Staying on Top"* provides a set of values and behaviors for establishing a culture that achieves sustainable results and enables continuous performance improvement. Annual *"Staying on Top"* assessments are conducted to ensure we are driving excellence in all areas. Our commitment to excellence will serve as our strongest asset in maintaining our position as a leader in the industry.

A few of Darlington NGS's achievements and initiatives during the current licence term are discussed below, with further details provided in Sections 2 and 3 of this application.

Integrated Implementation Plan

The Darlington NGS Integrated Safety Review (D-ISR) IIP NK38-REP-03680-10185, *Darlington NGS Integrated Implementation Plan (IIP)*, outlines improvements that support Darlington NGS's continued safe operation and focus on enhancing the station's safety and reliability. The D-ISR was performed in support of refurbishment and life extension. The IIP presents the scope and schedule for the implementation of actions resulting from environmental assessments, integrated safety reviews, addressing code gaps, component condition assessments, and integrated aging management programs. Overall, 541 of 622 of the IIP refurbishment and continuing operation commitments have been completed up to Q1 2024. In support of continued long-term operation into the next licence period, a Periodic Safety Review (D-PSR) was completed to confirm that the design, condition and operation of the

Darlington NGS supports continuing commercial operation from 2025 to 2035. The D-PSR IIP NK38-REP-03680-11940, *Darlington NGS Periodic Safety Review (D-PSR): Integrated Implementation Plan,* was accepted by CNSC staff in Q1 2024.

Darlington Refurbishment Project

The Darlington NGS Refurbishment Project is a multi-year, multi-phase project that is enabling the Darlington NGS to continue safe and reliable operation. The project includes the replacement of life-limiting critical components, the completion of upgrades to meet applicable regulatory requirements, and the rehabilitation of components at Darlington NGS's four units. To date, Units 2 and 3 have been successfully returned to service and Units 1 and 4 refurbishment activities are progressing on schedule with planned completion of the refurbishment project in 2026.

While the primary focus of refurbishment is the proactive replacement of the reactor core components, there has also been a considerable number of initiatives and improvements completed ensuring Darlington NGS's continued safe operation through the next 30-years.

Equipment Reliability

OPG has made a considerable investment in Darlington NGS over the current licence term in equipment reliability. This includes $800M+ on projects to improve equipment reliability and address aging and obsolescence. These initiatives will improve system and equipment reliability in support of safe and reliable operation for years to come.

Fuel Handling Equipment Reliability

Significant improvements have been made in fuel handling equipment reliability where we experienced a best in CANDU fleet performance score of 98% in December 2023, in contrast to 82% in December 2016.

Over the past few years, the Darlington NGS Fuel Handling team has been integral to the success of the station, supporting major outages and refurbishment campaigns. This includes the successful defuel of all four reactor units, and the refuel and return to service of Unit 2 and Unit 3. To support the station's continued operation post-refurbishment, Fuel Handling developed and implemented a reliability improvement program in 2019. The program consists of approximately 1000 scopes of work, including major equipment replacements, upgrades and refurbishments. To date over 50% of the program has been completed, with the remainder of the program expected to be completed by the end of 2026 to support the long-term reliability of the fuel handling equipment and the return to four-unit fueling.

Emergency Mitigating Equipment

In response to the 2011 Fukushima Daiichi event, OPG has implemented Emergency Mitigating Equipment (EME) at Darlington NGS to enhance reactor cooling and monitoring capabilities. The EME is deployed in two phases.

Phase 1: Rapid deployment of on-site mobile equipment for immediate restoration of reactor cooling, monitoring and containment protection.

Phase 2: Deployment of three portable diesel generators stored at Pickering NGS that can be deployed to Darlington NGS within 12 hours to provide additional cooling and containment protection.

EME is securely stored, staged, maintained and tested by OPG's Emergency Response Team on a recurring schedule.

Additionally, a containment filtered venting system has been installed to filter radioactive materials from the vacuum building, preventing their release.

In February 2022, OPG conducted Exercise Unified Command, a full-scale exercise simulating a beyond-design-basis accident at Darlington NGS. The exercise involved multiple agencies and tested OPG's ability to respond to a large-scale emergency using the EME, demonstrating the effectiveness of both on-site and off-site emergency preparedness measures.

OPG continues to benchmark industry best practices for EME processes, procedures and equipment.

Emergency Power Generators

Darlington NGS has increased nuclear safety redundancy with the installation of a third Emergency Power Generator (EPG). This was followed by the replacement of EPG2 in 2020 and the replacement of EPG1 in 2023. Each EPG is a standalone mini power plant capable of supplying eight megawatts of reliable backup electricity to the Emergency Power System at Darlington NGS in the unlikely event of an emergency.

Tritium Removal Facility

Since 2015, the TRF has removed approximately 157.5 million Curies (5.81e+18 Bq) of reactor heavy water tritium from Ontario CANDU reactors. Initiatives to improve and ensure continued detritiation capability include:

- Commissioned a new building, the West Annex, which has an additional 1900 Mg of storage capacity for heavy water, as well as drum handling facilities;
- Installed a wet scrubber on the recombiner outlet and ventilation systems of the TRF to further enhance tritium reduction.

1.4 Innovation at OPG

OPG has made advancements in innovation during the current licence term, including the Monitoring & Diagnostics (M&D) Centre, X-LAB and innovations in training.

Monitoring & Diagnostics Centre

The M&D Centre was established in 2017, leveraging data analytics and remote continuous online monitoring to closely track critical components, utilizing more than 2,400 Advanced Pattern Recognition models and about 20,000 data points across the OPG fleet.

The M&D Centre provides early detection to support the condition-based maintenance strategy to execute the right work at the right time. The Centre also provides Darlington NGS with thermal performance monitoring service to minimize generation losses from the turbine cycle.

The M&D Centre received the 2022 Canadian Nuclear Society Innovative Achievement Award in recognition of significant innovative achievements and the implementation of new concepts displaying clear qualities of creativity, ingenuity and elegance in the nuclear field in Canada.

The M&D Centre has also benchmarked against various utilities through organizations such as Electric Power Research Institute (EPRI) and has been recognized as one of the industry leaders, leveraging data analytics to enhance plant reliability and to minimize generation loss.

OPG's Innovation Department (X-Lab)

OPG is recognized as a world class leader regarding the implementation of innovative strategies, often benchmarked for innovation practices and processes. OPG's innovation department, coined the "X-Lab", was established in 2017 and is dedicated to transforming mindsets, fostering creativity, and implementing cutting-edge technologies and processes. The X-lab has brought value and efficiency to OPG's daily operations, while advancing the company towards its net-zero climate goals. The X-Lab Innovation Team spearheads innovation in the utility sector with a mission to redefine standards. The team's vision is to drive enhancements in equipment reliability, safety, and employee efficiency while nurturing an innovation culture.

- OPG is positioning itself as an industry leader in robotic utilization through the adoption of the SPOT Robotics Platform by Boston Dynamics. This platform drives efficiency while maintaining OPGs high level of executional excellence and safety. The SPOT robot has enabled OPG to perform tasks online, and in harsh environments that would otherwise require a unit outage to perform safely by a human.
- In 2023, the EPRI Global Innovation Effectiveness (GIE) Cohort reviewed OPG's innovation practices and processes and recognized the X-Lab Innovation Team for industry-leading practices. The GIE aims to provide insights into the effectiveness of innovation by examining how utilities strategize, structure, and cultivate an innovative culture.
- OPG has leveraged an internal cloud-based idea management system, Launchpad, to capture innovative ideas from employees across OPG. Ideas are visible to all employees who can then vote, comment, and/or collaborate to develop ideas into actionable projects. The X-Lab team ensures every voice is heard, fostering an environment where ingenuity thrives.
- Micro-drone Operation enables lightweight drones to be utilized by staff. This allows for visual inspections to be performed more efficiently.

By empowering employees and facilitating seamless collaboration, the X-Lab Innovation Team remains committed to shaping the future of energy delivery, setting new benchmarks for innovation in the process.

Innovative Strategies for Training

Training has embedded innovation in its program.

- Fuel Handling Simulators: the updated simulator allows Operators to become more proficient in fuel handling activities while working in a low-risk environment. The Fuel Handling team has utilized the simulator to not only expose the Operators to enhanced procedures, but to fine tune first-of-a-kind procedures.
- TRF Simulator: the simulator allows Operators to become more proficient in TRF evolutions such as startup and shutdown as well as time to practice team effectiveness, human behaviours utilizing human performance tools and first-of-a-kind procedures while working in a zero-risk environment. Simulator improvements are being implemented in 2024 to better model transients, start-up and shutdown evolutions.

- Virtual Reality Crane Simulators: maintenance training instructors improved crane operator performance by incorporating a virtual reality simulator into crane operator training.
- Flight Simulator: incorporation of a flight simulator for human performance training. This places individuals in an unfamiliar environment where they are able to observe the full benefits of human performance tools/techniques while being challenged with distractions and competing priorities.
- Simulated Radiological Source Generator: Radiation Protection (RP) training has improved RP technician performance by incorporating a simulated radiological source generator into their continuing training. A radio frequency simulated source eliminates actual live radiological sources. Technicians are demonstrating greater radiological risk mitigation proficiency while eliminating any exposure to radiological sources. The simulation equipment includes portable wireless dosimeters, survey meters, gamma sources and scenarios that mimic conditions that were unachievable in previous training conditions.

1.5 Improvement Plans and Significant Future Activities

An overview of OPG's planned improvement plans and significant future activities concerning Darlington NGS during the requested 30-year licence term is discussed below, with further details provided in Sections 2, 3, and 4 of the application.

Completion of the Darlington Refurbishment Project

Completion of the refurbishment project is on track for 2026 and through the major component replacements, inspection, and modifications to improve the plant, will enable OPG to continue safe and reliable operation of Darlington NGS through a 30-year licence term.

Completion of Integrated Implementation Plan Activities and Future Periodic Safety Reviews

Completion of the improvements outlined in the D-ISR IIP and the D-PSR IIP support Darlington NGS's continued safe operation, with focus on enhancing the station's safety and reliability. The D-PSR IIP covers the period of operation of Darlington NGS units from November 2025 to November 2035.

PSR's will continue to be conducted at approximately 10-year intervals through the requested licence term. PSRs are conducted in accordance with CNSC regulatory document REGDOC-2.3.3 and improvements identified, and documented in an IIP, will support continued safe operation of Darlington NGS.

Asset Management

Darlington NGS will continue to invest in station equipment through developed aging/asset strategies and Life Cycle Management Plans that provide asset investments using a risk-based value framework through 2055.

Tritium Removal Facility Major Component Replacement Project

The TRF will undergo a major component replacement in six outages commencing in 2026. This will extend the life of the facility for decades to come. Major scope in these outages includes re-design and replacement of the Cryogenic Refrigeration System (CRS) oil turbine, and the installation of additional CRS hydrogen compressor capabilities. This work will improve safety and plant reliability by addressing obsolescence and improving redundancy.

Isotopes Production

Darlington NGS's support for safe production of isotopes includes the planned production of Cobalt-60 (Co-60), Molybdenum-99 (Mo-99), and Yttrium-90 (Y-90) and there is potential for additional growth in this fast-changing and life-saving field. The reactor cores are analyzed to be safe in this configuration and processes and procedures are in place to ensure safe handling and hand-off of the resultant isotopes to OPG's strategic partners.

Darlington for the Future

The Darlington for the Future (D4F) initiative includes focus areas that will allow OPG to achieve and sustain industry leading top quartile performance over the station's 30-year post-refurbishment operations window. The D4F initiative started in 2019 and is planned to continue to 2030, with key focus areas including (but not limited to):

- Plant Reliability: develop asset life cycle plans to end of Darlington NGS extended life;
- Pressure Tube Life: implement fuel channel improvements to support pressure tube operational targets to 250,000 equivalent full power hours.
    - During refurbishment, Darlington NGS completed major life extension activities, including replacement of pressure tubes as well as other major reactor core assembly components. Improvements were made to these replaced components through the manufacturing process to mitigate known aging mechanisms based on pre-refurbishment industry operating experience.
    - Baseline Inspections: The condition of the fuel channel components is regularly monitored via inspection programs, consistent with the life cycle management approach used for all major components, demonstrating that component condition remain within the licensing basis and fitness-for-service criteria. Largescale inspection campaigns completed pre-refurbishment across the OPG nuclear fleet, particularly during late-life operation, have enabled the development of improved modelling capabilities that increase confidence in long term projections of known degradation mechanisms. The breadth of operating experience that OPG has accumulated will be applied along with industry lessons learned to improve upon existing life cycle management.

OPG's Reconciliation Action Plan

In the fall of 2021, OPG launched the RAP, which outlined the commitment to advancing reconciliation with Indigenous peoples under the pillars of leadership, relationships, people, economic empowerment, and environmental stewardship:

- Leadership: Commit to reconciliation as a journey and track progress with metrics and targets around commitments.

- Relationships: Build positive and mutually beneficial relationships with Indigenous communities and peoples based on respect and understanding.
- People: Create an engaged and inclusive workforce that reflects the broad diversity of Indigenous communities and people across OPG.
- Economic Empowerment: Advance economic reconciliation with Indigenous communities and businesses through meaningful engagement, collaboration and partnership.
- Environmental Stewardship: Be a trusted partner in environmental stewardship and an ally in addressing climate change.

The RAP is our road map for how we intend to work in partnership with Indigenous communities, businesses and organizations to advance reconciliation. It's also about how we intend to grow and continue learning as an organization. The 2021 edition of the RAP included 38 specific action and commitments with clear deliverables and timelines spanning between 2022 and 2031.

An annual report was published in the fall of 2022, which noted that the first-year goals were achieved through much work, dedication, and collaboration with communities. OPG remains on track and ahead of schedule to meet its commitment of expanding opportunities for Indigenous businesses to participate in nuclear procurement under its "Economic Empowerment" pillar. The RAP is being updated and published in Q2 2024 with over 20 new commitments that were developed through internal discussions and input from Indigenous Nations, communities, and businesses. Included in the RAP update will be a report on our 2023 results.

The RAP is aligned with the Truth and Reconciliation Commission's Call to Action #92, which urges corporate Canada to create a better future by applying a reconciliation framework to business activities. For OPG's supporting activities refer to Section 4.2.

OPG's Climate Change Plan

In 2020, OPG released its first-ever climate change plan to create a cleaner environment to help tackle climate change, with the goal of becoming a net-zero carbon company by 2040 and helping the markets that OPG operates in achieve net-zero economies by 2050. The guiding principle of this climate change plan is to be the catalyst that enables the transformation to clean economies, in the most efficient and responsible way possible.

Tackling climate change will take a combination of electricity generating technologies and innovative solutions. To reach these goals, OPG has implemented a Climate Change Action Plan organized around four pillars:

- Mitigate Carbon Emissions: OPG is working towards the electrification of the economy, addition of clean power (hydro, nuclear, and renewable) and is exploring the reduction of emissions in natural gas generating stations through means such as carbon capture.
- Adapt to the Impacts of a Changing Climate: OPG will continue to invest towards all generating asset-based climate vulnerabilities to ensure continued production of clean and reliable power.
- Innovate and Deploy New Technologies: OPG will continue to innovate through investments such as Small Modular Reactors (SMRs), deploy nature-based climate

solutions, and increase OPG's aggregate resource pool of distributed energy resources to meet changing electricity demands.

- Lead the Decarbonization of Ontario's Economy: OPG will continue to lead in and share the expertise to help decarbonization through SMRs and hydro development, electrification infrastructure, and sustainably focused operational excellence.

2.0 Safety and Control Areas (SCAs)

This section documents CNSC's regulatory requirements for the safety performance of programs. The sections are sub-grouped as 14 Safety and Control Areas (SCAs) that are further divided into specific areas that define the key components of each SCA. The SCAs cover the functional areas of:

Management:	**(SCAs 1, 2 and 3)**
Facility and Equipment:	**(SCAs 4, 5 and 6)**
Core Control Processes:	**(SCAs 7, 8, 9, 10, 11, 12, 13 and 14)**

Section 2.1

Management System

2.1 Management System

OPG maintains a nuclear management system in accordance with the current operating licence and associated Licence Conditions Handbook. OPG's nuclear management system is applicable to all OPG nuclear facilities and is compliant with CSA N286-12, *Management System Requirements for Nuclear Facilities*.

The fundamental objective of OPG's nuclear management system is to ensure OPG nuclear facilities are operated and maintained using sound nuclear safety and defence-in-depth practices to ensure radiological risks to workers, the public, and the environment are As Low As Reasonably Achievable (ALARA), and in keeping with the OPG *Nuclear Safety and Security Policy* and the best practices of the international nuclear community.

OPG's nuclear management system sets out the principles, required supporting actions and documentation to support safe and reliable nuclear facilities, and brings together in a planned and integrated manner, the processes necessary to satisfy requirements and to carry out licenced activities safely.

Management system requirements provide direction to develop and implement management practices and controls. Programs and processes are created such that all applicable regulatory requirements and codes and standards are embedded and integrated within the nuclear management system, including aspects of health, safety, environment, security, economics and quality.

OPG's nuclear management system satisfies the requirements set out in the Nuclear Safety and Control Act (NSCA), regulations made pursuant to the NCSA, the PROL, and the measures necessary to ensure that safety is of paramount consideration in operation of OPG's nuclear facilities.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 1: SCA 1 – Management System

Document	Title
N-CHAR-AS-0002	Nuclear Management System
N-PROG-AS-0001	Nuclear Management System Administration
OPG-PROG-0001	Information Management
OPG-PROG-0039	Project Management Program
OPG-STD-0140	Managing Change
N-STD-AS-0020	Nuclear Management System Organizations
OPG-PROC-0166	Organization Design Change
N-POL-0001	Nuclear Safety & Security Policy
N-STD-AS-0023	Nuclear Safety Oversight
OPG-PROG-0005	Environment Health and Safety Managed Systems
N-PROC-AS-0077	Nuclear Safety & Security Culture Assessment
N-PROG-RA-0010	Independent Assessment
N-GUID-09100-10000	Contingency Guideline for Maintaining Staff in Key Positions When Normal Station Access is Impeded
OPG-PROG-0033	Business Continuity Program
OPG-PROG-0009	Items and Service Management

2.1.1 Management System

OPG's nuclear management system is documented in charter N-CHAR-AS-0002, *Nuclear Management System* (the Charter), and provides the framework for programs and processes which collectively ensure that Darlington NGS operates safely and reliably.

The Charter takes authority from N-POL-0001, *Nuclear Safety & Security Policy*, established by OPG's Board of Directors. In accordance with N-POL-0001, the Chief Nuclear Officer (CNO) is accountable to the Chief Executive Officer (CEO) and Board of Directors to establish a management system that fosters nuclear safety and security as the overriding priority.

The Charter, consistent with N-POL-0001, communicates the expectations of the CNO. Collectively, the Charter and its reference processes establish a quality program, the nuclear management system, and fulfill the requirements of CSA N286-12.

Every employee in the organization is responsible for and held accountable for complying with the expectations of the Charter and referenced programs, and for ensuring their actions are deliberate and consistent with protecting worker health and safety, the health and safety of the public, and the environment.

The nuclear management system has evolved over the licence term, to support the OPG centre-led business model. Several programs have transitioned from being Nuclear-only, to being owned by corporate business units (e.g., Items and Services Management, Information Management, and Environment and Health and Safety). For these programs, ownership and accountability for the program resides with the Corporate program owner but the CNO remains accountable for the effectiveness of the implementation of these programs in Nuclear, and in meeting the requirements of CSA N286-12. Oversight and review of the health and effectiveness of these corporate programs continue to be part of the nuclear management system.

2.1.2 Organization

N-STD-AS-0020, *Nuclear Management Systems Organizations*, describes the organization and responsibilities of OPG in support of the Charter and CSA N286-12. The objectives are to:

a) Maintain a sufficient number of qualified staff to safely operate, maintain, and support the nuclear generating stations, and;

b) Maximize the efficiency and effectiveness of its workforce.

Under the current governance requirements outlined in N-STD-AS-0020, applicable documents must be updated when role accountabilities change to ensure currency and accuracy.

Organizational change includes changes to all components of the organization, including but not limited to safe and effective operations, work, people, processes and practices technology systems, governance/policies, programs, organization design, financial performance, culture, information systems, and internal and external stakeholder relationships and agreements.

Organization design change specifically refers to changes to the organization structure (i.e. structure, hierarchy, spans and layers, reporting lines, positions, accountabilities, role documents, jobs, classifications, locations, etc.). OPG-PROC-0166, *Organization Design Change*, describes the process for managing changes to the organization structure as outlined above which, depending on the nature of the change, may result in changes to role documents identified in N-STD-AS-0020. OPG-PROC-0166 assigns accountabilities and related

requirements for preparing, reviewing, approving and implementing organizational changes. The documented change process includes the following:

a) Gated criteria to evaluate the complexity of the change; minor or material;

b) Direction to assess various aspects of the change (e.g. requirement for pressure boundary and/or regulatory interface, governance changes, cumulative impact of several minor changes);

c) Approval levels that correspond with the level of change;

d) Communications according to the level and complexity of change.

N-STD-AS-0020 and OPG-PROC-0166 support N-PROG-AS-0001, *Nuclear Management System Administration* in the Nuclear Management System (N-CHAR-AS-0002).

Figure 1 provides the current Darlington NGS organizational structure. The Darlington NGS organizational chart information is updated each year and submitted to the CNSC. Figure 2 provides the Darlington NGS Refurbishment organizational structure.

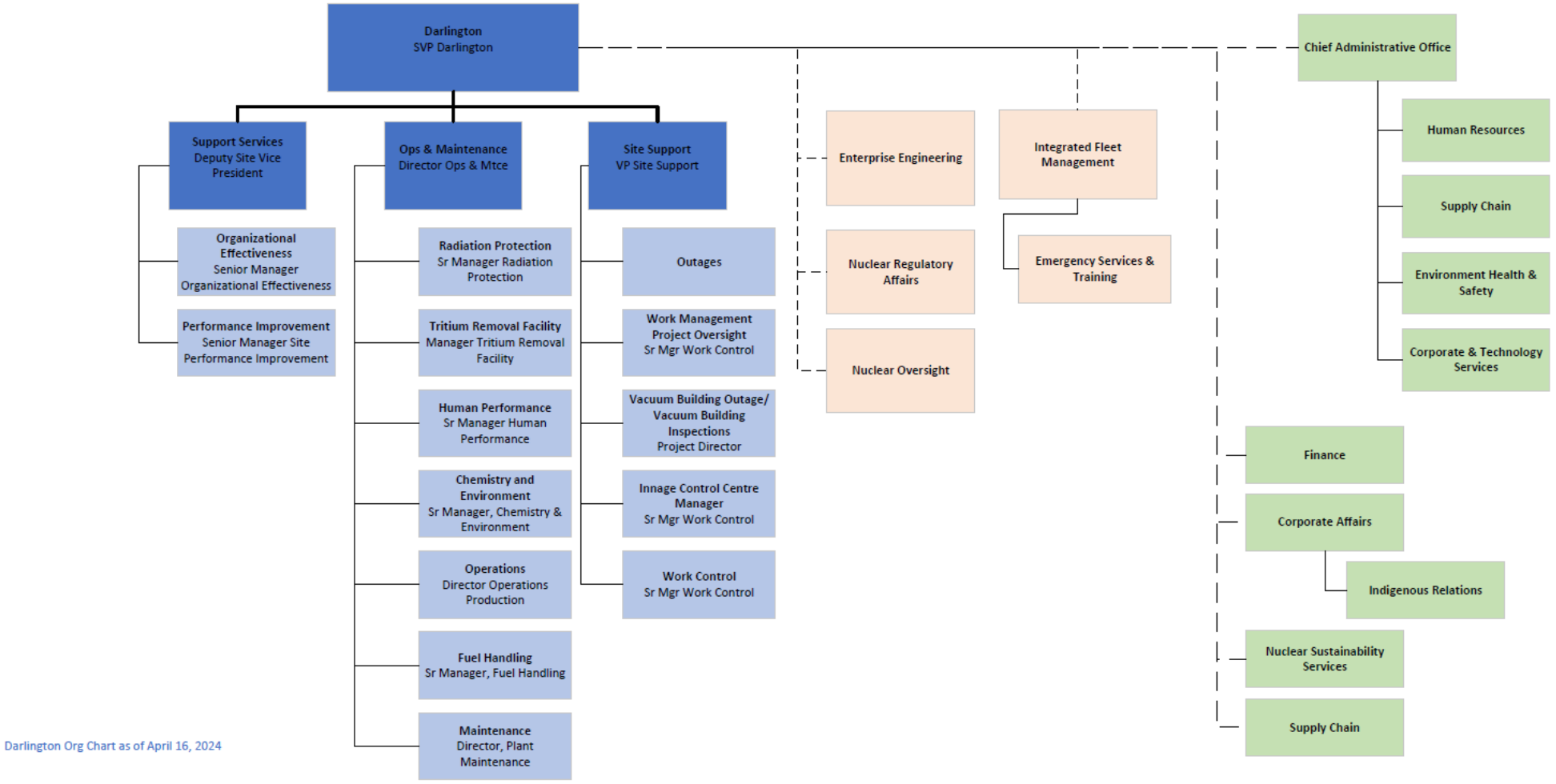


Figure 1: Darlington NGS Organizational Chart

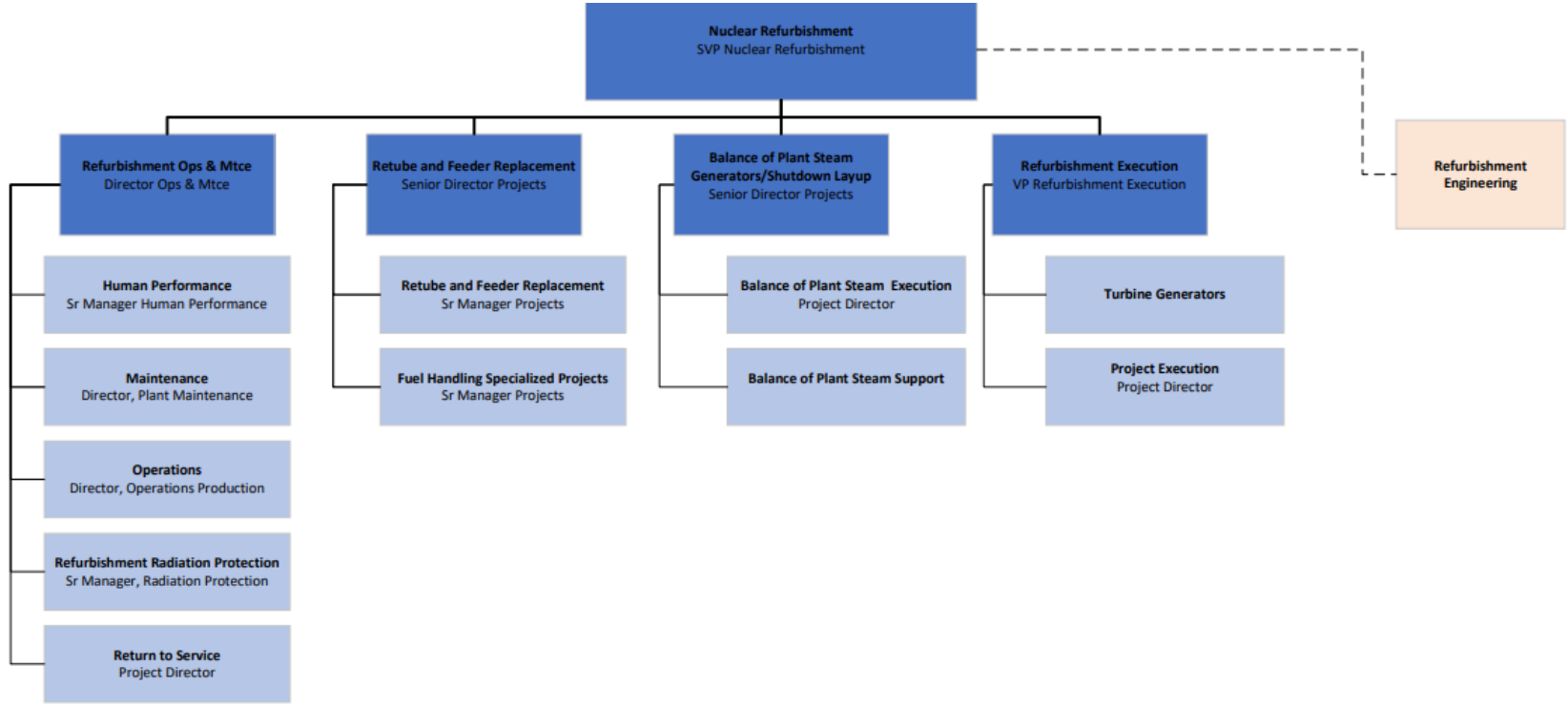


Figure 2: Darlington Refurbishment Organizational Chart

2.1.2.1 Staffing Management

Workforce planning is an integrated and continuous process that identifies and addresses critical gaps between the current workforce and future needs in the context of Darlington NGS's operating strategy.

Staffing plans at OPG use workforce planning data (i.e. approved business plan demand, supply and attrition assumptions) to proactively identify potential resourcing gaps and risk areas requiring mitigation. The plans are prepared annually and are periodically reviewed throughout the year to ensure any changes to workforce profiles are regularly assessed for risks, mitigation plans are incorporated, and adequate qualified staffing levels are maintained for safe reliable operation of Darlington NGS.

Recruitment and Onboarding

OPG has a number of internal and external recruiting programs that are administered through the Recruitment and Onboarding team within the Human Resources organization. The Recruitment and Onboarding organization works with hiring managers to source and attract a diverse and high performing workforce.

The sourcing strategies are multi-faceted and include partnerships with educational institutions, apprenticeship programs, use of hiring halls for trades, internal and external job posting and career sites, talent pipelining, direct sourcing, retained/ contingent recruitment agencies and succession planning discussions.

Further, OPG proactively seeks Indigenous post-secondary student participation in co-ops, internships and summer employment opportunities in an effort to build an Indigenous talent pipeline. OPG has partnerships with ED&I and Indigenous programs at Ontario Tech University, Durham College, Humber College, Queen's University, Lakehead University, and Trent University and continues to expand post-secondary partnerships.

To advance hiring of qualified equity-deserving candidates in the four designated groups (Women, Indigenous Peoples, Racialized People, Persons with Disabilities) in the labour market and increase representation at OPG, Recruitment in partnership with Ethics & Equity has designed a special recruitment program that will extend substantive equity, address historic and ongoing hardship, and reduce the risk of discrimination against Indigenous Peoples and those in the four designated groups in various stages of the hiring process. When jobs are posted as part of this program, opportunities expressly state the position is to increase designated group members at OPG. Applicants will be advised that self-identification as a member of a designated group is an eligibility criteria.

OPG's Indigenous Opportunities Network (ION) is dedicated to the recruitment of Indigenous Peoples through a network of employers in the energy industry and in partnership with Kagita Mikam, an Indigenous recruitment agency, develops approaches to Indigenous recruitment to build career pathways to OPG and across the industry.

OPG's onboarding program integrates high-quality employees and contractors into the organization. It promotes exceptional performance aligned with company goals and values. The Onboarding Centre, a centralized hub, provides new hires with essential information and tools for productivity. Collaborating with internal stakeholders, it ensures access, training, and safety protocols. OPG prioritizes an inclusive and supportive experience, enabling effective contributions to organizational success.

Knowledge Management

OPG has many well-established methods to ensure people have the qualifications, knowledge and skills required to perform competently. The knowledge management program complements these foundational programs by providing tools and techniques to consider and share tacit knowledge.

OPG has invested in knowledge management for ongoing operations as well as the delivery of projects and initiatives to ensure that the critical knowledge and expertise of employees is sustained.

Talent and Succession Planning

The OPG talent review and succession planning program is a foundational element of OPG's strategic corporate human resources plan and business model. The talent management strategy includes the retention and knowledge transfer that is used to ensure that necessary talent and skills will be available when needed, and that essential knowledge and abilities will be maintained. Succession planning is one component of this strategy, with the objective to identify and develop future leadership and to integrate this with the staffing needs to ensure continuity in critical roles.

The OPG succession planning process follows an annual Enterprise talent review cycle. In Nuclear, monthly succession planning meetings are held to address current and future planning talent requirements. Nuclear Leadership Team members are an integral part of the process.

The Nuclear organization has an integrated succession planning process that includes identifying critical positions and determining the priority of each role. The level of management oversight of the succession planning of these critical positions is determined by the priority given to the role.

The OPG talent review and succession planning program is fully integrated into the broader human resources management programs within OPG that include performance measurement, individual development planning, leadership development, skills and capability development, diversity and inclusion, and culture.

2.1.3 Performance Assessment, Improvement and Management Review

OPG program N-PROG-RA-0010, *Independent Assessment* provides independent assessment (internal and external) processes to perform a comprehensive and critical evaluation of all activities affecting OPG nuclear facilities. This program ensures the management system under N-CHAR-AS-0002 is reviewed with sufficient frequency to confirm its continuing effectiveness. The program is comprised of the following processes:

- Internal independent assessments performed by Nuclear Oversight.
- External independent assessments performed by the Nuclear Safety and Review Board (NSRB).

An annual audit plan identifies the specific audits to be conducted by Nuclear Oversight in the upcoming year. The annual audit plan is based on key risk areas, legal and regulatory requirements.

The NSRB reports to the CNO who reports to the President and CEO on nuclear related matters. The NSRB also reports annually to the Generation Oversight Committee of the Board of Directors. The Generation Oversight Committee is responsible for performing the duties set

out in their Charter to assist the Board in fulfilling its oversight responsibilities, including the safe, secure and efficient operations of OPG's generating facilities and compliance with nuclear, health and safety, and environmental laws and regulations.

The NSRB performs the following:

a) Provides the CNO with an independent assessment of OPG activities that may impact on Nuclear Safety and performance.

b) Communicates directly with OPG personnel on matters of NSRB interest.

c) Observes and reviews any aspect of OPG performance related to safety, productivity, human performance, material condition and reliability.

d) For site reviews, the NSRB gets perspective from, and assesses the relationship between, the CNSC and the site being assessed.

e) Reports on the effectiveness of Nuclear Oversight in the execution of the Independent Assessment program.

f) For site reviews, reports on Corporate Functional Area Manager (CFAM) for performance around oversight and support.

g) Provides, as applicable, advice on lessons learned and good practices coming out of the nuclear industry, and recommendations on improving Nuclear Safety and performance.

h) Provides results of assessments, including recommendations on actions to improve performance, to the CNO and senior management team.

As a learning organization, Darlington NGS strives for continuous improvement. OPG program N-PROG-RA-0003, *Performance Improvement*, establishes the processes that support the conduct of performance improvement and, by extension, employ the principles of problem prevention, detection and correction at OPG. This program covers the key areas of performance improvement, namely; corrective action, self-assessment, benchmarking, operating experience, and nuclear safety culture.

Self-assessment and benchmarking activities for functional and line organizations of OPG are performed in accordance with N-PROC-RA-0097, *Self-Assessment and Benchmarking*. Self-assessments and benchmarking are utilized to evaluate actual performance against management expectations, industry standards of excellence and regulatory requirements. OPG's Self-assessment and benchmarking program is aligned with the World Association of Nuclear Operators (WANO) performance objectives and criteria. The WANO performance objectives and criteria is a comprehensive guideline of industry practices and standards and lessons learned from operating experience, and as a result reflects a global standard for nuclear excellence. N-PROC-RA-0097 provides methods for identifying shortfalls in performance of processes, programs, practices, behaviours, roles, responsibilities and organisational expectations. It also defines those elements required to plan, execute, report, and monitor self-assessments.

Any adverse conditions are identified during the performance of audits or self-assessments are documented as per procedure N-PROC-RA-0022, *Processing Station Condition Records*, with corrective actions assigned as required.

In addition to the above, OPG performs regular program health and performance reviews for all applicable programs within the nuclear management system in accordance with N-PROC-RA-0023, *Fleetview Program Health and Performance Reporting*. Fleetview Program Health and

Performance is a fleet-wide functional review and reporting process to monitor and routinely report on overall program effectiveness. The reporting process involves three key areas:

- Program oversight and leadership.
- Program execution performance indicators.
- Program action plans.

A Fleetview Program Health and Performance Report for every program is completed at minimum annually (programs that directly impact or support nuclear plant safety, reliability and generation complete a report tri-annually) for CNO and Nuclear Executive Committee review. The inputs into the report support OPG to drive continuous improvement efforts and sustainable performance. The oversight provided by Nuclear Executive Committee ensures that gaps are self-identified and self-corrected through sustainable actions in order to achieve industry top quartile performance. For programs that may require additional oversight, the Nuclear Executive Committee will conduct focused meetings to further drive improvement of program performance.

The effectiveness of the Performance Improvement program is routinely assessed through a set of Key Performance Indicators (KPI) in the monthly Performance Improvement Health Report. The monthly Performance Improvement Health Report is distributed to the Performance Improvement departments fleetwide and is shared and discussed at the Performance Improvement peer team meetings.

The KPIs are also included in the Fleetview reports for Nuclear Executive Committee review where any decline in performance or failure to meet targets will be challenged. It is expected that an action plan is provided for any KPI failing to meet the target.

The Corporate function provides next-level oversight to 14 key nuclear programs. CFAMs and Site Functional Area Managers (SFAMs) collaboratively use the Governance, Oversight, Support and Perform (GOSP) model to critically measure performance using methods described in corporate oversight governance. Routine peer team meetings are effectively used to share site and industry best practices, discuss tactical and strategic actions to correct performance shortfalls and gaps to excellence. To assist CFAMs with strategically and consistently managing the GOSP model, each CFAM has developed an oversight plan for their functional area, routinely updating them based on awareness of current industry and site performance. CFAM performance and reflection meetings are routinely held to share best practices and sustain proficiency.

2.1.4 Operating Experience (OPEX), Problem Identification and Resolution

OPG's Performance Improvement program (N-PROG-RA-0003), also establishes the process to ensure deficiencies, non-conformances, weaknesses with a process, document, service, or conditions that adversely impact, or may adversely impact plant operations, personnel, nuclear safety, the environment or equipment and component reliability, are promptly identified and corrected.

For those issues considered significant or repetitive in nature, these processes ensure that the appropriate levels of management are notified, causes are identified, and actions are taken to preclude recurrence, and actions taken to address the identified issues are verified to be complete and effective. Refer to Section 2.3.3 for further details.

Under N-PROG-RA-0003, N-PROC-RA-0035, *Operating Experience Process* (OPEX) establishes processes to prevent reoccurrence of significance internal and external events by ensuring internal and external OPEX is evaluated, distributed to appropriate personnel, and applied to implement actions that improve plant safety and reliability.

The OPEX process is comprised of three elements:

1) External OPEX: Information received from nuclear industry sources, coordinated weekly through the CANDU Owners Group (COG), are reviewed to identify any vulnerabilities and weaknesses that could result in similar events or problems at OPG. Sources of external OPEX include, but are not limited to, WANO, Institute of Nuclear Power Operations (INPO), International Atomic Energy Agency, US Nuclear Regulatory Commission and other CANDU stations. Relevant non-nuclear OPEX is also considered in areas such as Industrial safety and balance of plant operations. As per N-PROC-RA-0022, actions are identified when required to address these vulnerabilities or weaknesses and implement lessons. External OPEX is also used to keep OPG staff informed of relevant industry information.
2) Internal OPEX: Internal events and lessons learned are reviewed in accordance with N-GUID-01533-10001, *OPEX Guideline*, and are communicated as appropriate to WANO, INPO, COG, and other OPG sites.
3) Use of OPEX: OPEX repositories are made available for convenient access by OPG staff, in support of their daily activities.

Combined, these elements meet the objectives by ensuring consistency for evaluating, integrating, accessing and sharing external and internal OPEX and ensuring repositories are accessible by OPG and external staff in support of daily activities.

In 2021, OPG developed and released a new OPEX database to facilitate the distribution of external OPEX from COG to departmental OPEX Single Points of Contact, 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.

As part of ongoing improvements for the OPEX process and use of OPEX at Darlington NGS, there are number of initiatives in progress:

- Development of a web based OPEX search engine. The new search engine will be able to extract information from various sources such as the Station Condition Record (SCR) database, OPEX Database, Work Reports from Asset Suite, *Iconnect* database, etc., and be user friendly, easy to navigate and able to provide quick access to key OPEX events relevant to line organization tasks.
- A revision of the current OPEX Health Metrics indicators to challenge status quo for indicators with consistent green scores over a long period and raising the target score for green, yellow, white and red ranges to further improve performance and challenge the fleet for maintaining excellence. A second part of this initiative is OPEX Health Metrics automation of KPIs to provide efficiency in completing monthly metrics and provide visibility to line organizations of where the data is specifically feeding from. This feature will help identify trends (declines or improvements) in specific KPIs and which line organizations are contributing to it. The benefit will provide line organizations the opportunity to check and adjust their behaviours towards implementing OPEX internally and from external sources.

- Adding OPEX items from the weekly screening package from COG into each day of the Integrated Station Brief meeting package as a point of discussion and understanding lessons learned from new key OPEX items that are applicable to the station.

Establishing a Plant Information Center Impact Identifier program to support line organizations in understanding how internal events that are Industry Reporting and Information System (IRIS) reports are impacting station performance. OPG's governance, oversight and internal reporting structure have been aligned with Plant Information Center and IRIS to drive sustainable performance improvements in all business areas through comparison against top performances in the North American nuclear industry.

2.1.5 Configuration Management and Change Management

Configuration Management at OPG is governed by N-STD-MP-0027, *Configuration Management*. This standard ensures the station physical configuration for all essential Structures, Systems and Components (SSC) match the configuration documents for all plant states. In addition, the standard ensures configuration information is maintained accurate, consistent and readily accessible along with defining clear scope, responsibilities, authorities and interfaces among organizations. This information is uniquely identified, maintained current and consistent.

The standard controls the changes which may affect configuration by:

- Requiring regulatory and licensing reviews, approvals and safety evaluations to ensure physical configuration or configuration information changes conform to the design and licensing basis.
- Reviewing impacts so that related configuration information is maintained consistent with the change.
- Ensuring changes to the design and licensing basis receive appropriate verification and approvals before the change is made.
- Ensuring change processes work in accordance and consistently with each other for design, procurement, construction, installation, commissioning, operation and maintenance, including surveillance, training, and testing.

Figure 3 shows the relationship between nuclear management system activities, programs and configuration management.

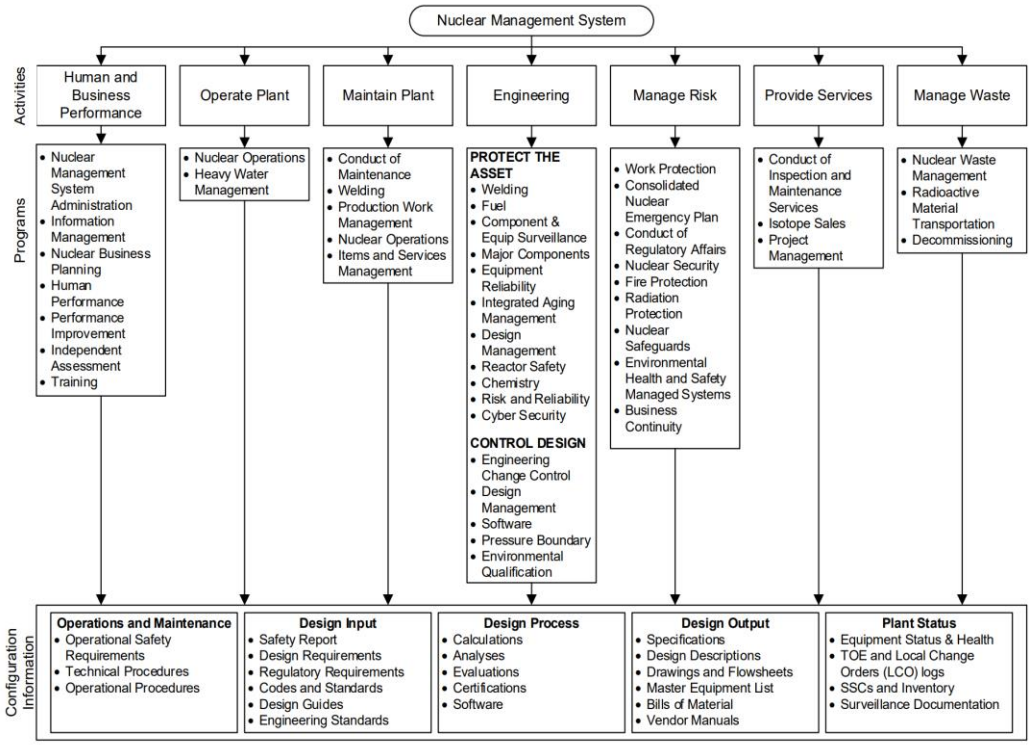


Figure 3: Configuration Management Relationships

Change Control programs such as Engineering Change Control (ECC), support configuration management by ensuring design changes, document changes and physical configuration changes that impact design and the licensing basis are tracked to completion and are traceable throughout the life of facility. Adverse configuration management issues are documented using SCRs.

Design changes are performed in accordance with OPG's program N-PROG-MP-0001, *Engineering Change Control*. The program and its implementing procedures have been written to be consistent with N-POL-0001, CSA N286-12, all relevant legal, statutory and regulatory requirements, including those of the CNSC, as wells as Industry guidelines. The ECC program ensures design changes to each OPG facility (including SSC, software and engineered tooling) are controlled such that the facility configuration is managed in accordance with the design and licensing bases and remains within the Safe Operating Envelope (SOE).

For pressure boundary SSC, OPG's program N-PROG-MP-0004, *Pressure Boundary* complies with the general configuration management requirements and additional requirements in N-STD-MP-0027. The ECC process detailed in N-PROC-MP-0090, *Engineering Change Control Process*, ensures that OPG's pressure boundary processes are described in the Pressure Boundary program.

Configuration management is an important aspect of maintaining and keeping Darlington NGS in an assessed state within the SOE and is reviewed both by internal and external organizations regularly. Actions are taken as appropriate to correct any identified adverse conditions.

OPG's Nuclear Oversight audits of the ECC program in 2017, 2020 and 2023 found that the managed system controls are effective and that overall, the program achieves its goal of

execution and control of engineering changes to support the safe and reliable operation of OPG facilities.

The ECC program documents undergo cyclic review and revision. Such revisions include improvements based on industry OPEX and as suggested by users. Ongoing process improvements are also generated through two monthly meetings intended to identify any problem areas and share OPEX. The Design Managers' Working Group consists of the OPG facility Design Authorities and other managers of various OPG and vendor design organizations, while the Engineering Change Control Working Group consists of working-level staff from those organizations. Thus, the process is regularly examined from varying points-of-view to ensure that it meets requirements and is efficient.

OPG continues to make use of vendor companies to Engineer, Procure, Construct (EPC) modifications that will improve the reliability of Darlington NGS and OPG facilities. To ensure use of EPC is successful, OPG is continually working to better define the requirements and level of oversight required for contracted work. EPC is managed through a quality assurance program to ensure that OPG's expectations for vendor design and installation quality are met. Refer to Section 2.1.8 for additional details regarding supply and contractor management.

2.1.6 Safety Culture

N-POL-0001 is issued by the Board of Directors and establishes the fundamental principles for OPG employees. It emphasizes the vital importance of nuclear safety and security as the top priority in all activities performed in support of OPG facilities and underscores the value that OPG places on ensuring the highest level of protection for individuals, the environment, and surrounding communities. The policy highlights the organization's firm commitment to prioritizing nuclear safety over any other consideration, including cost, schedule, or production. By adhering to this policy, OPG employees can be confident that they are contributing to a culture of safety and responsibility that is paramount to the success of the organization.

The requirements of N-POL-0001 are outlined as follows:

As Nuclear Professionals, everyone shall demonstrate respect for nuclear safety and security by:

- Knowing how your work impacts on Control the power, Cool the fuel and Contain radioactivity (3C's).
- Knowing how you can Deter access, Detect a threat and Delay the assailant (3D's).
- Applying Event-Free tools and defences to prevent events.
- Reporting adverse conditions and unusual behaviours.
- Being vigilant around the control of sensitive information and equipment.
- Acknowledging that a credible threat to security exists and that Nuclear Security is important.

Everyone shall conduct themselves in a manner consistent with the following Traits of a Healthy Nuclear Safety and Security Culture:

1. Personal Accountability;
2. Questioning Attitude;
3. Effective Safety Communication;

4. Leadership Safety Values and Actions;
5. Decision-Making;
6. Respectful Work Environment;
7. Continuous Learning;
8. Problem Identification and Resolution;
9. Environment for Raising Concerns;
10. Work Processes;
11. Vigilance.

In accordance with the policy, the Nuclear President and CNO are accountable to the CEO and the Board of Directors to establish a management system that fosters nuclear safety as the overriding priority.

The above safety and security culture traits are incorporated into OPG's organization and administrative procedures starting at the policy level and cascading throughout the charter, programs and procedures as demonstrated in Figure 4:

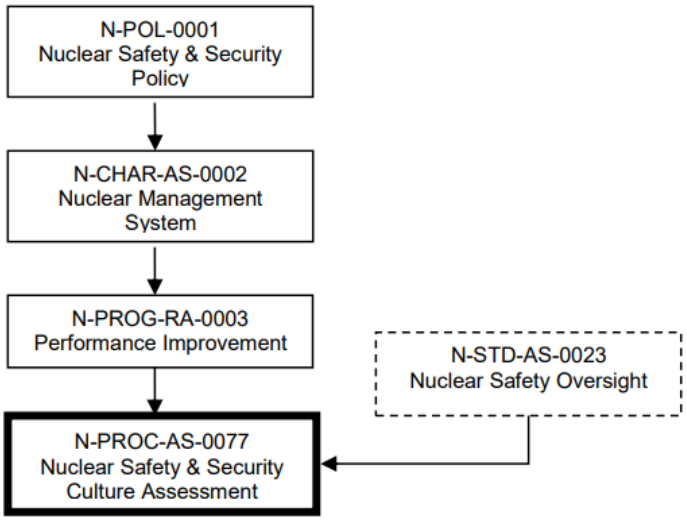


Figure 4: Safety and Security Programs and Procedures

N-STD-AS-0023, *Nuclear Safety Oversight,* summarizes the framework and accountabilities for nuclear safety oversight as well as the external and internal processes used for oversight and assessment of nuclear safety. This standard applies to all aspects of nuclear operations and to all work and other activities undertaken at or in support of the stations. Nuclear safety oversight is conducted in a manner consistent with the Traits of a Healthy Nuclear Safety and Security Culture as detailed below in Figure 5:

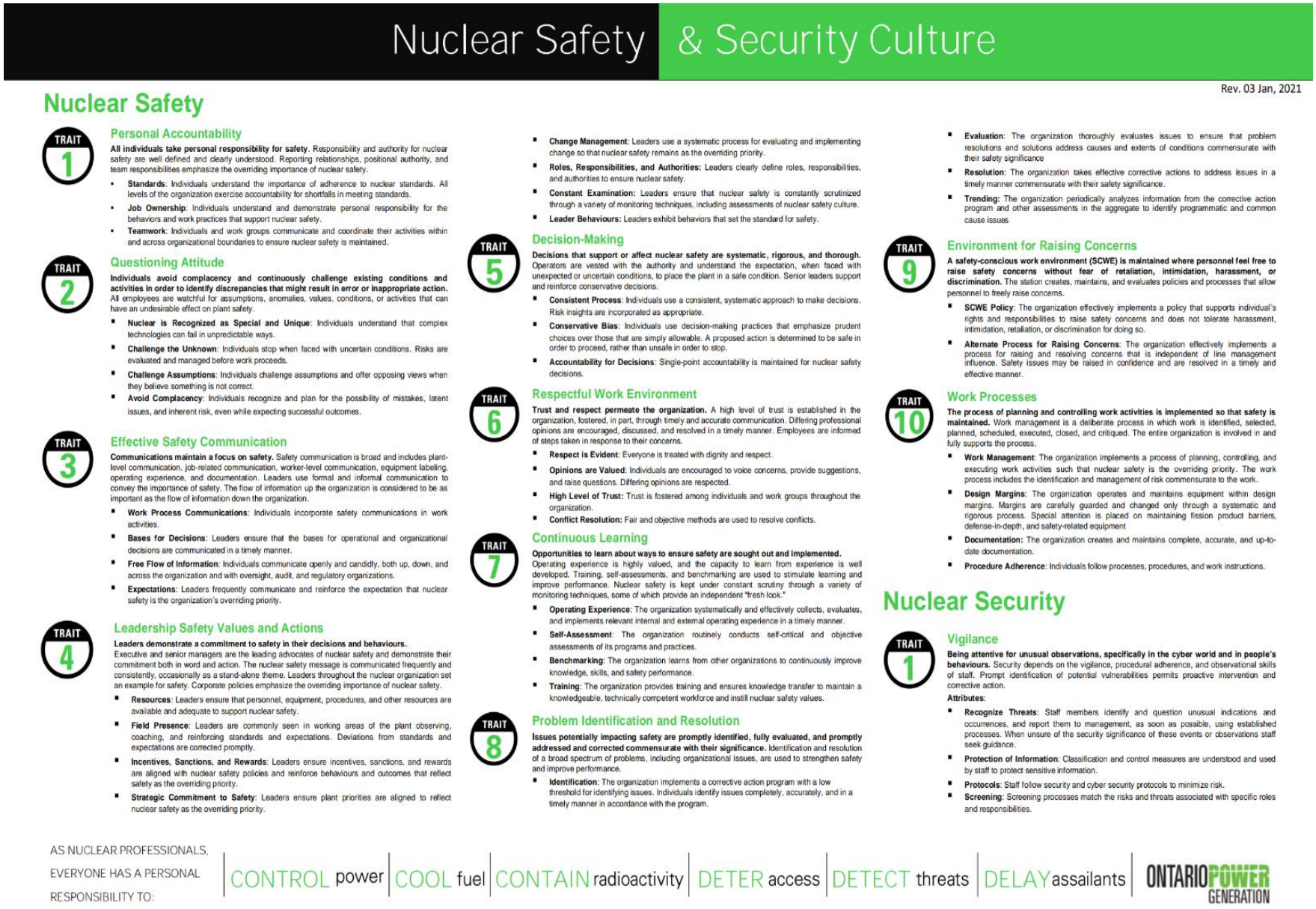


Figure 5: Nuclear Safety and Security Culture

OPG conducts comprehensive, systematic and rigorous safety culture assessments at least every 5-years in compliance with CNSC regulatory document REGDOC-2.1.2, *Safety Culture*.

In June 2021, Darlington NGS successfully conducted a station-wide Nuclear Safety and Security Culture Assessment in order to identify areas for improvement or areas of strength. The assessment included a staff survey of all Darlington NGS employees and Contract Partners on the site, as well as an on-site evaluation; including document reviews, staff interviews and observations. The 22-person assessment team included a mix of both internal and external members. 2378 people responded to the survey (equivalent to a 99.2% participation rate) with over 2300 comments provided. The on-site interviews yielded approximately 2698 data points and over 2200 comments.

The assessment focused on perceptions, attitudes and behaviours of the organization, and concluded that Darlington NGS has a healthy nuclear safety culture, strong respect for nuclear safety, and nuclear safety is not compromised by production priorities. In particular, station personnel feel they can challenge any decision if needed, without fear of reprisal. The assessment team also noted a few areas where additional focus is required, such as: expanding the qualifications of the work force, developing the proficiency of new staff, and improving the efficiency of the work management process.

This marked Darlington NGS's first evaluation since the implementation of REGDOC-2.1.2, of the Vigilance trait in Nuclear Security. The evaluation determined that Darlington NGS has a healthy nuclear security culture. However, from this first-time review, there is room for improvement in raising awareness and comprehension of potential risks and threats linked to nuclear security, including cyber security.

All results were documented in a self-assessment report in accordance with N-PROC-RA-0097 and N-PROC-AS-0077, *Nuclear Safety & Security Culture Assessments*. As per N-PROC-AS-0077, the results were communicated to staff by the Vice President via a communication within a month following the assessment, and action plans were developed with input from the Site Vice President’s direct reports and the Host Peer of the assessment. Areas for improvement were documented and actions taken to address the findings were tracked.

Since the 2021 assessment, COG, in collaboration with Canadian Nuclear Utilities, has developed a tool to assist in the assessment of the Nuclear Safety and Security Culture. This tool can efficiently process and compare all the survey and interview data, significantly accelerate the report generation process, and provide a more precise depiction of the culture within OPG facilities.

OPG will continue to conduct station-wide assessments at least every 5-years as per REGDOC 2.1.2. Current internal best practices recommend assessments at a 3-year frequency, therefore OPG has scheduled the next assessment for Darlington NGS staff and contract partners on site for 2024.

In addition to the comprehensive station-wide assessment, OPG has instituted a Darlington Nuclear Safety and Security Culture Monitoring Panel (NSSCMP) tasked with overseeing the key process indicators that reflect the state of the organization's nuclear safety and security culture. This panel, comprised of the senior plant leadership team, convenes three times annually to deliberate on the 11 nuclear safety and security culture traits. In doing so, strengths and potential concerns that merit additional attention by the organization are identified and acted upon. The use of the NSSCMP is considered to be a Periodic Safety Review strength as it exceeds the requirements of CNSC REGDOC 2.1.2 and further promotes meaningful

conversations and the sharing of lessons learned amongst station leaders to ensure any emergent issues that could impact Nuclear Safety and Security Culture are addressed.

One component contributing to these discussions is facilitated by the NSSCMP Power App. This online tool, developed in 2020, enables frontline station personnel to evaluate the 44 attributes constituting a robust Nuclear Safety and Security Culture and provide input directly to the NSSCMP. This approach allows OPG to capture insights from staff regularly working in and around the plant, helping to discern faint signals within the organization.

During the current licence term, OPG also implemented the Nuclear Safety and Security Culture Trait of the Week and accompanying App to remind staff about each of the attributes under the Traits on a rotating basis. Figure 6 depicts Trait 4 *Leadership Safety Values and Actions*.

Figure 6: Leadership Safety Values and Actions

OPG continues to have an extensive Management and Leadership development program that includes Shift Manager licensing, the First Level Manager program for managerial positions, Nuclear Professional Development Seminar training, and Senior Nuclear Plant Manager training. These courses include training on the tools that supervisors use to reinforce the expected behaviours in the workforce that reflect a strong Nuclear Safety Culture and enhance supervisors' ability to identify, analyze and solve leadership issues encountered in nuclear plants and sustain and strengthen job performance. The Safety Culture for Managers training is in the process of being updated and refreshed for new managers coming into role using updated OPEX from industry events.

OPG has a strong commitment to use external review mechanisms, such as WANO and the NSRB, to ensure that the company maintains high standards of operational performance. An extensive framework of internal oversight, including the Generation Oversight Committee, Nuclear Executive Committee, Nuclear Safety Oversight Committee, and independent

assessments conducted by Nuclear Oversight, provides a comprehensive and critical evaluation of all activities affecting OPG on an on-going basis. These internal and external assessment mechanisms are used to identify opportunities for improvement and reinforce the culture of a learning organization.

The processes described above also ensure that a strong Nuclear Safety Culture is pervasive throughout the organization.

2.1.6.1 Safety Culture and Organizational Effectiveness

Organizational effectiveness is monitored using the INPO Staying on Top (SOT) values. INPO's SOT values is a tool used by Industry for assessing organizational effectiveness and is based on the analysis of specific, common characteristics that exist in organizations that have achieved uninterrupted high performance for decades. SOT values include: Setting Long-Term Direction, Leadership and Talent Development, Excellence Standards, Continuous Learning, and Self-Awareness and Self-Correction. OPG performs an assessment of SOT at Darlington NGS every year to constantly monitor and course correct as required.

Another tool used to monitor organizational effectiveness is the Employee Engagement survey. This pulses the organization on several key areas including commitment to the organization, the perspective of the leadership team, communication effectiveness, and alignment. This was recently done in 2022 and again at the end of 2023 OPG-wide.

Information gathered from SOT meetings and the annual assessment as well as the Employee Engagement survey are included among the inputs managers use in the NSSCMP for each Nuclear Safety and Security Culture Trait assessment.

The interactive Organizational Roadmap metrics are reviewed by the NSSCMP as part of the package put together for the NSSCMP meetings. This roadmap, developed by INPO, shows the relationship between Leadership and Team Effectiveness, SOT, Nuclear Safety Culture and Organizational Effectiveness as well as key INPO documents such as Integrated Risk Management, Technical Conscience and Operations and Maintenance Fundamentals. OPG has tied its performance objective and criteria codes that are applied to SCRs to this roadmap so that we can see if there are any trends arising that align with Nuclear Safety and Security Culture and ultimately, Organizational Effectiveness. The outcomes from the Organizational Effectiveness Reflection sessions and the SOT annual assessments are also used as indicators to the overall health of Nuclear Safety and Security culture.

2.1.7 Records Management

OPG-PROG-0001, *Information Management,* establishes a set of standards and procedures for the management of OPG's information throughout its life-cycle, regardless of media, including electronic systems such as e-mail, SharePoint, and the Intranet to ensure consistent and appropriate use. The program describes requirements for a management system of activities related to information. It also establishes uniform and efficient processes for management, maintenance, and final disposition of records and documents throughout OPG as well as the overall OPG process for governance including electronic filing, approval, distribution, and maintenance of the OPG governance framework.

Procedures under this program establish a consistent process across OPG including the establishment of a hierarchy of authority for documents, only one owner for the document, controlled release of the document for revision, controlled review of the document by stakeholders and individuals affected by the change, and the controlled approval and

authorization of the document before it is issued as a governing document. The Information Management program is applicable to all OPG employees and agents (i.e., temporary staff and contractors).

One objective of the Information Management program is the advancement of electronic, digital, and mobility solutions that provide tools that effectively and efficiently capture, change, issue, and make content available electronically to end users with the highest quality. During the current licence term, a number of enhancements were made to Information Management tools used by OPG staff. For example:

- OPG's enterprise software, Asset Suite, was recently upgraded to incorporate new features, to improve the user experience, and to maintain full vendor support. Cyber security has also evolved rapidly and is covered in Section 2.12.5.
- A new application allows workers to electronically submit and file their records and documents in Asset Suite/Curator rather than waiting on Records Centre to manually index and upload images. The tool significantly reduces turnaround time on availability and cuts manual entry of key information (metadata) about the record/document by 50% or more. The average turnaround time is less than 5 days. The application has the ability to pre-set documentation specific metadata elements (e.g., System Classification List, retention, Pressure Boundary flags, etc) to reduce keying and indexing errors. Further screens have been added to the application's automated tools to improve human performance in the governance submission process.
- The Vendor Document Management (VenDM) tool continues to be used by Nuclear Refurbishment and the Projects Organization as an electronic system for the management of vendor documentation deliverables. Vendors and OPG recipients use VenDM to process requests for information, to perform review and commenting, and for the approval of documentation including application of electronic stamps.
- Electronic Work Packages are used by Darlington NGS Maintenance to allow the use of tablets for downloading work order tasks and associated documentation for use in the field. Workers can mark up/place keep using the electronic procedures and proceed to record their test results and final work completion reports. This solution eliminates a paper-based process from Work Order binders to final records.

A new application is planned to be used to further automate OPG's client service processes. Initial consultations are complete to embed key information management processes in the tool, to improve control for the many OPG workers who handle confidential security information, and to automate external information exchange and Legal Hold processes.

In conjunction with the Cyber Security program data protection project, the security document access process is planned to be upgraded/modernized to take best advantage of evolving encryption protections and to automate the approvals and Asset Suite access.

Records projects are underway to decrease the amount of legacy paper records in physical vaults and to scan quality assurance records for ease of access and secure fast retrievals.

2.1.8 Supply and Contractor Management

Supply and Contractor management are performed in accordance with OPG-PROG-0009, *Items and Service Management*, which interfaces with OPG-PROG-0038, *Contract Management* for managing contracts for services.

OPG-PROG-0009 establishes a governing document framework that meets regulatory requirements and ensures effective and efficient planning for, and procurement of items and service. OPG-PROG-0038 establishes a governing document framework for managing contracts related to contractor services.

The supply chain organization is responsible for providing the necessary services and materials in a timely manner and of the appropriate quality to the Darlington NGS site. Supply Chain confirms all the quality aspects for receipted materials based on designated quality requirements. The contract owner confirms quality aspects for services. Vendor quality is maintained through audits, receiving inspections, and vendor oversight and surveillance.

OPG's Counterfeit, Fraudulent and Suspect Items (CFSI) program is implemented through N-PROC-MM-0021, *Supply Inspection*, N-GUID-08173-10010, *Receiving Inspection Guideline,* Supply Chain Quality Services Supplier Audit Checklist(s) N-TMP-10294 and N-GUID-01900-10005, *Guideline to Identify Counterfeit, Fraudulent and Suspect Items*, and is aligned to industry best practices. All suppliers to OPG are required to have an implemented CFSI program and this is verified by supplier audits carried out by OPG.

Enhanced purchasing clauses and receiving inspections have been in place for several years to prevent CFSI material from being supplied to or received by OPG. Standardized training on CFSI was developed and implemented to support this program. External reviews and benchmarking indicates that OPG's CFSI program is an industry-leading, well established and an effectively implemented program.

OPG has also improved the supply chain quality engineering and supplier performance management process (N-PROC-MM-0041, *Quality Engineering and Supplier Performance Management*), which involves identifying and managing supplier quality issues from SCRs, audits, receiving inspections, and vendor oversight and surveillance activities.

2.1.9 Business Continuity

The objective of OPG-PROG-0033, *Business Continuity Program,* is to establish a managed system for business continuity, and to provide direction related to business and operational continuity, and recovery planning.

The Business Continuity program is aligned with OPG's business goals and objectives. It ensures that if a disruption occurs or if there is a threat of disruption, critical business and operational processes continue to be available, or resume to at least the defined minimum operability within required time limits. Business Continuity is structured as an 'all hazards' program adaptable to a range of hazards, or a combination of multiple hazards, including Human Health Emergency (e.g., COVID-19 pandemic).

OPG has continuity plans in place for Darlington NGS which were revised in 2022 to reflect an approach which considers many different natural and technological hazards, as well as the pandemic scenario and staffing strategies during pandemics (principles which also apply to other considerations such as labour disruptions). These plans will continue to be reviewed and updated at a minimum every 3-years or when major changes occur.

OPG has an enterprise-wide Infectious Disease Response Guideline which replaces previous pandemic plans. This response guideline outlines OPG's strategic approach to respond to any infectious disease introduced into the workplace from a singular incident up to a full pandemic response. This guideline and the associated Infectious Disease Incident Response Team were utilized effectively as a part of OPGs Emergency Response Organization in response to the

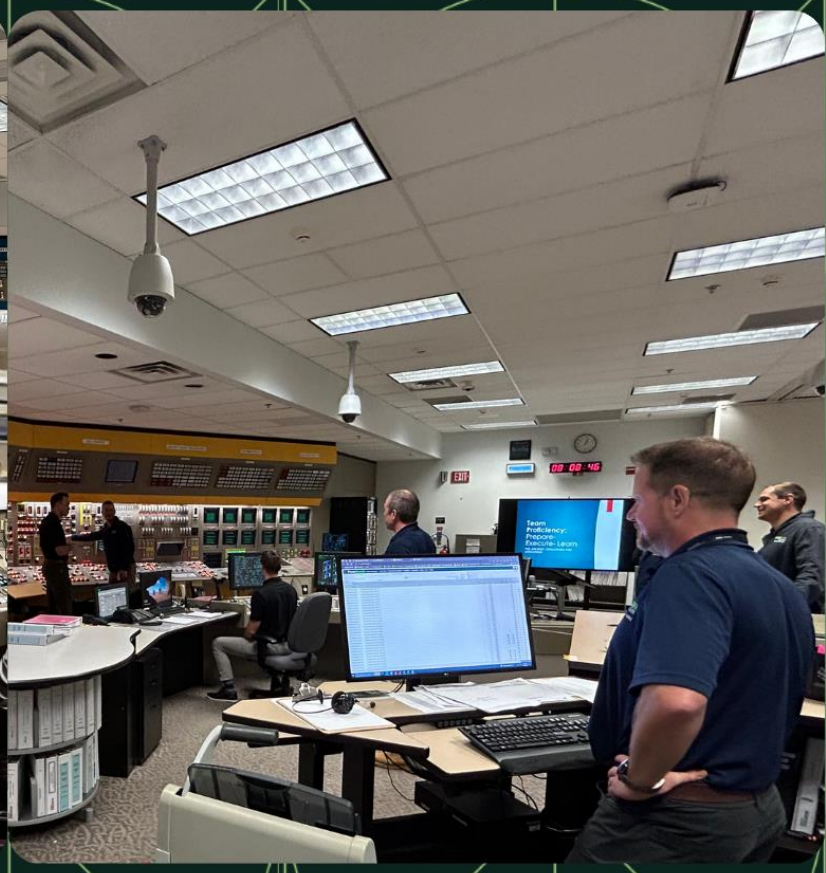
COVID-19 pandemic to support safe operations during this period. Following the COVID-19 pandemic, OPG conducted a review of the response to capture lessons learned, best practices and identify areas for improvement within the Business Continuity program to maximize OPGs preparedness against future pandemics.

In 2022, Nuclear Oversight conducted an audit of the Business Continuity program at Darlington NGS, to determine whether the program requirements defined in governance are met and are effectively implemented to support safe and reliable operation with deficiencies corrected as required. This performance-based audit of the Business Continuity program identified that the managed system controls are effective.

OPG continues assessing and further developing effective response strategies to address enterprise ransomware events. As previously mentioned, cyber security has also evolved rapidly and is covered in Section 2.12.5.

Section 2.2

Human Performance Management



2.2 Human Performance Management

Darlington NGS has an effective Human Performance Management Program that meets or exceeds all applicable regulatory requirements and related objectives to enable effective Human Performance through implementation of processes that ensure a sufficient number of licensee personnel are in relevant job areas, have the necessary knowledge, skills, procedures and tools in place to safely carry out their duties.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 2: SCA 2 – Human Performance Management

Document	Title
N-PROC-OP-0047	Limits of Hours of Work
N-LIST-09110-10005	Listing of Broad Population and Safety Sensitive Job Codes
N-PROG-AS-0002	Human Performance
N-STD-AS-0002	Procedure Use and Adherence
N-STD-OP-0002	Communications
N-STD-OP-0004	Self-Check
N-STD-OP-0012	Conservative Decision-Making
N-STD-RA-0014	Second Party Verification
N-PROC-OP-0005	Pre-Job Brief / Safe Work Plan and Post-Job Debriefing
N-CMT-62808-00001	Continuous Behaviour Observation Program (CBOP) – Participants Materials – Workbook Components
D-PROC-OP-0009	Station Shift Complement
D-INS-09260-10001	Duty Crew Minimum Complement Assurance
N-PROG-TR-0005	Training
N-PROC-TR-0008	Systematic Approach to Training
N-INS-08920-10004	Written and Oral Initial Certification Examination for Shift Personnel
N-INS-08920-10002	Simulator-Based Initial Certification Examinations for Shift Personnel
N-INS-08920-10001	Requalification Testing of Certified Shift Personnel
N-MAN-08131-10000-CNSC-031	Responsible Health Physicist
N-MAN-08131-10000-CNSC-006	Shift Manager, Darlington Nuclear
N-MAN-08131-10000-CNSC-010	Authorized Nuclear Operators
N-MAN-08131-10000-CNSC-008	Control Room Shift Supervisor
N-MAN-08131-10000-CNSC-025	Unit 0 Control Room Operator

2.2.1 Human Performance Program

The objective of the Human Performance Program is defined by program document N-PROG-AS-0002, *Human Performance*. Darlington implements the program vision from Section 1.1:

> *"Nuclear is recognized as an event-free operator, applying error reduction techniques and controls to achieve safe, reliable, and cost-effective generation of electricity. The goal of the Human Performance program is to continually reduce the frequency and severity of events through the systematic reduction of human error and the management of defences in pursuit of zero events of consequence."*

Through the following supporting standards, N-PROG-AS-0002 drives continuous improvement of Human Performance and establishes processes to monitor and correct any organizational deficiencies to minimize human error:

- N-STD-AS-0002, *Procedure Use and Adherence:* provides requirements for usage of, and adherence to approved procedures.
- N-STD-OP-0002, *Communications:* specifies requirements for both verbal and written communication practices when performing maintenance and operating activities including expectations for three-way communication and use of phonetic alphabet.
- N-STD-OP-0004, *Self-Check:* describes the features of the Nuclear Self-Check program.
- N-STD-OP-0012, *Conservative Decision-Making:* provides management expectations for a conservative decision-making culture and establishes responsibilities and accountabilities for affected managers to ensure conservative decisions are made.
- N-STD-RA-0014, *Second Party Verification:* establishes the scope and extent of verification and degree of independence required and, to prevent errors going undetected, specifies requirements for verification when a second person confirms a specific task or activity satisfies established requirements.

Darlington NGS Refurbishment implements NK38-NR-PLAN-09701-10001, *Nuclear Refurbishment Human Performance Plan*, for Darlington NGS units which are operating within the construction island. NK38-NR-PLAN-09701-10001 is aligned with and referenced in N-PROG-AS-0002.

Darlington NGS leaders recognize that an understanding of the role of Human Performance in safety, supported by leadership and employee behaviours, helps prevent human error-related events. Human Performance standards and expected behaviours are defined, established, and incorporated in processes, procedures and training.

The primary intention of the Human Performance Program is to create continuous improvement within the organization and to reduce the potential for human error through the use of appropriate analysis methods or techniques. The advantages of this are in improved safety, quality, and efficiency. Initiatives to provide staff with an understanding of the factors that influence Human Performance and provide them with a set of tools and references to predict, manage, and prevent error-likely situations include:

- Enhanced communications (e.g., station spotlight, weekly focus area), increased awareness during periods of time when there are higher vulnerabilities for errors, outage

and on-line unit/station specific messaging delivered to key audiences at appropriate times using past Operating Experience (OPEX), and current trending data.

- Station Condition Records and Corrective Actions Plans are leveraged to improve performance trends in accordance with N-PROC-RA-0022, *Processing Station Condition Records*;
- In 2022, OPG implemented OPG-STD-0173, *Fail Safe Strategy*, which focuses on adding barriers, capacity, and defences rather than relying on humans to be error free;
- A new digital/electronic platform was created in 2023 to embed fail safe into safe work planning, Pre-Job Briefs and Post Job De-briefs;
- An emphasis has been placed on implementing and enhancing N-INS-09030-10004, *Observation and Coaching*. Observation and Coaching (O&C) have three main groups:
    1. Peer-to-peer coaching: Staff are encouraged to coach each other to ensure safety and promote learning.
    2. Supervisor Oversight/Field Presence: Planned O&Cs. Usually from the direct supervisor on a specific activity to improve performance of the workers.
    3. Paired O&C: A leader observing another supervisor perform an O&C and provide feedback to improve performance of our supervisors.

  Since 2020, O&Cs have been recorded in a data repository software called *iConnect.* The data is trended and reviewed in various forums.
- There is focus on individual and team proficiency through oversight of crew composition and individual development. Darlington NGS understands that qualifications are an important piece of proficiency, but not the only part of ensuring that a job is completed safely.
- Tracking, trending and actions taken on organizational learnings identified from Department Event Free Day Resets and lower-level events identified as Crew Learnings in accordance with N-INS-09030-10002, *Site and Department Level Event Free Day Resets*.

The effectiveness of the Human Performance Program has resulted in Darlington NGS achieving top industry performance in Site Event Free Day Resets (SEFDRs). N-INS-09030-10002, establishes the criteria which is used to measure the Human Performance events. Monitoring this performance as depicted in Figure 7 below demonstrates a reduction in consequential events attributed to Human Performance errors. Figure 7 also shows the trend of SEFDRs rates, yearly counts and their associated targets from 2015 to date.

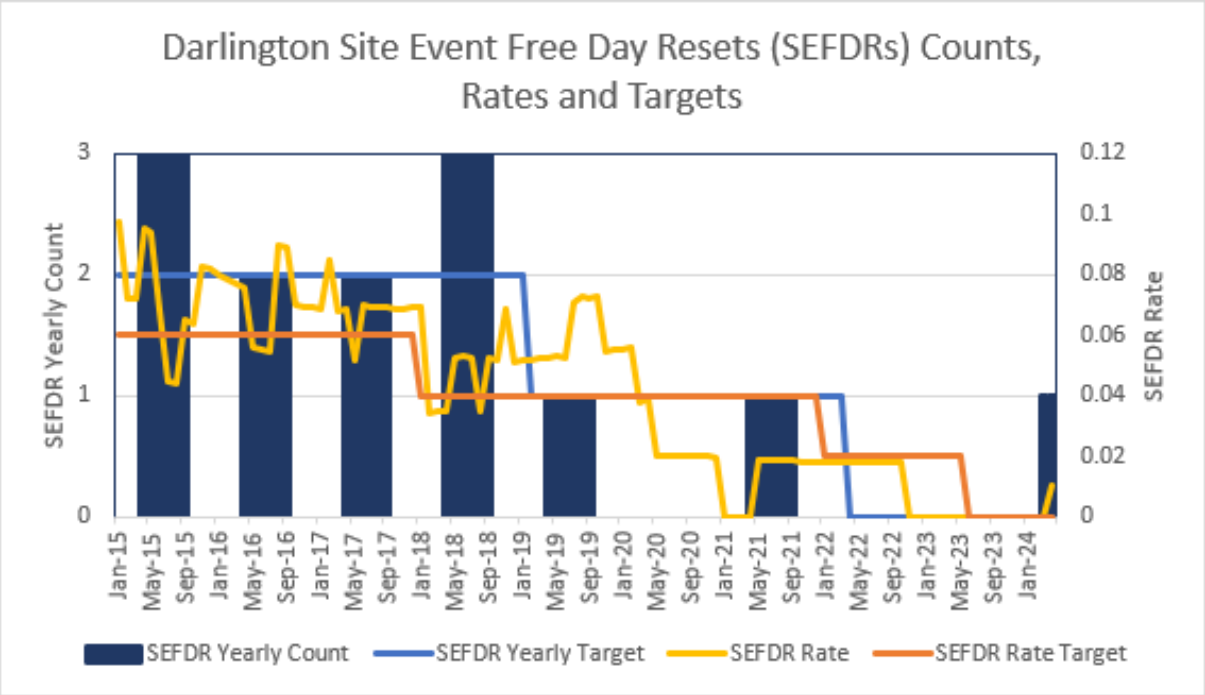


Figure 7: Darlington Site Event Free Day Resets

The number of SEFDRs had decreased since 2015 and the target was improved from 2 to 1 in 2019. To further challenge ourselves for continual improvement, the target was improved to 0 in 2022. The last SEFDR occurred April 23, 2024; a record 1074 days between events during the licencing period.

Planned Improvements

OPG is aligning with current industry best practices by enhancing Human Performance tools. These tools, specifically *Event Prevention Tools* help the individual worker maintain positive control of a work situation by increasing self-awareness, understanding and focus to identify hazards and risks which require mitigation. This is further enhanced by the application of the *Core 4+* initiative which is applied during work activities, regardless of the risk perception associated with the task. *Core 4+* comprises of the following event prevention tools:

- Pre-Job Briefing/Post Job Debriefing;
- Procedural Use and Adherence;
- 2-minute Job Site Drill;
- Verification Practices.

At the center of these tools is *Stop When Unsure* that is to be used at anytime during the job process as illustrated in Figure 8.

Figure 8*:* Core 4+

The addition of *Stop When Unsure* to *Core 4+* is also aligned with creating and supporting a healthy nuclear safety and security culture with the support of the *Positive Stop Work Program* where an environment for raising concerns is cultivated, encouraged, and positively recognized by Leaders in the organization. As part of this initiative, training associated with *Stop When Unsure* will enhance the use of questioning attitude by teaching supervisors and workers how to recognize cues when they are unsure and the steps for how to resolve any aspects that are required to reduce potential for error and to safely execute the work event-free.

Darlington NGS continues to leverage internal and external training courses to enhance staff and leaders' knowledge in Human and Organizational Performance Principles. Dynamic Learning Activities such as the flight simulator, implemented in 2019, will continue to be used to train and reinforce the importance of event prevention tools.

As part of continuous improvement practices, Darlington NGS continues to perform routine self-assessments and benchmarking to continually identify and address areas for improvement in the implementation of the Human Performance Program.

2.2.2 Personnel Training

The training program for regular staff, contractors, temporary personnel and other staff assigned work at OPG is defined by N-PROG-TR-0005, *Training*. This document, in combination with internal training procedures, defines the key activities involved in our training process and is compliant with REGDOC-2.2.2*, Personnel Training.*

The training program provides the structure, processes, and tools for defining, developing, implementing, documenting, assessing, and improving the training required to ensure staff have the appropriate knowledge, skill, and attitudes for safe and efficient plant operation. For tracking, OPG utilizes the Training Information Management System (TIMS) which is a database application that stores and tracks training and qualification information for all staff, including contractors. The system also provides automatic updates via email for upcoming scheduled training and identifying expiring qualifications to employees and their supervisors. In 2023 alone, TIMS tracked a total of 36,644 hrs of training for Darlington NGS, comprising of computer-based training, classroom and on-the-job training.

The health of training is carefully monitored with a defined program to ensure that there is a Systematic Approach to Training (SAT) foundation for OPG's nuclear training programs upon which it continues to build and improve. Operations, Maintenance and Engineering departments have a robust continuing training program, and continuing training plans are revised and reissued on a 5-year cycle.

The Health of Training reports continue to drive improvements to OPG's major training performance areas. The quarterly reports are used to assess against World Association of Nuclear Operators (WANO) performance objectives and criteria. The reports are prepared by the training organization in co-operation with the applicable line organization and the training for each major job family is evaluated using the following objectives:

- Teamwork between Training and Line Organizations.
- Rigorous Use of SAT.
- Quality Trainers and Quality Learning Experiences.
- Organizational Capacity Sustained through Succession Planning.

Actions from the Health of Training reports successfully maintain a solid SAT foundation for OPG's Nuclear Training Programs upon which it continues to build and improve. Improvements to the training programs are driven by feedback from internal and external OPEX, Station Condition Records, Curriculum Review Committees, self-assessments, audit reports, CNSC inspections and in response to the training committee’s needs.

Planned Improvements (Innovation in Training)

The objective of innovation in training is to incorporate innovative solutions and technology into our training. Line and Training Managers effectively collaborate to create learning solutions and technologies that support exemplary worker and station performance.

Some examples of where innovative training techniques were developed include:

Fuel Handling Simulator:

Operations Training instructors improved Fuel Handling Panel Qualified Operator and Field Operator defueling performance by delivering Just-in-Time (JIT) training utilizing the newly updated Fuel Handling simulator. The updated simulator allows Operators to become more proficient in fuel handling activities all while working in a zero-risk environment. Simulator improvements include high fidelity screens and realistic cockpit and keyboards that incorporate simulated defueling scenarios. As well, the Fuel Handling team has utilized the simulator to not only expose the Operators to enhanced procedures but to fine tune the flow of what are now first-of-a-kind procedures.

Virtual Reality Crane Simulator:

Maintenance Training instructors improved crane operator performance by incorporating a virtual reality (VR) simulator into crane operator training. Training material improvements include the incorporation of simulated scenarios such as precision lifts, crane failures, and risk management decision points. The VR crane simulator offers a learning opportunity that is personalized, on-demand and realistic.

Tritium Removal Facility (TRF) Simulator:

Operations Training instructors improved TRF Panel Qualified Operator and Field Operator performance by delivering JIT training utilizing the TRF simulator. The simulator allows Operators to become more proficient in TRF evolutions such as startup and shutdown as well as time to practice team effectiveness, human behaviours utilizing Human Performance tools and first-of-a-kind procedures while working in a zero-risk environment. Simulator improvements are being implemented in 2024 to better model transients, start-up and shutdown evolutions.

Current Learning Culture and Use of Technology

Darlington NGS has established a learning culture where development is encouraged and learning resources are available at the time of need to promote proficiency and encourage employee development. At OPG we started a journey a few years ago to establish the enablers for enhancing our learning culture and the actions we will be taking as a result of our external benchmark self-assessment will help us enhance our learning culture in support of continued operational excellence. Our future growth strategy will include:

- Proficiency Heat Maps and Individual Development Plans have been created.
- Extensive use of Dynamic Learning Activities, JIT Training, Job Familiarization Guides.
- Micro-learning through Video Learning-On-Demand library with 550 videos is available to refresh skills.
- Adaptive Learning was piloted in 2021 in our Nuclear General Employee Training program and is now used in more than 10 high demand courses. It provides the right training to the right people based on previous experience, training and education.
- All Leaders are trained on Facilitative Leadership Techniques to enable learning and development.

Operations Training

Operations Training supports Darlington NGS through the development of knowledgeable, skilled, and highly competent Operations staff. This is accomplished through comprehensive initial and continuing training programs for non-licensed Operators and for persons in Certified positions, including Authorized Nuclear Operators, Unit 0 Control Room Operators, Control Room Shift Supervisors and Shift Managers. The training programs are based on the principles of Systematic Approach to Training and incorporate elements of continuous learning and performance improvement.

The Operations Training program supports safe and reliable plant operation through training and reinforcement of Operator Fundamentals and Human Performance error prevention tools. Operator Fundamentals are embedded in all aspects of the training program and are utilized as a basis for evaluating operator performance. Inclusion of OPEX in training is a key element of continuous learning and performance improvement.

JIT training is delivered to ensure critical evolutions are conducted safely and efficiently. It reinforces Nuclear Safety culture, expectations and behaviour. Some examples of when JIT training is conducted for Operations include unit shutdown, heat transport system warm-up and cooldown, approach to critical and turbine run-up and shutdown. The effective implementation of JIT training has been instrumental in the successful return to service of the refurbished Darlington NGS units which contain a fresh fuel core and where systems have been modified such as the turbine-governor control system.

More recently, the use of Prepare-Execute-Learn as a methodology was introduced to minimize the probability and consequences of Human Performance events. This is accomplished by identifying Human Performance precursors up front, by implementing well established Human Performance tools to prevent and mitigate errors and by strengthening feedback processes to promote continuous learning. Operations Trainers assist line management by promoting self-awareness among staff and reinforcing the use of Human Performance error reduction tools and techniques during training activities in the classroom, the simulator and in the field.

Other initiatives include:

- Incorporation of a flight simulator in Human Performance training. The course introduces the trainees to the psychology behind the Human Performance tools. Following completion of the theoretical classroom portion, the trainees are provided an opportunity to practice the Human Performance tools/techniques using various interactive simulations in a flight simulator. This places the trainee in an unfamiliar environment, different from the station, where they are able to observe the full benefits of the Human Performance tools/techniques while being challenged with distractions and competing priorities.
- Development and upgrades to control panel simulators for the Fuel Handling, Tritium Removal Facility and Target Delivery Systems.
- Use of Video Learning-On-Demand as a valuable tool that is available 24/7 to enhance work preparation and pre-job briefs.
- Development of Dynamic Learning Activities to promote effective use of Operator Fundamentals and Human Performance error prevention tools.
- Main Control Room simulator upgrades to improve versatility and maintainability.

Maintenance Training

Maintenance Training and Station Maintenance organizations continue to collaborate on Workshops and Dynamic Learning Activities to build proficiency and verify performance to standards and expectations. The scope is defined through Curriculum Review Committee, Staying on Top, and Continuous Improvement meetings based on direct observations of performance. Technical areas that have been delivered through continuing training cycles including: ground fault detection and correction using a systematic based approach, foreign material exclusion, compressors, troubleshooting plan development, bolted joint workshops on performance standards, governance and best practices, electrical safety, bearing alignment which included use of laser alignment tools, tube bending, and precision measuring tools. Human Performance elements include: verification practices, peer coaching, interactive pre-job briefings, and the 2-Minute Job Site Drill are also included.

Maintenance Training have implemented innovative solutions using virtual interfaces, including a Crane Virtual Reality Simulator. This training approach also improves accessibility to training resources when station equipment is in use. In addition, portable demonstration units have been implemented for gasket and leak mitigation training. These units focus on bolted joint proficiency building and are available for use in both the training environment and onsite to support work preparation and ongoing rehearsal.

Engineering Training

Engineering training focuses on core elements of nuclear professionalism and culture by concentrating on key elements of conduct and behaviours within the learning material. Training material has been organized to expand and make engineers aware of the library of proficiency enhancing learning material. A strong collaborative effort has been directed to collect and share learning to improve knowledge transfer and OPEX. Engineering training has built an extensive library of videos and other presentation material of individuals sharing lessons learned.

Engineering training has a robust continuing training program. An important component of this training program is the Conduct of Engineering Workshops. Every year senior engineering leaders select a new topic and the material is developed and delivered to approximately 1200 OPG engineers. The chosen topic is a backdrop to the application expected behaviours within the engineering community and an opportunity to reinforce culture.

Many others outside of Enterprise Engineering take some components of this training to enhance knowledge of nuclear operations.

Leadership Training

Leadership Training at OPG designs and delivers enterprise-wide leadership development programing to all leaders. Applying a blended training approach, initial and continuing training programs are co-delivered with line leaders and subject matter experts from across the company to bring diverse thoughts, ideas and perspectives, to enhance the learning and sharing of OPEX. The program focuses on supervisor fundamentals and accountabilities (safety and compliance) and leadership behaviours (culture, coaching, communication and facilitative leadership).

Throughout 2022 and 2023, continuing leadership training focused on Facilitative Leadership, promoting the power of collaborative action through the seven practices of a Facilitative Leader. Additionally, OPG offers leadership development opportunities through industry partners and experts including Institute of Nuclear Power Operations, World Nuclear University, CANDU Owners Group (COG) and WANO (including *Leading Nuclear,* an international partnership with EDF Energy UK). Examples include:

- Nuclear Professional Development Seminar to benchmark and learn best practices of leadership, working relationships, human performance, human behaviours, safety culture, teamworking and change management. The course, designed for senior plant staff, allows participants to review management issues and problem solving through case studies and industry experience.
- Leading Nuclear Program which focuses on strengthening knowledge transfer between nuclear sites and developing staff through mentoring.

  Participants form lifelong support networks with counterparts from different plants and countries. It's a valuable opportunity for senior managers looking to enhance their leadership skills and prepare for higher-level responsibilities in nuclear power plants.

Emergency Response Organization Training

Alignment between Emergency Preparedness Training and Enterprise Emergency Management teams is maintained through formal reviews of potential training needs identified in field performance observations during training sessions, both through classroom and on-the-job training. OPG extensively uses drills and real events as means of continuous learning through post training critiques and feedback. In 2022, a broad improvement initiative was implemented to improve the documentation and analysis of training program elements and benchmarking and best practices with OPG Training.

2.2.3 Personnel Certification

As per the Power Reactor Operating Licence (PROL), the initial and continuing training programs for the certified persons at Darlington NGS are designed in accordance with CNSC regulatory document, REGDOC-2.2.3, *Personal Certification, Volume III, Certification of Persons Working at Nuclear Power Plants*. This regulatory document specifies the requirements to be met by persons working, or seeking to work, in positions for which a certification by the CNSC is required. It also specifies the requirements regarding the programs and processes supporting certification of their workers that licensees must implement to train and examine persons seeking or holding a certification issued by the CNSC.

Darlington NGS's PROL requires individuals who are appointed to the following positions have valid CNSC certification:

(i) Responsible Health Physicist (RHP);

(ii) Shift Manager (SM);

(iii) Control Room Shift Supervisor (CRSS);

(iv) Authorized Nuclear Operator (ANO);

(v) Unit 0 Control Room Operator (U0 CRO).

Consequently, Darlington NGS is responsible for training and testing workers to ensure that they are fully qualified to perform the duties of their position, in accordance with the regulatory requirements.

The processes used to train and qualify persons for initial certification as SMs, CRSSs, ANOs and U0 CROs are outlined in the following training qualification documents:

- N-TQD-101-00001, *Authorized Nuclear Operator Initial Training and Qualification Description;*
- N-TQD-102-00001, *Nuclear Shift Manager/Control Room Shift Supervisor Initial Training and Qualification Description;*
- N-TQD-105-00001, *Darlington Unit 0 Control Room Operator (CRO) Initial Training and Qualification Description.*

The process used to train and qualify persons for initial certification as RHPs is outlined in:

- N-TQD-443-00001, *Radiation Protection Training and Qualification.*

The processes used to ensure certified persons maintain their qualification are outlined in:

- N-TQD-103-00001, *Nuclear Certified Personnel Continuing Training and Qualification Description;*
- N-TQD-443-00001, *Radiation Protection Training and Qualification.*

Both initial and continuing training programs are based on N-PROC-TR-0008, *Systematic Approach to Training* as required by REGDOC-2.2.3 Vol III and REGDOC-2.2.2.

Table 3 contains the number of certified staff at Darlington NGS as of May 6, 2024.

Table 3: Certified Staff at Darlington Nuclear

Certified Position	Number of Certified Staff	Number of Trainees
Shift Manager and Control Room Shift Supervisor	29	26
Authorized Nuclear Operator	64	6
Unit 0 Control Room Operator	18	1
Responsible Health Physicist	5	0

The continuing training program for Certified Operating staff is at a mature stage. This training includes refresher training and update training for design or engineering changes, infrequently performed test and evolution exercises, JIT training and formal evaluations (knowledge and performance) of certified staff. Certified Operating staff complete greater than 200 hours per year of continuing training.

In line with our industry peers, Certified Operating staff have internalized the need to maintain a Line of Sight to the Reactor Core in all aspects of unit operations. This includes initiatives to improve leadership and team effectiveness; creating a culture of continuous learning, promotion of conservative decision-making; recognition and mitigation of proficiency shortfalls, improving operator training, promoting understanding of procedures important to the protecting the core and utilizing independent oversight. Integral to this is a Training to Improve Performance initiative whereby line-identified performance issues are addressed in a timely fashion through training. This initiative has been very effective at preparing crews to respond proficiently to unit upsets.

All Certified Operating staff have been trained and qualified on the restart and operation of the refurbished units according to the process outlined in the following document:

- N-TQD-901-00001, *Nuclear Refurbishment Training and Qualification Description.*

Knowledge and performance-based training has been and will continue to be provided to Certified Operating staff prior to the restart of each refurbished unit.

Planned Improvements

In October 2023, the Commission superseded regulatory document REGDOC-2.2.3 *Personnel Certification, Volume III: Certification of Persons Working at Nuclear Power Plants* with REGDOC-2.2.3 *Personnel Certification, Volume III: Certification of Reactor Facility Workers, Version 2*. OPG has since requested a licence amendment via Reference 2.2-1 to amend the PROL replacing the current reference to the regulatory document with REGDOC-2.2.3, *Personnel Certification, Volume III: Certification of Reactor Facility Workers, Version 2.*

Version 2 incorporates changes that provides more flexibility for those persons acquiring initial certification. The update streamlines the requirements for maintaining and reinstating certification.

To ensure long-range Certified Operating staffing requirements are met, a team has been established at the OPG fleet level to model staffing numbers to 2030. The projection considers internal and external attrition as well as Certified Operating staff returning to Darlington NGS Operations as the Darlington NGS Refurbishment Project draws to a close in 2026.

The Certified Operating staffing requirements feed a long-range training plan. The long-range training plan is updated annually based on Certified Operating staffing demand and identifies Authorization Trainer resources required to meet the demand. Authorization Trainer resources are drawn from Certified Operating staff and are qualified as Trainers.

In cooperation with our industry partners through COG, Darlington NGS will be investigating opportunities to optimize and strengthen the initial training programs for Certified Operating staff. This includes improvements to selection process, optimization of program length and reviewing the scheduling of the on-the-job training to improve the development of Control Room Shift Supervisor in Training. The desired outcomes will be to improve the trainee learning experience, reduce program duration and improve candidate throughput.

2.2.3.1 Initial Certification Examinations and Requalification Tests

The following CNSC documents contain the requirements for administering the certification examinations and requalification tests required by REGDOC-2.2.3 for persons in Certified Operating positions, e.g., SM, CRSS, ANO and U0 CRO:

- CNSC-EG1, Rev.0: *Requirements and Guidelines for Written and Oral Certification Examinations for Shift Personnel at Nuclear Power Plants;*
- CNSC-EG2, Rev.0: *Requirements and Guidelines for Simulator-based Certification Examinations for Shift Personnel at Nuclear Power Plants;*
- CNSC document: *Requirements for the Requalification Testing of Certified Shift Personnel at Nuclear Power Plants, Revision 2.*

Initial certification examinations for persons who are seeking certification in one of the Certified Operating positions are conducted in accordance with the following instructions:

- N-INS-08920-10002, *Simulator-Based Initial Certification Examinations for Shift Personnel;*
- N-INS-08920-10004, *Written and Oral Initial Certification Examinations for Shift Personnel.*

Adherence to these OPG instructions ensures that initial certification examinations are administered in a consistent manner and in accordance with the requirements of CNSC-EG1 and CNSC-EG2.

OPG's Simulator Training program maintains two Darlington NGS Full Scope Training Simulators. The Simulators are used for the training and examination of persons seeking or holding certification as SM, CRSS, ANO and U0 CROs. The simulators replicate the main control room - Unit 2 and Unit 0. The simulators are modelled to operate and respond as plant systems will do under normal and transient conditions. The design, modification, and upkeep of the simulators are governed by N-PROC-TR-0023, *Simulator Quality Assurance*, and N-PROC-TR-0024, *Simulator Change Control.*

The initial certification examinations provide assurance that, at the time of their certification, candidates for certified positions have acquired the level of knowledge and skills required to work competently in their assigned position.

Requalification Testing for persons in Certified Operating positions is conducted in accordance with the following instruction:

- N-INS-08920-10001, *Requalification Testing of Certified Shift Personnel.*

This includes Written Tests and simulator-based Comprehensive Simulator Tests and Diagnostic Simulator Tests for all Certified Operating staff.

Adherence to this instruction ensures requalification tests are administered in a consistent manner and in accordance with the requirements endorsed by CNSC in e-Doc# 3385987, *Implementation of Requirements for the Requalification Testing of Certified Shift Personnel at Nuclear Power Plants, Revision 2, May 1, 2009.*

As per REGDOC-2.2.3, the initial certification examinations and requalification tests for the Responsible Health Physicist continue to be administered by the CNSC.

As required under REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, Section 3.3, Item 6 (b), OPG submits a report detailing certification exam results and pass/fail rates. Results are also supplied to the CNSC in accordance with CNSC-EG1 and CNSC-EG2 *Examination Follow-up* sections during the Certification process.

The CNSC obtains assurance that each person it certifies is qualified to carry out the duties of the applicable position by means of a regulatory oversight regime of the licensees' training programs and certification examinations based on a combination of appropriate regulatory guidance and compliance activities.

Authorization Training staff are qualified as examiners according to the requirements outlined in the following documents:

- N-TQD-602-00001, *Nuclear Trainer Training and Qualification Description;*
- N-QG-602-00001, *Operator Training Instructor Qualification Guide.*

Planned Improvements

The LCH currently permits, as a pilot project, the use of Multiple Choice Question (MCQ) format examinations for General Written Initial Certification Examinations. As part of the Authorization Program Optimization Project, OPG will be seeking to formalize the use of the MCQ format not only for General Written Initial Certification Examinations but also to extend use of this examination format to other Initial Certification knowledge-based examinations. MCQ format examinations are widely used across the industry and are used for requalification testing at OPG currently. With the MCQ format, the design and development of questions and the grading of candidate answers is more objective than modified essay style examinations. MCQ format examinations allow for the sampling of a greater number of knowledge areas over a given examination time period.

OPG will continue to demonstrate to the CNSC its capability to self-administer the Certified Operator staff training and examinations and to ensure sufficient qualified staff are available to ensure safe and reliable operation of the Darlington NGS station. This includes the requirement

that sufficient trained and qualified staff will be available to deliver these training programs throughout the continued operation and refurbishment timeframe.

2.2.4 Work Organization and Job Design

Minimum Shift Complement

The processes that ensure an adequate number of qualified workers with the correct skills and competencies within the facility at all times are captured within D-PROC-OP-0009, *Station Shift Complement*, D-INS-09260-10001, *Duty Crew Minimum Complement Assurance*, and D-INS-03490-10003, *Minimum Shift Complement Resources, Qualifications and Procedures required for Responding to Resource-Limiting Events.*

Darlington NGS Minimum Shift Complement is the minimum number of qualified workers who must be present at all times to ensure the safe operation and maintenance of the facility, to respond to all station emergencies that may arise, and to ensure adequate emergency response capability for the most resource intensive conditions.

Procedure D-PROC-OP-0009 documents and describes the qualifications and minimum number of workers required under all operating states (including Refurbishment, where applicable) and their roles and responsibilities. It also states policies in place to prevent minimum shift complement violations as well as the mitigating measures to be taken in the event a violation occurs.

Instruction D-INS-09260-10001 defines the responsibilities and describes processes to ensure that the shift minimum complement is always met. This includes usage of the Minimum Complement Coordinator Program (MCCP), Main Control Room turnovers, person-to-person relief, Duty Crew accounting, absence reporting for the Emergency Response Organization (ERO) and shift personnel and emergency role qualifications.

Instruction N-INS-03490-10003, provides instructions to ensure that procedures and qualifications linked to Minimum Shift Complement are maintained.

Management of Minimum Shift Complement

MCCP is the approved information management system dynamic software program to manage the minimum shift complement system. There are many capabilities of the system, including:

- Assignment of ERO roles for each shift.
- Tracking ERO / shift complement staff as they arrive (badge in) and leave (badge out) the protected area.
- Forecasting of staff requirements.
- Various reporting including expiring qualifications, time exception and several accounting lists.

To ensure MCCP uses the most up to date information, it is live linked to the following software programs:

1. Training Information Management System – ensures the qualification of staff assuming minimum shift complement roles.

2. Time reporting software (MyTime) – tracks the schedules of staff, including shift assignment and time off (vacation etc.).

The MCCP software reflects D-PROC-OP-0009 updates on staffing numbers and positions (after CNSC review).

Every year, changes are made to the software to update it, adding improvements, increasing efficiency, and making it more robust. Some of the most notable changes since the last licence term, starting in 2015 were:

- Daily automatic emails sent to supervisors and managers with notification of any shifts within the next two weeks that are forecasted to be below minimum complement.
- Automatic notification (email) to SMs and appropriate staff at beginning of day shift if minimum complement is not met to enable corrective actions can be taken.
- Addition of crew schedules beyond shift crews A-E (XYZ, STU, NOPQ).
- Real-time link to all ERO and workgroup positions in the Training Information Management System.
- Addition of complement history reporting capabilities.
- Added the capability to search other facilities (Pickering NGS) for qualified Emergency Response Maintainers that could be loaned to Darlington NGS if required.
- The addition of various menus, sub-menus, and new commands to improve functionality and user experience.
- Provide the ability to automatically limit the number of times an employee can be stepped up within a certain period of time.
- Implement changes that if an employee's minimum shift complement role (workgroup role) will expire within a certain time frame, it will be highlighted on the main display screen.

Changes to Minimum Complement

Since 2015, Darlington NGS has gone through organizational changes that have led to changes to the Minimum Shift Complement such as:

- Moving to a days-based maintenance program.
- Removal of the Shift Advisor Technical (SAT) position.
- Changes to Radiation Protection qualification requirements for ANOs and CROs.

To ensure the changes required to the Minimum Shift Complement would not impact the stations' ability to maintain safe operation and to respond to resource-limiting emergencies, tabletop, and field walkdown review exercises were conducted, and gaps were addressed through a Corrective Action Plan.

Darlington NGS has also implemented a mass texting system for notifying employees of the need for minimum complement coverage. The text is sent out to those with the relevant qualification, detailing the shift required and who to communicate with to volunteer for the coverage.

2.2.5 Fitness for Duty

Darlington NGS maintains robust procedures and policies to ensure that all staff members are fit for duty. OPG prioritizes the safety and well-being of the employees and recognizes the importance of their physical and mental readiness to perform their roles effectively. To achieve this, comprehensive measures to assess and monitor the fitness of the workflow are in place in order to comply with:

- REGDOC-2.2.4, *Fitness for Duty: Managing Worker Fatigue;*
- REGDOC-2.2.4, *Fitness for Duty, Volume II: Managing Alcohol and Drug Use, Version 3;*
- REGDOC-2.2.4, *Fitness for Duty, Volume III: Nuclear Security Officer Medical, Physical and Psychological Fitness.*

Regarding the implementation of REGDOC-2.2.4, *Fitness for Duty, Vol. II: Managing Alcohol and Drug Use, Version 3,* OPG has implemented programmatic elements to comply with certain requirements as mandated by REGDOC-2.2.4. On June 6, 2023, the Federal Court of Canada endorsed the CNSC's move to require pre-placement and random alcohol and drug testing for workers in Safety-Critical positions at high-security nuclear facilities however, the implementation of these requirements is currently stayed, pending the outcome of an appeal filed by the Unions' on the Federal Court's decision. All licensees, including OPG, are currently restricted from implementing pre-placement and random alcohol and drug testing pending the final disposition of the appeal, which was heard in January 2024.

Procedure OPG-PROC-0208, *Fitness for Duty: Policy of Managing Alcohol and Drug Use* identifies the processes for addressing fitness for duty as it applies to alcohol and drug use including:

- Testing procedures.
- Responsibilities and expectations.
- Prevention, assistance, and rehabilitation.
- Investigations and consequences.

Initial and continuing training elements address fitness for duty. These focus on explaining company policies, expectations, and the various employee support programs available, such as:

- The Continuous Behaviour Observation Program (CBOP). CBOP is designed to develop a supervisors and managers ability to recognize and respond to behaviours that could impact worker performance and safety.
- Additional training is provided for SMs and CRSSs on monitoring fitness for duty for safety sensitive and safety critical personnel.
- Training is conducted for the Fitness for Duty: Policy of Managing Alcohol and Drug Use program through 3 computer-based training courses:
    - A module in the yearly Nuclear General Employee Training (for all site staff).
    - Fitness For Duty – Managing Alcohol and Drug use for workers.
    - Fitness For Duty – Managing Alcohol and Drug use for supervisors.

If an OPG Security Officer suspects a worker is unfit, they deny access to the facility, and notify appropriate supervisory personnel. OPG also periodically uses canine drug monitoring at the security monitors as an additional barrier to alert Security Officers to review the fitness for duty of suspected staff entering the protected area.

Employee's Hours of Work (HoW) is also monitored. Procedure N-PROC-OP-0047, *Hours of Work Limits and Managing Worker Fatigue* prescribes the process for monitoring and controlling the HoW for Nuclear Broad Population and Safety Sensitive employees to meet the requirement set out by CNSC REGDOC-2.2.4, Ontario Employment Standards Act and Collective Agreement provisions. It includes guidance and instruction on the following:

- Hours of work (Including Regulatory limits, shift schedules and special exceptions).
- Monitoring requirements for workers.
- Reporting requirements.
- Management of worker fatigue.

The process requires that employees are aware of their time limitations, track work hours and promptly notify the first line manager in advance of a potential violation. Supervisors are also required to ensure that their employees are aware of their prescribed limit and are also responsible for monitoring their employees' HoW.

Additional HoW monitoring is completed by workgroup Single Point of Contacts. OPG has implemented a new time keeping and reporting system (MyTime) that allows for custom reports to be generated which has improved the discernment of HoW. Each workgroup SPOC monitors and reports on HoW for their departments. There has been a concerted effort by the SPOCs to educate those that approve time sheets on how to identify situations that can lead to HoW violations and how to disposition when they are identified. OPG's guide, N-GUID-08945.1-10000, *Limits of Hours of Work – Nuclear Monitoring and Reporting Process* ensures that reporting requirements are understood and complied.

Employee Programs

OPG strives to create a work environment that fosters optimal physical and mental fitness of the staff by providing a variety of employee support and educational programs.

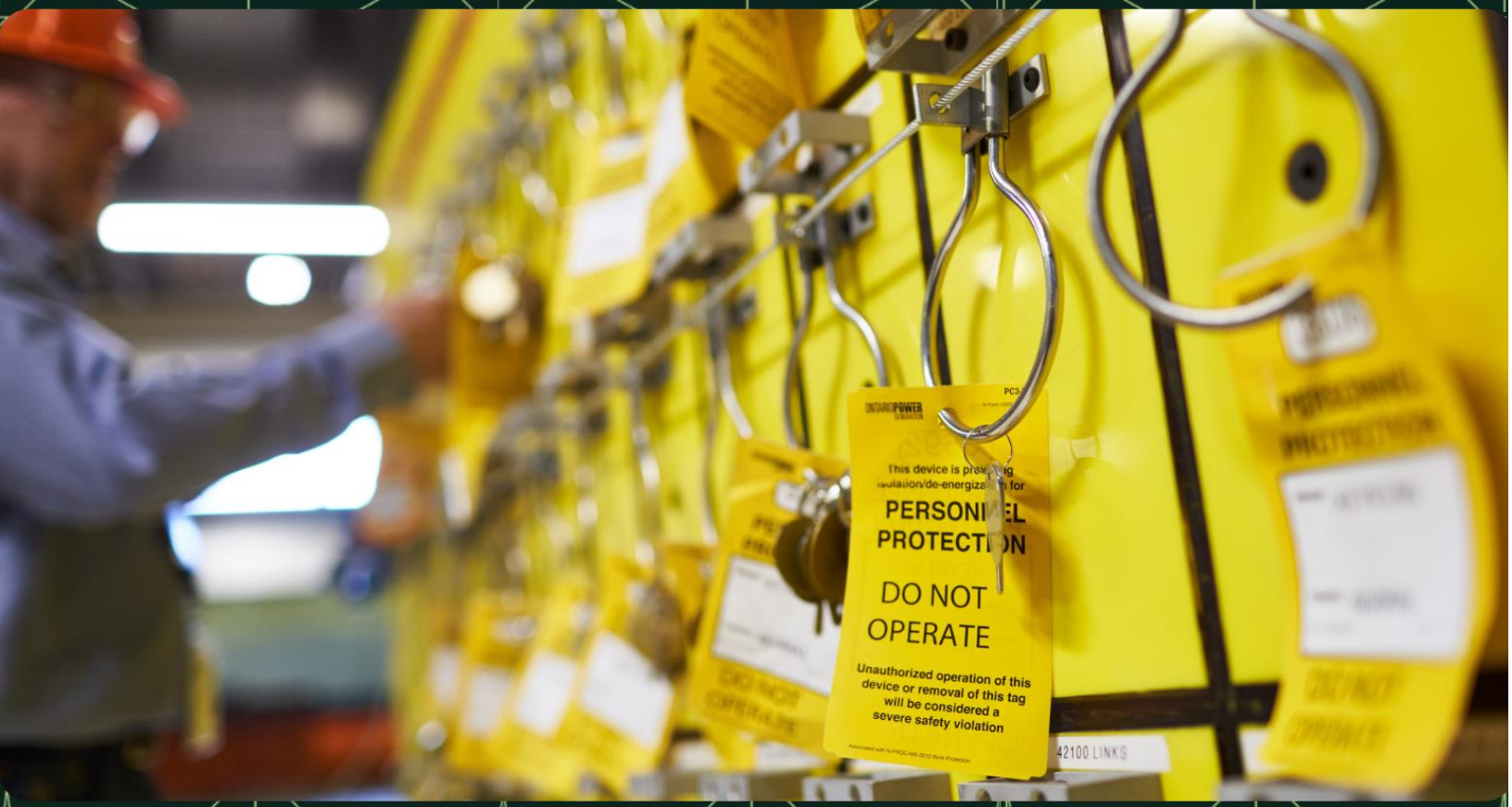
Telus Health (Employee Family Assistance Program) - supports employees and their families in dealing with a range of personal and work-related challenges by providing confidential and accessible resources including counselling and emotional support, manager/supervisor resources, educational resources etc.

Maple Telemedicine - provides employees and their families access to a licensed physician for a variety of health concern by text, phone, or video.

Addictions Treatment Services - provides virtual and confidential assistance to employees and their families who are experiencing problems with alcohol, drugs, or process addictions (ex. gambling).

Section 2.3

Operating Performance



2.3 Operating Performance

Darlington NGS has an effective Operations Program which meets or exceeds all applicable regulatory requirements and related objectives. The program ensures that plant operation is safe and secure, with adequate regard for health, safety, security, radiation and environmental protection, and international obligations.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 4: SCA 3 – Operating Performance

Document	Title
NK38-OPP-03600	Darlington Nuclear Operating Policies and Principles
N-STD-MP-0016	Safe Operating Envelope
N-STD-OP-0025	Heat Sink Management
N-STD-OP-0024	Nuclear Safety Configuration Management
N-PROG-OP-0001	Conduct of Operations/Nuclear Operations
N-PROG-OP-0004	Chemistry
N-STD-OP-0012	Conservative Decision-Making
N-STD-OP-0036	Operational Decision Making
N-STD-MP-0019	Beyond Design Basis Accident Management
N-STD-OP-0011	Operations Performance Monitoring
N-PROC-RA-0035	Operating Experience Process
N-PROC-RA-0022	Processing Station Conditions Records
N-PROG-RA-0003	Performance Improvement
N-STD-OP-0017	Response to Transients
N-PROG-MP-0014	Reactor Safety Program
N-STD-OP-0009	Reactivity Management
N-STD-OP-0021	Control of Fuelling Operations
NK38-OSR-08131.02-10001	Operational Safety Requirements: Emergency Coolant Injection System
NK38-OSR-08131.02-10002	Operational Safety Requirements: Emergency Water System
NK38-OSR-08131.02-10003	Operational Safety Requirements: Fuel and Reactor Physics
NK38-OSR-08131.02-10004	Operational Safety Requirements: Shutdown Systems
NK38-OSR-08131.02-10005	Operational Safety Requirements: Main Steam Supply System
NK38-OSR-08131.02-10006	Operational Safety Requirements: Containment
NK38-OSR-08131.02-10007	Operational Safety Requirements: Steam Generator Emergency Cooling System
NK38-OSR-08131.02-10008	Operational Safety Requirements: Moderator System
NK38-OSR-08131.02-10009	Operational Safety Requirements: Powerhouse Steam Venting System
NK38-OSR-08131.02-10010	Operational Safety Requirements: Reactor Regulating System
NK38-OSR-08131.02-10011	Operational Safety Requirements: Group 1 Service Water Systems
NK38-OSR-08131.02-10012	Operational Safety Requirements: Emergency Power Supply System
NK38-OSR-08131.02-10013	Operational Safety Requirements: Feedwater System
NK38-OSR-08131.02-10014	Operational Safety Requirements: Shutdown Cooling System

Document	Title
NK38-OSR-08131.02-10015	Operational Safety Requirements: Heat Transport System
NK38-OSR-08131.02-10016	Operational Safety Requirements: Group 1 Electrical Power Systems
NK38-OSR-08131.02-10017	Operational Safety Requirements: Darlington NGS Toxic Gas Monitoring and MCR Breathing Air
NK38-OSR-08131.02-10018	Operational Safety Requirements: Fuel Handling System and Irradiated Fuel Bays
NK38-OSR-08131.02-10019	Operational Safety Requirements: Powerhouse Steam and Flooding Protective Provisions
NK38-OSR-08131.02-10020	Operational Safety Requirements: Annulus Gas System
NK38-OSR-08131.02-10021	Operational Safety Requirements: Critical Safety Parameter Monitoring Instrumentation
NK38-OSR-08131.02-10022	Operational Safety Requirements: Shield Cooling System
NK38-CALC-63432-10001	Darlington NGS ECIS Instrument Uncertainties and Allowable values
NK38-CALC-68200-10001	Darlington NGS SDS1 Instrument Uncertainties and Allowable values
NK38-CALC-68300-10001	Darlington NGS SDS2 Instrument Uncertainties and Allowable values
NK38-CALC-63420-10001	Darlington NPCS Instrument Uncertainties and Allowable values
NK38-CALC-63671-10001	Darlington NGS Steam Generator Emergency Cooling System Instrument Uncertainties and Allowable Values
NK38-CALC-63210-10001	Darlington NGS Moderator System Instrument Uncertainties and Allowable Values
NK38-CALC-67322-10001	Darlington NGS PSVS Instrument Uncertainties and Allowable Values
NK38-CALC-63700-10001	Darlington NGS Reactor Regulating System Instrument Uncertainties and Allowable Values
NK38-CALC-64320-10001	Darlington NGS Feedwater System Instrument Uncertainties and Allowable Values
NK38-CALC-63341-10001	Darlington NGS Shutdown Cooling System Instrument Uncertainties and Allowable Values
NK38-CALC-63330-10001	Darlington HTS Instrument Uncertainties and Allowable Values
NK38-CALC-67320-10001	Darlington NGS Powerhouse Steam and Flooding Protective Provisions Instrument Uncertainties and Allowable Values
NK38-CALC-63488-10001	Darlington NGS Annulus Gas System Instrument Uncertainties and Allowable Values
NK38-CALC-60350-10001	Darlington NGS Critical Safety Parameter Monitoring Instrumentation Uncertainties and Allowable Values
NK38-CALC-63411-10001	Darlington NGS Shield Cooling System Instrument Uncertainties and Allowable Values
N-PROC-RA-0005	Written Reporting to Regulatory Agencies
N-PROC-RA-0020	Preliminary Event Notifications

2.3.1 Conduct of Licensed Activity

N-PROG-OP-0001, *Nuclear Operations*, implements a series of standards and procedures to ensure that the plant is operated safely, reliably and per regulatory requirements. The program establishes safe, uniform, and efficient operating practices and processes within nuclear facilities that provide nuclear professionals at Darlington NGS the ability to ensure the facility is operated in such a manner that the PROL, NK38-OPP-03600, *Darlington Nuclear Operating Policies and Principles*, and other applicable regulations and standards are followed. It also supports the alignment and prioritization of equipment maintenance in a manner that protects the health and safety of workers, the public and the environment.

The following standards under the Nuclear Operations program provide instructions and requirements for consistent and safe operation of Darlington NGS.

- N-STD-OP-0036, *Operational Decision Making,* provides instructions on the systematic approach to decision making. It describes the principles and attributes, roles and responsibilities, and various levels of authority when making operational decisions.
- N-STD-OP-0011, *Operations Performance Monitoring*, provides a consistent manner of identifying and reporting common and site-specific performance. It is a tool used by station management to ensure standards for performance are being maintained or improved, and opportunities for continuous improvement are identified.
- N-STD-OP-0021, *Control of Fuelling Operations*, establishes the standard requirements such that fuelling operations and conduct of activities do not adversely affect reactivity control, containment of the fuel, and cooling of the fuel.

Furthermore, N-STD-OP-0012, *Conservative Decision-Making* (under N-PROG-AS-0002, *Human Performance*) describes management's expectations on conservative decision making with regards to the safe operation of the plant, such that decisions are made with full regard to the potential safety consequences and conservative actions are taken in the face of uncertainty.

The following subsections describe critical aspects of the Nuclear Operations program.

Heat Sink Management

N-STD-OP-0025, *Heat Sink Management*, specifies the requirements for management of reactor heat removal in all planned reactor states and planned configurations when the reactor is operating in low power conditions. A variety of analyzed heat sink configurations are described in detail in operating manuals and are by design, diverse from one another such that the heat sinks are physically and electrically independent. For planned outages, heat sinks are determined and planned to account for the various stages of maintenance. For forced outages or accident conditions, the heat sink will be determined by the responsible personnel, and reactor systems are aligned by following the applicable abnormal operating procedures or Emergency Operating Procedures (EOPs).

During the refurbishment of Darlington NGS units, a project was undertaken to install two additional, conceptually different Auxiliary Shutdown Cooling (ASDC) pumps in each unit to provide an additional back up heat sink for use during outages (i.e. low pressure and low temperature conditions). The ASDC pumps and their support services are to be independent, diverse, and physically separated from the main shutdown cooling pumps to the extent practicable. The ASDC pumps provide sufficient flow to maintain primary heat transport system temperature below 90°C (194°F) from 24 hours after shutdown.

Response to Transients

N-STD-OP-0017, *Response to Transients*, defines the roles and responsibilities of operating crews when responding to transients, to ensure the unit is placed in the appropriate safe state. Operating crews regularly practice these roles through continuing training and self-assessed crew drills. Following any transient event and once the unit is in a safe operating state, a post-transient response meeting is held to confirm the cause of the event, verify that all systems and components of the unit operated as expected, ensure responses were per procedures, and initiate the appropriate corrective actions where required. Furthermore, a control room performance critique of the event will be conducted after the unit is in a stable steady state to evaluate the team's behaviours and use of operator fundamentals. Utilizing lessons learned allows for the operations team at Darlington NGS to continually improve their performance and ensure continued safe operation of the station. Detailed descriptions of transient events are well documented.

Reactivity Management

N-STD-OP-0009, *Reactivity Management*, applies systematic processes for monitoring and controlling reactivity in the core and stored nuclear fuel to ensure that reactivity is consistent with fuel design and operating limits.

Reactivity management performance of the station is measured using the Reactivity Management Index (RMI) (refer to Figure 9). It is a standard calculation used in the industry to gauge performance and facilitate benchmarking comparisons between individual plants and utilities. Prior to 2020, Darlington NGS had a RMI target of 95%. Due to demonstrated consistent improvement and high performance in reactivity management in recent years, Darlington NGS has raised its RMI target, including a target of 99.1% in 2023.

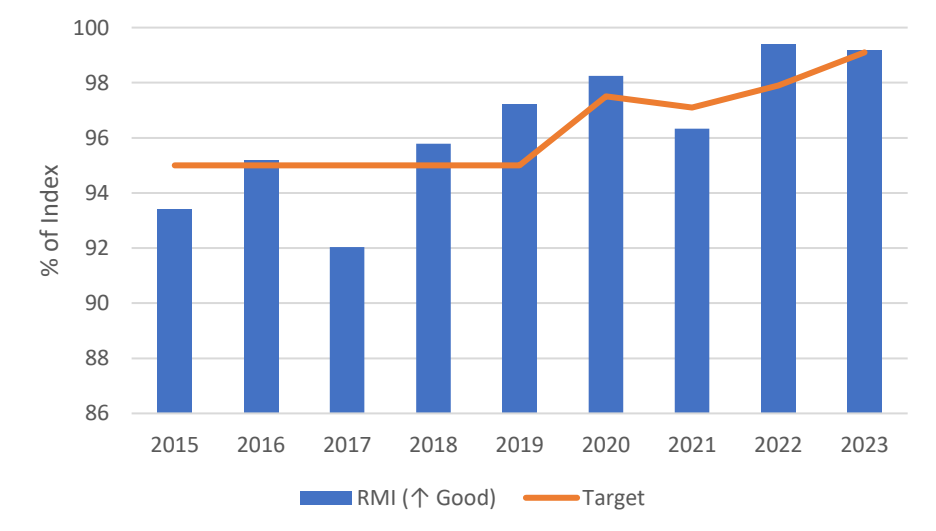


Figure 9: Darlington Average RMI vs Target (by Year), 2015-2023

Plant Status Control

The Plant Status Control program consists of different elements such as N-STD-OP-0024, *Nuclear Safety Configuration Management*, and N-STD-OP-0003, *Operations Narrative Logging*, to ensure that configuration of the station systems and components are monitored and controlled. It involves tracking the various operating conditions, parameters, and activities of the plant in real-time to ensure safe and efficient operation. Plant status control serves several important purposes including ensuring safety, improving operational efficiency, and fault detection.

Darlington NGS tracks significant mispositioning events using Mispositioning Index Value (MIV) (refer to Figure 10). Prior to 2020, Darlington NGS had a target of 97% which has been increased in recent years to drive continual improvement, along with the implementation of several initiatives and corrective actions for improved performance.

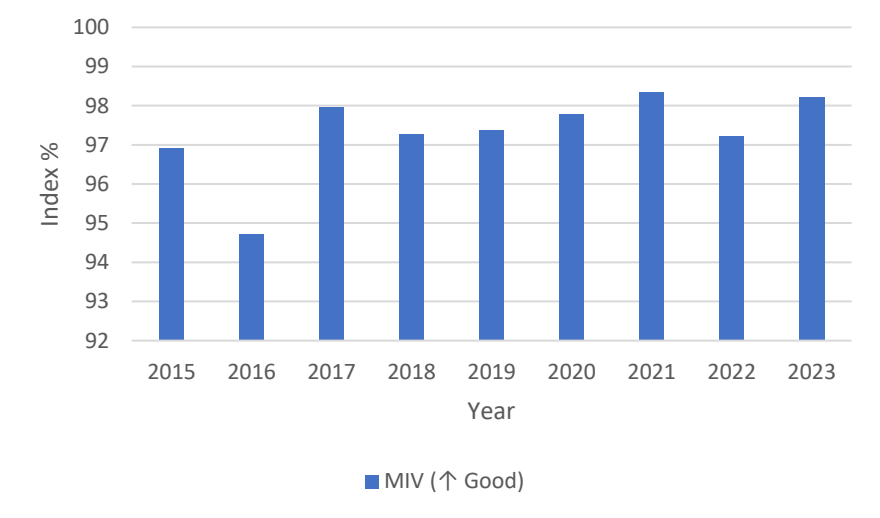


Figure 10: Average Mispositioning Index Value (by Year), 2015-2023

The Plant Status Control program at Darlington NGS strives for continuous improvement through new initiatives, innovation, and automation. The following software applications are utilized by Darlington NGS to support plant status control, and improvements have been made to the applications as discussed below.

- Equipment Status Monitoring (ESM) is used for tracking the position of system devices and components, work protection administration, temporary change requests for documenting system modifications and reactor outage alignments, flowsheet management, and creating equipment tags and status control tags. The current version of the program, ESM3R, is fully electronic and upgraded from the previous versions, which has improved efficiency in the work protection process. The improved electronic work protection process eliminates potential for human errors of older processes that were a combination of electronic and paper-based.
- Operator Shift Log (OSL) is a computer program for administrating Operational narrative logging requirements. It documents the chronological summary of shift activities and is used as part of shift turnovers to acquaint operators with unit conditions. It allows for quality operations logs to be maintained and include pertinent information such as

enhanced monitoring requirements, equipment condition summaries, and abnormal station conditions. A new HTML-based version of the OSL program has been implemented, which has benefits such as remote accessibility and being linked in real-time to other key applications such as ESM3R and Equipment Status Log (ESL).

- ESL is used at Darlington NGS by Fuel Handling and Chemistry for control and monitoring of ion exchange columns, in addition to monitoring, controlling, and tracking of changes to plant systems, structures, and components. The ESL program was updated during the current licence term to improve speed and user experience.

Improvements have been made to signage at the station including signage updating and simplification to ensure proper access and operation of overhead doors, and signage installation for emergency mitigating equipment to ensure clearance is maintained for emergency access.

Current ongoing initiatives for the Plant Status Control program include:

- New harsh environment tags being created for over 4000 tags to ensure compliance with N-PROC-OP-0034, *Equipment Labelling*.
- Signage updates for chemical storage areas.
- Main Control Room (MCR) key storage equipment and labelling has been updated. Key lists and tracking logs are in the process of being updated.

Work Protection

The Work Protection program is governed by N-PROG-MA-0015, *Work Protection,* which describes requirements that are in place within OPG Nuclear to isolate and de-energize equipment to ensure worker safety. These isolation and de-energization requirements are known as "Work Protection". The program includes a description of management processes, existing corporate governance that further operationalizes this program, and roles and responsibilities that are in place to ensure worker safety where work on equipment requires isolation and de-energization.

Worker safety is achieved through the effective application of a work protection standard and procedures to ensure physical and administrative barriers are established between the energy source and the worker. Work Protection establishes safe conditions for work by creating a Safe Work Area to ensure complete isolation and de-energization of isolated equipment.

The objective of the physical and administrative barriers is to prevent breakthrough events that can expose staff to hazardous energy. As such, the key measure is the number of Level 1 events (events where there were no barriers for potential exposure to hazardous energy). The results of this measure will determine the corrective action requirements to improve performance. Operations Managers own the Work Protection program at the site and provide oversight through the:

- Nuclear Work Protection Review Board: review and provide oversight of the work protection performance in Nuclear. This includes significant trends or events and their associated corrective action plans.
- Local Work Protection Review Board (LWPRB): provide oversight of the Work Protection performance at the Site. The LWPRB reviews and provides oversight and analysis of recent events at all sites, corrective actions of events, Operating Experience (OPEX) and work protection training issues.

- Site Work Protection Working Committee: monthly meetings held to allow workers the opportunity to raise any work protection issues at site. Issues and actions to be reported to LWPRB as required.

The Work Protection Performance Index (WPPI) is a measure of work protection performance. The number and significance of work protection events that occur on site each year affects the index. The annual trend in the WPPI metric is shown in Figure 11. An improvement in WPPI has been realized in the current licence term.

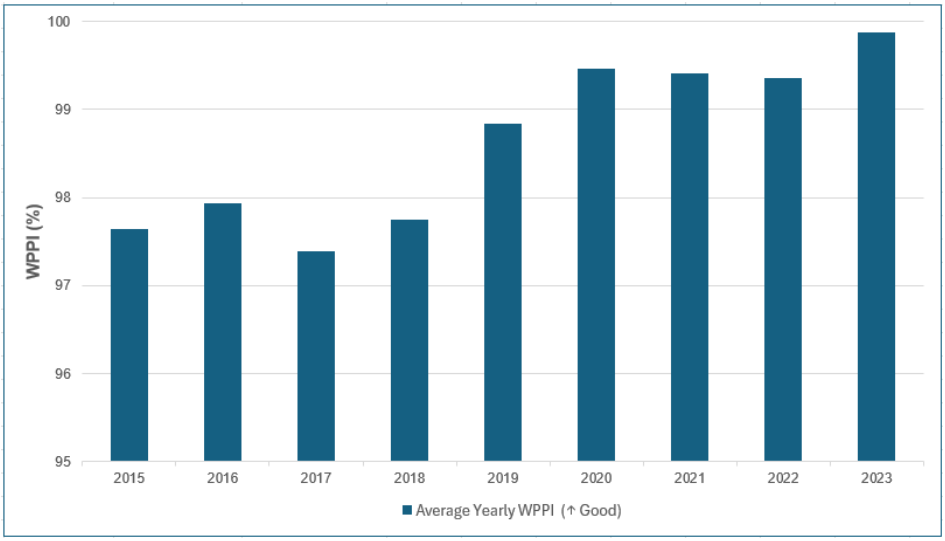


Figure 11: Darlington NGS Yearly Average WPPI

2.3.2 Procedures

As part of the Nuclear Operations program, clear, concise, and accurate procedures are essential for the safe operation of the plant and for efficient and adequate response to transient situations. N-STD-AS-0002, *Procedure Use and Adherence* is in place and provides the requirements on how to use and adhere to administrative and technical procedures. Darlington NGS's operating procedures are developed and revised using defined processes to ensure compliance with operational limits and regulatory requirements, incorporating human performance and error-prevention tools such as second-party verification and place-keeping. N-PROC-AS-0028, *Development, Review and Approval of Technical Procedures* is in place for the development, review, and approval of technical procedures; it outlines the levels of authority required for verification and review, the categorization of Technical Procedure Action Requests (TPARs), and validation and distribution requirements. Additional instructions and standards are in place to provide detailed requirements on content, structure, and usage and adherence of technical procedures (e.g. operating manuals, EOPs, tests, etc.) and work instructions.

Validation is completed on both new procedures and procedures with extensive revisions. For procedures normally executed by MCR staff, the validation is completed before issuance by certified staff using the full-scope simulator, with additional input sought from trainers. Field

validations are normally completed after issuance. Procedures requiring field validation are issued with a validation watermark and contain instructions on how to complete the validation.

Darlington NGS has multiple departmental procedures groups (e.g. Maintenance, Operations, Refurbishment, Fuel Handling, Tritium Removal Facility (TRF) Operations Support, Nuclear Sustainability Services) that are dedicated to updating the technical procedures that their department has ownership of. Due to interfaces between different systems, the different procedures groups collaborate as required to revise various procedures.

Numerous procedure updates have either been completed during the current licence term or are ongoing due to the large amount of station projects and modifications in addition to Darlington NGS Refurbishment. Several measures have been initiated to reduce TPAR backlog and improve the prioritization of implementing procedure updates. This includes development of training materials for new procedure authors, increasing staffing in procedures groups, increasing collaboration with Refurbishment procedures group, streamlining the processes for reviews, verifications and approvals, and consolidation of databases into a single software application.

The software application simplifies the process of submitting a TPAR and increases accessibility and engagement with users. This allows for more detailed information to be requested for specific situations, such a project TPARs or TPARs submitted as part of Corrective Action Programs.

Darlington Refurbishment Procedures

The large scope of the Darlington NGS refurbishment project across all four reactor units has resulted in the necessity for thousands of operational procedure revisions. Revisions to procedures must adhere to the strict safety standards of Darlington NGS operations to ensure refurbishment work is executed safely and with high quality. A specific procedures group was created to manage and author these procedure updates. While the other procedures departments are separate from the Refurbishment group, the Refurbishment procedures group revises the same documentation and significant coordination has been required throughout the project. Strong teamwork and communication between all the procedures groups has been essential. A total of 2,117 TPARs were issued from 2016 to 2023 for Darlington NGS Refurbishment. Procedural updates continue to be tracked and completed as required to meet each milestone within the Refurbishment project.

Electronic Based Procedures

OPG is currently working on implementing its Electronic Based Procedures (EBP) project. This digital procedure software will allow the organization to digitize procedural documentation, moving away from manual, paper-based procedures. Overall, EBPs improve the efficiency, accuracy, and accessibility of procedural documentation. It streamlines processes, enhances collaboration, and facilitates compliance with industry regulations and standards. Some key features of this software are:

- Document Creation: This software will improve the ability to standardize procedure organization and formatting across multiple business units.
- Search and Navigation: Improved search functionality to locate specific procedures or specific sections within procedures. Intuitive navigation tools will help users move through the content seamlessly.

- Integration with other applications: EBP can interface real-time with several other applications. For instance, it will interface with Asset Suite to ensure that users are using the most up to date procedure revision. Upon completion of the procedure, it can be uploaded directly to Records without requiring printing or scanning. EBP can also access plant information data which will increase efficiency for filling out procedure steps that require data that is not used for operational decisions, such as daily panel checks in the MCR.
- Error-prevention and human performance functionality: Many features of the EBPs will reduce human performance errors, such as preventing a user from moving to the next step before the current step is checked off as complete or prompting for additional authorization.
- Analytics and Reporting: Increases insights into procedure usage, completion rates and user performance. This can help identify areas for improvement and optimize procedural workflows.

The Darlington NGS Operations Procedures group is in the process of developing its procedures within EBP. It will be a staggered integration, beginning with the MCR panel checks. A trial electronic version of the panel checks using an Excel spreadsheet was able to withdraw data from plant information data successfully. It was decided to move forward with EBP instead of the spreadsheet to improve quality assurance, ease of updating, and to broaden the applicability beyond panel checks.

2.3.3 Reporting and Trending

As described in Section 2.1, N-PROG-RA-0003, *Performance Improvement*, establishes the processes that support the conduct of Performance Improvement (PI) and, by extension, employs the principles of problem prevention, detection, and correction at OPG Nuclear.

The implementing processes under this program allow for the prompt identification of adverse conditions, proactive identification and resolution of potential issues, or opportunities for improvement. Non-conformances, deficiencies, and adverse conditions must be promptly identified to prevent impact on plant operations, personnel, nuclear safety, the environment, or equipment and component reliability. These processes ensure that problems are corrected or dispositioned with a level of rigour commensurate with their risk significance. For those problems deemed to be of higher significance or systemic in nature, these processes ensure appropriate levels of management are notified, causes identified, actions taken to minimize or prevent recurrence, action completion and effectiveness verified, and lessons learned communicated.

N-PROC-RA-0022, *Processing Station Condition Records*, provides instruction on how adverse conditions are reported and outlines the process for effective evaluation, resolution, and trending of the adverse conditions. Each Station Condition Record (SCR) is reviewed and dispositioned by an SCR co-ordinator before going through two levels of review, a screening committee, and a management review committee to ensure the disposition was accurate and complete. Most of the SCRs generated are determined to be not significant on their own and are dispositioned for trending (Category D), closed out to another SCR (Category CO) or determined to be non-events (entered in error, a duplicate or does not represent an adverse condition at Darlington NGS). The remainder of the SCRs require an evaluation of known facts

or an investigation to determine the cause and related corrective action(s) that will reduce the frequency of recurrence of the adverse condition(s). Refer to Figure 12 for distribution of SCR categories. This distribution of the SCR population is closely aligned with industry best practices based on benchmarking with nuclear utilities.

Additionally, N-PROC-RA-0035, *Operating Experience Process*, is in place for conducting OPEX evaluations for applicable SCRs. The procedure establishes OPG Nuclear processes for evaluating, integrating, accessing, and sharing OPEX information. External OPEX received from nuclear industry sources is used to prevent similar events at OPG Nuclear and initiate the required actions, incorporate OPEX lessons learned into training, and keep staff informed of relevant industry information. Internal OPEX is used to communicate internal events to non-incident OPG Nuclear sites and to applicable external organizations. Refer to Section 2.1.4 for further details on the OPEX process.

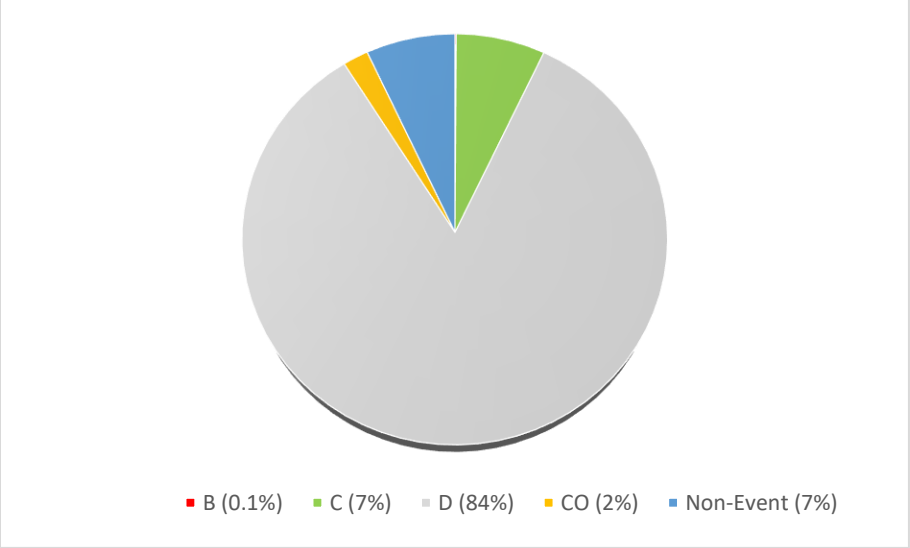


Figure 12: Distribution of SCR Categories (Avg)

Root cause and apparent cause investigations are conducted for higher significance events to improve plant reliability and human performance at Darlington NGS. Reporting and trending analysis is conducted to identify trends in performance at a lower level before they become a more significant issue. The trending includes aspects from cognitive analysis, data analysis and industry experience. Reporting is done quarterly through SCR trending and PI reports. Identified adverse trends are addressed by initiating an SCR and corrected as required through the corrective action program.

The following improvements have been made in the areas of reporting and trending through leveraging technological advancements and collaborative approaches in communication strategy:

- Integration of Smart Performance Objective & Criteria Artificial Intelligence (SPOCAI) auto-coding and advanced trend analysis marks a pivotal shift towards data-driven decision-making processes.

- The inception of the Weekly Proactive Trend Meeting encompasses cross-functional team discussions and underscores the imperative of fostering a communicative environment.
- The Validation of Trend process acts as a safeguard, proactively scrutinizing and challenging the potential impact of identified trends to prevent the development of consequential organizational issues.
- The implementation of a trend watch list and the utilization of trend performance indicators enhance the team's ability to meticulously observe, assess, and predict evolving patterns, ensuring that strategic actions are rooted in robust analytical foundations.
- Evolution in trend management, through centralizing trend reports within process improvement and integrating World Association of Nuclear Operators (WANO) Performance Objectives & Criteria (PO&C) codes through SPOCAI, negates personal biases and delivers a consistent coding database for the entire fleet. This improves the effectiveness of navigating through quantified data, identifying emerging trends, and taking the appropriate actions in alignment with organization strategies and objectives.

Regulatory Reporting

OPG Darlington NGS reports “Operating Performance” to CNSC in accordance with Darlington NGS Licence Conditions Handbook, Licence Condition 3.3 “Reporting Requirements”, and REGDOC 3.1.1, *Reporting Requirements for Nuclear Power Plants*, which include both scheduled and unscheduled reports. Darlington NGS meets the requirements of REGDOC 3.1.1 by adhering to the following governance, which are part of the management system per CSA N286-12, *Management System Requirements for Nuclear Facilities*:

- N-PROC-RA-0020, *Preliminary Event Notification*, identifies the process by which preliminary notification requirements to facility and off-site organizations, management, and external officials and agencies are made after an event has occurred.
- N-PROC-RA-0022, *Processing Station Condition Records* provides instruction on how adverse conditions are documented. It further outlines the use of reporting, documentation, evaluation and oversight process for the effective resolution and trending of adverse conditions at OPG. This procedure meets management system requirements that are directed by N-PROG-RA-0003, *Performance Improvement*. Adverse conditions typically have some level of risk-significance associated with them taking into consideration any actual or potential impacts on operability or whether it is reportable.
- N-PROC-RA-0005, *Written Reporting to Regulatory Agencies*, defines roles, accountabilities, and processes for complying with regulatory requirements for Written Event Reports to regulatory agencies and for scheduled reports to CNSC.

Throughout the current licence term, Darlington NGS has submitted all routine scheduled reports in accordance with REGDOC-3.1.1. OPG submits various scheduled reports as defined in REGDOC 3.1.1, which permit both CNSC and OPG to proactively determine if decreases in performance are occurring. Darlington NGS has submitted unscheduled reports in accordance with REGDOC-3.1.1. There have been no significant events that affected the conduct of licensed activities at Darlington NGS.

2.3.4 Outage Management Performance

The objective of the outage management program is to ensure that inspections, testing, maintenance, and modifications activities are correctly identified and safely completed while the reactor is in the shutdown state. The Outage Management processes for preparation and execution of planned and forced nuclear unit outages within OPG Nuclear receive authority from N-PROG-MA-0019, *Production Work Management*. Governance associated with planned outages is in accordance with N-PROC-MA-0013, *Planned Outage Management*. Governance associated with forced outages is in accordance with N-PROC-MA-0049, *Forced Outage Management*. Governance associated with TRF outages is in accordance with D-INS-39000-10003, *Tritium Removal Facility Planned Outage Management*. These procedures include a standard set of milestones that provides the methodical approach for guiding an outage through its life cycle. The milestones provide direction to plan, execute, monitor, and control outage activities to bring about the successful completion of outage goals and objectives while maintaining safety as the overriding priority. During the current licence term, Darlington NGS outages have been managed in a safe and effective manner.

Planned outages are performed at Darlington NGS to perform inspections and undertake preventative and corrective maintenance of station components and equipment that require a unit shutdown state. Outage plans are focused on nuclear, radiological, and conventional safety and follow a detailed schedule. Outage preparation and execution involve organizations across the station and close coordination amongst work groups. Per REGDOC-3.1.1 requirements, Darlington NGS follows a process for submitting outage plans and schedules to the CNSC to ensure details of regulatory undertakings and commitments are clearly defined and communicated. The outage management program includes provisions to ensure that following the restart of the reactor, an outage completion assurance is submitted to the CNSC to confirm that all regulatory undertakings and major work on safety related systems have been completed successfully.

The primary objective of forced outage management is to correct the unit issue which caused the unit to shutdown, and safely return the unit to service. In addition, the forced outage provides a potential opportunity to complete other critical outage related work within the regulated market rules. Darlington NGS maintains ready to execute forced outage plans to be completed in the event a forced outage occurs. Regularly scheduled meetings between the Outage Department and all stakeholders are held to ensure that the correct work is identified on the forced outage plan should a unit be forced to shut down. Work identification for forced outage includes mandatory scope to be completed such as routine items required for readiness for service criteria, routine start-up and shutdown inspections/testing and regulatory commitments.

The Darlington for the Future (D4F) initiative includes actions that would allow OPG to achieve and sustain industry leading top quartile generation performance over the station's 30-year post-refurbishment operations window. One focus area initiative is planned outage duration with the objective to reduce planned outage durations by optimizing schedule, leveraging innovation, technology, and improved resource strategies. The result will be more efficient outage performance, maximized reliability, fitness for service and operational stability. The D4F initiative will be guided by the current procedures and will use the same rigorous outage planning process to ensure the right work is selected, equipment reliability is maintained, and safety is the overriding priority. This initiative is led by a dedicated team that has started detailed planning to ensure these advanced strategies are developed and ready to implement in outages following refurbishment.

2.3.5 Safe Operating Envelope

The Safe Operating Envelope (SOE) at Darlington NGS is defined, implemented, and maintained per N-STD-MP-0016, *Safe Operating Envelope*, which is compliant with the requirements of CSA Standard N290.15 2010, *Requirements for the Safe Operating Envelope for Nuclear Power Plants*. The standard defines the processes, organizational responsibilities, and key program elements to ensure the SOE is defined and documented in a manner which is consistent with the station operating documentation. Furthermore, the standard for SOE is critical to the implementation of N-PROG-MP-0014, *Reactor Safety Program*. The objective of the SOE is to define the set of limits and conditions within which the plant shall be operated to ensure conformance with the Safety Analysis upon which reactor operation is licensed. This set of limits and conditions are monitored and controlled by operators, as applicable per operating requirements. Limits and conditions that are part of the SOE include safety limits, safe operating limits, conditions of operability, actions and action times, and surveillances.

Station systems included within the SOE have, where applicable, corresponding Operational Safety Requirements (OSRs), Instrument Uncertainty Calculations (IUCs), and Compliance Tables (CTs). The preparation methodologies for OSRs and IUCs are described in the applicable OPG standards, and the limits and conditions contained in OSRs and IUCs, along with any system surveillance requirements, are incorporated into station operating documentation. SOE CTs list all SOE parameters for a specific system, and connect all Safe Operating Limits, Conditions of Operability and Surveillance Requirements to applicable station operating documentation.

As SOE documents are considered living documents, they are revised and updated as required to reflect new safety analyses and modifications. OPG's Engineering Change Control program has controls in place to ensure the need to revise SOE documentation is appropriately flagged as well as ensure these revisions are conducted and implemented correctly.

The SOE program at Darlington NGS has undergone continuous improvements driven by internal and external inspections and audits. As a continuous improvement opportunity, the Darlington NGS SOE Improvement Project was initiated to iteratively improve SOE documentation over time. As part of this initiative, OPG self-identified an opportunity to provide further clarity to the technical basis of some existing safety limits and availability requirements in the OSRs.

A Nuclear Oversight audit of the Reactor Safety program across OPG's nuclear facilities was conducted in May and June 2023, and included an assessment of the implementation and maintenance of the SOE. The Reactor Safety program was found to be effective as a whole. When benchmarked with reference to WANO PO&C, OPG met these requirements along with the requirements of CSA Standard N290.15. Furthermore, the results found that the program goals, standards, and expectations exhibit industry standards of excellence.

2.3.6 Accident and Severe Accident Management and Recovery

OPG maintains an Accident Management program for Darlington NGS, which meets the requirements of CNSC regulatory document REGDOC-2.3.2, *Accident Management: Severe Accident Management Programs for Nuclear Reactors* in conjunction with the elements of safety analysis described in Section 2.4.

For Anticipated Operational Occurrences and Design Basis Accidents for Darlington NGS, OPG maintains Abnormal Incident Manuals (AIMs). AIMs consist of the procedures for responding to events which have an immediate effect on a reactor unit, requiring the response of several major systems, and involving failure or impairment of one or more of the following:

- Reactor power control;
- Fuel cooling;
- Breach of one or more barriers to containment of radioactivity.

These are event-based procedures, based on the design-basis accident set.

An EOP is required for all single failure process upsets which directly and adversely affect reactor power control, and/or fuel cooling functions which are not satisfactorily terminated by automatic action of the process or mitigating systems. The Darlington NGS EOPs are included in the AIMs.

For Beyond Design Basis Accidents (BDBAs) at Darlington NGS, OPG maintains Emergency Mitigating Equipment Guidelines and Severe Accident Management Guidelines (SAMGs). OPG's BDBA management program is implemented through N-STD-MP-0019, *Beyond Design Basis Accident Management*. Severe Accident (SA) management provides an additional layer of defence in depth to mitigate the consequences of accidents that fall beyond the scope of events considered in the plant design basis. Instead of the rule-based approach, SAMG uses a symptom-based/knowledge-based approach that includes steps for plant status diagnosis and equipment evaluation, making it well suited for responding to events involving failures affecting multiple components, systems, or lines of defense. The transition of the different strategies to prevent an event from progressing are shown below in Figure 13.

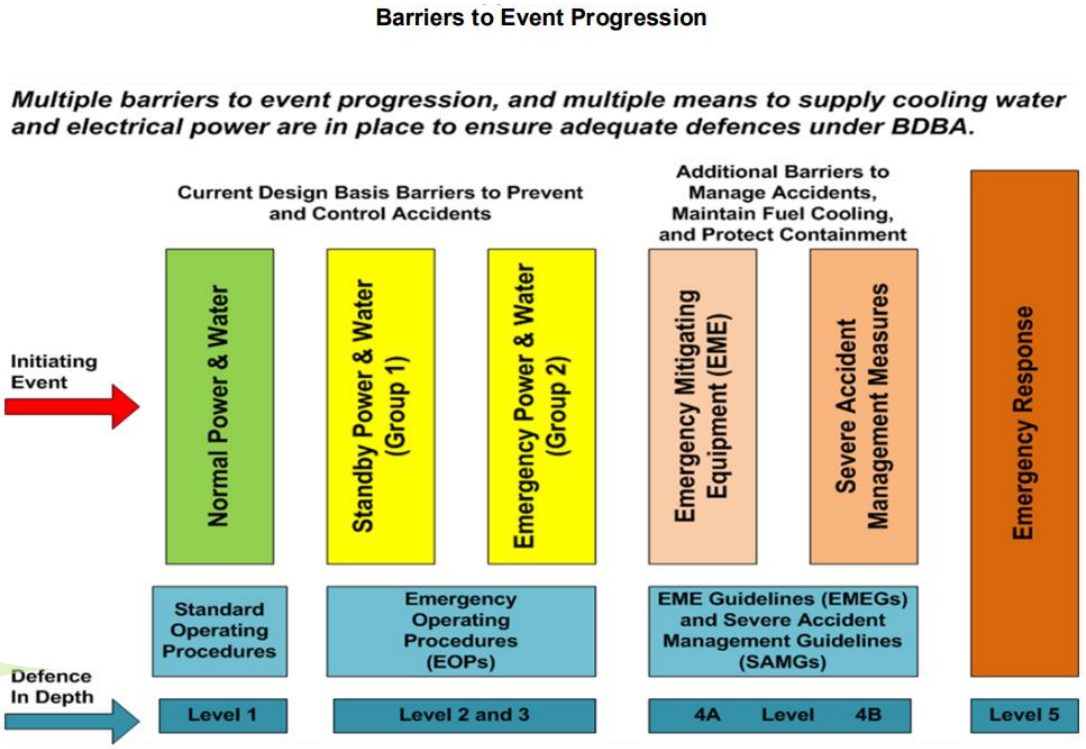


Figure 13: Barriers to Event Progression

In response to a plant transient, control room staff are expected to diagnose the initiating event and to select the appropriate event-specific response procedure. It is critical to achieve acceptable fuel cooling in accident scenarios, through correctly diagnosing the initiating event, correctly implementing the response procedure(s), and ensuring functionality of mitigating equipment. In parallel with this event-based response, independent control room staff employ a symptom-based approach to assess the effectiveness of the procedure and its implementation by monitoring Critical Safety Parameters (CSP). In case any of the above-mentioned criteria for achieving acceptable fuel cooling are not met, one or more of these CSPs may exceed its specified setpoint, in which case control room staff will take specified actions to restore the CSP value(s) within an acceptable range. These CSPs, their setpoints, and the related restoration procedures are specified in the AIMs.

For SA response and recovery, there are several key positions, roles and responsibilities established to support SAMG implementation at Darlington NGS, such as the Site Management Centre decision making authority (i.e. Emergency Response Manager/Authorized Duty Manager), the SAMG Technical Support Group, the Shift Manager, and the operations crew. Critical actions in the SAMG are listed below, and each action has different steps of responsibility (i.e. evaluate, recommend, authorize, implement), with specific personnel assigned to each step.

- Transition from EOPs to SAMG;
- Implement SA mitigation actions;
- SA recovery strategies;
- End SAMG use and initiate long term recovery.

Details on the roles and responsibilities of OPG staff during a nuclear emergency, including communication strategies and interface with the public and with regulatory or other agencies can be found in N-PROG-RA-0001, *Consolidated Nuclear Emergency Plan*.

As per the requirements of the Reactor Safety program, OPG regularly performs self-assessments of the SAMG and BDBA management framework. The scope of these self-assessments is to review relevant engineering changes and confirm their implementation in the BDBA framework documents, address pending corrective actions, and verify completion of the actions initiated as a part of the previous self-assessments and/or audits.

Section 2.4

Safety Analysis

2.4 Safety Analysis

Darlington NGS has an effective Safety Analysis program which meets or exceeds all applicable regulatory requirements and related objectives. The program ensures the maintenance of the safety analysis that supports the overall safety case for the facility. It also ensures there is demonstrated acceptability of the frequency and consequences of design-basis and beyond design basis events, with the ability of protective systems and emergency mitigating equipment to adequately control power, cool the fuel and contain or limit any radioactivity that could be released from the plant.

The safety analysis is governed by N-PROG-MP-0014, *Reactor Safety Program*, which establishes organizational responsibilities and key program elements for the management of issues related to Nuclear Safety Analysis (NSA) and the following major aspects of safe operation:

- Safety Analysis Basis and Safety Report Updates;
- Safe Operating Envelope (SOE);
- Beyond Design Basis Accident (BDBA) Management.

In addition, the Reactor Safety program governs generic Canada Deuterium Uranium (CANDU) Safety Issues (CSIs) management, the Discovery Issue Resolution Process, the Technical Operability Evaluation process, and Operational Safety Requirements (OSRs) and Instrument Uncertainty Calculations (IUCs) preparation and revision processes.

The Safety Analysis Basis includes the NSA and assessments performed to demonstrate regulatory and design requirements are met and to determine safe operating limits. Safety Analysis consists of three primary parts as discussed in the below subsections:

- Deterministic Safety Analyses (refer to Section 2.4.1);
- Hazard Analyses (refer to Section 2.4.2);
- Probabilistic Safety Assessments (PSA) (refer to Section 2.4.3).

The BDBA and Severe Accident (SA) management program is discussed in Section 2.4.4, along with the safety analysis performed for these areas.

The existing safety analysis at the Darlington NGS is a comprehensive and systematic evaluation of the hazards that can potentially result from operation of the plant and considers the effectiveness of preventive and mitigative measures and strategies in reducing the effects of the hazards. The existing safety analysis supports the overall safety case for Darlington NGS. Improvements to the safety case are continuously made including through CANDU Owners Group (COG) programs, and implementation of CNSC regulatory documents REGDOC-2.4.1, *Deterministic Safety Analysis* (refer to Section 2.4.1) and REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 5: SCA 4 – Safety Analysis

Document	Title
NK38-SR-03500-10001	Darlington NGS Safety Report: Part 2 – System Descriptions
NK38-SR-03500-10002	DN 1-4 Safety Report: Part 3 – Accident Analysis
NK38-REP-00531.7-10001	Darlington Analysis of Record
N-STD-MP-0019	Beyond Design Basis Accident Management
N-PROG-MP-0014	Reactor Safety Program
N-PROC-MP-0086	Safety Analysis Basis and Safety Report
N-PROG-RA-0016	Risk and Reliability Program
N-STD-RA-0034	Preparation, Maintenance and Application of Probabilistic Safety Assessment
N-PROG-MP-0006	Software
NK38-REP-09701-10344	RWPB Safety Analysis Summary Report
NK38-REP-09701-10326	Darlington Retube Waste Processing Building – Safety Assessment
NK38-CORR-09701-0597849	RWPB Worker Dose During Normal Operation and Under Accident Conditions

2.4.1 Deterministic Safety Analysis

The primary objectives of performing Deterministic Safety Analysis (DSA) are to confirm that the design of the Nuclear Power Plant (NPP) meets design and safety requirements, and to derive or confirm operational limits and conditions that are consistent with the design and safety requirements. Furthermore, DSA must confirm that the structures, systems, and components, in combination with plant procedures and operator actions, are effective in fulfilling their safety functions and keeping the releases of radioactive material from the plant below acceptable limits. DSA is a systematic process of calculating the public dose consequences for specific Postulated Initiating Events (PIEs) (refer to Section 2.4.1.2) and upset conditions at the plant.

DSA is used to determine the limits that define the SOE of the plant, which is the boundaries in which the plant must be operated. SOE is defined in CSA N290.15 2010, *Requirements for the safe operating envelope for nuclear power plants*, as "the set of limits and conditions within which the nuclear generating station must be operated to ensure compliance with the safety analysis upon which reactor operation is licensed and which can be monitored by or on behalf of the operator and can be controlled by the operator." The SOE is defined by the safety analysis and the credited systems and equipment in the analysis. The SOE is implemented through the OSRs, IUCs, and other safety related limits and system credits that ensure operation within the safety analysis basis. Refer to Section 2.3.5 for further details on the SOE.

N-PROG-MP-0014, *Reactor Safety Program*, and its subsidiary governing documents define the organizational responsibilities and key program elements for the planning, execution, and management of DSA. N-PROC-MP-0086, *Safety Analysis Basis and Safety Report Updates*, governs the updating of Safety Reports and describes documentation of safety analysis. NK38-SR-03500-10001, *Darlington Safety Report Part 1 and 2*, provides a general description of the plant and site in sufficient detail for understanding the interaction of plant systems to facilitate DSA. The results of the DSA are documented in NK38-SR-03500-10002, *Darlington Nuclear 1-*

4 Safety Report: Part 3 – Accident Analysis and NK38-REP-00531.7-10001, *Darlington Analysis of Record*. The documented DSA demonstrates compliance with licensing limits and derived acceptance criteria, identifies limits on process parameters and safety system requirements, and thereby establishes the SOE for the station to satisfy OPG's N-POL-0001, *Nuclear Safety and Security Policy*, requirement to control reactor power, cool the fuel, and contain radioactivity (3 C's).

The performing and documenting of DSA is governed by REGDOC-2.4.1, *Deterministic Safety Analysis*, which was issued in 2014. As DSA that had been performed up to that point was not fully compliant with the new REGDOC, OPG developed the REGDOC-2.4.1 Implementation Plan in 2014 (Reference 2.4-1) for the OPG nuclear fleet which outlined the framework for performing new DSA and identified the scope of the new analysis. Execution of the work defined in this plan is progressing and OPG continues to report on the safety analysis upgrades to meet REGDOG-2.4.1 requirements on an annual basis to the CNSC. The latest update on the status of REGDOC-2.4.1 implementation was issued in 2023.

As required by REGDOC-2.4.1, DSA takes into account the appropriate level of conservatism for the class of event analyzed, the acceptance criteria and trip coverage for each event analyzed, and demonstrates applicable dose limits are met for the events. Any significant gaps between the requirements and analysis results will be evaluated and addressed using a graded approach as allowed for by REGDOC-2.4.1.

OPG maintains DSA current with ongoing analyses and assessments. In addition, DSA is also performed as required for operational support. Primary Heat Transport (PHT) system Aging Management (refer to Section 2.4.1.1 below) and REGDOC-2.4.1 implementation/compliance are two of the major programs contributing to maintaining DSA. Since these programs were created, several safety analysis submissions demonstrating sufficient margin for the plant have been made. Updating the current analysis in the Safety Report to be compliant with REGDOC-2.4.1 is progressing according to the REGDOC-2.4.1 implementation plan. The CNSC monitors these programs regularly and reports the findings in annual Regulatory Oversight Reports.

Per the Reactor Safety program, safety analysis undergoes an ongoing process of review and improvement including self-assessments, corrective actions, and independent assessments. Additionally, the scope of REGDOC-2.4.1 implementation will be updated depending on the significance of new technical insights. For example, the current version of the REGDOC-2.4.1 implementation plan includes analysis of a broader scope of small break loss of coolant accident events beyond the initially identified scope, as well as increased scope of Darlington loss of moderator heat sink events to support increased moderator and PHT system tritium concentration limits.

2.4.1.1 Primary Heat Transport System Aging Management Strategy

OPG's PHT system aging management activities were initiated in 2000 to evaluate the impact of component aging on safety margins. OPG developed an overall Heat Transport System Aging Management Strategy (HTS-AMS) in 2010 to manage all issues related to aging. HTS-AMS also interfaces with the broader N-PROG-MP-0008, *Integrated Aging Management*, in program execution.

The objective was to provide an integrated assessment on the cumulative effects of the identified aging mechanisms, and to develop effective safety margin management strategies based on the results of these assessments. The identification of known PHT system aging

mechanisms and effects was completed as part of the Technical Basis Document for PHT system safety margin management. This document was submitted to the CNSC in 2009 (Reference 2.4-2). Key parameters and safety phenomena for all important systems and sub-systems with direct interfaces with the PHT system main circuit have been identified and based on these, the critical accident scenarios from the perspective of PHT system aging impacts were determined.

OPG reports to the CNSC on the status of HTS-AMS and that strategy was updated for 2021 to 2025 and submitted to the CNSC in March 2021. OPG also reports to the CNSC on the progress of safety analysis related to PHT system aging, and the latest progress report was submitted in 2023.

The Refurbishment of all four Darlington NGS reactor units is in progress, and completion will significantly improve issues associated with margin erosion due to aging. However, OPG's programs for monitoring the aging processes and implementing strategies to maintain safety margins will continue.

2.4.1.2 Postulated Initiating Events

Formal identification of PIE is a requirement specified in REGDOC-2.4.1 for performing DSA. These events could lead to a situation which can potentially challenge the safety functions of the nuclear facility and pose radiological hazards to plant, personnel, and public. These PIEs are identified through a systematic process which takes into account a number of factors, including but not limited to, failure modes and effects analysis, regulatory requirements, past licensing experience, engineering judgement, operating experience, design of the plant, and previous DSAs and PSAs.

The identified PIEs include common hazards that can cause upset conditions in one or more units, leading to potentially unsafe conditions in more than one unit simultaneously. For example, common cause events or steam line breaks are part of the licensing basis and are documented in the Darlington NGS Safety Report.

In compliance with REGDOC-2.4.1, all new safety analysis will have PIEs identified through a systematic process and classified into accident categories of Anticipated Operational Occurrences (AOOs), Design Basis Accidents (DBAs) and BDBAs. The delineation between various accident categories is based on initiating event frequencies. The requirements and guidance for analysis of different accident categories are per REGDOC-2.4.1 and COG Guideline for DSA.

The current Darlington Safety Report Part 3, Section 2 contains a listing of PIEs for all DBAs in the Safety Report. These are categorized into Event Class 1 through 5, which was the classification method under which Darlington NGS was originally licensed, specifically to CNSC Consultative Document C-6 Rev 0, *Requirements for the Safety Analysis of CANDU Nuclear Power Plants*. All the current and future safety analyses will be performed to satisfy the REGDOC-2.4.1 requirements, and as such, the events will be classified as AOOs, DBAs or BDBAs, while continuing to comply with the radiological dose limits established under C-6 Rev 0 in accordance with the LCH. Refer to Section 2.5.3.1 for further details on how the design of the station ensures that the PIEs from the safety analyses are taken into account to meet all safety design requirements.

2.4.2 Hazard Analysis

Hazard Analysis for Darlington NGS is performed in compliance with REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*. Hazard Analysis has two main components; the initial Hazard Screening Analysis and the subsequent PSAs of the required hazards. The Hazard Screening Analysis first involves the identification of a list of the internal and external hazards which could affect the safety of the reactor or the non-reactor sources of radiation (i.e. Irradiated Fuel Bays (IFBs) and used fuel dry storage containers). The list is subsequently screened using both qualitative and quantitative methods to identify the hazards for which PSA must be conducted.

The Hazard Screening Analysis for Darlington NGS is updated every 5-years in compliance with the requirements of REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*. The Hazard Screening Analysis is completed using the OPG PSA Guides for External and Internal Hazards. The OPG PSA guides were sent to the CNSC for review, and the CNSC has accepted the methodology documented in the guides.

NK38-REP-03611-10043, *Hazards Screening Analysis – Darlington*, was last updated in 2019 as part of the 5-year update cycle for the Darlington NGS PSAs. The report documents the hazard identification and screening of both internal and external hazards which are applicable to Darlington NGS. The scope of this screening analysis addresses hazards on both the reactors and the non-reactor sources. The hazard screening analysis was conducted as per OPG's PSA Guides and was compliant with REGDOC-2.4.2.

External hazards are hazards which originate outside of the site boundary or are outside of OPG's direct control. The external hazards are divided into two major categories: human induced external hazards (e.g. hazards such as airplane crashes and railway accidents) and natural external hazards (e.g. hazards such as earthquakes and severe weather). Internal hazards are those which originate within the site boundary and consist of hazards such as onsite transportation accidents and turbine missiles. Hazards which affect multiple reactor units such as earthquakes or high winds were also considered within the scope of the 2019 analysis.

Once a list of the hazards has been generated, the next step is to perform a screening assessment on the hazards. The goal of this step is to simplify the PSA by identifying hazards and combinations of external hazards which do not need to be assessed (i.e. screening them out of the PSA). First, hazards and combinations of external hazards are screened using qualitative criteria. That is, a hazard or a combination of external hazards may be screened out if it meets one of the following criteria listed in Table 6. If a hazard or combination of external hazards cannot be screened out using the qualitative screening criteria, they are then screened quantitively. If a hazard or a combination of external hazards satisfies at least one of the quantitative criteria listed in Table 7, then it may be screened out of the PSA.

Table 6: Qualitative Hazard Screening Criteria

Criterion	Description	Applicable to Reactor and/or Non-Reactor Sources
QL-1	The event is of equal or lesser damage potential than similar events for which the plant has been designed.	QL-1 through QL-5 apply to both the reactor and the non-reactor sources
QL-2	The event has a significantly lower likelihood than another event that has been screened out, and yet the event could not result in worse consequences than the other event.	
QL-3	The event cannot occur at the site or close enough to the site to affect the plant.	
QL-4	The event is included in the definition of another event.	
QL-5	The event is slow in developing such that it can be demonstrated that there is sufficient time to eliminate the source of the threat or provide an adequate response.	
QL-6	The event does not cause an initiating event (including the need for a controlled shutdown) as well as safety system function losses needed for the event.	QL-6 and QL-7 apply only to reactor sources and not to the non-reactor sources.
QL-7	The consequences to the plant do not require the actuation of front-line systems.	

Table 7: Quantitative Hazard Screening Criteria

Criterion	Description	Applicable to Reactor and/or Non-Reactor Sources
QN-1	Severe Core Damage Frequency < 10^{-6} / yr	QN-1 through QN-4 apply only to the reactor sources and not to the non-reactor sources
QN-2	Design Basis Hazard Frequency < 10^{-5} / yr and Conditional Core Damage Probability (CCDP) < 0.1	
QN-3	Severe Core Damage Frequency < 10^{-7} / yr	
QN-4	Design Basis Hazard Frequency < 10^{-6} / yr and CCDP < 0.1	
QN-5	Initiating Event or Hazard Frequency may be screened out if it can be shown that their frequency is < 10^{-7} / yr	QN-5 applies to both the reactor and the non-reactor sources

At the conclusion of the 2019 Hazard Screening Analysis, the required downstream assessments were identified, after systematically screening out most of the internal and external hazards based on the established methodology in the associated PSA Guides. Specifically, Hazard PSAs were subsequently performed (e.g., seismic events, internal fires, high winds, and internal floods) in conjunction with activities under Section 2.4.3. Similarly, certain meteorological hazards such as extreme temperatures and ice-storms were not further addressed as their impacts were already considered in the baseline PSA models to cater to events such as loss of switchyard and loss of bulk electricity supply.

As part of the 2019 Darlington NGS Hazard Screening Analysis, combinations of external hazards were also assessed. This analysis included combinations of human induced hazards with other human induced hazards, human induced hazards with natural hazards, and natural hazards with other natural hazards. Applying qualitative and quantitative methods, the majority of these hazard combinations were screened out from further assessments, and those hazard combinations which remain are addressed in the external events PSAs (refer to Section 2.4.3) or in supporting analysis (such as hydrological assessments) separately submitted to the CNSC.

OPG has updated five PSA Guides for External and Internal Hazards. The guides were revised to ensure that the hazard screening analysis performed for OPG nuclear stations is aligned with industry best practices. OPG recently submitted the Hazard Screening guides to the CNSC for review and CNSC have concluded that the revised PSA Guides meet REGDOC- 2.4.2 requirements and are acceptable.

OPG is planning on performing an update to the Darlington NGS Hazard Screening Analysis set to be completed in 2024. This update will be compliant with REGDOC-2.4.2 Version 2 (2022), *Probabilistic Safety Assessment (PSA) for Reactor Facilities*, and will be conducted according to the revised OPG PSA guides.

OPG is aware that natural external hazards, e.g., severe weather, may become more significant during the operating life of Darlington NGS due to climate change. OPG revisits the Hazard Screening Assessment as the initial step for its periodic PSA update as per regulatory requirements. This is sufficient to capture the incremental effects of climate change as an input to the PSA updates.

2.4.3 Probabilistic Safety Analysis

The purpose of a PSA is to establish whether the design and operation of the plant poses an acceptable level of risk to the public and to identify the primary sources of risk. PSA is a systematic process of radiological hazard identification and risk estimation using quantitative methods. The Darlington NGS PSA identifies the various event sequences that may lead to radioactive releases, assigns them to different categories of consequences, and calculates their frequencies of occurrence. The level 1 PSA estimates the frequency of accidents which may cause severe damage to the reactor core, and this is referred to as the Severe Core Damage Frequency (SCDF). The level 2 PSA estimates the frequency of accidents which may result in a release of radionuclides outside of the boundary of the station, and this is referred to as the Large Release Frequency (LRF).

The entire suite of PSAs for Darlington NGS, performed in compliance with REGDOC-2.4.2, includes:

- Level 1 Internal Events At-Power PSA;
- Level 2 Internal Events At-Power PSA;
- Outage Internal Events PSA;
- Internal Fire PSA;
- Internal Flood PSA;
- High Wind PSA;

- Seismic PSA;
- Non-Reactor Sources PSA.

These PSAs are updated every 5-years to ensure that the PSA models accurately reflect the current design and operation of the station. This regular PSA update is performed to comply with the requirements of REGDOC-3.1.1. OPG has established Safety Goals for the LRF and SCDF which the station PSAs are required to meet, and these Safety Goals are governed by N-PROG-RA-0016, *Risk and Reliability Program*. The PSAs are completed by following the OPG PSA Guides and N-STD-RA-0034, *Preparation, Maintenance and Application of Probabilistic Safety Assessment*. As part of the compliance with REGDOC-2.4.2, the OPG PSA guides were sent to the CNSC for review, and the CNSC has accepted the methodology documented in the guides.

In 2020, OPG performed an update of the Darlington PSAs (NK38-REP-03611-10072, *Darlington NGS Probabilistic Safety Assessment Report*). The purpose of this update was to meet the regulatory obligation to ensure the PSA models reflect the current design of the plant for the 5-year cycle required by REGDOC-3.1.1. For each PSA performed, the OPG Safety Goals were achieved for SCDF and LRF. This demonstrates that the current design and operation of Darlington NGS poses an acceptable level of risk to the public. The updated PSA models are now being used to support the day-to-day operation of Darlington NGS through their use in the software, Phoenix Risk Monitor. All software used by OPG for the PSAs are governed by N-PROG-MP-0006, *Software* which is compliant with CSA N286-12, *Management System Requirements for Nuclear Facilities* and CSA N286.7 1999 (R2012), *Quality Assurance of Analytical, Scientific, and Design Computer Programs for Nuclear Power Plants*.

OPG performs importance analysis as a part of the periodic PSA updates to identify the components and equipment of high importance. PSAs are also used to identify any Single Point Vulnerabilities (SPVs) and eliminate these SPVs with appropriate modifications or procedural changes. This process of identifying and eliminating the vulnerabilities feeds back into the PSA models to reduce the risk by lowering the probabilities of event sequences that could lead to SAs. An example of this is the implementation of the Containment Filtered Venting System to mitigate releases to the environment by providing additional capability to cope with multiple reactor units experiencing SAs and challenging the containment systems.

OPG also credits human action as described in the emergency procedures (i.e. Abnormal Incident Manuals, Emergency Mitigating Equipment Guidelines (EMEGs), and Severe Accident Management Guidelines (SAMGs) to verify the adequacy of the emergency procedures during a SA. Also, OPG performs periodic SA drills and exercises as per N-PROC-RA-0045, *OPG Nuclear Emergency Response Organization Drills and Exercises*, to evaluate the adequacy of the emergency procedures.

The PSA process also interfaces with the SA management program (i.e. procedures and modifications). This linkage facilitates the verification of the adequacy of the SA management program, by utilizing the specific PSA models to identify areas for improvement in the SA mitigating measures.

OPG is performing an update to the Darlington NGS PSAs scheduled for completion in December 2025. This update will be compliant with REGDOC-2.4.2 Version 2 and will be conducted according to the revised OPG PSA guides. PSA model refinements that have been

identified since 2020 will be incorporated into the 2025 update with the goal of continually improving the PSA results for Darlington NGS.

OPG acknowledges the importance of continuous enhancement in our PSA practices and methodologies. Upon completion of the Darlington NGS PSAs by the end of 2025, OPG expects the SCDF and LRF results for individual hazards to provide additional insights and inform future opportunities for improvement, including the consideration of physical changes, improvement in operating procedures, and analysis refinement.

2.4.4 Severe Accident Analysis

A BDBA is a classification of an accident with a low frequency of occurrence (less than 10 e-5 occurrences per year) and is therefore not part of the design basis of the station. A SA is a subset of a BDBA, which has potential to release a large amount of radioactive material. Severe Accident Analysis (SAA) is the means by which OPG assesses and manages SAs, to ensure that the risk from the operation of nuclear reactors remains low. The ability to control, cool and contain are challenged in a SA, and event progression may occur in an unpredictable manner, unlike in design basis conditions. As such, the approach to decision-making and prioritization must be different from that applied to normal operation and response to AOOs and design basis events. The response to a SA applies a symptom based/knowledge-based approach that includes steps for plant status diagnosis and equipment evaluation, making it well suited for responding to events involving failures affecting multiple components, systems, or lines of defense.

OPG performs SAA as a part of its periodic PSA updates as per the requirements of REGDOC-3.1.1. OPG last performed SAA as a part of the Level 2 Internal Events PSA update for Darlington NGS in 2020 also known as 2020 DARA-L2P, which was submitted to the CNSC. The Darlington NGS 2020 PSA updates (including DARA-L2P and SAA) were performed in conformance with the requirements of REGDOC-2.4.2.

SAA has been conducted to support the Darlington NGS Level 2 PSA, as part of REGDOC-2.4.2 compliance, and in response to the Fukushima Action Items. Extensive analysis has been carried out to identify BDBAs with the potential to transition to SAs. Included in this work are habitability studies to evaluate the impact of such events on the ability of station personnel to carry out actions as part of the emergency response.

SAA is an integral part of the comprehensive Level 2 PSA methodology. SAA follows a systematic approach which starts with defining the Plant Damage States (PDS) using the Level 1 PSA Fuel Damage Category 2 cutsets that could lead to core damage end states. The plant damage states are defined as follows:

- PDS1 – Events sequences that result in core damage originating from failure to shutdown the reactor;
- PDS2 – Single unit event sequences that could lead to severe core damage;
- PDS3 – Multi-unit event sequences that could lead to severe core damage;
- PDS4 – Event sequences with existing containment impairment known as Containment Bypass events;
- PDS5 and 6 – Limited Core Damage events.

Accident sequences, once binned into the representative PDS, are then analyzed using MAAP-CANDU SAA program. MAAP-CANDU is the Canadian Industry Standard Toolset (IST) for PSA SAA. The current version of the MAAP code used by OPG is MAAP5-CANDU 5.00a which is the most recent code release version.

Credits of relevant realistic system and human actions, along with various BDBA and SAMG strategies and modifications, are also modeled using a best-estimate approach in the SAA simulations using MAAP-CANDU. Each accident sequence analyzed in the SAA is categorized into individual Release Category (RC) bins ranging from RC1 to RC6 based on the Cs-137 and I-131 release source terms. The release categories are defined in the OPG Level 2 PSA Guide as follows:

- RC1 - Early large release with potential for acute offsite radiation effects;
- RC2 - Early Large Release;
- RC3 - Late Large Release;
- RC4 - Early Small Release;
- RC5 - Late Small Release;
- RC6 - Mitigated release.

SAA using MAAP-CANDU also produces accident progression results which provide relevant phenomenological information such as timing for core collapse, calandria vessel failure, hydrogen source terms, hydrogen fires/explosions, core-concrete interaction, and containment failure to facilitate understanding of accident progression for various event scenarios.

The SAA performed as a part of the Level 2 PSA provides further insights in terms of effectiveness of the various BDBA modifications, SAMG strategies, and human interventions by performing sensitivity analysis to assess the importance of key actions and equipment. The results of the SAAs are also evaluated and used as input to the OPG BDBA and SA management program. The insights from the SAA are used in accordance with REGDOC-2.3.2, *Accident Management: Severe Accident Management Programs for Nuclear Reactors*, and REGDOC-2.4.1 to identify areas for improvement. This includes plant modifications and/or updates to the guidelines and procedures such as Emergency Operating Procedures, EMEGs, and SAMGs. OPG assesses BDBAs at Darlington NGS as per the requirements of REGDOC-2.4.1 to ensure that the NPP as designed meets the requirements for release limits established, and that the procedures and equipment put in place to handle the accident management needs are effective, taking into account the availability of cooling water, material, and power supplies.

For emergency preparedness planning, SAA is performed to determine timing of event progression and to perform a consequence assessment of potential releases (i.e. to determine timing of release and dose rates to public to determine time to evacuate and the necessary radius of evacuation).

As mentioned in Section 2.4.3 above, OPG is performing an update to the Darlington NGS PSAs scheduled for completion in December 2025. This update will be compliant with REGDOC 2.4.2 Version 2. As part of the update for the Level 2 PSA, OPG will also review and update the suite of SAA for Darlington NGS.

Refer to Section 2.3.6 for further details on event mitigation and implementation of BDBA Management program through N-STD-MP-0019, *Beyond Design Basis Accident Management*.

2.4.5 Criticality Safety

The objective of criticality safety focuses on the prevention of fuel criticality both inside and outside the core, for either fresh or irradiated fuel.

Darlington reactors use only natural uranium (0.7% U-235) or depleted uranium (0.4% U-235) fuel, which cannot achieve criticality without an unpoisoned heavy water (D2O) moderator. Fresh fuel is stored in such a manner that segregates it from D2O and D2O systems. Thus, ex-core fresh fuel cannot be made critical. Ex-core irradiated fuel is stored in the IFBs under light water (H2O) where the fuel's low fissile content cannot be made critical in any configuration; therefore, no criticality risk exists.

In-core criticality safety control is achieved by procedures specified in the Guaranteed Shutdown State (GSS) Manual. The four types of GSS are over-poisoned GSS, drained GSS, rod-based GSS, and alternate shutdown configuration. Application of GSS is prescribed by the Operating Policies and Principles.

All criticality configurations are addressed as discussed above to ensure continued criticality safety.

2.4.6 Management of Safety Issues

The Safety and Licensing (S&L) Research and Development (R&D) program addresses issues related to the safety design basis and SOE of existing nuclear plants, in collaboration with COG. There is a strong focus on supporting the resolution of outstanding generic S&L issues and safety margin improvement initiatives. The program takes into consideration both Canadian and international operating experiences in identifying and selecting R&D work to be performed. In part, this work also supports safety assessments for new plant designs and refurbishments and assists in maintaining the core capabilities, scientific expertise, and the infrastructure necessary for an ongoing nuclear safety R&D program.

Darlington NGS-specific safety analysis issues are also addressed via the OPG Reactor Safety program as well as the Risk and Reliability program (for PSA issues).

The COG IST Program is a consolidation of the maintenance and support, development and qualification activities of the computer codes used for the design, safety analysis and operational support of CANDU reactors.

The COG R&D program overview report and operational plans are submitted to the CNSC as part of annual reporting requirements in accordance with REGDOC-3.1.1. This submission provides a summary of the work completed in the previous year and the on-going R&D activities that are being performed under the COG R&D and IST program. As well, COG-CNSC R&D seminars are held bi-annually.

2.4.6.1 Management of Safety Issues

A safety issue is defined as an issue related to the design or analysis of a NPP that has the potential to challenge safety functions, safety barriers or both.

In 2007, the CNSC assessed the status of CSIs and, while the safety case was not in question, the CNSC identified control measures to address residual concerns on nuclear safety. The

initial list of issues was developed using the IAEA TECDOC-1554 *Generic Safety Issues for Nuclear Power Plants with Pressurized Heavy Water Reactors and Measures for their Resolution*, and each issue was classified into one of the following three categories:

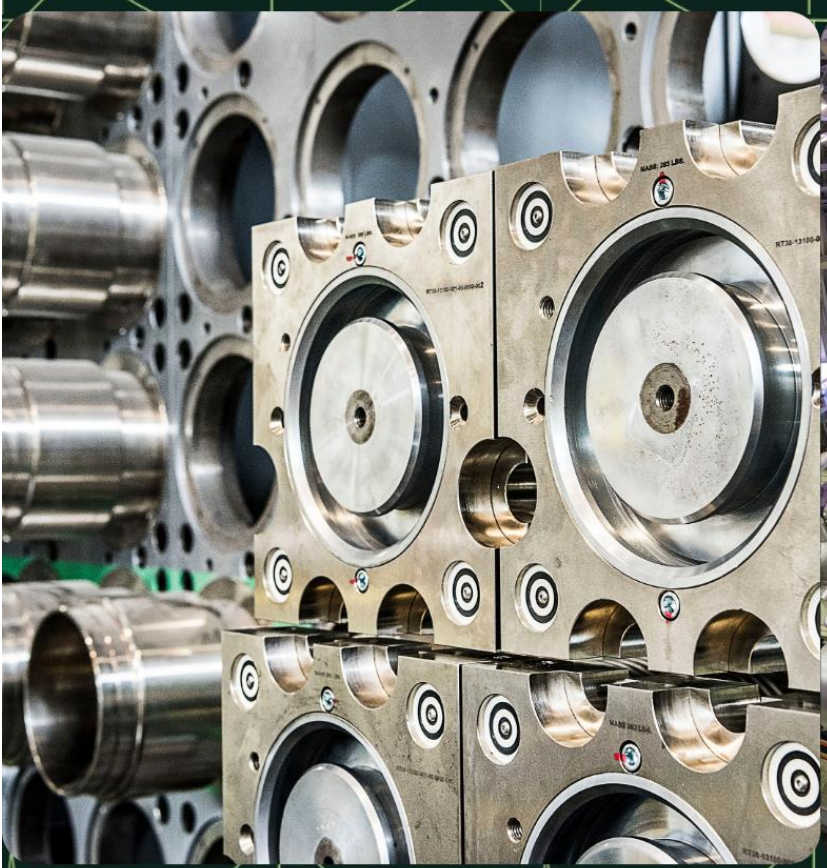
- Category 1: Not an issue in Canada;
- Category 2: The issue is a concern in Canada. However, the licensees have appropriate control measures in place to address the issue and to maintain safety margins;
- Category 3: The issue is a concern in Canada. Measures are in place to maintain safety margins, but further experiments and/or analysis are required to improve knowledge and understanding of the issue, and to confirm the adequacy of the measures.

In 2009, the CNSC identified sixteen Category 3 CSIs of which four were related to Large Break Loss of Coolant Accident (LBLOCA) and twelve were non-LBLOCA (N-REP-03611-0381169, *Application of the CNSC Risk-Informed Decision Making Process to Category 3 CANDU Safety Issues – Development of Risk-Informed Regulatory Positions for CANDU Safety Issues*). For the Darlington NGS station, all 12 non-LBLOCA Category 3 CSIs were previously recategorized to a lower category (Reference 2.4-3). One of the LBLOCA related Category 3 CSI was recategorized to a lower category in 2013 (Reference 2.4-4), and the remaining three were recategorized in 2023 (Reference 2.4-5).

OPG has demonstrated that appropriate control measures have been implemented and currently are in place to address all sixteen CSIs and maintain safety margins.

Section 2.5

Physical Design



2.5 Physical Design

Darlington NGS has an effective program to maintain its design basis which meets or exceeds all applicable regulatory requirements and related objectives. The program ensures that Structures, Systems and Components (SSCs) meet and maintain their design basis given new information arising over time and taking changes in the external environment into account.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 8: SCA 5 – Physical Design

Document	Title
N-STD-MP-0028	Conduct of Engineering
N-PROG-MP-0001	Engineering Change Control
N-STD-MP-0027	Configuration Management
N-PROG-MP-0009	Design Management
N-PROG-MA-0016	Fuel
N-INS-08173-10050	Procurement from Licensed Canadian Nuclear Utilities
N-PROC-MP-0090	Engineering Change Control Process
N-PROG-MP-0004	Pressure Boundary Program
N-PROC-MP-0040	System and Item Classification
N-PROC-MP-0082	Design Registration
N-MAN-01913.11-10000	Pressure Boundary Program Manual
N-LIST-00531-10003	Index to OPG Pressure Boundary Program Elements
N-CORR-00531-19076	Authorized Inspection Agency for Pressure Boundary Inspection and Registration Services
N-PROG-RA-0006	Environmental Qualification

2.5.1 Design Governance

OPG's design program satisfies the requirements of CSA N286-12, *Management system requirements for nuclear facilities* as defined in N-CHAR-AS-0002, *Nuclear Management System*. The program ensures that SSCs of facilities operate safely, reliably, and effectively, and are consistent with the design basis, safety analysis and quality control measures. The program also provides assurance that all design activities and their resulting documentation are controlled in a manner consistent with the plant's licensing basis.

N-PROG-MP-0009, *Design Management*, which receives its authority from N-CHAR-AS-0002, sets the overall requirement for execution and control of activities that provide design support and documentation for the nuclear facility. This program complies with CSA N286 and CSA N285.0-08 (and update no. 2), *General Requirements for Pressure-Retaining Systems and Components in CANDU Nuclear Power Plants*. The program defines the minimum set of documentation that identifies and describes the design basis, design outputs, design processes, and the procurement engineering process ensuring implementation and maintenance of the physical nuclear facilities to meet the design basis requirements. The following governance documents receive their authority from N-PROG-MP-0009.

- N-PROC-MP-0040, *System and Item Classification*, defines the requirement and process to be followed for code classification of pressure retaining systems in OPG Nuclear.
- N-PROC-MP-0082, *Design Registration*, defines the requirement and process to be followed for design registration of pressure boundary and legacy pressure boundary systems. Refer to Section 2.5.5.1 for further details on pressure-retaining SSCs.
- N-STD-MP-0028, *Conduct of Engineering*, provides a framework for performing engineering activities in a consistent manner across OPG Nuclear.

N-PROG-MP-0001, *Engineering Change Control (ECC)*, which receives its authority from N-CHAR-AS-0002, sets the overall requirement for modifications to the nuclear facility. The ECC program ensures design changes to each OPG Nuclear facility (including SSCs; software; and engineered tooling) are planned, designed, installed, commissioned, and placed into or removed from service such that the facility configuration is managed and remains within the Safe Operating Envelope (SOE) or safety and design envelope, design basis, and licensing conditions. This program complies with CSA standards N285.0 and N286. This program ensures all steps of a modification are properly assessed, analyzed, and evaluated including identifying the problem statement, determining requirements and risk level, design, review by stakeholders, installation, commissioning and close-out. The following governance documents receive their authority from N-PROG-MP-0001.

- N-PROC-MP-0090, *Engineering Change Control Process*, defines the process to be followed for all changes to the OPG Nuclear design basis, including modifications to, removal of, or abandonment of any SSC, software, or engineered tooling designs;
- N-INS-06700-10000, *Preparation of Human Factors Engineering Worksheet,* provides instruction in the preparation of Human Factors Engineering (HFE) Worksheet. HFE is considered in every modification having a Human System Interface. OPG uses a systematic graded approach to determine the appropriate level of HFE effort and rigor required for a modification. CSA N290.12-14, *Human Factors in Design for Nuclear Power Plants Compliance Assessment Summary*, compliance is generally achieved through the ECC and Design Management programs.

N-STD-MP-0027, *Configuration Management*, which receives its authority from N-PROG-AS-0001, *Nuclear Management System Administration*, ensures that OPG nuclear facilities are operated, maintained, and modified in conformance with their design basis and licensing basis. During all life-cycle phases of the ECC process, it is ensured that constructability, operability, maintainability, and safety issues are identified and incorporated into the design requirements of nuclear design projects and modifications.

N-PROG-MP-0006, *Software,* which receives its authority from N-CHAR-AS-0002, identifies the process and overall requirements for an effective software program. Modifications and design changes involving software complies with CSA N286 and CSA N286.7-99 (R2012), *Quality Assurance of Analytical, Scientific, and Design Computer Programs for Nuclear Power Plants*, and ensures software changes support safe and efficient plant operation. The software program identifies the processes and overall requirements for classification of software and identifies governing standards for each software classification defining requirements for software development, maintenance, procurement, qualification, use and retirement.

Any modification which may affect the International Atomic Energy Agency (IAEA) monitoring systems or equipment, is reviewed to ensure the changes do not impact compliance with the

safeguards agreements. This includes, but is not limited to, potential obstruction of fields of view for the IAEA equipment or impact to the power supplies for IAEA equipment. Refer to Section 2.13 for more details.

The health of the design and ECC programs is monitored using the ECC site index. The index incorporates metrics associated with quality of design ECC packages, ECC process compliance, and the timely updating of records and closeout of modifications. Refer to Section 2.1.5 for additional information.

The Plant Design department at Darlington NGS oversees the physical design SCA requirements and maintains the station design basis to ensure that systems remain in compliance with applicable standards, codes and licence conditions. As the Design Authority for Darlington NGS, this department specifies design requirements and authorizes design modifications to SSCs to ensure that all changes are within the SOE, design basis, and licensing conditions as per the station's Power Reactor Operating License (PROL).

2.5.2 Site Characterization

The Darlington NGS site is located in Michi Saagiig Territory, in the township of Darlington within the Municipality of Clarington and Regional Municipality of Durham, in the Province of Ontario. Within the immediate 8 km radius of the station, the area is primarily rural with Bowmanville being the only urban area.

The Darlington NGS site consists of the property described as follows:

- The site lies south of the south limit of the South Service Road of the MacDonald-Cartier freeway (Highway 401) in the township of Darlington. The land area of the site is about 460 ha and has a frontage on the north shore of Lake Ontario of about 3160 m. Darlington NGS occupies half of the site west of Holt Road in Lots 21 to 24 inclusive (refer to
- Figure 14 and Figure 16 below).
- A water lot was provided for the water intake tunnel and the discharge pipe from Lake Ontario.

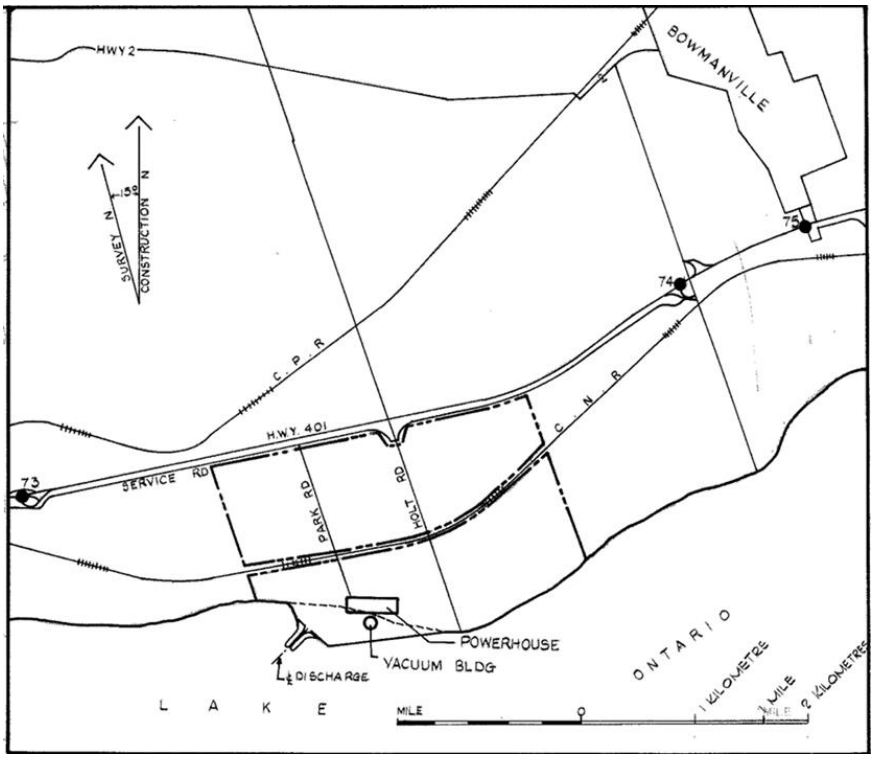


Figure 14: Darlington Site and Surrounding Area

The site is easily accessed for supply of off-site emergency aid and for ease of evacuation of non-essential personnel in case of an emergency. The site may be easily reached by car or rail. The multi-lane Macdonald-Cartier freeway runs east/west, immediately north of the site. There are three controlled entries to the Macdonald-Cartier freeway; one directly through Holt Road and two others less than 3 km on either side of the Darlington NGS facility. Rail access can be provided by the Canadian National Railway's (CNR) main line, which bisects the site in an approximate east to west direction. A rail siding area has been provided at the east boundary limit of the OPG Property.

The Darlington NGS site is situated in an undulating to moderately rolling limestone till plain, spotted with remnants of a lake plain deposit. Over most of the site, bedrock is covered by deep soil deposits. The bedrock elevation north of the powerhouse area near the CNR tracks is about 91 m while the bedrock at the shoreline is around 88 m. At a distance of 1000 m from the shoreline, the bedrock elevation is about 85 m. The bedrock is composed of nearly flat lying sedimentary rocks of Middle Ordovician age. The upper rock unit consists of dark brown, very thin to medium bedded shaley limestone of the Whitby Formation. The Whitby Formation ranges in thickness from 8 m to 1.5 m, thinning towards the eastern part of the site. The shaley limestone is underlain by grey, thick to massive bedded, fragmental limestone of the Lindsay Formation, which has thin inter-beds of shaley limestone throughout. The Lindsay Formation has a confirmed thickness of about 61 m at the site. The nuclear containment structures are founded on hard and sound shaley limestone of more than adequate bearing capacity to carry the structural loading without any adverse response. A detailed description of all site characteristics is provided in NK38-SR-03500-10001, *Darlington Safety Report Part 1 and 2*.

Darlington NGS has a campus plan in place, which details site infrastructure improvement activities through to the end of 2030 supporting the current and future needs of the Darlington NGS site including Refurbishment. The campus plan includes consideration of the impact that activities relating to development of the Darlington New Nuclear Project lands are likely to have on the rest of the site.

2.5.3 Facility Design

Darlington NGS is located on the north shore of Lake Ontario at Raby Head in the township of Darlington. The site location is shown in Figure 15 below:

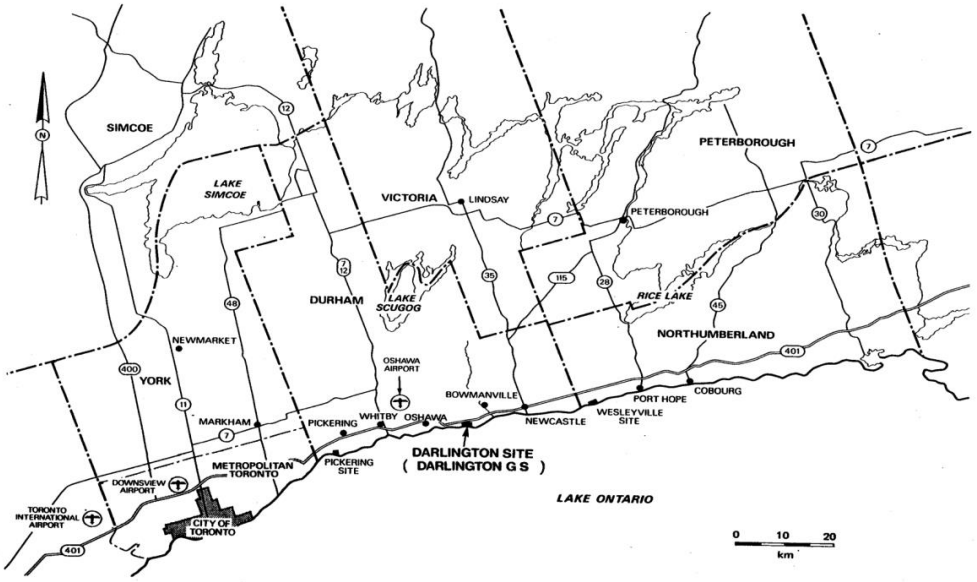


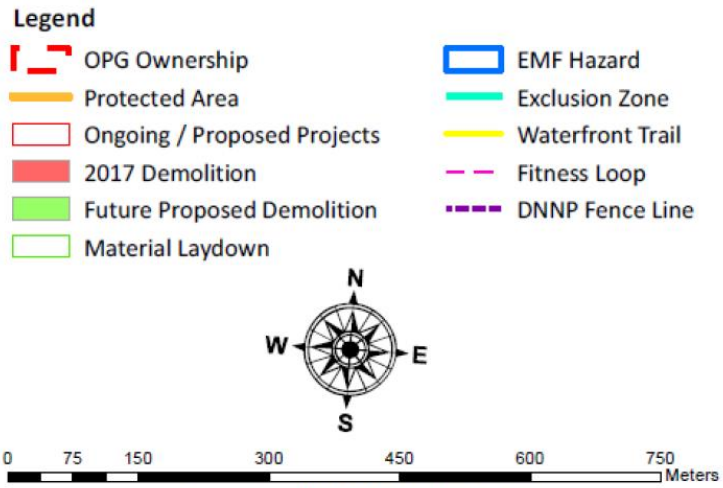
Figure 15: Site Location (from Darlington Safety Report, Part 1)

A summary of the station size and type is as follows:

- Four reactor unit station.
- CANDU pressurized heavy water nuclear steam supply system.
- Reinforced-concrete containment structure.
- Core fission power of 2776 MW(th) per unit.
- Nominal net unit output of 881 MW(e).

Darlington NGS comprises four nuclear reactors and four turbine generator sets, along with associated equipment, services and facilities arranged as shown in the site layout in Figure 16. The heat balance table for a reactor is shown in Table 9, and a simplified flow diagram for one unit is shown in Figure 17.

COOT'S POND
CN RAILWAY
1ST LINE
HOLT RD
OLD HOLT RD
2ND LINE
3RD LINE
PARK RD
EMF
LAKESHORE ROAD
PARKING
WTP
PARKING
PARKING
PARKING
PARKING
PARKING
PARKING
504
502
444
450
401
P455
P403
P412
P414
P414
443
424
423
443
P355
P352
P357
356
359
362
313
F2N
F5S
P353
329 / 330
312
F2SW
F2SE
311
P354
358
363
364
F7
F6
F9
F8
302
300
VSF
138
128
131
136
140
143
141
125
124
142
116
118
201
112
113
114
D9
513
512
416
415
411
8
P1
P2
WTP
P3
P4
1
10
208
207
T204
P455
17
16
15
18
20
23
22
65
36
42
43
46
50
58
59
32
31
38
39
61
40
T44
C.VS
48
54
55
56
62
WE
U1
U2
0
U3
U4
EF
9
PW
RPC
RCC
45
47
63
51
LSW
2MM
UFD53
UFD54
RM4



Operating Island Buildings		Site Buildings		Site Buildings	
0	Unit 0	107	(Project and Mod) Building Maintenance Shop	400	Baseball Diamond
1	Powerhouse	112	Turbine Parts Shop	401	Information Centre
U1	Unit One	113	Field Skills Facility	403	West Parking Lot
U2	Unit Two	114	Drawing Storage Facility	411	Operations Support Building (OSB)
U3	Unit Three	115	Computer Development Facility	412	East Parking Lot
U4	Unit Four	116	Project Office	414	Upper & Lower Parking Lot
WF	West FFAA	118	Lakeshore Garage	415	Bill Gearing Guardhouse
EF	East FFAA	119	Surplus Furniture Warehouse	416	Main Security Building
P1	Pumphouse One	124	Hydro Transformer Substation DS2	420	Chlorine Addition Station
P2	Pumphouse Two	125	Steamheating Boiler House	421	Domestic Water Pumphouse
P3	Pumphouse Three	126	Steam Relief Stack	422	Settlement Pond
P4	Pumphouse Four	128	Site and Facility Maintenance Shop #1	423	Hydro Transformer Substation
WTP	Water Treatment Plant	130	Warehouse Annex	424	DWMF Firewater Backflow Preventer Shed
8	FPS Firehall - Building #8	131	East Warehouse	432	Emergency Vehicle Garage
9	Construction Change Room	134	Sewage Treatment Plant	440	Rail Siding North
10	Retube Waste Processing Building	136	Flammable Storage building	441	Rail Siding South
T11	Recycle Shed	137	Gas Bottle Storage	443	MISA HUT
14	Lube Oil Tanks	138	HMS & HWS Facilities	444	Emergency Equipment Storage Bldg #1
15	EPS Building	140	Warehouse Yard	500	Soccer Fields
16	ESW Pumphouse/Chlorine Addition Bdg	141	Maintenance Computer Development Facility	502	Fitness Trail Parking Lot
17	Circulating Water Discharge Structure	201	Yard Maintenance Shed	504	SF6 Building
18	Emergency Power Generator (EPG) #1	T204	Hydrogen Trailer	505	Holt Road Guardhouse
19	Stairwell Enclosure (to EPG Tunnels)	206	Heavy Sand Shed/Facilities	506	Hepcoe Garage
20	EPG #2	300	Auxiliary Security Building	507	Hepcoe
21	Stairwell Enclosure (to EPG Tunnels)	301	Modification and CMO Office	508	Meteorological Tower
22	EPG Fuel Management Building	302	Pipe Fab/Machine Shop	509	Domestic Water Meter and Valve Station
23	EPG #3	305	Facilities Storage Building	510	Radiation Emission Monitor STA#2
T27	NTS Periodic Inspections Trailer	306	Paint Shop	511	Radiation Emission Monitor STA#1
29	Reactor Maintenance Building	311	Facilities Vehicle Garage #2	512	Radiation Kiosk
T30	Reactor Maintenance CCTV Trailer	312	Quonset Building	513	Covered Walkway
31	Sheet Metal Shop	313	BBH Building	514	Seismic Monitoring Station
32	Inactive Liquid Waste Storage	323	Cable Reel Yard		
36	Standby Generators Fuel Storage	324	Pipe Hanger Storage Shop		
T37	TRF Maintenance Offices	325	Warehouse Yard (YD 26)		
38	Standby Generator One	326	Warehouse Yard (YD 25)		
39	SG1 and SG2 Fuel Management Building #1	327	Warehouse Yard (YD 27)		
40	Standby Generator Two	329	Darlington Learning Centre (DLC)		
41	HWMB West Annex	330	Engineering Service and Support Building (ESSB)		
42	D20 Management Building (TRF)	331	OSB Parking Lot		
43	Stairwell Enclosure (to SG Tunnel)	332	ESSB Parking Lot		
T44	Hydrogen Trailer	353	ESSB Parking Lot		
45	Stairwell Enclosure (to SG Tunnel)	354	Executive Parking Lot		
46	Vacuum Building	355	MSB Parking Lot		

47	Stairwell Enclosure (to SG Tunnel)	356	DWMF Amenities Building		
48	Stairwell Enclosure (to SG Tunnel)	357	Bus Shelter		
T49	Service Maintenance Storage Trailer	358	UFDS Sampling Station Bldg		
50	Compressed Gas Bottle Storage	359	DWMF Process Building		
51	Service and Storage Building/Vehicle Maintenance Garage	362	DWMF Storage Building		
T53	Security Personnel Access and Gate	363	DWMF Storage Building #2		
54	Standby Generator Three	364	Retube Waste Storage Building		
55	Standby Generator Fuel Management Building #2	208	Refurbishment Project Office (RPO)		
56	Standby Generator Four				
58	Island Garage				
59	Standby Generators Fuel Storage				
61	Inergen Fire Protection System Enclosure (Standby Generators 1, 2)				
62	Inergen Fire Protection System Enclosure (Standby Generators 3, 4)				
63	Scaffold Storage Building				
65	Retube and Feeder Replacement Island Support Annex				
T96	T-G Hall Relocatable Outage Trailer				
T97	T-G Hall Relocatable Outage Trailer				
T98	T-G Hall Relocatable Outage Trailer				
T99	T-G Hall Relocatable Outage Trailer				
C24	Firewater Pumphouse				
CFVS	CFVS: Containment Filtered Venting System				

NOTE: This figure is for general reference only. Not all buildings on site may be shown or labelled.

Figure 16: Darlington Site - General Layout

Table 9: Heat Balance for one Darlington NGS Unit (from Darlington Safety Report, Part 1)

Heat Generation Balance (By Fission) in MW(th)	
Fuel channels	2651
Moderator and reflector	108
Miscellaneous, including reactor components shields and structures	17
Total heat generated by fission	2776
Heat Removal Balance (Heat Transport)	
Heat removed from fuel channels by coolant	2651
Heat losses to moderator, end shields, piping and Heat Transport Purification System	20
Total	2631
Heat gain from heat transport pumping energy	26
Total	2657
Heat Balance (Turbine Cycle)	
Heat transferred to steam generators	2657
Heat losses to blowdown and main steam pipes	7
Net heat input to turbine cycle	2650
Generator output from turbine cycle	936
Energy rejected in turbine cycle	1714
Total Unit Energy Balance	
Generator output from turbine cycle	936
Station service including exciter	55
Net unit output	881

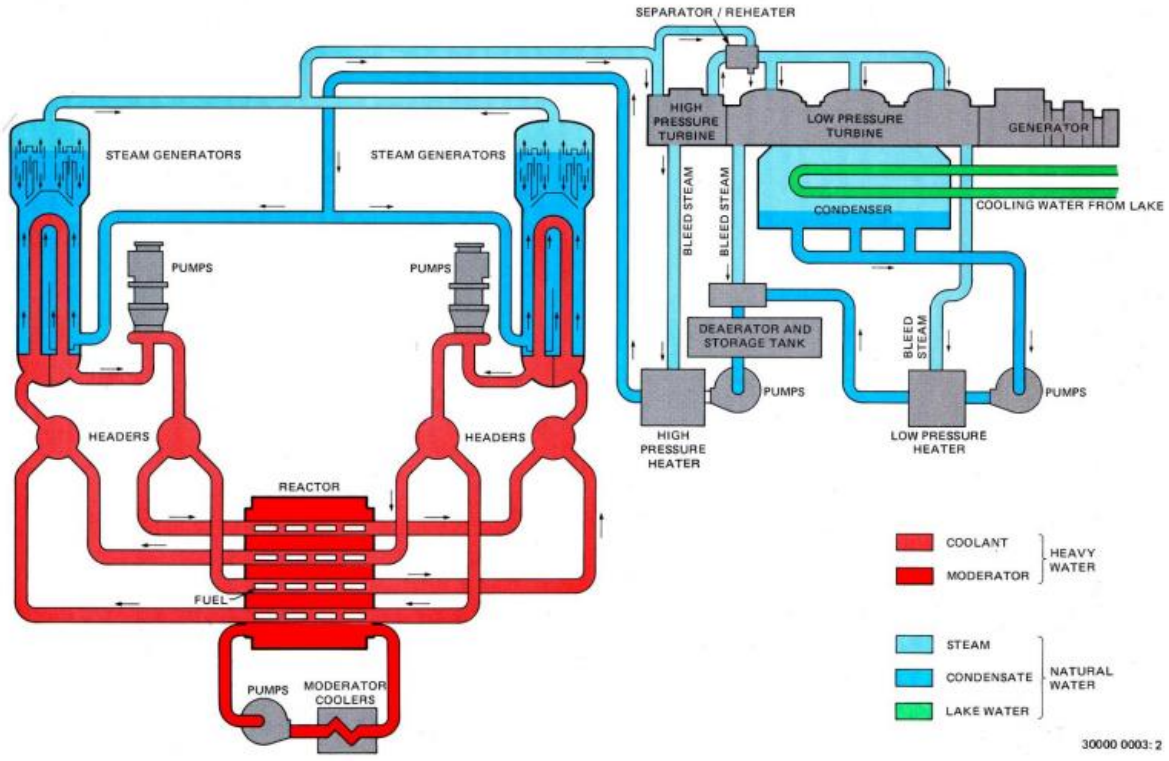


Figure 17: Simplified Unit Flow Diagram

The description of the systems and equipment at Darlington NGS, including the system objectives, functional and performance requirements, interfacing systems, and design and operating conditions are provided in the following documents:

- Darlington Safety Report Part 1 and 2 (updated every 5-years as required by REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*). The latest update of the Safety Report Part 1 and 2 was completed in November, 2023.
- Design Manuals.
- System design drawings.
- Design Guides identifying requirements and standards, which must be met in the design of various systems of a Nuclear Power Plant (NPP).

The Safety Report (Part 2, Section 1) describes the development of Canadian Nuclear Safety Design and Regulation. It contains a detailed description of the design philosophy and safety design requirements of the Darlington NGS.

N-LIST-01300-10000, *Bounded Document Set*, lists the sets of documents that shall be maintained when modifying the plant or when modifying other bounded document set documents. The bounded document set provides for a consistent set of configuration managed documentation across OPG Nuclear. The bounded document set lists the set of documentation or data that:

a) Represents physical plant.

b) Represents design (design input or output).

c) Ensures physical plant is operated consistently within the design envelope (including training) and licensing basis.

d) Maintains physical plant in a state consistent with the design requirements or assumptions used in analysis and assessments.

e) Establishes acceptability or suitability of detailed design and physical entity.

f) Should be controlled to ensure that the physical plant is consistent with the paper plant and its operation and maintenance.

2.5.3.1 Design Principles and Requirements

OPG is responsible for ensuring that the station is designed, constructed, and operated to meet safety requirements that protect the public. To this end, OPG has constructed a station, which meets all safety requirements and regulations, and will do adequate in-service inspections, maintenance, and improvements throughout the life of the station to ensure that it remains safe and reliable. Details of the safety philosophy followed are provided in the Darlington Safety Report.

The design of Darlington NGS utilizes a defence-in-depth methodology with redundant safety systems and barrier to control the reactor power, cool the fuel, and contain radioactivity, for the protection and safety of workers, the public, and the environment. The design of the fuel has five layers of defence-in-depth that prevent radioactive exposure as listed below:

- The UO_2 fuel pellets, which bind the majority of radioactive fission products within its solid matrix.
- The fuel sheath, which contains fission products not retained in the fuel matrix.
- The Primary Heat Transport (PHT) system boundary, which contains any leakage from the fuel sheath.
- Negative Pressure Containment System (NPCS) including concrete containment and associated structures (e.g. vacuum structure), which contains any release from the PHT system.
- The exclusion zone surrounding the facility, which provides for dilution of any release from containment.

The first three barriers prevent radioactive release accidents and ensure that, while they are intact, very little radioactive material will escape into the reactor building. NPCS and the exclusion zone come into play to mitigate doses in scenarios where all of the first three barriers are breached, such as in a severe loss-of-coolant accident.

Primary heat production control and heat removal control are performed using dual digital computers for critical functions such as reactor power control and boiler pressure control. The system consists of two independent computers, each capable of complete unit control, and contains a digital control computer, with annunciation and command processing. The software and hardware operations are continuously monitored by a combination of internal self-checking software and hardware plus an external watchdog timer.

Darlington NGS has four special safety systems as listed below. The special safety systems have the purpose of shutting down the reactor, cooling the fuel, and preventing radioactive

releases following any abnormal events. The special safety systems are, as far as practical, independent of the process systems so that any process system impairment will not adversely impact the functionality and performance of a safety system.

- Two independent and diverse Shutdown Systems (SDS) (SDS1 and SDS2), which rapidly shut down the reactor by introducing sufficient negative reactivity to make the reactor subcritical with the aid of two independent and diverse neutron absorbers.
- Emergency Coolant Injection (ECI) system, which ensure fuel cooling is maintained.
- NPCS, which is designed to prevent the release of radioactive material to the environment.

To protect against common mode events, independent and redundant equipment has been incorporated into the design of the station. These redundancies in the design ensure essential safety functions are maintained and will be performed during a postulated event. There are several other systems with important safety related functions such as Emergency Service Water (ESW), Steam Generator Emergency Cooling, Emergency Power System, Standby Class III Power, Interunit Feedwater Tie, Post Accident Hydrogen Ignition System, Containment Filtered Venting System (CFVS), Shutdown Cooling (SDC), and Powerhouse Steam Venting.

Systems and components classified as systems important to safety and components important to safety are listed in NK38-REP-03611-10100, *Darlington NGS Systems and Components Important to Safety*. Systems classified as Safety Related are listed in NK38-LIST-06937-10001, *List of Safety Related Systems and Functions*. Detailed descriptions of these systems are provided in Part 2 of the Darlington NGS Safety Report. CSA N290.0-11, *General requirements for safety systems of nuclear power plants*, compliance is achieved through design governance and is applied to modifications.

Plant states and operational configurations considered in design of the Darlington NGS facility are described in the Darlington NGS Safety Report. Part 3 of the Safety Report provides the detailed description of the accident analysis for Darlington NGS. This section presents the analysis of all Design Basis Accidents (DBAs) to demonstrate that the safety design objectives of all postulated accidents are met.

Code effective dates of various design codes and standards at the time of issuance of the Construction Licence for the station are identified in the System Classification List. Ongoing modifications for pressure-retaining systems and components will be done in accordance with the version of CSA N285.0, *General requirements for pressure-retaining systems and components in CANDU nuclear power plants*, in the current licence. The applicable codes and standards used in the nuclear and conventional design of Darlington NGS is provided in the Darlington Safety Report.

Safety and Design Envelope are the boundary conditions provided by the licensing basis for the Darlington NGS facility. OPG nuclear standard N-STD-MP-0016, *Safe Operating Envelope*, defines the processes, organizational responsibilities, and key program elements to ensure that the SOE is defined and documented in a correct, complete and consistent manner and reflected in the station operating documentation. Refer to Section 2.3.5 for more details.

Design for reliability and safety design concepts incorporated into the Darlington NGS are described in Part 2, Section 1 of the Safety Report. Furthermore, reliability targets to meet the

requirements of REGDOC-2.6.1, *Reliability Programs for Nuclear Power Plants*, are discussed in Section 2.6.

Station and system design considers mitigation of acute radioactive releases, Severe Accident (SA) initiators, and post-accident actions. Beyond Design Basis Accident (BDBA) management includes the use of Emergency Mitigating Equipment (EME), Severe Accident Management Guidelines (SAMG) and Emergency Heat Sink (EHS). Use of EME has a primary focus on fuel cooling and is used to mitigate accident progression when design basis equipment is unable to provide adequate core cooling, intending to prevent an event from progressing to a SA. SAMG has a focus on both containment integrity and fuel cooling, and its use is initiated if an event has progressed to the SA stage. The EHS is a new connection installed on all post-refurbishment units that allows ESW or water from the forebay directly into the PHT system. Emergency response planning is also undertaken and emergency drills are run on a periodic basis to ensure staff are prepared to respond as required.

Radiation Protection (RP) is a critical factor and requirement which is considered as part of the ECC process when completing modifications. The limitation of external and internal radiation exposures to plant staff is ensured by several design features incorporated into the station design, and by adherence to a set of approved operating procedures and the *Radiation Protection Regulations*. Radiation exposure is limited by controlling access to areas where high radiation fields and radioactive contamination may exist, by plant layout and structural shielding arrangements, and by the use of protective equipment and decontamination facilities. Personnel monitoring and dosimetry facilities are provided to monitor the individual's exposure. A detailed description of the RP design elements incorporated into the Darlington NGS design is in Part 2, Section 12 of the Safety Report. Refer to Section 2.7 for more details.

OPG has a robust Foreign Material Exclusion (FME) program, and has controls in place through the design and modification process to ensure the requirements of the program are met. The goal of the FME program is to cultivate a focus on prevention among workers and contractors, and to plan and execute work activities to include precautions for preventing introducing foreign material into plant equipment. This applies to the plant, warehouses, calibration labs, and on-site fabrication facilities.

2.5.4 Structure Design

The Darlington NGS consists of four units with one Main Control Room and a Central Service Area. Each unit consists of a single reactor housed in a reinforced-concrete vault, with the steam generators protruding into shielded access-controlled rooms above this vault, and a single turbine/generator housed in an adjacent powerhouse. The station is close to the lake with the nuclear portion of the station and the vacuum structure located on the south side of the powerhouse. All nuclear structures are on bedrock.

The Darlington NGS site contains the following buildings and structures:

1. Four reactor building structures.
2. Four reactor auxiliary bays.
3. A powerhouse comprising four turbine halls, four turbine auxiliary bays, and a central service area.
4. A vacuum structure.

5. Four combined cooling and service water pumphouses.
6. An emergency electrical power and water supply complex, consisting of an ESW pumphouse, Emergency Power Supply (EPS) generator sets buildings, EPS fuel management structures, and emergency electrical rooms and associated tunnels.
7. Two administrative buildings (OSB and ESSB/DLC).
8. A Water Treatment building.
9. Two Fuelling Facility Auxiliary Areas (FFAAs), including two Irradiated Fuel Bays (IFBs).
10. Four Standby Generator buildings.
11. A Heavy Water Management Building (HWMB).
12. Tritium Removal Facility.
13. Flammable Storage building.
14. High-Pressure Gas Cylinder Storage building.
15. Sewage Treatment Plant.
16. Emergency Response Team Facility.
17. Hazardous Material and D2O Storage Building.
18. Security Access through the Main Security Building (MSB), Auxiliary Security Building (ASB) and the Refurbishment Project Office (RPO).
19. Nuclear Sustainability Services – Darlington.
20. Auxiliary Heating Steam Boiler House.
21. CFVS Outdoor Shielding Space.
22. HWMB West Annex.

The reactor building is a rectangular reinforced-concrete building, which serves as a support and an enclosure for the reactor and some of its associated equipment. The portion of the reactor building, which forms part of the containment envelope, is called the reactor vault.

The fuelling duct, which is connected to each of the reactor vaults, runs the length of the station under the vaults. It serves as a connection between the reactor and the FFAAs at each end of the duct. A provision for future plant extension has been provided in the end wall of the fuelling duct in the east FFAA. A Pressure Relief Duct (PRD) connects the fuelling duct to the vacuum structure.

The containment envelope comprises the four reactor vaults, the fuelling duct, the PRD, the pressure relief valve manifold, the vacuum structure, the fuelling machine head removal area, and a fuel handling and service area at each end of the fuelling duct.

Each reactor vault is surrounded by a reactor auxiliary bay. This building contains reactor auxiliaries and secondary circuits of low temperature, pressure, and generally of low radioactivity level. The reactor auxiliary bay consists of a basement with concrete floors below elevation 100 m, and a conventional steel-frame structure with concrete floor slabs above elevation 100 m.

The central service area is divided into the central service area-nuclear and the central service area-conventional. The central service area serves the entire station. The central service area-nuclear contains facilities for fuelling machine head removal, treatment and storage of heavy water, spent ion exchange resins, and active wastes. It is located below grade in the south portion of the central service area and is of reinforced-concrete construction. The central service area-conventional contains stores, laboratories, workshops, electrical and air conditioning equipment, and the central control area. For the most part, it is of steel-frame construction with concrete floors. The central control area is located above the central service area-nuclear and is enclosed on all four sides by reinforced-concrete walls. The control area also has a reinforced-concrete roof.

The emergency electrical power and water supply complex is of reinforced-concrete construction throughout. The other buildings listed are of conventional steel-frame construction on reinforced-concrete foundations.

The design criteria and description of station structures is provided in Part 2, Section 3 of the Darlington Safety Report. Further information regarding design and physical characteristics of plant structures is provided in the Design Manuals for each respective structure.

CSA N291, *Requirements for safety related structures for CANDU nuclear power plants*, compliance is generally achieved through the ECC and Design Management programs. Inspection requirements of N291-19 are achieved through N-PLAN-01060-10004, *Aging Management Plan for Concrete Containment Structures and Safety Related Structures.* Darlington NGS containment structures are routinely inspected at regular intervals in accordance with CSA N285.5-18, *Periodic inspection of CANDU nuclear power plant containment components* and CSA N287.7-08, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants*. Refer to Section 2.6.5 for information on Darlington NGS inspection programs.

2.5.5 System and Component Design

The following subsections describe details on the physical design of the station, design and performance requirements of systems and components, key results from the current licensing period, and ongoing and future activities over the next licencing period, which collectively support that:

- SSCs at the station are fit to continue commercial operation and programs will ensure fitness-for-service during the next license period.
- OPG continues to invest in Darlington NGS to support the assurance of fitness for service through procurement, fuel inspections, and improvement/upgrade modifications.
- Nuclear safety is assured by maintaining the plant's Pressure Boundary (PB) and ensuring key safety and mitigating equipment is qualified.

Appendix B provides additional details on specific systems such as the functional and performance requirements, nuclear safety requirements, and projects and modifications on each system or various components within the system.

2.5.5.1 Pressure-Retaining Structures, Systems and Components

N-PROG-MP-0004, *Pressure Boundary,* manages the processes that control the quality of PB activities at OPG Nuclear with a goal of no failure of pressure retaining parts. The program establishes the infrastructure and defines the activities necessary to maintain a sustainable managed process that allows OPG to perform activities associated with repairs, replacements, modifications and alterations to pressure retaining items, components and systems, including installation of new systems.

The OPG PB Program ensures PB activities at Darlington NGS are in accordance with the codes and standards required by the Darlington NGS PROL. The PB program is a mature program that is compliant with the mandated codes and standards. Darlington NGS Engineering and Maintenance are responsible for implementing the program at the Darlington NGS site.

N-MAN-01913.11-10000, *Pressure Boundary Program Manual*, describes the program used to control the quality of PB activities at OPG Nuclear facilities and stations including Darlington NGS. It complies with CSA N285.0-08 and update no. 2, *General requirements for pressure-retaining systems and components in CANDU nuclear power plants*, and CSA B51-09, *Boiler, Pressure Vessel and Piping* Standards. PB requirements for all states of work, from design through procurement, installation and testing, are implemented through OPG Nuclear governing documents.

Based on the agreement reached with the CNSC (Reference 2.5-1), all PB activities at Darlington NGS are compliant with CSA N285.0-08 and update no. 2. until the end of the Darlington NGS Refurbishment Project. In addition, as per the current LCH and N-LIST-00531-10003, *Index to OPG Pressure Boundary Program Elements*, OPG maintains a PB Program Document roadmap that is in compliance with Annex N of CSA N285.0-12 and update no. 1. The index is a document that correlates OPG's processes and procedures to the PB program elements identified in CSA N285.0-12 and update no. 1, Annex N, Table N.1.

Darlington NGS has been using the Technical Standards and Safety Authority (TSSA) as the Authorized Inspection Agency (AIA), under a contract between OPG and TSSA, to comply with CNSC requirements for inspection of pressure boundaries. Darlington NGS reports all PB degradations to CNSC (immediate and quarterly) as per REGDOC-3.1.1.

Darlington NGS has had four successful PB Certificate of Authorization (CofA) renewal audits conducted by the TSSA demonstrating PB processes to be in compliance with the OPG Nuclear Pressure Boundary Program Manual since the last license application. The four audits were conducted in 2014, 2017, 2020 and 2023 respectively. OPG's PB CofA has been renewed and new certificates have been issued by the TSSA. These certificates will expire on April 15, 2026, before which the 3-year rolling renewal process will continue.

Annual internal self-assessments and internal audits are performed as per requirements of the Pressure Boundary Program Manual, which have contributed to further improvement of the PB program and associated procedures. The audit findings and self-assessment report observations have generally shown compliance to the Pressure Boundary Program Manual. The results of self-assessments and internal audits are documented and associated corrective action plans are developed to address the Areas for Improvement (AFIs).

As was done for Units 2 and 3 refurbishment, Enterprise Project Contractors (EPC) perform PB activities under their own CofA for the refurbishment of Units 1 and 4. OPG issued a Letter of Authorization to the EPC to prepare registration and reconciliation packages and to submit them to the AIA for registration on OPG's behalf. OPG then receives the registration package. The EPC is also required to prepare Code Classification and Exemption evaluation packages. Should a variance or deviation from code be required, the EPC prepares and submits the proposed resolution to the AIA for evaluation on OPG's behalf.

OPG is accountable for all communications with the CNSC related to code class approvals and notifications regarding registration and changes to PB documentation.

Darlington NGS Class 1 systems were assessed for life extension in which formed part of the Darlington NGS Refurbishment Integrated Safety Review (ISR). This assessment recommended the implementation of a transient/fatigue monitoring program to support Darlington NGS life extension. NK38-PLAN-01060-10015, *Fatigue Monitoring of Nuclear Class I Piping Systems at Darlington NGS*, documents Darlington's formal Fatigue Monitoring program which was accepted by the CNSC. The Fatigue Monitoring Project was initiated as part of this plan to develop a program to track fatigue usage of Class 1 components inclusive of environmental factors. The project has been in-service as of 2022. Darlington NGS has chosen FatiguePro 4, an industry standard software for fatigue monitoring.

2.5.5.2 Environmental Qualification of Equipment

Per CSA N290.13-05 and update no.1, 2009, *Environmental qualification of equipment for CANDU nuclear power plants*, Environmental Qualification (EQ) shall demonstrate that equipment will perform its required function during and following a DBA, taking into consideration stressors associated with all service conditions.

N-PROG-RA-0006, *Environmental Qualification,* establishes an integrated and comprehensive set of requirements that provides assurance that essential equipment can perform as required if exposed to harsh DBA conditions and this capability is preserved over the life of the plant. Implementation of these program requirements provides consistent methodology, programmatic controls, and interfaces for establishing and maintaining EQ of equipment and components at Darlington NGS. The EQ program is in accordance with CSA N290.13-05 and update no. 1, 2009.

Effectiveness of the EQ program at Darlington NGS is evaluated using the EQ Program Health Report, and the current status of the program meets requirements and is sustainable. A fleetview health report is also performed for the program encompassing both the Darlington and Pickering stations.

EQ program controls are integrated into the engineering change governance to ensure engineering changes conform to EQ requirements.

Ongoing improvements continue from the combination of the Darlington, Pickering, and Corporate EQ groups. Learnings are shared and incorporated into the daily processes at each site to increase the effectiveness of benchmarking between sites and improve implementation of the program.

2.5.5.3 Electromagnetic Interference

OPG has guidelines in place for Electromagnetic Compatibility (EMC) testing in conjunction with the ECC process. The guidelines provide design engineering teams with International Electrotechnical Commission (IEC) standards and test levels to consider in their design and testing requirements for instrumentation and electrical equipment. This allows for the mitigation of potential Electromagnetic Interference issues (EMI), and appropriately considers the criticality and safety classification of the SSCs.

Both susceptibility and emission aspects are considered to ensure SSCs are protected from EMI-induced faults without introducing significant electromagnetic disturbances to other equipment within the plant. Considerations for grounding and shielding are covered through the ECC process, which includes references to design guides that provide strategies and best practices.

Due to evolving technologies and increased EMI boundaries with new technology, the OPG guidelines for EMC are in the process of being revised to take into account guidance from Electric Power Research Institute TR-102323, *Guidelines for Electromagnetic Interference Testing in Power Plants*, and updates to the IEC 61000 series, *Electromagnetic Compatibility*, of standards.

2.5.5.4 Seismic Qualification

Darlington NGS is designed and constructed to ensure that the effects of an earthquake do not lead to unacceptable radiological releases as specified in the Nuclear Safety and Control Act, as a minimum requirement. Seismic qualification is demonstrated in accordance with the requirements of CSA N289.1-08, *General requirements for seismic, design and qualification of CANDU nuclear power plants*, for those SSCs which ensure that, as a minimum, the following safety functions are provided:

a) In the event of an applicable earthquake (generally referring to the Design Basis Earthquake (DBE) or Margin Design Earthquake (MDE)):

   1) Safely shut down the reactor and maintain it in that state indefinitely.
   2) Remove decay heat from the fuel and maintain pressure integrity of the primary coolant system PB during the shutdown period.
   3) Contain radiological releases in the NPCS within the specified limits.
   4) Monitor performance of the functions specified in Items 1) to 3).
   5) Limit consequences of potential failure of those SSCs that are not servicing the reactor, but are containing or preventing the release of radioactive materials; and
   6) Prevent seismic interaction of other SSCs that can lead to substantive damage impairing the safety function of any of the SSCs included in Items 1) to 5).

b) In the unlikely event of a Loss of Coolant Accident (LOCA) due to an applicable earthquake, necessary portions of the ECI system, SDSs, NPCS, monitoring equipment, and supporting systems shall remain functional following the Site Design Earthquake (SDE) during the recovery period after the LOCA.

The ECC program ensures that modifications to seismically qualified SSCs are subjected to the applicable stakeholder review process and that the seismic qualification is not degraded by a proposed design change. It also reviews and ensures that the qualified systems are located in (or in the vicinity of) structures that are likewise qualified, and seismic interaction by unqualified SSCs is prevented. Furthermore, plant modifications are controlled to not compromise the function of the seismic routes. Seismic routes are marked on floors or ground to provide assured operator access to safety-related SSCs for which short term actions (in the first 2 to 3 hours) are credited following an earthquake. Procedures are in place at Darlington NGS to ensure plant operations do not interfere or degrade the function of the seismic routes.

In addition to the seismic qualification of the safety-related SSCs to the DBE/MDE and SDE, the SSCs are also assessed for Beyond Design Basis Earthquakes (BDBE) for seismic robustness, which is to assure redundancy of the SSCs and defense-in-depth through common cause failures and to meet the seismic requirements stated in CSA N289.1. These assessments provide an estimate of the overall frequency of predetermined plant-level damage states, such as core damage frequency and frequency of large release of radioactive materials to the environment. As a means to evaluate the seismic robustness of the SSCs for redundancy and defense-in-depth beyond the DBE and MDE, the Seismic Probabilistic Safety Assessment (SPSA) is performed for Darlington NGS to assess the risks of severe core damage and large releases. Two risk metrices are evaluated, Severe Core Damage Frequency (SCDF) and Large Release Frequency (LRF), and compared to the OPG safety goals specified in N-PROG-RA-0016, *Risk and Reliability Program*. In the scenario where the SPSA results indicate that design modifications are required to meet the OPG safety goals, the modifications would be executed in a timely manner.

The last Darlington NGS SPSA (also known as DARA Seismic) was submitted to the CNSC in 2020, and the next submission will be in 2025 per the 5-year submission requirement of REGDOC-3.1.1. The SPSA demonstrated that the seismic SCDF and LRF meet the OPG safety goals. Refer to Section 2.4.3 for details.

Darlington NGS maintains a list of seismically qualified SSCs that are credited to fulfill the safety requirements mentioned above. It compiles all the seismic qualification requirements including seismic classification and categorization for the SSCs which have been documented within the bounded document set.

Depending on required safety functions during and following the DBE, the seismically qualified SSCs are classified into the following four categories, which exceed the minimum requirements of CSA N289.1:

- Category-A: Those SSCs which must retain their PB integrity during and following an applicable earthquake. This category also includes containment boundary.
- Category-B: Those SSCs which must retain a specified performance capability during and following an applicable earthquake.
- Category-C: Those SSCs which must retain a specified performance capability following an applicable earthquake.
- Category-D: Those structures and components which must maintain their structural form and support function during and following an applicable earthquake.

The original investigations of the historical seismicity in the region of the Darlington NGS site were undertaken to provide an estimate of the design basis ground motion. These studies resulted in the original definitions of the DBE and SDE for the Darlington NGS. Seismically qualified SSCs are capable to resist the DBE and SDE without compromising the required safety functions. In addition to the DBE and SDE requirements, MDE is introduced into the seismic qualification of applicable SSCs. The MDE is defined as 1.5 times the DBE, which provides additional safety margin above the DBE and is to align with new requirement of the design basis earthquake defined in CSA N289.3, *Design procedures for seismic qualification of nuclear power plants*. Darlington NGS has a seismic design guide which is utilized in determining seismic qualification requirements for SSCs and modifications, and provides delineation of the uses of DBE and MDE requirements. Seismic qualifications at the Darlington NGS are primarily done by analysis, testing, or a combination of analysis and testing in accordance with the requirements of CSA N289.1, N289.3, and N289.4, *Testing procedures for seismic qualification of nuclear power plant structures, systems and components*. The code-over-code reviews of the seismic qualification standards CSA N289 series are performed to identify significant technical changes due to evolutions of new standard editions. The ECC process requires that any significant technical changes are addressed, as appropriate, for any planned modifications to existing SSCs or new installations.

In-plant seismic instrumentation is installed in the plant to monitor and record in-plant seismic motions in compliance with the requirements of CSA N289.5, *Seismic instrumentation requirements for nuclear power plants and nuclear facilities*. Within the plant facilities, seismic motions are recorded if the vibrations exceed a threshold level. Outside the plant facilities, the seismic motions are recorded by the Southern Ontario Seismic Network (SOSN) that records detailed free-field seismic activities covering Southern Ontario. The in-pant seismic monitoring network includes eight accelerometers spreading over critical nuclear structures. In addition to the in-plant seismic monitoring network, two accelerometers locate on free field near the Darlington NGS property boundary, which are part of the SOSN. Recorded seismic motions are assessed against the DBE, MDE, and other seismic design bases. The records of the SOSN are also used to support the probabilistic seismic hazard assessment.

Seismic qualifications of the SSCs are reviewed periodically as part of the Periodic Safety Review (PSR) process and as part of N-CHAR-AS-0002, *Nuclear Management System*, for their overall effectiveness and opportunities for improvement. PSRs have been performed systematically at the Darlington NGS to review the design, condition, and operation of the plant and identified gaps for code compliances and improvements. All the seismic qualification gaps identified by the recent PSR have been either closed by addressing the issues or re-classified as acceptable deviations. The combination of the original seismic designs and the current seismic practices provide high confidence that Darlington NGS can withstand applicable design and reference earthquakes.

N-PROC-TR-0008, *Systematic Approach to Training*, ensures that engineering, operations, and maintenance staff are aware of station requirements including seismic qualification while performing their respective duties, and that they receive the appropriate training on seismic qualification. N-PROG-MA-0004, *Conduct of Maintenance,* outlines precautionary measures to counter incidents that could impact the operation of seismically qualified equipment and seismic routes. N-PROG-MP-0008, *Integrated Aging Management,* requires seismic qualification requirement be considered during condition assessment of critical SSCs as the plant ages.

2.5.5.5 Fire Safety and Fire Protection System

As part of its PROL, the Darlington NGS is required to implement and maintain a Fire Protection Program (FPP). The OPG FPP establishes provisions to prevent, mitigate and respond to fires such that fire risk to OPG Nuclear workers, public, environment, nuclear physical assets, and power generation is acceptably low and controlled. For additional FPP details, refer to Section 2.10.

The FPP goals are to:

- Minimize the risk of radiological releases to the public due to fire.
- Protect plant occupants from death or injury due to fire.
- Minimize economic loss resulting from fire damage to structures, equipment, and inventories.
- To manage impact to the environment resulting from fire.

In the event of a fire, the plant shall be capable of achieving the following nuclear safety objectives:

- Achieving and maintaining the reactor in sub-critical conditions.
- Achieving and maintaining decay heat removal.
- Maintaining the integrity of the fission product boundaries.
- Limiting the release of radioactive materials that are located outside the reactor.

The following life safety performance objectives shall be met during all operational modes and plant configurations:

- Fire hazard controls shall be included in design and operational stages.
- Fire notification means shall be provided.
- Safe egress and/or areas of refuge shall be provided for occupants for use in the event of a fire.
- A safe environment and other required support shall be provided for essential staff so they can perform all necessary plant control functions during and following a fire.
- Protection for personnel performing emergency services shall be provided both during and following a fire.
- Access and emergency lighting shall be provided for all areas where manual fire fighting, evacuations, or operator field actions are excepted.

The overall approach to the FPP is based on the defense in depth provisions of fire prevention, fire detection and suppression, and limiting or mitigating the effects of fires.

CSA N293-12, *Fire protection for CANDU nuclear power plants*, provides the fire protection requirements for design, construction, commissioning, operating, and decommissioning of NPPs, including SSCs that directly support the plant and protected area.

Fire Protection Assessment (FPA) are engineering evaluations that assess the plants or facilities against the requirements of CSA N293 to ensure safety in the event of a fire in any plant or

facility location. The evaluations are documented for each station in three assessments which are updated every 5-years:

1. Fire Protection Code Compliance Report (CCR) including Third Party Inspection, Testing, and Maintenance (ITM) Reports.
2. Fire Safe Shut Down Analysis (FSSA) report.
3. Fire Hazard Assessment (FHA) report.

The Fire Protection CCR assesses the as found fire protection conditions against the relevant codes. Although most of the buildings were constructed prior to Darlington NGS obtaining its current operating license, the CCR examined the station from the lens of new construction given the intent to operate the station for an additional 30-years. The CCR covered all buildings inside the protected area except buildings exempted from CSA N293 per NK38-LIST-78000-10001, *Application of CSA N293 to Structures, Systems and Components for Darlington Nuclear*. It was the general conclusion of the 2023 CCR, with the resolution of the outstanding deviations, that Darlington NGS is in compliance with the requirements of CSA N293-12 (R2017), National Building Code of Canada (NBCC)-2015, and National Fire Code of Canada (NFCC)-2015.

The ITM portion of the CCR consists of two reports:

- Fixed fire protection systems (detection and suppression).
- Manual fire protection equipment (firefighting equipment such as fire hose and nozzles, fire vehicles etc.).

The ITM activities for fixed fire protection systems and manual fire protection equipment are intended to document the state of compliance of the station with the ITM requirements of CSA N293, NFCC, and other applicable codes and standards. It is the general conclusion of the 2024 fixed fire protection systems and manual fire protection equipment ITM Reports that the station is in compliance with the applicable codes and standards, and that the Darlington NGS ITM Program meets the objectives defined in CSA N293-12 (R2017). These reviews are conducted every 5-years.

The FHA is a set of analyses and assessments for evaluating potential fire hazards, as well as the appropriate fire protection systems and features used to mitigate the effects of a fire. The FSSA is an analysis conducted for NPPs to demonstrate that at least one means of achieving nuclear safety objectives and performance criteria is available. The FHA and FSSA are contained within the FPA report. The 2021 FPA concluded that the station is provided with effective design, construction, fire protection features and operational controls to mitigate the fire hazards present and maintain the fire, life and nuclear safety goals defined in CSA N293.

Third-party audits have been conducted on OPG's Nuclear Fire Protection Program, with respect to the requirements of CSA N293. As per CSA N293-12, the audit is required to be conducted at least once every 3-years by a qualified third party. The 2023 audit results confirmed that the FPP was in good overall health and effective, and that Darlington NGS meets the objectives defined in Clause 8.3.4 of CSA N293-12 (R2017).

Annual plant condition inspections are performed to confirm compliance to CSA N293-12 and the NFCC per Clause 8.3.5 of CSA N293-12 (R2017). The 2023 Annual Plant Condition Inspection (APCI) saw sufficient evidence to conclude that the fire protection program was being

followed and effectively maintained the condition of the plant in compliance with requirements of CSA N293, NFCC, and NBCC.

During the current licence term, significant projects / modifications have been undertaken to improve the reliability and performance of fire safety and the fire protection system. These projects have and will continue to ensure safe operation. Specific projects include:

1. Upgrade of fire panels from conventional to addressable:

   Conventional fire panels throughout the plant are being upgraded to addressable fire panels to improve system reliability and maintainability.

2. Upgrade of Public Address (PA) System:

   Darlington NGS PA System provides paging for voice instructions, fire alarm signals, emergency warning signals to all areas of the generating station, associated buildings, and outdoor areas. The PA System is being upgraded to ensure reliability, and maintainability. Refer to Section 2.10, for further information on PA System status and ongoing improvements.

3. Transformer Deluge System increased coverage:

   As part of the Darlington NGS Refurbishment Integrated Safety Review (ISR), the currently installed transformer fire protection was evaluated against CSA N293-07 and a code gap was identified that the non-absorbing ground areas adjacent to the main output transformer, unit service transformer, and system service transformer were not protected by automatic water spray systems. Each deluge system is being upgraded in their respective Refurbishment outage to increase coverage. There is no impact to fire safety prior to completion of the modification.

4. Installation of additional detection in higher-risk areas:

   As a result of the FHA and FSSA, it was recommended to provide additional fire detection coverage in the following areas: Instrument Air compressors room, PHT pumps, silicone filled transformer in room R-321, PHT system auxiliary room, Annulus Gas System room, ECI low pressure pumps, ECI high pressure pumps, ESW pumps.

5. ESW Pump Oil Spill Containment Dikes:

   As a result of the FHA and FSSA, a 25 ft^2 dike which can contain at least 125% volume of oil was installed around each of the four (4) ESW pumps. The purpose of the dike is to limit the spread of a potential oil fire from a failed ESW pump, and addresses the economic and safety risks associated with multiple ESW pump failures.

2.5.5.6 Reactor and Reactor Coolant Systems

The reactor is contained in a cylindrical, horizontal, single-walled stainless steel vessel called the calandria. It provides containment for the heavy water moderator and reflector. It is axially penetrated by 480 calandria tubes. These tubes contain the pressure tubes, which contain the fuel and heavy water coolant. The calandria, the two end shields, and the shield tank form an integral, multi-compartment structure.

The subsections below provide further details on the design and performance of reactor and reactor coolant systems, along with improvements made during the current licence term and planned improvements for the upcoming licence term.

Design of Fuel System

N-PROG-MA-0016, *Fuel*, establishes a formal and systematic process for integrating and reviewing information related to fuel, and reporting its performance, condition, and compliance with fuel design basis documents.

The fuel is in the form of compacted and sintered natural uranium dioxide pellets, sheathed and sealed in zirconium alloy tubes. Thirty-seven tubes or elements are assembled between two end plates, forming one fuel bundle. Each of the 480 channels contains 13 bundles.

There was no change to the design of the fuel bundles used by Darlington NGS during this period and Modified 37-element (37M) bundles continue to be used for running units in both "standard" and "long" lengths. Small numbers of depleted 37M bundles also continue to be used when required to ensure compliance with core physics parameters, e.g. the fresh core load after each Refurbishment outage.

The design capability to execute fuel recycling (fuel shuffling) during the post-refurbishment pre-equilibrium period of operation has been re-introduced at Darlington NGS by means of a minor change to Fuelling Machine software. A fuel recycling campaign has been successfully executed in Unit 3 (2023) after its return to service following refurbishment, with good fuel performance and a significant reduction in the number of low irradiation fuel bundles prematurely discharged to the bay.

Fuel Handling and Storage

The reactor is refuelled on-power by two remotely controlled Fuelling Machines (FMs). One is located at each face of the reactor. They work at opposite ends of the same fuel channel, inserting new fuel and accepting irradiated fuel while the reactor continues to operate. The irradiated fuel is transported by the fuelling machine trolleys to the ends of the fuelling duct to be discharged into one of the two IFBs in the FFAAs. Storage of the discharged fuel is maintained in the adjacent storage bays until ready for dry storage in the Waste Management Facility. There are three pairs of fuelling machine heads shared by the four reactors. Safe, reliable, and predictable performance of the fuelling machines is necessary to maintain core reactivity and support outage activities. Online refuelling operation on a routine basis is required to ensure sufficient reactivity to maintain reactor operation at full power and maintain average zone levels in the target range for optimum control.

The objectives of the Fuel Handling and Storage program are to:

- Ensure FMs are available to maintain average zone levels across the four operating units.
- Support execution of outage activities related to reactor inspection and maintenance.
- Provide safe handling and storage of fuel.
- Maintain fuel accounting.

Completed projects, modifications, and initiatives which have improved reliability and performance of the Fuel Handling (FH) Systems over the term of the current operating licence include:

- FM vessels/supports reanalysis/qualification.
- FM D_2O circulation and auxiliary circuit sub-system components replacement.

- FH process computer peripherals and components replacement.
- New Fuel Transfer Mechanism transporter assembly replacement for large-scale unit defuel upgrade.
- IFB heat exchanger replacement for large-scale unit defuel upgrade.
- Inverter motor drive sub-system replacement.
- FH Irradiation Fuel Port isolation valves replacement.
- FH Control System power supplies replacement.
- FM Input Drive upgrade modification.
- FH Powertrack carrier track and roller components replacement.
- FH control power auto transfer relays replacement.
- Fuel Inspection Facilities modification, including upgrade of Module Unloader mechanisms.
- FH Control Room alarm window annunciation sub-system replacement.

In-progress and planned projects, modifications, and initiatives for continued improvement in reliability and performance of the FH Systems include:

- In-progress and planned replacement of FH equipment and components such as motors, pumps, controllers, relays, valves, digital cards, actuators, hard drives, cables, and Reactor Area Bridge ball screws.

Design of the Reactor Internals

Darlington NGS refurbishment resulted in complete replacement of all 480 calandria tubes and all 480 pressure tubes during each refurbishment outage. Replacement pressure tubes are nominally thicker: 4.29 mm (0.169”) versus 4.19 mm (0.165”) in the original Unit 2 design.

Additionally, design changes have also been made to the fuel channel annulus spacers for post-refurbishment Darlington NGS units. All fuel channels have been installed with the novel Zr-Nb-Cu tight fitting garter springs to eliminate known material degradation issues with pre-refurbishment Inconel X-750 annulus spacers.

For Unit 2 (2020) and Unit 3 (2023), there was no change in the design of the adjuster rods - “like-for-like” replacement with new rods of the same types, and each reactor core was confirmed to be consistent with existing design documentation during return to service activities. Refer to subsection below for discussion on cobalt adjuster rods.

A minor change for Unit 2 reactor internals is associated with installation of the Molybdenum-99 Isotope Irradiation System (Target Delivery System) following CNSC approval of the licence amendment (PROL 13.03/2025). Due to their low neutron absorption properties and low mass, both the permanent in-core TDS components and the moveable molybdenum targets did not change core characteristics.

Nuclear Design and Core Nuclear Performance

A design change has been successfully implemented in Darlington Units 2, 3 and 4 to use Enriched Boric Acid (EBA) instead of natural boron as the moderator liquid poison of choice,

while maintaining the existing capability to add gadolinium. Unit 1 conversion to EBA will be completed during its refurbishment outage. The details of this design change (required concentration of EBA and insertion rate) were chosen such that reactor control was not affected and operating procedures were not significantly impacted. Using EBA as the poison of choice for reactivity banking (fuelling ahead) has facilitated longer maintenance windows to improve the reliability of FH equipment, as well as improved coordination with refurbishment activities.

A permanent core design change is planned to replace existing adjuster rods with cobalt adjusters of similar reactivity worth in all units. This modification is planned to be first commissioned in Unit 1 return to service, subject to the Commission decision on the Darlington NGS PROL amendment for the production of the Cobalt-60 radioisotope. This design change is of a nature that does not significantly affect core characteristics, including flux and power distributions, reactivity coefficients, reactor control or reactor stability. Refer to Section 3.4 for further information on isotopes, including Cobalt-60.

Modifications and Projects for Reactor and Reactor Coolant Systems

The following modifications and projects have been completed or are in progress during the current and upcoming licence terms:

1. Auxiliary Shutdown Cooling (ASDC) Pumps: the installation of two completely diverse ASDC Pumps per unit is a safety improvement that provides a maintenance cooling mode and a supplement to the currently installed SDC main pumps.
2. Emergency Heat Sink Alternate Supply to PHT system: this modification provides an alternate supply of cooling water to the PHT system from the ESW system.
3. Loss of Moderator Accident (LOMA) due to End Fitting Ejection (EFE) and random failure of ECI: this modification provides a permanent pipe connection to provide water to the PHT system.
4. End Shield Cooling (ESC) Tank Make-Up Water and Level Monitoring & Water to PHT: instrumentation was installed to provide level monitoring of the end shields and shield tank water level post BDBA.
5. Fixed Vibration Monitoring replacement: the Vibration Monitoring System (VMS) at Darlington NGS is designed to warn operations staff of vibration problems and requires replacement due to aging, obsolescence, and spare parts issues.
6. ESC Shield Tank Overpressure Protection (STOP) modification: a rupture disc was installed on the End Shield and Shield Tank Cooling System in Units 1 to 4 to provide overpressure protection in the event of a BDBE.
7. Single Loop Controller replacements: existing controllers are used to monitor and control variables such as temperature, level, flow, and pressure and require replacement due to aging and obsolescence.
8. PHT liquid relief valve (LRV) replacements: during refurbishment, the existing PHT LRVs are being replaced with new valves that have slower opening and closing times to reduce water-hammer to an acceptable level, while maintaining overpressure protection requirements.
9. Spectacle Flange installation: the purpose of the modification is to install a spectacle flange in the D_2O Collection System downstream of various Pressure and Inventory Control (P&IC) vent/drain valves to maintain leakage rates and D_2O Collection tank temperatures to within acceptable limits.

10. Moderator Main Isolators replacement: the main and auxiliary Moderator pump and heat exchanger isolation valves have been, or are scheduled to be, replaced during the refurbishment outages.
11. PHT Isolators replacement: this modification ensures D_2O supply to the PHT system is maintained via the D_2O transfer header for operating units during refurbishment, without the risk of spilling tritiated D_2O into the outage units.
12. P&IC Heater Controllers replacement: this modification replaces the existing pressurizer heater controllers with new variable controllers. The controllers are required to control the pressurizer variable heaters output which in return controls the pressure of the PHT system.
13. PHT Pumps, Seals and Pump Motors replacement: these replacements were made to improve reliability performance with reduced leakage to collection.
14. Feeder Scanner System modification: due to obsolescence and aging issues, the feeder scanner system has been upgraded to a new system with improved data quality and data interpretation technologies to ensure reliable detection of fuel defects during outages.
15. Gaseous Fission Product (GFP) modification: the GFP detection computer had an alternative power supply installed to ensure availability and reliability.
16. Primary Side Clean (PSC) to restore PHT system Reactor Inlet Header (RIH) temperature margins: due to corrosion induced magnetite deposits, the Primary Side (tube side) portion of all Steam Generators were cleaned during refurbishment to improve heat transfer capacity, coolant flow, and by extension RIH Temperature Margins.
17. Moderator Pump Motor procurement and first-time replacement during the refurbishment of Unit 1 as part of 4kV motor refurb project: these motors at Darlington NGS are reaching end of recommended service life and are being proactively refurbished/replaced to ensure reliable operation.
18. PHT feed pump spare procurement and first-time replacement as part of 4kV motor refurb project: these motors are reaching end of recommended service life and are being proactively refurbished/replaced to ensure reliable operation.
19. Upgrade PHT Feed Pump Seals to Diamond faced model to eliminate risk of leakage to collection: due to a history of mechanical seal leaks, these seals have been replaced with an upgraded model.

2.5.5.7 Waste Treatment Control

Waste is generated at Darlington NGS as a result of daily operations and maintenance activities, and during execution of outage activities. Waste is characterized as either radiological or conventional depending on the radiological zones of its origin, and from radiological surveys and analysis that are performed on it as it is generated. The Waste Management Program ensures that adequate provisions are in place to limit the production of radioactive and conventional waste, and to control its handling, storage, and disposal. This is done to continuously improve environmental performance in support of OPG's Environmental Policy. All activities involving handling, processing, transportation and storage of waste are performed in a manner that protects the workers, the public and the environment, and ensures compliance with applicable regulatory and license basis requirements. Refer to Section 2.11 for more details on the Waste Management Program.

2.5.5.8 Class II Nuclear Facilities

A Class II nuclear facility, or Radiation Calibration Facility (RCF), is located within the Darlington NGS and contains a J.L. Shepherd gamma irradiator. The irradiator contains three Cs-137 sources; one 37000 GBq, one 370 GBq and one 3.7 GBq. It is used to irradiate radiation detection instrumentation and thermoluminescent dosimetry (TLD) badges for the purposes of calibration and quality assurance. This facility is licenced in accordance with the Class II Nuclear Facilities and Prescribed Equipment Licence 12861-18-26.7.

The RCF is located within the Darlington NGS (S-003 and S-004) in the Powerhouse and, as a result, has the security controls of a Class I Nuclear Facility. Access control keys for the facility and irradiator controls are issued by Operations. The RCF adheres to OPG's RP program along with the associated governance procedures. OPG's RCF physical design is in compliance with the Class II Facilities and Prescribed Equipment Regulations Section 15.

2.5.5.9 Laboratories

The Darlington NGS chemistry laboratory focuses on providing timely and accurate results to support station operation. Laboratory staff participate in interlaboratory blind samples programs run by the CANDU Owners Group once per year. The objective of the interlaboratory comparison is to check OPG's analytical capability relative to a group of peer laboratories. A range of proficiency testing blind samples are prepared and distributed by a program administrator which also provides a statistically derived acceptance criteria to participating laboratories.

The Darlington NGS chemistry laboratory also has an intralaboratory blind sample program which continuously assesses the performance of laboratory staff. This internal program consists of six rounds per year of analytes consisting of blind samples for Quality Control Level 1 parameters. A Quality Control Level 1 parameter is one which an Operating Policies and Principles limit applies or has a safety limit in the Operational Safety Requirements.

Chemistry fundamentals are consistently reinforced during pre-job briefs to ensure safe and accurate laboratory operation. Monthly checks of chemical storage are also performed. Darlington NGS regularly reviews and reports sub-indicators in the Chemistry Laboratory Quality Control Indicator (CLQCI) which is an overall measure of the Chemistry Quality Management System. The CLQCI is calculated by equally weighting five sub-indicators (Instrument Availability, Control Chart Usage, Intralaboratory Proficiency, Laboratory Reporting and Laboratory Safety) and determining the monthly score as a percent against a rolling yearly target of 95%. Since the inception of CLQCI in 2018, Darlington NGS Chemistry has exceeded the annual rolling average of >95%, showing a robust Quality Management program.

The laboratory has upgraded instrumentation during the current licence term in order to ensure redundancy and refine accuracy through newer technologies. Equipment that has been upgraded include gamma spectroscopy equipment, ion chromatographs, gas chromatographs, UV visible spectrophotometers, total organic carbon analyzers, inductively coupled plasma spectrometer and fourier transformer infrared spectrometers. Darlington NGS will continue to evaluate and make upgrades to equipment throughout the upcoming licence term to ensure the requirements of the chemistry laboratory are met with safety as the top priority, while adapting to new technologies and analysis methods.

Section 2.6

Fitness for Service

2.6 Fitness for Service

The Darlington NGS fitness for service program ensures all equipment is available to perform its intended design function when called upon to do so. The physical condition of structures, systems and components at Darlington NGS remain available, reliable, effective and consistent with design, analysis and quality control measures.

The reliability, maintenance and aging management programs at Darlington NGS meet the requirements of CNSC regulatory documents REGDOC-2.6.1, *Reliability Programs for Nuclear Power Plants*, REGDOC-2.6.2, *Maintenance Programs for Nuclear Power Plants*, and REGDOC-2.6.3, *Aging Management*, respectively.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 10: SCA 6 – Fitness for Service

Document	Title
Maintenance	
N-PROG-MA-0004	Conduct of Maintenance
N-PROG-MA-0017	Component and Equipment Surveillance
N-PROG-MA-0019	Production Work Management
N-PROG-MP-0008	Integrated Aging Management
N-PROC-MA-0013	Planned Outage Management
N-PROC-MA-0049	Forced Outage Management
Reliability	
N-PROG-MA-0026	Equipment Reliability
N-PROG-RA-0016	Risk and Reliability Program
N-STD-RA-0033	Reliability and Monitoring of Systems Important to Safety
NK38-LIST-06937-10001	List of Safety Related Systems and Functions
Aging Management	
N-PROG-MA-0025	Major Components
N-PLAN-01060-10001[1]	Feeders Life Cycle Management Plan
Feeders	
NK38-PIP-33160-10001	Darlington Nuclear Unit 1 Fuel Channel Feeder Pipes Periodic Inspection Program Plan
NK38-PIP-33160-10002	Darlington Nuclear Unit 2 Fuel Channel Feeder Pipes Periodic Inspection Program Plan
NK38-PIP-33160-10003	Darlington Nuclear Unit 3 Fuel Channel Feeder Pipes Periodic Inspection Program Plan
NK38-PIP-33160-10004	Darlington Nuclear Unit 4 Fuel Channel Feeder Pipes Periodic Inspection Program Plan
Pressure Boundary	
N-PLAN-33110-10009	Steam Generators Life Cycle Management Plan
Stream Generators	
NK38-PLAN-33110-00001[2]	Darlington Units 1-4 Steam Generator Life Cycle Management Plan
Fuel Channels	
N-PLAN-01060-10002	Fuel Channels Life Cycle Management Plan

Document	Title
NK38-PIP-31100-10001	Darlington Nuclear 1-4, Unit 1 Fuel Channel Pressure Tubes Periodic Inspection Program Plan
NK38-PIP-31100-10002	Darlington Nuclear 1-4, Unit 2 Fuel Channel Pressure Tubes Periodic Inspection Program Plan
NK38-PIP-31100-10003	Darlington Nuclear 1-4, Unit 3 Fuel Channel Pressure Tubes Periodic Inspection Program Plan
NK38-PIP-31100-10004	Darlington Nuclear 1-4, Unit 4 Fuel Channel Pressure Tubes Periodic Inspection Program Plan
N-PLAN-01060-10003	Reactor Components and Structures Life Cycle Management Plan
NK38-PLAN-31160-10000[3]	Long Term Darlington Life Management Plan for Inconel X-750 Spacers
Periodic Inspection Plans	
NK38-PIP-03641.2-10001	Darlington Nuclear Generating Station Periodic Inspection Plan for Unit 1
NK38-PIP-03641.2-10002	Darlington Nuclear Generating Station Periodic Inspection Plan for Unit 2
NK38-PIP-03641.2-10003	Darlington Nuclear Generating Station Periodic Inspection Plan for Unit 3
NK38-PIP-03641.2-10004	Darlington Nuclear Generating Station Periodic Inspection Plan for Unit 4
NK38-PIP-03642.2-10001	Darlington Nuclear Generating Station – Periodic Inspection Program for Unit 0 and Units 1 To 4 Containment Components
NK38-PIP-03643.2-10002	Darlington Nuclear – Unit 0 Containment Periodic Inspection Program
N-PLAN-01060-10004	Aging Management Plan for Containment Structures
NK38-PIP-03643.2-10001	Darlington Nuclear – Reactor Building Periodic Inspection Program
NK38-PIP-03643.2-10003	Darlington Nuclear – Vacuum Building Periodic Inspection Program
NK38-TS-03643-10001	Inspection of Post Tensioning Tendons on DNGS Vacuum Building
N-PROC-MA-0066	Administrative Requirements for In-Service Examination and Testing for Concrete Containment Structures
NK38-PLAN-01060-10010[4]	Aging Management Plan for Darlington NGS Non-Containment Building Structures
Balance of Plant	
NK38-REP-34200-10066	Darlington NGS Main Containment Structure In-Service Leakage Rate Test Requirements in Accordance with CSA N287.7-08
NK38-REP-26100-10005	Darlington NGS Vacuum Structure In-Service Leakage Rate Test Requirements in Accordance with CSA N287.7-08

Notes:
1. OPG recommends N-PLAN-01060-10001 be moved under the *"Feeders"* section of the table.
2. OPG recommends N-PLAN-33110-10009 be removed from the table as this is the technical basis document and not the LCMP.
3. OPG recommends NK38-PLAN-31160-10000 be removed from the table as it is no longer in use and information is now included in N-PLAN-01060-10002.

4. N-PLAN-01060-10010 has been superseded by N-PLAN-01060-10004, *Aging Management Plan for Concrete Containment Structures and Safety Related Structures*.

2.6.1 Equipment Fitness for Service / Equipment Performance

Equipment Reliability

The objective of the Equipment Reliability (ER) program, N-PROG-MA-0026, *Equipment Reliability*, is to ensure high levels of equipment reliability and reduce forced loss rate by ensuring reliable performance of critical components important to nuclear safety and production.

The ER program leverages various activities to ensure ongoing high levels of reliable performance of critical components. This includes identification of critical components and maintenance strategies, executing Predictive Maintenance (PdM) and Preventative Maintenance (PM) programs, monitoring system and component condition, identifying and predicting aging and obsolescence issues on important components and embedding mitigating strategies and actions into the business plan.

The Plant Health Committee (PHC), provides oversight, direction, and leadership for resolving ER issues and implementing actions from System and Component Health Plans. The PHC consists of managers and/or directors from the key functional organizations at Darlington NGS involved in implementing ER actions. The key activities for the PHC are conducted in accordance with N-PROC-MA-0097, *Equipment Reliability Implementation*.

The ER key performance indicator through 2023 was the Equipment Reliability Index (ERI). CANDU Owners Group (COG) established the ERI, which the industry used to assess health of a plant's reliability program and equipment performance and enabled benchmarking against other plants. The ERI provided a measure of long-term trends of ER improvements and sustainability, utilizing a composite of key sub-indicators that have a weighed value to add up to 100 as the highest score.

Figure 18 below depicts the ERI score trends from 2015 to 2023 for Darlington NGS in comparison to the target. Darlington NGS's ERI greatly improved over the current licence term. The 2023-year-end ERI score for Darlington NGS was 91, which is an improvement from the 2022 Q4 score. Darlington NGS has maintained an average ERI score of 86 points since 2017. Darlington NGS has focused on several initiatives to sustain an improved ER. Key actions include backlog reduction, PM program sustainability, establishing System Health Teams (SHTs), improvements to scheduling of critical PM work orders to ensure equipment reliability.

In 2024, the ER key performance indicator transitioned from ERI to the Institute of Nuclear Power Operators (INPO) Equipment Performance Index (EQP). This standardized metric for ER performance is utilized for INPO reporting stations from Canada, USA, Mexico, Romania, UAE, and South Africa, allowing for broader comparison and industry benchmarking. Five weighted sub-indicators measuring equipment reliability performance balanced across both a 12-month (EQP12M) and 18-month (EQP18M) rolling period add to a score of 100, with performance measured at the unit level and station level.

Darlington NGS has performed benchmarking against other plants through physical and virtual benchmarking of CANDU and non-CANDU station best practices as well as participation in the COG ER Working Group and Fuel Handling Equipment Reliability Working Group, INPO ER Peer Group, and various technical committees from the Electric Power Research Institute (EPRI) to continuously improve performance.

Over the current licence term, Darlington NGS has undertaken a multi-year, multi-phase, multi-unit refurbishment project that will enable continued safe and reliable operation through 2055. This program includes replacement of life-limiting critical components, equipment upgrades, and rehabilitation of components. Darlington NGS refurbishment project is expected to be complete in 2026, which will return to service all four units fully refurbished.

In addition, Darlington NGS has made a considerable investment ($800M+) in the past two years in projects to improve equipment reliability and address aging and obsolescence. These initiatives will improve system and equipment reliability, redundancy in support of safe and reliable operation for years to come. For examples of these initiatives refer to Section 2.5 and Appendix B.

Darlington NGS is actively advancing multiple initiatives to enhance ER for the future. These initiatives aim to reinforce a robust safety and human performance culture, ensure high plant reliability of station systems and equipment, and enhance work planning and execution. They also support sustainability and the future development of the station. Throughout 2024, Darlington NGS is committed to driving continuous improvement in ER by focusing on enhanced oversight and monitoring of plant reliability risks and cross-functional ER behaviors. Efforts include implementing actions to prevent consequential events such as stronger cross-functional support, stronger mitigating strategies, and stronger bias to risk elimination. Additional strategies involve cross-functional engagement for identifying and mitigating system vulnerabilities, optimizing the preventive maintenance program, and strengthening organizational resilience and depth with qualified, competent staff to meet the station's needs.

Darlington NGS has intensified its focus on Fuel Handling Equipment Reliability (FH ER), supported by a cultural shift towards a 'Fuel First & for the Future' mindset. This initiative is overseen by the monthly Fuel Handling Oversight Committee, which monitors risks and Key Performance Indicators (KPIs). As a result, FH ER has shown improvements in Q4-2023, with continued enhancements anticipated in future years.

Additionally, Darlington NGS has established dedicated SHTs for critical systems that have historically contributed to significant equipment-related events. These systems include main power output, fuel handling, turbine, generator, and primary heat transport. The SHTs facilitate cross-functional analysis and collaboration, enhancing equipment reliability through improved self-awareness and proactive self-correction.

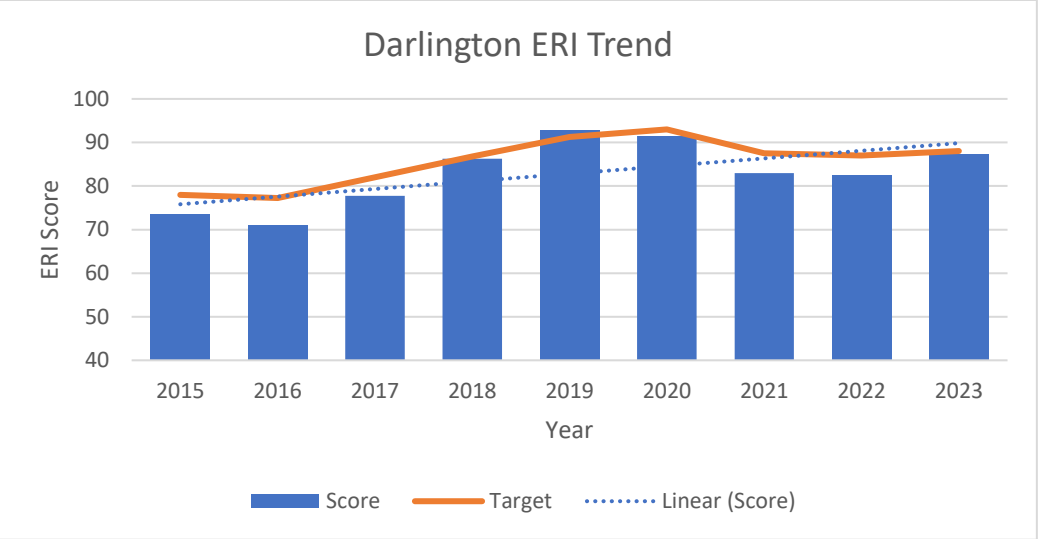


Figure 18: ERI Trend from 2015 to 2023

Reliability of Systems Important to Safety

The Risk and Reliability Program, N-PROG-RA-0016, ensures Systems Important to Safety (SIS) and Components Important to Safety (CIS) are identified and their performance measures and targets are established with Probabilistic Safety Assessment (PSA) insights being used in the process. SIS and CIS are those station systems and components which contribute significantly to the initiation, prevention, detection, or mitigation of any failure sequence which could lead to damage of fuel or associated release of radionuclide or both.

The program requires operational performance of SIS be monitored, assessed and reported and component reliability data be compiled, analyzed and applied to maintain unavailability models. Nuclear standard N-STD-RA-0033, *Reliability Monitoring and Reporting of Systems*, provides requirements for reliability monitoring and reporting of SIS and CIS, and is consistent with CNSC regulatory documents REGDOC-2.6.1 and REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*.

The SIS/CIS list is developed using all available plant PSA studies. Expert panel reviews are completed to ensure that deterministic insights, historical licensing practices and industry reviews are considered while finalizing this list. This methodology for generating the initial SIS/CIS list is based on COG document COG-15-2068, *Developing List of Systems & Components Important to Safety*. The SIS and CIS at Darlington NGS are listed in NK38-REP-03611-10100, *Darlington NGS Systems and Components Important to Safety*.

Darlington NGS has identified 14 SIS as listed below. Individual components which were not part of a SIS but found to exceed risk-importance thresholds were designated as CIS. There are currently 49 CIS at Darlington NGS.

Of the 14 total SIS, the following 11 systems were designated as being important to safety based on deterministic insights and historical licensing practices and contributions to Control, Cool and Contain functions, and were agreed upon during the expert panel review.

Special Safety Systems:

1. Shutdown System 1;
2. Shutdown System 2;
3. Emergency Coolant Injection System;
4. Negative Pressure Containment System;

Standby and Emergency Heat Sinks:

5. Emergency Service Water to the Steam Generators;
6. Inter-Unit Feedwater Tie;
7. Steam Generator Emergency Cooling System;
8. Shutdown Cooling System;

Backup and Emergency Electrical Systems:

9. Emergency Power System;
10. Standby Class III Power;

Additional Systems:

11. Powerhouse Steam Venting System;

The three remaining systems were selected based on probabilistic methods. Specifically, system importance was calculated using SYSImp (System Importance), which is an industry standard tool used to calculate collective importance of basic events in a given PSA model. The calculated system importance was then held against industry standards thresholds which are used as recommended indicators of SIS.

12. Low Pressure Service Water;
13. Emergency Service Water to the Calandria;
14. Class 1 Power.

Per REGDOC-3.1.1, the reliability and performance of SIS/CIS is documented and reported through the Annual Risk and Reliability Report (ARRR). The ARRR discusses changes to the SIS/CIS list and their reliability targets, SIS/CIS performance, updates to unavailability models, reviews of surveillance activities, the number of initiating events, and major changes in failure modes/failure rates. SIS performance is measured using unavailability models, which incorporate internal and external component failure data to reflect current design, operation, and maintenance practices to calculate the Predicted Future Unavailability (PFU) of each system. Furthermore, SIS operational performance is evaluated through routine testing per the requirements described in N-STD-OP-0018, *Operability Testing of Safety-Related-Systems*. The field reliability data collected from operability testing and other sources is then incorporated into system unavailability models to improve the accuracy of PFU calculations.

ARRRs have been submitted to the CNSC each year of the current licence term, where annual SIS performance is documented and directly compared to respective reliability targets. As per the 2023 Darlington NGS ARRR, all 14 SIS were operating within their defined reliability targets.

The strength of the reliability program and its implementation at Darlington NGS is demonstrated through inspections and audits, such as the 2022 Nuclear Oversight audit of OPG's reliability program. An assessment of SIS reliability monitoring and reporting practices were within the scope of this audit and the audit team did not identify any findings and assessed the overall implementation and performance of the program across OPG to be fully effective.

2.6.2 Maintenance

Darlington NGS meets the requirements of REGDOC-2.6.2, which states that effective maintenance is essential for the safe operation of a nuclear power plant. Specifically, the Darlington NGS facility must be monitored, inspected, tested, assessed and maintained to ensure that Systems, Structures, and Components (SSCs) function as per design. Various maintenance concepts are used to form the Darlington NGS Maintenance strategy and the relevant documentation that supports the strategy is summarized in the following sections.

The majority of maintenance activities are divided into preventive or corrective maintenance. Where the performance or condition of an SSC does not allow it to function as per design, corrective action is taken. The results of all maintenance activities are fed back through an optimization process which enables the continuous improvement of the program.

The Programs, Procedures and Standards documentation described here are used to implement the maintenance strategy and cyclically reviewed and/or updated as required to ensure that the information and instructions are aligned with all regulatory requirements. A typical review cycle is 5-years, however, when changes occur within the normal cycle, documentation is updated and issued prior to the normal cycle. Additionally, each document used has a retention period with defined review parameters for supervision as well as storage timeline requirements. This provides transparency for internal/external audits and becomes the basis for assurance that work is executed safely, consistently and with quality.

The Darlington NGS Maintenance program, directed by N-PROG-MA-0004, *Conduct of Maintenance*, is designed to ensure personnel and public safety, protection of the environment and reliable operation. The program includes work planning, work execution, tool calibration and control, personnel and training as well as performance indicators and assessment. This document also provides authority for N-PROC-MA-0015, *Tool Control*, whereby, it is the expectation that anyone who uses, handles or manages/administers tooling tracked in the Tool Control System shall comply with the processes/requirements outlined. Managed tools encompass those deemed high value, those with issuance/return tracking and those that require inspection and/or calibration as defined by this procedure.

The Darlington NGS Maintenance program interfaces with N-PROG-MA-0019, *Production Work Management* to support the process by which maintenance, modifications, surveillances, testing, engineering support and any work activities that require plant coordination or schedule integration are implemented.

The Component and Equipment Surveillance program, N-PROG-MA-0017 is a set of activities to assure the health of a select group of nuclear facility components. Darlington NGS Maintenance implements standards and procedures in support of component and equipment performance which further supports the overall safe, reliable and economic operation of OPG Nuclear.

The outage management processes for preparation and execution of planned and forced nuclear unit outages within OPG Nuclear receive authority from N-PROG-MA-0019, *Production Work Management*. Governance associated with planned outages is in accordance with N-PROC-MA-0013, *Planned Outage Management* and governance associated with forced outages is in accordance with N-PROC-MA-0049, *Forced Outage Management*. Refer to Section 2.3.4 for additional information on outage management.

The maintenance program is organized to align closely with the Engineering, Work Management, Operations and Supply Chain organizations to support equipment fitness for service requirements.

The intent of the program is to ensure that safety systems remain available and that equipment failures are minimized. This is accomplished through corrective and preventative maintenance activities as well as routine inspections of system components to ensure they continue to operate as expected. N-PROG-MA-0019, *Production Work Management*, details the requirements for identifying, prioritizing, planning, scheduling, and executing work in support of the operation, maintenance and modification of the plant.

Maintenance is key to equipment reliability. Maintenance at Darlington NGS largely consists of preventative maintenance with a focus on condition-based maintenance, wherein systems with the ability to measure or monitor parameters that determine when the maintenance is required are used. This allows for efficient work scheduling and completion of maintenance on a time-based approach.

The Maintenance organization works closely with the work group responsible for planning and scheduling of work – known as Work Control. Through N-PROC-MA-0002, *Work Planning*, Work Control establishes the process of planning work to ensure common base requirements are uniformly supported across nuclear. Through a collaborative and cross functional series of meetings, required tasks are prioritized and scheduled to preserve, repair and/or test equipment that supports safe operation of the Station. In addition, this process is benchmarked against the industry standard to ensure alignment with top performing nuclear stations.

Through N-PROC-MA-0006, *Work Performance*, Maintenance establishes the process of performance of maintenance activities within OPG to repair or replace malfunctioning SSCs to re-establish conformance with program requirements. This allows Maintenance and Work Control to optimize the planning and execution of work that directly and indirectly supports continued operation and/or maintaining the safe operation envelope within licence limits.

Upon completion of maintenance activities, Post-Maintenance Tests (PMTs) are conducted as per N-STD-MA-0008, *Station Material Condition and Housekeeping* which establishes the PMT process and specifies the requirements.

Corrective Maintenance

Darlington NGS's goal is to ensure that maintenance backlog levels are inline or better than industry benchmark targets. The volume of maintenance backlogs have improved annually since the creation of the backlog dashboard that provides granular details of overall performance. Since 2020, the backlog has been reduced from a peak total of approximately 500 Work Orders (WOs) to the end of year projection to meet the station target of 70 WOs in 2024.

Preventative Maintenance Activities

The Predefined Process, N-PROC-MA-0020 (or PM process) provides a formal means to facilitate planning, scheduling, and execution of work of a recurrent nature. The associated rigors and controls of the process generate administrative demand, so predefineds are established to meet station needs. Nuclear refurbishment PMs are PMs that have been created, scheduled, and accepted for execution during the nuclear refurbishment outage (including return to service) and are managed by the nuclear refurbishment organization to meet the needs of the project.

PM program improvements have focused on changing behaviours and reinforcing expectations around performance metrics that promote a healthy, and sustainable living program. Key performance indicators have been established and are reviewed weekly at the oversight forum, or Preventative Maintenance Review Board (PMRB), to monitor progress and take actions as required.

Key cross-functional initiatives driven through Engineering, Work Management and Maintenance include:

1. Maintenance consistently achieving greater than 95% as found condition compliance, which prompts engineering to evaluate and refine PM strategies. This ensures maintenance is performed at the correct frequency.
2. Reduced PM Modification Requests (PMMRs) Backlog: minimize the backlog of PMMRs, maintaining a “live zero”. This translates into PM strategy changes to the program on an on-going basis.
3. The PMRB focuses on operating experience and critically evaluates PMMRs modification requests, challenging their necessity, enabling factors, and required resources. This ensures that each modification is justified and aligned with the overall goals of the PM Program.

The target due date for every PM is followed by a “late” date where the PM must be executed. The time between the target due date and the late date is known as “grace”. Grace is divided into two halves with the second half referred to as being “deep in grace”. The number of PM WOs completed during the second half of the grace period was reduced from 417 in Q1 2022 to 207 in Q3 2023 which was attributable to the monitoring and updating of each Unit as they return to service post refurbishment.

Enhancing the management and reduction of time spent working on equipment that impacts online Unit operation is another opportunity for improvement. This will be achieved by explicitly identifying and emphasizing T-reviews that include maintenance activities to ensure the risk is known and the recall time is sufficient. This will facilitate improved management of critical handoffs, increase robust tracking, and improve oversight of work with detailed risk reviews and challenge meetings.

In this context, T-reviews refers to work being executed in an upcoming work week. T-8 refers to work being executed 8 weeks in the future. A T-review is required prior to execution and T-meetings are held at regular intervals to determine if the schedule needs to be adjusted due to impacts such as available resources and/or materials.

The station team has also undertaken a Plant Reliability Station Excellence Initiative to systematically review the PM program. Under this initiative the team will review and update the frequencies of PM WOs based on available operating experience.

Maintenance Program Assessment

The Darlington NGS Maintenance program demonstrates a commitment to continuous improvement through the Self Assessment (SA) process. Darlington NGS Maintenance conducts annual department SA on maintenance fundamentals and technical skills to identify improvement opportunities where focused actions will sustain performance. In addition, specific programmatic elements are reviewed on a rotating cycle to ensure that documentation, performance and behaviours are aligned with the expectations of those processes. These assessments demonstrate that Darlington NGS is a self learning organization that seeks continuous improvement.

By participating in divisional SAs, Darlington NGS Maintenance ensures that they contribute to cross-functional teams that work to achieve and sustain high levels of plant reliability. In 2023 a comprehensive self assessment addressed actions to improve cross-functional risk recognition, mitigation, and elimination behaviors at Darlington NGS, lowering the number of equipment-related consequential events. The Darlington NGS demonstrated improvements in applying the recommendations and applied a multi-pronged approach to close the gap to excellence. This includes but is not limited to a communication campaign to raise awareness for all stakeholders as to how they can contribute to high-level plant reliability, identification and prioritization of highest risk equipment to ensure mitigating and/or bridging strategies are in place and an examination of potential parts issues related to procurement lead times and obsolescence. These proactive efforts align with the overall maintenance strategy of balancing preventative and corrective maintenance in the desired proportions.

Maintenance continues to actively perform SA at divisional and departmental levels to intrusively evaluate the effectiveness of individual aspects of the program (eg. FME, Hoisting and Rigging, Work Protection) as well as overall program effectiveness using N-PROC-RA-0097, *Self-Assessment and Benchmarking*. By overtly demonstrating a commitment to self identification of preventative and corrective actions, Darlington NGS Maintenance effectively merges the requirements set forth by the regulator with evidence that supports continuous learning and improvement initiatives across a broad spectrum of programmatic oversight. The effort to self identify and transparently report out to oversight bodies is further validated through their independent reviews, audits and inspections. Proactive initiatives, corrective actions and development of leading and lagging indicators better inform our continuous improvement plan and provide a path to consistent improvement, with supporting evidence both internally and through independent sources that are external to Maintenance.

2.6.3 Aging Management

The Integrated Aging Management (IAM) program is an overarching and comprehensive program, which provides the framework for managing aging at OPG and demonstrates how the current processes and programs meet the requirements for effective aging management in accordance with REGDOC-2.6.3. Program document N-PROG-MP-0008, *Integrated Aging Management* is the governing program and procedure N-PROC-MP-0060, *Aging Management Process* is the implementing program for aging management at OPG.

The objective of the IAM program is to ensure that the condition of critical nuclear facility equipment is understood and that required activities are in place to ensure the health of these components and systems while the plant ages. This is accomplished by establishing an integrated set of programs and activities to ensure that the performance requirements of all critical station equipment are met on an ongoing basis. The IAM program covers all SSCs defined as critical based on a nuclear safety, production, environment and cost significance perspective. The IAM process is summarized in Figure 19.

To ensure effective implementation and management of the IAM program at Darlington NGS, roles and responsibilities are defined in Section 2.0 of N-PROG-MP-0008. The responsibilities for the IAM program are split between corporate groups and the station.

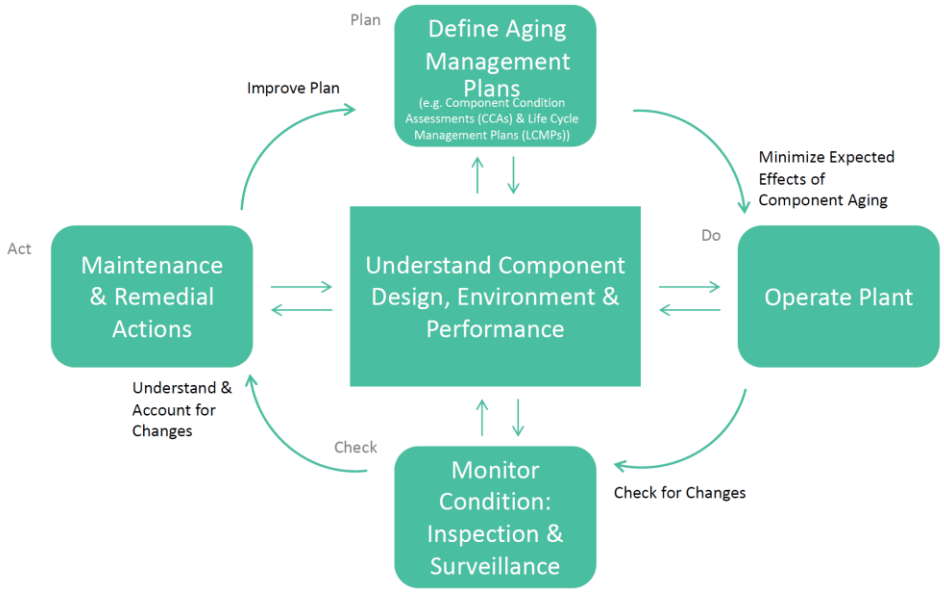


Figure 19: Integrated Aging Management Process

Implementing procedure N-PROC-MP-0060 describes the process for performing the following aging management activities:

- Effective aging management planning for SSC.
- Scoping to identify and group SSCs based on aging related characteristics.
- Screening to determine the method of Condition Assessment (CA) (whether an SSC within aging management scope requires a CA report to be developed), and.
- CA to identify actions required to ensure the health of SSCs as the plant ages and to maintain the overall effectiveness of the aging management plans (CAs are prepared as per N-GUIDE-01060-0001, *Component Condition Assessment Preparation Guide*).

The aging management process uses a systematic and comprehensive approach to assess the effectiveness of an SSC's aging management plan and address any aging related issues.

An SSC's CA report provides a "road map" of its respective aging management plan through the application of the nine attributes in REGDOC-2.6.3, which are embedded within the CA process. The method of CA is determined and defined in N-PROC-MP-0060 and is accomplished through the following:

- Component and system surveillance for components important for safe and reliable operation.
- Fitness for service assessments and Life Cycle Management Plans (LCMPs) for major components such as fuel channels, steam generators, reactor components, turbine generators, and other strategic and long-lead SSCs.
- CA records for the balance of AM critical plant equipment.

To ensure effective implementation and management of the IAM program at Darlington NGS, roles and responsibilities are defined in Section 2.0 of N-PROG-MP-0008. The responsibilities for the IAM program are split between corporate groups and the station.

Sections 4.0 and 5.0 of implementing procedure N-PROC-MP-0060 set the requirements for data collection and record-keeping in support of the IAM program. Data and records relevant to aging management are divided into the following categories:

- Baseline information consisting of data on the design and condition of the SSC at the beginning of its service life.
- Operating history regarding test and service data on the availability and failure of the SSC.
- SSC maintenance history.
- Records of SSC screening, Condition Assessment (CA) reports, and LCMPs.

The aging management process requires SSC screening and CAs to be appropriately documented, per N-PROC-MP-0060. The following data is recorded and stored in such a way that it is secure and retrievable:

- Screening records retained in Asset Suite.
- CAs documented and retained in Asset Suite as controlled documents.
- Recommended actions to be traceable; for example, as action tracking assignments, in respective health report action plans, or in work management.

All reports are required to be complete, valid, legible, retrievable, and traceable to the parts and activities to which they refer, as outlined in CSA N286-12, *Management System Requirements for Nuclear Facilities*, Section 4.7. Management of data is conducted in accordance with OPG-PROG-0001, *Information Management* and all records are maintained in an approved records repository, in accordance with OPG-PROC-0019, *Records and Document Management*.

Aging Management Interfacing Programs

The following aging management interfacing programs are in place to support reliability and availability of required safety functions of SSCs throughout the service life of Darlington NGS. This includes programs that ensure all equipment is available to perform its intended design function.

N-PROG-MA-0025, *Major Components*: this interfacing program establishes an integrated set of processes and activities to demonstrate fitness for service for the four major component areas: fuel channels, feeders, steam generators, and reactor components and structures. Developing a long-term LCMP is one of the primary objectives of this program. It provides a framework for integrating and reporting of the component performance, condition, and compliance with the licence requirements. This program ensures that these four major components will perform safely and reliably until the end of commercial operations, maintaining design and licensing bases and operational safety requirements while optimizing production and cost effectiveness.

N-PROG-MA-0017, *Component and Equipment Surveillance*: this interfacing program document describes the program elements that establish a focused surveillance monitoring process. Implementation of these programmatic requirements provides a consistent methodology for performing component and equipment surveillance for select components at all OPG nuclear stations and Nuclear Sustainability Services Facilities. It consists of activities to evaluate, inspect, test and report on the health of a select group of nuclear facility components. The effectiveness of the component and equipment surveillance engineering programs are periodically evaluated against the nine attributes of an effective aging management program as listed in REGDOC-2.6.3.

N-PROG-MA-0026, *Equipment Reliability*: this interfacing program established the process for maintenance activities and system performance monitoring of critical components. The Equipment Reliability program and its implementing procedures ensure that critical components meet their defined or desired level of reliability for the lifespan of the station.

N-STD-MA-0024, *Obsolescence Management*: this interfacing process takes authority from the aging management governance. The purpose of this standard is to define and implement a sustaining process to manage the proactive and reactive obsolescence issues associated with critical equipment and components. The process activities should interface with equipment reliability and life-cycle management strategies designed to sustain continued safe and reliable plant operation.

N-PROG-OP-0004, *Chemistry*: this interfacing program specifies processes, requirements, and staff accountabilities to ensure effective control of plant chemistry, including provisions for analytical services. Systems are operated and consistently tested using approved operating procedures and chemistry specifications to ensure aging degradation remains as documented in the design basis and completed condition assessments.

There are several other programs, processes and activities implemented throughout the facility's life cycle, including design, construction, commissioning, operation (including extended shutdowns) and decommissioning. The description of these programs and their purpose in supporting aging management are described in Section 1.6 of N-PROG-MP-0008, and include such programs as Environmental Qualification, Fuel, Design Management, Engineering Change Control, Performance Improvement, Nuclear Operations, Conduct of Maintenance, Reactor Safety, Risk and Reliability, Decommissioning, Nuclear Waste Management, and Items and Services Management.

OPG Nuclear's comprehensive monitoring of component and equipment aging is accomplished through the implementation of all the above programs and the integration of interfacing activities that are managed under the various programs listed above.

2.6.3.1 Systems, Structures or Components-Specific Aging Management Plans

An SSC-specific Aging Management Plan (AMP) defines all relevant aging mechanisms, current condition, any accredited engineering, inspection, or maintenance programs, and preventative actions to maintain or improve the health of the SCC and minimize degradation.

AMPs are addressed via LCMPs for major components (listed below) as per the guidelines described in procedure N-PROC-MA-0100, *Major Components Life Cycle Management Plan*, which is based on the methodology presented in N-PROC-MP-0060, and compliant with the requirements of REGDOC-2.6.3. A 10-year outlook detailing the required inspection and maintenance activities is provided within each of the following plans and updated annually to capture the operation of Darlington NGS Units 1 to 4 into and out of refurbishment.

The LCMPs for the Major Components are:

- N-PLAN-01060-10001, *Feeders Life Cycle Management Plan*;
- N-PLAN-01060-10002, *Fuel Channels Life Cycle Management Plan*;
- N-PLAN-01060-10003, *Reactor Components and Structures Life Cycle Management Plan*;
- N-PLAN-33110-10009, *Steam Generators Life Cycle Management Plan*.

Fuel Channel Aging Management

Fuel channel aging management is a comprehensive program of in-service inspection, maintenance, engineering assessments and research and development for fuel channels. The fuel channel LCMP describes and summarizes the major known fuel channel aging mechanisms, identifies expected life limits posed by each aging mechanism, and provides strategies required to manage fuel channels to station specific target operating life. Detailed reports regarding the status of aging mechanisms, compliant with REGDOC-2.6.3, are available as separate documents for Darlington NGS. Some of the aging-based inspection and maintenance activities are as follows:

- Flaw monitoring;
- Body of tube and rolled joint scrapes;
- Elongation measurements;
- Diametral expansion;
- Wall thinning;
- Rolled joint predictions;
- Pressure tube fretting;
- Pressure tube to calandria tube (PT-CT) gap measurements;
- Pressure tube volumetric inspection;
- Annulus spacer fitness for service.

The fuel channel LCMP is updated annually to capture new information from outage inspections, research, and operating experience, in addition to activities planned in compliance

with CSA N285.4, *Periodic inspection of CANDU nuclear power plant components*. With the implementation of the fuel channel LCMP, OPG will continue to demonstrate that aging mechanisms are understood and confirm that component condition remains acceptable via monitoring and inspection for post-refurbishment operation.

Improvements to the manufacturing process of pressure tubes installed during Refurbishment for all Darlington NGS Units are expected to mitigate known major life-limiting aging mechanisms. Trace amounts of impurities including hydrogen and chlorine remain in the pressure tube from the manufacturing process which contribute to decline of pressure tube material properties over the operating life of the unit. Reducing the level of impurities during manufacturing is expected to control initial concentration levels to improve fracture toughness of the pressure tubes and reduce susceptibility to delayed hydride cracking.

Design changes have been made to the annulus spacers for post-refurbishment Darlington NGS units. All fuel channels will be installed with the novel Zr-Nb-Cu tight fitting garter springs to eliminate known material degradation issues with pre-refurbishment Inconel X-750 annulus spacers.

Reactor Components and Structures Aging Management

The Reactor Components and Structures LCMP, N-PLAN-01060-10003, establishes the strategy or identify necessary actions to ensure that the effects of aging on reactor components and structures are appropriately managed for the operating life of OPG's fleet of nuclear units. The aging management of the components addressed within the reactor components and structures section are as follows:

- Calandria and shield tank assembly;
- Calandria tubes;
- Calandria Tube to Liquid Injection Shutdown System (CT/LISS) nozzle clearance;
- Guide tubes;
- Moderator inlet nozzles/pipes;
- Calandria end shield support;
- Lattice tubes;
- End fittings;
- Calandria relief ducts;
- Other reactor internals to maintain fitness for service.

The reactor components and structures LCMP is updated annually to capture new information from outage inspections, research, and operating experience, in addition to activities planned in compliance with CSA N285.4.

Manufacturing improvements were made to the calandria tubes installed during Darlington NGS refurbishment. The changes are to increase the overall integrity of the fuel channel during accident scenarios. Potential contact between the calandria tube and LISS nozzle was eliminated with the replacement of the calandria tubes for post-refurbishment operation. OPG expects that continued inspections and monitoring confirm the reactor components fitness for service to the target end of life through the existing LCMP.

Feeders Aging Management

The feeder piping system aging management program, documented in N-PLAN-01060-10001, contains the CSA N285.4 periodic inspection program, in-service inspection, and PROL compliance inspection activities during and post Darlington NGS refurbishment, the overall strategy to maintain the system integrity, and the fitness for service guidelines. The most significant feeder aging management programs are listed below:

- Flow Accelerated Corrosion, managed through scheduled wall thickness measurements and stress analysis;
- Fretting damage, managed through visual or clearance inspections and chafing shield installations on the reactor face and in the feeder cabinets.
- Instrument line fretting inside the feeder cabinet, managed through visual inspections.
- Feeder replacement, in place for feeders that are not expected to reach the end of the planned operating life of the unit.

The feeders LCMP is updated annually to capture new information from outage inspections, research, and operating experience, in addition to activities planned in compliance with CSA N285.4. The LCMP is updated annually to incorporate changes to these requirements that may be warranted from inspection results on the rates and extent of active degradation, as well as significant feeder related operating experience from OPG and other CANDU stations. The plan also contains strategies to deal with plausible aging mechanisms that are not active but may become active. In the plan, the operational risk, areas of vulnerability in the piping system, and mitigating actions to ensure that feeders remain within the design basis are identified.

Feeder replacements were performed during refurbishment with the elimination and mitigation of major degradation mechanisms achieved through improved material, fabrication, and installation specifications. Continued monitoring of feeders through the LCMP is performed to ensure that the aging effects are appropriately managed to support post-refurbishment operation.

Steam Generators Aging Management

The Steam Generator (SG) aging management program, documented in N-PLAN-33110-10009, ensures all units operate safely and reliably with the existing steam generators through the service life of the station, while maintaining the design and licensing bases, and optimizing station reliability, production, and cost-effectiveness.

SGs are closely monitored by an inspection program to manage active and plausible degradation mechanisms. The main goal of the steam generator LCMP is to maintain thermal performance by means of an effective inspection and maintenance program to prevent or mitigate steam generator degradation and failures (i.e., tube leak). Inspection of pressure boundary shell welds, nozzles and external vessel supports is prescribed in the periodic inspection program specific to each unit in compliance with CSA N285.4 and the in-service inspection plan.

Through comprehensive life extension assessments, the existing Darlington NGS steam generators were retained and endorsed for post-refurbishment operation. The SG LCMP is optimized to support extended life beyond design and the detailed planning phase for mid-life refurbishment of these components being pursued by OPG.

Completed and planned replacements of the Primary Moisture Separators for all SGs are being performed to address active degradation mechanisms for the long-term, operation of Darlington NGS. Additionally, post-refurbishment operating margins are being managed through primary side cleaning of all units during refurbishment.

Periodic and In-Service Inspection Programs

Periodic Inspection Programs (PIP) define the inspection plans required to ensure acceptability of specific nuclear power plant and containment components, in accordance with the relevant edition of standards CSA N285.4, *Periodic inspection of CANDU nuclear power plant components*, N285.5, *Periodic inspection of CANDU nuclear power plant containment components*, N285.8, *Technical requirements for in-service inspection evaluation of zirconium alloy in pressure tubes in CANDU reactors*, and N287.7, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants*.

The PIP plans are developed and maintained within the relevant governing programs identified above and include non-destructive examination techniques and procedures developed and implemented as per the CSA standards, specific program requirements, the nature of the degradation, and the regulatory requirements, as applicable. The Darlington NGS CSA N285.4 PIP is divided into four system/component groups addressing specific clauses of CSA N285.4 including the general pressure boundary components, fuel channel pressure tubes, fuel channel feeder pipes, and SGs tubes. See Section 6.5 for further details on PIP.

2.6.3.2 Review and Improvement Process for Aging Management Programs

OPG ensures that AMPs are reviewed periodically to ensure continued effectiveness and that they meet the following requirements:

- Supplement the ongoing engineering surveillance activities.
- Are implemented in accordance with the overall IAM program framework.
- Address the nine attributes of an effective aging management program as listed in REGDOC-2.6.3.

Since OPG completed REGDOC-2.6.3 (2014) implementation in July 2017, two effectiveness reviews (in 2018 and 2019) to support compliance with REGDOC-2.6.3 (2014) have been performed and these reviews have confirmed that the implementation of Darlington NGS's IAM program is effective and sustaining, compliant with its governance and REGDOC-2.6.3 (2014).

In addition, a recent review of Aging Management was performed under the Darlington Periodic Safety Review (D-PSR) under Safety Factors 2 and 4. Refer to Section 3.3 for further details on the D-PSR.

2.6.4 Chemistry Control

Chemistry control refers to the control of chemical impurities which contribute to degradation and accelerated aging in plant systems. Plant fitness for service is adversely affected when uncontrolled chemistry results in equipment damage and reduced system availability. Through implementation of management system programs and procedures, OPG maintains a robust system of processes to control plant chemistry, allowing plants to remain fit for service.

OPG implements a chemistry program via N-PROG-OP-0004, *Chemistry*, which specifies processes, overall requirements, and staff accountabilities to ensure effective control of plant chemistry, including provision of analytical services. These activities are performed in order to ensure critical plant equipment performs safely and reliably over the life of the station. The chemistry program complies with CSA N286-12 and also interfaces with the environment program through NK38-MAN-03480-10001, *Environment Manual*, to limit and monitor the release of chemicals and radioactive material.

The technical basis for chemistry control is defined under a set of technical standards under N-STH-01807-10000, *OPG Nuclear Systems Chemistry Specification Manual* and reports N-REP-01807-10010, *OPG Chemistry Rationale and Operating Experience.* N-STH-01807-10000 and the chemistry program establishes requirements for effective chemistry control during operating and lay-up states.

Control of system chemistry and chemistry work management procedures establish the chemistry surveillance program to detect undesirable trends and consequences. It is implemented through the suite of OPG Nuclear systems chemistry specification manuals, NK38-OM-09160, *Chemical Control*, and suite of chemistry laboratory procedures.

N-PROG-OP-0004 and the following implementing documents capture the requirements to have defined chemistry specifications for systems, procedures for chemistry parameter monitoring, trending and monitoring activities, and procedures for the storage and handling of chemicals: N-PROC-OP-0012, *Control of Process Chemicals*, OPG-PROC-0126, *Hazardous Material Management*, and N-TS-01806.5-100XX, *Material Specifications* series manuals outline storage and handling requirements of chemicals. N-PROC-OP-0013, *Control of System Chemistry* defines processes to be followed to control system chemistry during all plant states and includes instructions regarding maintenance of chemistry specifications, monitoring of system chemistry conditions, control actions required to maintain optimum chemistry, and monitoring of actual performance. N-PROC-OP-0014, *Chemistry Laboratory Work Management* defines requirements for laboratory equipment, sampling and analysis, and quality control in order to perform chemistry monitoring.

Online Monitoring

Consideration is given to utilize online monitoring where possible through OPG nuclear systems chemistry specification manual and chemical control, under which specifications and corrective actions against online out-of-range chemistry are defined. The online instrumentation availability is tracked through performance indicator online analyzer availability to drive visibility and improvements throughout the station. The calibration and maintenance program for online and laboratory instrumentation is captured under chemistry work management.

Analytical Service Availability

The Darlington NGS chemistry laboratory ensures analytical services are available at all times. Defense in depth is employed through redundant instrumentation and satellite laboratories in the Tritium Removal Facility and an external laboratory.

Post Accident Sampling

In the case of post-accident sampling, NK38-OM-09013E, *Abnormal Incidents Manual - Part E - Post-Accident Response* requires sampling and analysis of emergency filtered air discharge system radiation monitor to be initiated to monitor noble gases, iodine, particulate, tritium and gross gamma in containment. The emergency response procedure is as per N-PROG-RA-

0001, *Consolidated Nuclear Emergency Plan*, which is implemented in the chemistry laboratory through D-INS-03490-10006, *Chemistry Laboratory – Emergency Response* to assign personnel emergency response tasks, and to sort, analyze and report samples.

Implementation and Management of Process Chemicals and Hazardous Materials

OPG has established procedures for the processes to prevent use of impure or ineffective process chemicals through the control of process chemicals procedure, and OPG-PROC-0126, *Hazardous Material Management* which outlines the approval, labeling, and training protocols to safeguard OPG employees and OPG supervised contract workers from risks related to working with or near hazardous materials. These procedures ensure the required quality of chemicals is maintained throughout their usage. OPG also maintains a list of approved process chemicals as specified by N-TS-01806.5-100XX, *Material Specifications*, and documented by the chemistry colour classification as per control of process chemicals procedure.

Chemistry Performance

The chemistry program is a Tier 1 program and oversight on program execution performance is provided through quarterly program fleetveiw reports (as per N-PROC-RA-0023) which is approved by the program authority and presented at the Nuclear Executive Committee for endorsement. The Chemistry Corporate Functional Area Manager (CFAM) provides oversight on station chemistry performance and operational chemistry control effectiveness is assessed using a set of KPIs; CNSC CI (Chemistry Index) and CCI (Chemistry Compliance Index) are reported in the Fleetview Program Health and Performance Report as one of the KPIs of the chemistry program functional area summary and in station program health reporting.

CANDU Owners' Group Intra Laboratory Studies (COGIS):

CANDU station laboratories are subject to routine inter-laboratory blind testing once per year. The purpose of this program is to evaluate laboratory methods, compared to industry peers. Results are evaluated by an external agency.

2.6.5 Periodic Inspection and Testing and Structural Integrity

The objective of the PIP is to ensure structural integrity of the nuclear plant systems and components, including containment components in Darlington NGS. The programs are documented in specific PIP plans and associated inspection schedules, and they are administered under corporate and station governing documents. The main objective of the PIPs is to ensure they satisfy the associated CSA standards as outlined in the sections that follow.

Periodic inspections shall be conducted to provide assurance of the improbability of:

a) A failure that can produce radiological conditions exceeding the health and safety limits for normal operation as stated in the safety report (CSA N285.4)

b) The structural failure of containment components when the containment system is required to perform its function as defined in the safety report (CSA N285.5).

c) Concrete components and their parts failing, and leading to: 1) compromising the leak tightness of the containment envelope; 2) adversely affecting the operability and structural integrity of the concrete containment systems (CSA N287.7).

d) The failure of structural components of non-containment, safety-related structures that could negatively impact nuclear safety systems (CSA N291).

Darington NGS CSA N285.4 and N285.5 Periodic Inspection Programs

The CSA N285.4-14 program requires inspection of approximately 1578 locations across four units. Each location is inspected once within each unit's 10-year inspection interval. Inspected components include, piping and vessel welds, pumps, valves, piping, and component supports, and mechanical couplings.

The CSA N285.5-18 program consists of approximately 1907 inspection locations across Units 0 and 1 to 4. Each location is inspected once within each unit's 10-year inspection interval; except for components whose inspection requires a Vacuum Building Outage (VBO), where inspections are performed at least once every 12-years. Inspected components include containment penetration seal welds, pipe supports, piping/ducting, valves, containment dampers and other containment components.

Inaugural inspections are performed for newly installed components in accordance with the requirements in the CSA N285.4 and CSA N285.5 standards. These inspections are performed to establish the condition of the components at the time it was placed into service. This ensures that when periodic inspections are performed, there will be at least one previous result for each component, thus allowing for comparative analysis between the inspection results.

Darington NGS CSA N287.7 Periodic Inspection Program

The CSA N287.7-08 program addresses inspection and testing of concrete containment structures. Separate PIP plans have been created, submitted to and accepted by the CNSC for the vacuum building, reactor buildings, and Unit 0 concrete containment components. These inspection plans identify the civil containment structures and components to be inspected, describe relevant mechanisms potentially affecting these components, identify inspection methods and acceptance criteria, and define reporting requirements.

The last N287.7 PIP inspections included:

- The reactor buildings (Units 1 to 4) were inspected between 2017 and 2023 (including refurbishment scope), in accordance with the relevant PIP plan. Overall concrete condition was found to be acceptable.
- The vacuum building interior was inspected during the 2015 planned VBO. Inspection scope during this outage included major concrete structures of the vacuum building: dousing water storage tank, main floor, dome, support structures, etc. Concrete condition was found to be overall acceptable and comparable to previous results.
- The Unit 0 containment components were inspected in 2022 and areas included the Central Service Area-Nuclear and the West Fuelling Facilities Auxiliary Area. Results showed that structural and containment integrity were in acceptable condition overall.
- The vacuum building post-tensioning system was inspection in 2021-2022. Overall, the inspection results were found to be acceptable.

Darlington NGS CSA N291 Periodic Inspection Program

CSA N291:19, *Requirements for nuclear safety-related structures* specifies requirements for the material, analysis and design, construction, fabrication, inspection, examination, and aging management of nuclear non-containment, safety-related structures. The N291 PIP plan, NK38-PIP-03643.2-10004, *Darlington NGS, In-service Inspection Periodic Inspection Program for Non-Containment Buildings and Safety-Related Structures and Components*, was prepared to

describe requirements for performing inspections, evaluating the results, and documenting inspection reports for the non-containment, safety-related structures at Darlington NGS. This PIP describes the processes and activities required to monitor, evaluate, and document aging effects on safety-related structures to ensure they will maintain their performance throughout the life of the plant to withstand design basis loads. The goal of inspection is to provide observations which lead to identification of deficiencies associated with building facades, concrete structures and components, masonry wall, roofings and steel structure condition. Selected components shall be inspected at no more than 6-years. For inaccessible areas, inspection shall be at frequency agreed upon by the CNSC.

2.6.5.1 Structural Integrity

The stations principal structures are discussed in Section 2.5.4.

Inspections to confirm structural integrity are performed in accordance with the associated PIP documents and to the requirements of CSA N285.5-18, CSA N287.7-08, and clauses 9 and 10 of CSA N291:19.

OPG carries out inspections and tests of the inaccessible components of the vacuum building, the dousing system and the pressure relief duct at least once every 12-years. A Vacuum Structure Positive Pressure Test and a test to measure the leakage rate, at full positive design pressure, of the Main Containment Structure is also be repeated every 12-years.

In addition, OPG inspects the accessible portions of the concrete structures of the Main Containment Structures and their components once every 6-years in accordance with the CSA N287.7-08 PIP.

Section 2.7

Radiation Protection

2.7 Radiation Protection

Darlington NGS has an effective Radiation Protection (RP) program that meets or exceeds all applicable regulatory requirements and related objectives. The health and safety of persons is protected through the implementation of the RP program, which ensures that radiation doses are kept below regulatory dose limits and are optimized and maintained As Low As Reasonably Achievable (ALARA). Radiological impacts of plant operation to workers and the public will continue to be of an acceptable level.

The RP program, N-PROG-RA-0013, *Radiation Protection* implements a series of standards and procedures for the conduct of activities within nuclear sites and with radioactive materials intended to achieve and maintain high standards of RP including the achievement of the following objectives:

1) Controlling occupational and public exposure.
    a) Keeping individual doses below regulatory limits.
    b) Avoiding unplanned exposures.
    c) Keeping individual risk from lifetime radiation exposure to an acceptable level.
    d) Keeping collective doses ALARA.
2) Preventing the uncontrolled release of contamination or radioactive materials from the nuclear sites through the movement of people and materials.
3) Demonstrating the achievement of (1) and (2) through monitoring.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 11: SCA 7 – Radiation Protection

Document	Title
N-PROG-RA-0013	Radiation Protection
N-STD-RA-0018	Controlling Exposure As Low As Reasonably Achievable
N-REP-03420-10001[1]	Occupational Radiation Protection Action Levels for Power Reactor Operating Licenses
N-PROC-RA-0019	Dose Limits and Exposure Control
N-PROC-RA-0027	Radioactive Work Planning, Execution and Close Out
N-MAN-03416-10000	Radiation Dosimetry Program – General Requirements
N-MAN-03416.1-10000	Radiation Dosimetry Program – External Dosimetry
N-MAN-03416.2-10000	Radiation Dosimetry Program – Internal Dosimetry
OPG-PROC-0132	Respiratory Protection

Note:
1. N-STD-RA-0044, *Occupational Radiation Protection Action Levels for Power Reactor Operating Licences* supersedes N-REP-03420-10001, *Occupational Radiation Protection Action Levels for Power Reactor Operating Licenses*.

2.7.1 Application of ALARA

Management of facility collective dose is implemented in tHe ALARA program and strategy. Annual collective dose targets established by the facility are developed based on the business planning cycle, planned maintenance scope, routine operations, and CANDU industry guidelines. The target accounts for anticipated dose savings from implementation of dose reduction initiatives, application of ALARA principles, and past operating experience and performance. The ALARA section provides oversight on the facility's performance against the established targets and establishes corrective actions, where required, with support from senior plant management. Another key element of the ALARA program is to develop a 5-year or long range ALARA plan to document specific strategies for reducing personnel exposures.

The Darlington NGS site ALARA strategy identifies initiatives, actions and programs that support achieving these objectives, and the means by which the effectiveness of these initiatives are measured. The strategy applies to all Darlington NGS units, whether the unit is operating (online), shutdown for planned maintenance, or in refurbishment, and applies to all Darlington NGS personnel, contractors and visitors.

The following subsections further demonstrate OPG's commitments to improving the ALARA culture and objectives.

Dedicated RP Division

Allocating appropriate resources, both financial and personnel, is necessary for the organization to support radiation protection and financial means to implement ALARA initiatives. The RP organization at Darlington NGS consists of a Department Manager, Section Managers (Field & Programs/ALARA), Senior (Responsible) Health Physicist, Health Physicists (with various program area specific qualifications), Field Supervisors and RP Technicians. Health Physicist qualifications can include program areas such as instrumentation, dosimetry and ALARA. Health Physicists with the ALARA qualification primarily support the ALARA program and long-term strategy to implement reduction initiatives and provide oversight to minimize collective dose.

ALARA Culture

The ALARA department plays an important role in managing the station Collective Radiation Exposures (CRE) and ensuring it is ALARA. To perform this function effectively, the ALARA department advocates for the workforce to be cognisant of the core ALARA principles by facilitating work groups to minimize their collective exposures for every task they perform. By providing expertise and knowledge in dose reduction and minimization efforts to all station departments and work groups, the station can achieve lower CRE and continue to be a high performing nuclear station with the highest ALARA standards.

Frequent updates of department RP performance are communicated to the station with an optimized dashboard, highlighting key RP metrics, latest RP events and current status of department's RP score. The department RP score is based on metrics such as collective dose and contamination control events. Departments are placed in various levels of oversight, depending on current RP performance and score.

Lessons Learned

The majority of annual station collective dose occurs during major planned maintenance outages. N-PROC-MA-0013, *Planned Outage Management* outlines key milestones required to

be met prior to and following planned maintenance outages including a review of lessons learned identified during planning and execution. RP and ALARA stakeholders play integral roles in reviewing lessons learned from all outage campaigns. They contribute valuable insights to a report that consolidates these lessons, outlining a strategic plan for their implementation in future outages. Online projects follow the same process for capturing lessons learned, the integrated online work schedule provides guidance and timelines for implementation. Darlington NGS executed the replacement of shutdown cooling heat exchangers across all units over multiple years. Implementation of dose reduction initiatives, lessons learned and ALARA oversight contributed to a 4-fold reduction in project collective dose per replacement.

Radiological Exposure Permit Dose Constraints

Radiological Exposure Permits (REPs) are one of the primary administrative controls by which radiological work is planned and controlled. Radiological controls are applied to all hazard levels of radioactive work and a graded approach is applied to higher risk work. Requirements to use full-scale mock-ups, participate in training and simulations are in place to familiarize workers prior to execution to minimize dose during actual execution. Additional radiological controls also include stay time limits, stay time keeping and remote dosimetry monitoring, to further reduce collective exposure.

The permitted dose and dose rate constrains are subjected to a thorough understanding of the workplace conditions based on radiological surveys and operating experience. In the latter, historical dosimeter records are periodically reviewed, and constraints are updated using industry guidance. Over the licensing period, the use of dose constraints in OPG has ensured no internal Administrative Dose Limits (ADLs) or regulatory dose limits have been exceeded (for all sources of radiation).

ALARA Input to Facility Design Changes

The standards for accommodating new designs or proposed engineering changes which may affect radiation exposure are supported through interfacing programs from Radiation Protection and Engineering. This interfacing processes of N-STD-RA-0018, *Controlling Exposures As Low As Reasonably Achievable*, and N-PROG-MP-0001, *Engineered Change Control*, drive the use of tools and checklists for radiological safety to ensure a comprehensive, robust review is performed during the design phase. These reviews help to understand how exposures can be eliminated or hazards reduced. When appropriate, the administrative controls within the RP program help bridge areas within the chosen design features. Extensive RP oversight has been present during the design of a medical radioisotope delivery system to produce Molybdenum-99 (Mo-99) during routine unit operation. Radiological safety aspects in design targets were established to include occupational and public dose during commissioning, routine operations, maintenance and upset conditions, dose rates around shielded components and accessible areas, surface and airborne contamination and environmental emissions.

Enhanced Pressure Tube Inspection Tooling

A new tooling design was developed to replace conventional sampling tools used to conduct CANDU pressure tube inspections during planned maintenance outages. Periodic inspections of pressure tubes are required according to CSA standards and are typically performed each outage, contributing to the majority of outage collective dose. The new tooling design minimizes required time spent at the reactor face, where dose rates are higher, and thus significantly minimizes personnel exposure for pressure tube inspections. The new inspection tooling in post

refurbishment outages is expected to achieve a 6-fold dose reduction compared to previous outages.

Darlington Nuclear for the Future (D4F)

This station-wide initiative, implemented post-refurbishment, benefits from newly replaced core components to reduce overall station outage dose. Post-refurbishment, component replacements have also reduced outage radiological source term, resulting in lower dose rates from reactor components and lower airborne tritium concentrations inside containment. Together, this reduces both collective external and internal exposures for all maintenance outage activities inside containment and further reduces outage collective dose targets.

Continuous Improvement

The ALARA program drives continuous improvement to align with industry best practices and latest technological development that can be used to minimize dose. ALARA performs annual assessments of the process and performance of the ALARA program to be self-critical and self-identify areas for improvement. Assessments focus on specific ALARA processes such as establishment of facility dose targets, radioactive work planning process, dose control events, source term and dose reduction efforts, and use of operating experience.

Continuous improvement is also driven through the RP dashboard, which identifies early indicators in decline of department-level RP performance. Additional oversight is provided to improve performance and lessons learned are shared with other station departments to drive overall station RP performance improvements.

2.7.2 Worker Dose Control

Individual worker doses, including those for contractors and visitors are managed to Exposure Control Levels (ECLs) that are below administrative control levels that are in turn below the regulatory limits. N-PROC-RA-0019, *Dose Limits and Exposure Control* specifies requirements to manage dose within ECLs and ADLs to control any worker's dose below CNSC regulatory limits. It receives authority from N-PROG-RA-0013, *Radiation Protection*.

Exposure to radiation is managed through:

- Limiting individual worker dose.
- Establishing facility design consistent with ALARA principles.
- Assessing hazards for planning and maintaining knowledge of conditions.
- Planning and performing radioactive work to keep exposures ALARA.
- Avoiding unplanned exposures and controlling the use of licensed radioactive devices and equipment.

N-INS-08965-10012, *Requirements for Radiological Respiratory Protection*, and OPG-PROC-0132, *Respiratory Protection*, reference the requirements for the selection, care and use of respiratory protection. OPG-PROC-0132 identifies conventional respiratory protection requirements (e.g. fit testing) while N-INS-08965-10012 outlines RP program requirements.

Collective dose performance targets for each facility are established annually by station management and consider the reductions achievable through the application of ALARA techniques. As work is planned in detail, collective dose projections shall be reviewed, and

actions taken to ensure dose is ALARA. Actual performance against targets is reviewed and corrective actions taken where warranted. Management of collective dose is implemented in N-STD-RA-0018.

When making engineering changes, engineers maintain or improve upon designs that reduce occupational exposures throughout the lifecycle of the facility, taking into account social and economic factors. RP staff review engineering changes to provide input for achieving these goals in accordance with N-PROC-MP-0083, *Constructability, Operability, Maintainability, and Safety (COMS).* Certain areas of the station are subject to high radiation fields as a result of normal reactor operation, irradiated fuel transfer, equipment operation or exposure of calibration sources. Accidental entry to these areas is prevented through the use of locked access points. When work is required in these areas, workers use procedures and physical controls to ensure the access hazards are not present or, if present, are strictly controlled.

All radioactive work is planned and includes anticipation and evaluation of radiation hazards, selection of appropriate protective measures and dosimetry. The degree of formalization of the planning process and the approval levels for a job is proportional to the potential for exposure. Plans include back-out conditions and contingencies. RP planning decisions are documented in a REP. When radioactive work is assigned, the supervisor ensures all workers have the appropriate radiation qualifications or that a qualified worker is assigned to provide RP to those that are not qualified to work independently. The supervisor ensures persons assigned to the work will not exceed exposure control levels in the course of performing the work as planned. The requirements for planning and execution are implemented in N-PROC-RA-0027, *Radioactive Work Planning, Execution and Close Out.*

Radiation Personal Protective Equipment (RPPE) is provided for workers and used by workers based on anticipated exposure conditions and maintained in accordance with N-PROC-RA-0096, *Lifecycle Management of Radiation Personal Protective Equipment*. The procedures for usage of RPPE are implemented in N-PROC-RA-0025, *Selection of Radiation Personal Protective Equipment.*

Action Levels

Action levels are either a specific radiation dose or other parameter that, if reached, may indicate a loss of control of part of the RP program. Action Levels have been established for CNSC issued licences. Events or conditions identified through these mechanisms that indicate real or potential deficiencies are filed as Station Condition Records (SCRs). SCRs are categorized, given a significance rating, and where warranted, evaluated for corrective actions to be taken to address deficiencies. SCRs are processed in accordance with N-PROC-RA-0022, *Processing Station Condition Records*. Any event that results in exceeding an action level is filed as a SCR and is reported to the CNSC within time frames specified in the applicable licence. Action levels for the PROL are provided in N-STD-RA-0044, *Occupational Radiation Protection Action Levels for Power Reactor Operating Licences* document.

Radiological Hazard Surveys

Radiological hazard surveys are performed using approved instruments on both a routine basis and prior to performance of radioactive work. Instruments used for performing surveys are approved by the Health Physics department to ensure they are appropriate and effective for use in measuring hazards encountered at the nuclear power plant and those facilities supporting its operation, namely the Tritium Removal Facility (TRF) and Heavy Water Management Building. The process for ensuring approved instruments are used, maintained and calibrated is implemented in N-PROC-RA-0066, *Lifecycle Management of Radiation Protection Instruments.*

As per the N-INS-09071-10009, *Requirements for the Calibration and Maintenance of Radiation Protection Instruments*. All RP instrument, fixed or portable, shall be calibrated at least once a year. An instrument record shall be generated each time an instrument is calibrated and a label indicating the calibration date shall be applied to the instrument. Darlington NGS uses a software solution for tracking of maintenance and calibration of RP instruments through N-PROC-MA-0070, *Calibration of Field* Equipment and N-PROC-MA-0015, *Tool Control*. When surveys are performed for Unconditional Transfer Permits, the initial surveyor and the verifier are required to document the serial number of the survey instrument.

Routine surveys are performed to support the early discovery of unexpected hazards and to identify longer term trends in hazard conditions. The location, type and schedule of routine surveys are approved by the Responsible Health Physicist (RHP). Airborne contamination monitoring is routinely carried out in order that hazards can be accurately assessed. In areas where variable high gamma radiation fields or high airborne radiological hazards could occur, area alarming monitoring equipment is provided, and set to warn against sudden unexpected increases in radiation levels, to prevent a significant acute dose to an individual. Hazard assessment is implemented in N-PROC-RA-0024, *Hazard Surveys Posting and Labeling*.

For more details regarding the TRF, refer to Section 3.1.

Bioassay and Reporting Doses for Workers

Through work planning, workers use dosimetry appropriate to the anticipated radiological hazard. Doses for individuals shall be measured and recorded. The OPG Dosimetry program is documented in N-MAN-03416-10000, *Radiation Dosimetry Program – General Requirements,* N-MAN-03416.1-10000, *Radiation Dosimetry Program – External Dosimetry and* N-MAN-03416.2-10000, *Radiation Dosimetry Program – Internal Dosimetry.* The criteria and methods for use of radiation dosimetry is implemented in N-PROC-RA-0012, *Dosimetry and Dose Reporting.*

All workers are required to wear dosimetry and to submit bioassay samples and perform Whole Body Counts (WBC) as required by procedures. Frequency of bioassay submissions and WBCs are determined based on the type of work performed. Electronic Personal Dosimeters (EPDs) are worn in conjunction with Thermoluminescent Dosimeter (TLDs) to record doses received while performing radioactive work. EPD dose is recorded in the Dose Management System (DMS) when the EPD is downloaded. This provides a record of the dose cumulative dose received by the worker. TLDs are collected and analyzed on a quarterly basis by the OPG dosimetry laboratory, operating in accordance with a CNSC Dosimetry Service License. Bioassay samples and other dosimetry (e.g., personal air samplers, extremity TLDs) are collected frequently and analyzed by OPG dosimetry laboratory. Health Physics staff at site review all EPD dose, bioassay and WBC results as received and investigate any unusual results. All dose data is reviewed on a quarterly basis by the Dosimetry Health Physicist prior to submission to the National Dose Registry. Workers are able to obtain their dose status via the DMS. All worker exposure controls and limits are specified in DMS. Dose reports are sent to all individuals at year-end, to fulfill OPG's obligation to annually provide them with their dose status in writing, as required by the CNSC Radiation Protection Regulations.

Monitoring of Workers During Emergency Conditions

During a station emergency, all staff on site are required to report to designated assembly areas and to refrain from drinking, eating or smoking until RHP approval granted. Frequent surveys are performed of the emergency assembly areas and personnel located there. Hourly habitability surveys are also performed at the Site Management Center (SMC). During an

accident or emergency, the Automated Source Term Gamma Monitoring System (ASTGMS) and Automated Near Boundary Gamma Monitoring Systems are available. ASTGMS provides remote gamma dose rates at transfer chambers (incident unit), Vacuum Building AL1 and CSA AL1. ASTGMS data is used for event categorization, adjustment of off-site dose projections, and associated on-site protective actions. Both Source Term and Near Boundary gamma measurement data is used by the Province to determine protective actions required in response to a potential radioactive release. The ASTGMS provides timely data collection, determination of possible fuel damage and eliminates the requirement for manual Source Term surveys. Health Physics Manager (HPM) in the Site Management Centre also reviews data from radiological survey teams, process system sample results, Fixed Area Alarming Gamma Meter (FAAGM) readings and Gaseous Fission Product monitor trends. Fixed Area Alarming Tritium Monitors (FAATM) are strategically located throughout the facility to support response to changing airborne tritium conditions. HPM also provides recommendations for on-site protective measures including issuance of KI pills, ongoing restrictions on eating and drinking and airborne on-site radiological controls. If there are suspected exposures or uptakes, the HPM arranges for expedited readout of bioassay samples or TLDs.

Radiation Protection Training and Qualification

All personnel working at a nuclear site are assigned an RP qualification level based on successful completion of training. Personnel maintain their qualification through the successful completion of periodic retraining and testing. The requirements for achieving and maintaining qualification levels documented in N-TQD-443-00001, *Radiation Protection Training and Qualification*. RP training is delivered in accordance with N-PROG-TR-0005, *Training*. Personnel performing radioactive work are either qualified to perform the associated RP activities, or there is an individual with the necessary qualification assigned to the work to provide RP for personnel performing radioactive work. The working rights and restrictions placed on each qualification level are specified in N-PROC-RA-0010, *Facility Access and Working Rights (Radiological).*

Key positions in the RP program organizations are given additional radiation protection related training to become qualified to perform in their specialized positions within the program.

2.7.3 Radiation Protection Program Performance

The RP program direction is established by the Director, Radiation Safety Division in response to the results of monitoring and oversight and based on recommendations and feedback from site RP managers and other stakeholders. The Darlington NGS RP manager is responsible for ensuring there is a CNSC certified RHP for the site. The RHP is accountable for ensuring that decisions regarding the RP program are technically consistent with sound RP practice and applicable regulations. The RHP approves the execution of specific key activities related to the RP program. The accountabilities of the RHP are documented in role document N-MAN-08131-10000, Sheet CNSC 031, *Responsible Health Physicist.* The Joint Committee on Radiation Protection provides a forum for communication between management and employee representatives on RP topics, and to develop recommendations to senior management for improvements in the RP program.

The design and execution of the RP program is subject to ongoing monitoring through mechanisms including but not limited to:

- Management review and assessment.
- Worker identified problems or errors in the design.

- Implementation or execution of the RP program.
- Reported non-compliances with radiation protection procedures.
- Results of exceptional dosimetry and unusual dose control device measurement results and dose trending.
- RP program self- assessments.
- Independent audits.
- Assessments conducted externally by organizations like the CNSC or other external industry bodies.

RP program self-assessments are conducted to identify opportunities for continual improvement and to confirm that work meets the requirements of the management system. Self-Assessment and benchmarking are utilized to evaluate actual performance against management expectations, industry standards of excellence and regulatory requirements. Reviews of the RP program are conducted in accordance with N-PROC-RA-0097, *Self-Assessment and Benchmarking.*

RP program performance indicators include effectiveness measures commonly used in the nuclear industry and OPG defined indicators established for the purpose of monitoring particular program elements. These indicators are established and tracked in accordance with N-PROG-AS-0001, *Nuclear Management System Administration.* Records generated by the RP program have an established retention period and are only destroyed when they exceed the retention period. Retention periods are consistent with good business practice. Retention and disposal of records meet the requirements of CNSC regulations.

The effectiveness of the RP program with respect to radiological hazard identification and assessment can be measured using collective dose for the facility and compared against industry benchmarks and station targets. These targets are established based on the approved work scope for the year. In some years the target may be impacted from additional approved work activities to maintain high plant reliability.

Collective and individual doses were managed well below administrative and regulatory dose limits in the current licence term. OPG employs exposure control levels to ensure administrative limits are not exceeded.

Darlington NGS's CRE, excluding unit refurbishment project dose, for the current licence term is summarized in Figure 20 below.

The station sustained strong dose performance due to various factors, including strong equipment reliability, reduced radiological source term following unit refurbishment, low unit forced loss rate and implementation of dose reduction initiatives. Some key achievements in radiological hazard identification and assessment during the licence term include:

- Implementation of shielding on areas with elevated radiological hazards; the design was customized such that installation and removal time is optimized. This has short and long-term benefits which will be realized during subsequent unit outages.
- Implementation of portable containment driers to control airborne tritium hazards to supplement current plant drier systems; this reduces dose to

personnel and the environment.

- Upgrades to fixed radiological instrumentation to monitor area conditions and personnel movement through the facility.
- Improvements to processes around liquid radiological hazards, including approvals from a Senior Health Physicist under special circumstances and pre-defined contingency and mitigation actions.

The stacked bar graph illustrated in Figure 20 below shows the contribution from station outage execution (forced and planned) and online routine operations (non-outage). For both planned and forced outages, the main driver for collective dose is outage work scope and duration.

Overall, the effective identification and assessment of radiological hazards has continued to ensure high standards in ALARA work planning, execution, and close-out. For example, in 2021 there were two major planned station outages with large maintenance scopes. This resulted in 91% of annual station CRE being attributed to outage execution dose. In comparison, 2023 had two short outages for Unit 3 and Unit 2 so there was a minor impact to overall station dose in comparison to routine online operations dose.

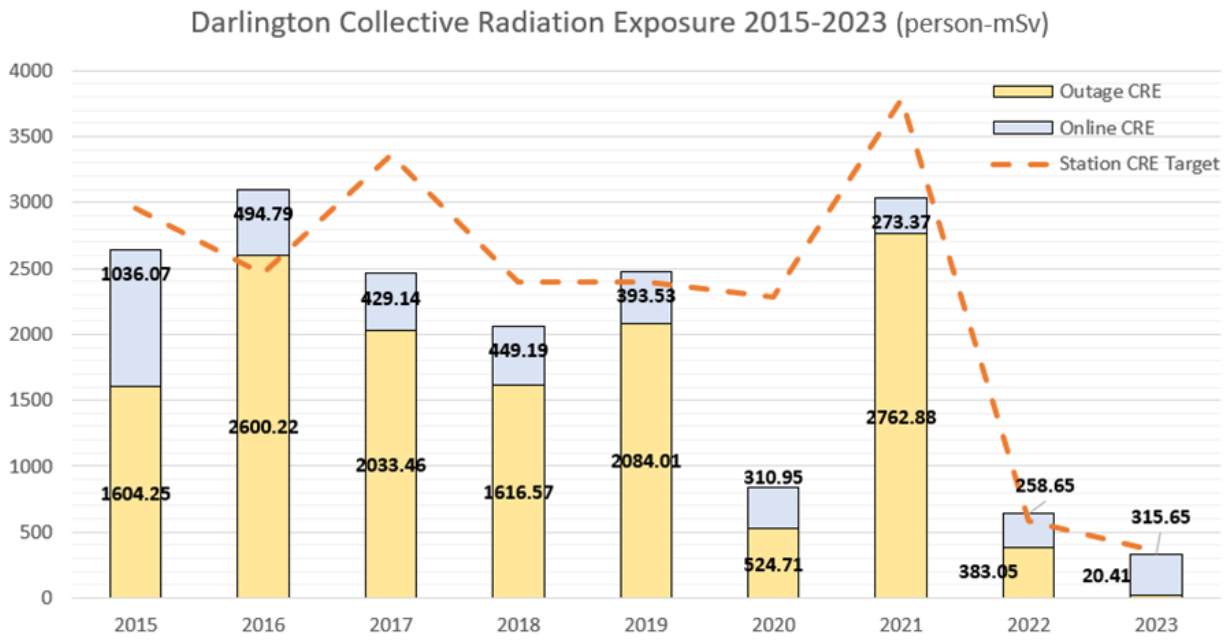


Figure 20: Darlington Collective Radiation Exposure 2015-2023 (person-mSv)

In 2020, there was a delta between the station CRE target and the actual station CRE. An outage was initially scheduled for 2020, which in turn incorporated the outage dose targets into the 2020 station target. However, the outage was deferred to 2021 which resulted in no major planned outage in 2020, thus the lower actual station CRE. Another outage was deferred from 2019 to 2020, to coincide with the start of the Darlington Unit 3 refurbishment outage (starting September 2020). This outage was shorter in duration, less scope and significantly lower dose compared to a major planned outage, hence the large delta for station CRE and the target in 2019.

Comparatively, the scheduling of major planned outages was the main driver for the total station collective dose in the years 2015 to 2019 and 2021. In 2022, there was also no major planned outage scheduled. The drivers for the station CRE target in 2022 were integrated planning group execution and the Mo-99 installation and commissioning mini outage, which required less dose than a major planned outage.

2.7.4 Radiological Hazards Control

The general processes for moving people and materials within and out of radiological zones, and the actions to be taken when contamination is discovered are documented in N-PROC-RA-0014, *Radiological Zoning, Personnel/Material Monitoring*. Workers moving through the radiological zones monitor themselves and material as required when crossing zone boundaries (depending on the direction of travel) and at other designated monitoring points. Loose contamination is not tolerated within the radiological zones except within established contamination control areas. Qualified workers shall ensure a contamination control area is established to control anticipated radioactive contamination in accordance with N-PROC-RA-0015, *Contamination Control While Performing Work.* Workers who detect contamination through monitoring processes work to limit the spread of contamination, take action to identify the source of contamination and ensure that it is contained or removed when found.

The protected area (inside the inner security fence) of the station is divided into zones to facilitate the movement of personnel and materials and control access to areas where radioactive systems are present. Radiological zones are those in which the RP program applies. Indoor areas of the station are divided into three zones (Zones 1, 2 and 3) based on the presence of radioactive systems and the potential for radioactive contamination in each area. Outdoor areas at ground level within the security perimeter, but outside the powerhouse are referred to as 'Unzoned Areas'. Boundaries of the zones are marked and changes to the boundaries are approved by the RHP. The consumption of food and beverages are not permitted in radiological zones except under circumstances approved by the RHP. All materials released into Zone 1 or public domain are monitored for contamination. Certain areas within the protected area are designated as clean laydown areas for materials that are contamination free and awaiting shipment off-site. The requirements for usage of these laydown areas shall be approved and documented by the RHP.

The requirements for transferring inactive material and material containing naturally occurring radioactive material under a permit are documented in N-PROC-RA-0124, *Transfer of Materials from Radiological Zones to Zone 1/Public Domain.* When approving the monitoring methods for determining that material is inactive, OPG meets the constraints specified in N-STD-RA-0029, *Unconditional Clearance of Low-Level Radioactive Materials from OPG Regulated Facilities.*

The objective of radiological hazard identification and assessment is to ensure sources of radiological hazards are assessed such that plant operations and maintenance can be safely conducted. This is primarily carried out through the use of specialized instrumentation for radiation detection and the communication of their results.

In addition, trained and qualified personnel utilize portable instrumentation to provide relevant job-site specific hazards for safely conducting work activities. Day-to-day conditions are routinely monitored by these trained personnel as well to ensure conditions are stable and controlled. The results of hazards are communicated to all workers in the facility through local hazard postings and electronically logged for reference in a common database. This information is used to provide a thorough assessment and plan prior to work execution. The common goal is to ensure work activities are predictable and doses to personnel and the public are kept ALARA.

2.7.4.1 Enhancements and Methods for Improved Radiological Hazards Control

The following outlines the various enhancements and methods OPG implements with respect to improving radiological hazards control.

Minimizing Worker Dose Exposure During Longer Outages

Units 2 and 3 were refurbished during the licence term and involved the replacement of major components in the Primary Heat Transport system, which accumulated some long-lived radionuclides from reactor operation. Following refurbishment, early source term data indicated dose contribution on replaced components are dominated by shorter-lived radionuclides. This created an opportunity to take advantage of radioactive decay and scheduling of radioactive work, especially on outages not dominated by radioactive critical path work.

Advanced Radiation Instrumentation

Periodic use of advanced radiation instrumentation has been used to provide visuals for updated radiological hazards. These updates can support advancements in work planning assessments and worker knowledge of the radiological hazards.

Real-Time Hazard Monitoring with Remote Instrumentation

Remote instrumentation is used to provide real-time hazard information to staff. This information is displayed directly outside certain radioactive work areas, through dedicated software available to qualified workers and supervisors, and includes historical logs for detailed reviews and trending. When applicable, approved radioactive work plans would mandate the use of remote instrumentation such that detailed area hazard maps can be used to optimize personnel exposure conditions during radioactive work activities. This is important for activities which present elevated risks or when multiple areas could be impacted. Monitoring of this instrumentation is conducted by personnel who often have direct line of sight to personnel at the work site through a dedicated audio and video system. Robotic equipment is used by operations staff to reduce exposure during on-power entries and allow for searches in areas previously inaccessible. In one case, robotic equipment was recently used to identify a hot spot and was used in support of its removal.

Procedural Updates on RPPE Usage Working in Wet Conditions

Darlington NGS has updated the procedures including standards and expectations on the use of RPPE when working in wet conditions and actions to be taken to minimize the possibility of skin wetting. Drills and dynamic learning activities have been developed to ensure staff recognize the potential for wetting events. These behaviours are continuously reinforced through approved work plans and management oversight.

Internal/External Operating Experience (OPEX)

Darlington NGS makes use of relevant CANDU operations outside of OPG with its participation in CANDU Owners Group (COG). COG actively collaborates with other CANDU organizations around the world to advance nuclear technologies, including successful RP programs. A recent COG Radiological Protection Task Force has collectively agreed to address management of tritiated hazards, based on common CANDU plant experiences. External and Internal operating experience reviews are completed for relevant radiological application. This includes the

disposition of how relevant internal and external plant experiences may help shape radiological hazard identification and assessment during routine and abnormal plant operations.

The organizational drive for continuous improvement within RP is also observed through the site's interface with the broader nuclear industry, including international organizations whose common goal is excellence in operational nuclear safety. This is manifested to the RP program through its own active internal self-assessments which may focus on understanding how industry best practices can be incorporated and taking defined actions following industry peer review evaluations, which provide an unbiased perspective to the site's RP performance. For example, external benchmarking drove improvements in area signage and key control management for radiological areas. Administrative controls through documented process forms support the improvements that drive workers to have increased accountability in their precision to understand area hazards prior to issuance of unique area keys. This change was an important step to align with industry best practices, but to ultimately improve the defenses against unplanned personnel exposure.

Additional methods for Improving Radiological Hazards Controls

- Characterization studies are independently performed by an approved vendor and verified by OPG to ensure the hazards identified remain within its predicted operating envelope.
- Darlington NGS's alignment meetings outline a risk matrix which may include equipment and area impact to radiological safety. These are communicated to the station to ensure work is assessed relative to its risk.
- Periodic review of industry standards are performed to ensure alignment and best practices for dose control events. Darlington NGS has updated the processes for establishing oversight of radiological work. The process for workers using specialized dose tracking technology has been improved to ensure there is accountability for monitoring radiological dose during work execution.
- Catered dose goals are used to anticipate external gamma dose prior to performing radiological work. During a pre-job brief, workers and supervisors discuss the time, distance, and shielding applicable to their assigned work activity. This form of communication is considered fundamental during the work planning and execution processes.
- OPG maintains an instrumentation lifecycle management process. Darlington NGS is currently updating instrumentation in support of personnel monitoring as a result of lifecycle management. Status reports are completed on the health of radiation instrumentation to track emerging issues and trends. Darlington NGS is in pursuit of new instrumentation to support work activities, a new intrinsically safe tritium meter as well as a new neutron instrument are being assessed for support of radiation dosimetry N-PROC-RA-0066, *Lifecycle Management of Radiation Protection Instruments.*
- Routine radiological surveys are performed in the facility at a frequency sufficient to prevent the prolonged presence of an unknown condition in accessible, normally frequented areas. Review of these surveys are performed to ensure there are no unexpected radiological hazards.
- Dynamic Learning Activities (DLA) engage facilitators and observers to examine how workers use their skills and knowledge while performing activities in a

simulated environment (e.g., mock-up). The activities reflect plant conditions as realistically and authentically as possible within a non-radiological environment. A DLA can be used to improve worker proficiency, work processes and procedures. Recent DLAs for radiological protection have included contamination control and radiological hazard identification.

Section 2.8

Conventional Health & Safety

2.8 Conventional Health and Safety

The foundation of OPG's Health and Safety Management System is the *Employee Health and Safety Policy*, OPG-POL-0001 which describes the approach and commitments to Conventional Health and Safety for the organization, and the requirements and accountabilities of all employees. OPG is committed to preventing workplace injuries and ill health, and continuously improving employee health and safety performance.

OPG's program OPG-PROG-0005, *Environment Health and Safety Managed Systems* puts the Health and Safety Policy into action. The Environment Health and Safety Managed Systems program and supporting governing documents establish process requirements that must be implemented and maintained to ensure that health and safety risks to workers are being mitigated. It also outlines the responsibilities of various levels in the organization to ensure the activities described above are performed to meet the requirements of OPG's *Health and Safety Policy*.

The Environment Health and Safety Managed Systems includes:

- Occupational conditions and factors that could affect the health and safety of workers in all workplaces, or work-related activities under OPG's control.
- Non-occupational health-related conditions and factors that could affect the health of OPG's workers, where it impacts achievement of OPG's business objectives.
- Contractor health and safety.

The goal of OPG's Conventional Health and Safety program is to ensure a healthy and injury-free workplace by managing risks resulting from the activities, products, and services associated with OPG's Darlington NGS operations. Risk reduction is primarily achieved through compliance to the program requirements, by competent workers, to operational controls, developed through risk assessment and safe work planning. Risk reduction is primarily achieved through implementation of the Health and Safety Management System (HSMS) program to manage workplace safety hazards and to protect personnel and equipment. OPG's HSMS program ensures alignment with internal and external specifications or standards such as OPG-POL-0001, *Employee Health and Safety Policy* and ISO 45001 *Occupational Health and Safety Management*. OPG's Health and Safety Management System is structured in accordance with the requirements of the ISO 45001 standard and is documented in the Environment, Health and Safety program document.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 12: SCA 8 – Conventional Health and Safety

Document	Title
N-PROG-MA-0015	Work Protection
OPG-POL-0001	Health and Safety Policy
OPG-PROG-0005	Environment Health and Safety Managed Systems
OPG-PROC-0132	Respiratory Protection
N-PROG-RA-0012[1]	Fire Protection
NK38-LIST-78000-10001	Application of CSA N293-07 to Structures, System and Components for Darlington Nuclear

Notes:
1. Refer to Section 2.10, *Emergency Management and Fire Protection*.

2.8.1 Performance

Darlington NGS continuously strives for excellence and continued improvement in our Health and Safety performance. Over the last two years, Health and Safety has focused efforts on benchmarking with industry leaders and has introduced new initiatives and programs for continual improvement in industrial safety.

Manager and employee engagement in personal safety and associated initiatives and programs has instilled behaviors within the organization that have contributed to a performance free of lost time injuries since 2019.

OPG's vision has been to cultivate a value-based culture by continuing to integrate and reinforce the iCare program. Additionally, the Health and Safety culture at OPG has been further strengthened through the station advocacy peer-to-peer coaching program. These initiatives are foundational in driving OPG's "value-based" safety culture shift and is integral in building a healthy and engaged workforce.

OPG's fail safe strategy drives continuous improvement of OPG's performance in HSMS and human performance. It relates to the concepts that OPG's programs afford protection against significant injury and consequence, even in the event of employee error or equipment failure. Our approach to safety and human performance is proactive and focuses on building a resilient organization.

During the current licence term, Darlington NGS has demonstrated excellent safety performance throughout its operations. Below are a few examples:

- Darlington NGS Serious Injury Incidence Rate (SIIR) has remained at zero since the introduction of the new safety performance metric in 2020 up to Q3 2023.
- OPG has been awarded nine times in the last 10-years for the Electricity Canada President's Award for Excellence in Employee Safety.

The following sections illustrate various safety performance metrics for Darlington NGS.

- Accident Frequency Rate.
- Industrial Safety Accident Rate (ISAR).
- Accident Severity Rate (ASR).

Additionally, the following proactive metrics are tracked to demonstrate our commitment to excellence and continuous improvement.

- Serious Injury Incidence Rate (SIIR).
- Timely Completion of Safety Corrective Actions (TCSCA).

Safety Performance Indicators (SPIs) from Conventional Health and Safety – SPI 21, are reported quarterly per REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* to the CNSC, such as Accident Frequency Rate, ISAR and ASR.

2.8.1.1 Accident Frequency Rate

The Accident Frequency is the sum of the fatalities, lost-time injuries and medically treated injuries multiplied by 200,000 person hours worked at a Nuclear Power Plant, per exposure hours.

OPG's commitment to continuously improve performance is reflected by setting challenging targets for safety performance metrics. Darlington NGS has continually tightened its target rate for disabling injuries, and its safety performance has been below (better than) target since 2019 as illustrated in Figure 21 below.

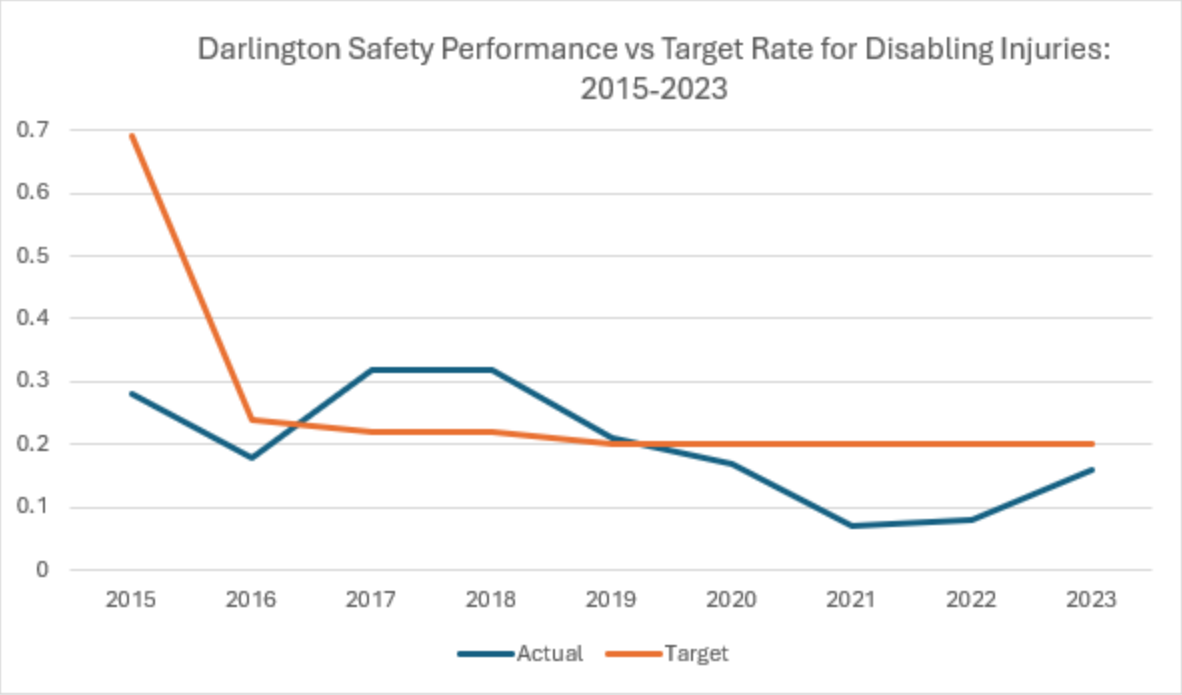


Figure 21: Darlington NGS – Accident Frequency Rate 2015-2023 YTD

2.8.1.2 Industrial Safety Accident Rate (ISAR)

The ISAR is a frequency rate based on the number of lost-time injuries for Nuclear Power Plant personnel per 200,000 hours worked (excluding contractors).

The Darlington NGS has upheld a consistent record of zero lost time injuries up to Q3 2023 since 2018 as shown in Figure 22.

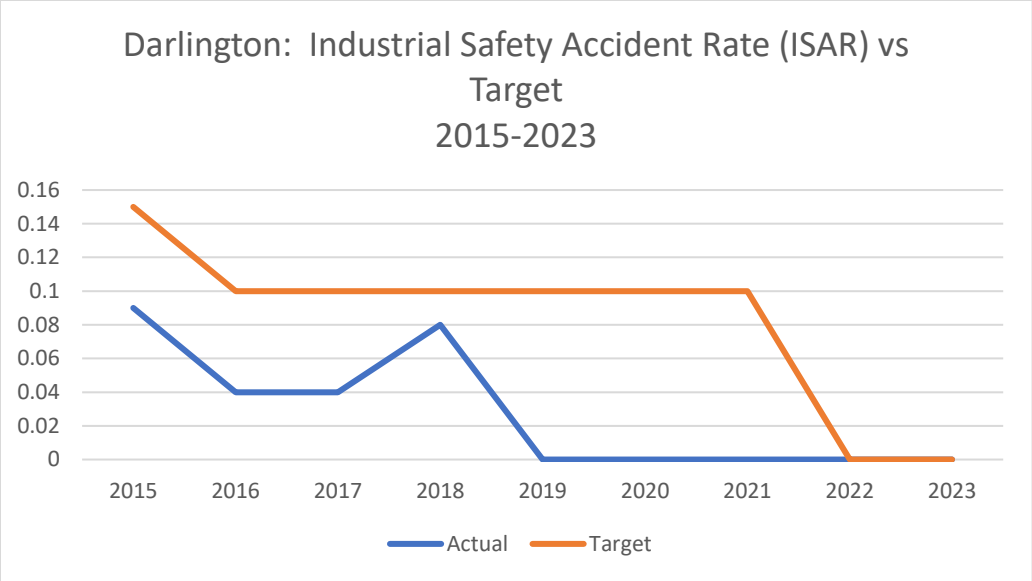


Figure 22: Darlington NGS – Industrial Safety Accident Rate (ISAR) vs. Target 2015-2023

2.8.1.3 Accident Severity Rate (ASR)

The ASR is the number of days lost multiplied by 200,000 person hours worked at a Nuclear Power Plant, per exposure hours.

Darlington NGS has upheld a consistent record of zero lost time injuries, resulting in no lost time days up to Q3 2023 since 2018 as shown in Figure 23. There are no targets set for ASR.

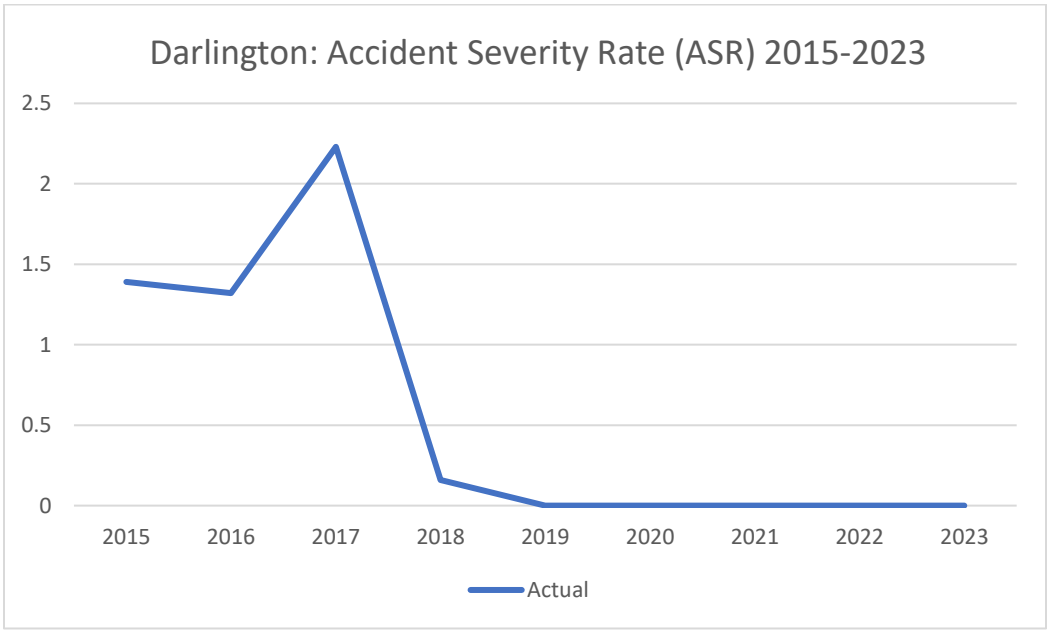


Figure 23: Darlington NGS – Accident Severity Rate (ASR) 2015-2023

2.8.1.4 Serious Injury Incidence Rate (SIIR)

The SIIR is defined as the number of work-related accidents for all OPG employees that result in serious injuries or fatalities, per 200,000 person-hours worked. This metric focuses on more serious injuries, assists in maintaining attention on high-consequence hazards, and accounts for the actual injury instead of the type of medical treatment.

Darlington NGS SIIR has remained at zero (0) since the introduction of the new safety performance metric in 2020 up to Q3 2023.

2.8.1.5 Timely Completion of Safety Corrective Actions (TCSCA)

TCSCA aims to prioritize completion of safety related actions in a timely manner. TCSCA is the percentage of corrective actions, arising from safety events, that are completed on or before the initial due date (zero extensions).

Darlington NGS consistently demonstrates its commitment to prioritizing safety-significant work since the introduction of the leading indicator metric in 2019. Darlington NGS has performed better than target since the introduction of the metric and maintained 100% for the past 3-years as shown in Figure 24.

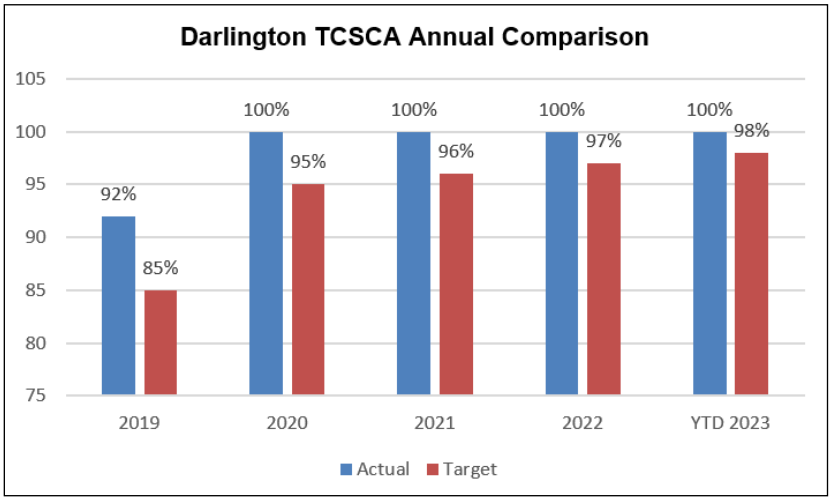


Figure 24: Darlington NGS – TCSCA Annual Comparison

2.8.2 Practices

The *Work Protection* program is governed by N-PROG-MA-0015 which describes requirements that are in place within OPG Nuclear to isolate and de-energize equipment to ensure worker safety. For more details on the *Work Protection* program, refer to Section 2.3.1.

Respiratory Protection, OPG-PROC-0132 references the requirements for the selection, care and use of respiratory protection. For more details on *Respiratory Protection*, refer to Section 2.7.2.

N-STD-RA-0008, *Incident Investigation* provides a systematic and consistent approach for evaluating adverse conditions at OPG Nuclear including determining the cause of an adverse condition or event and developing effective corrective actions to eliminate or reduce the probability of similar events occurring in the future.

OPG is committed to upholding robust workplace health and safety practices aimed at managing risks for both employers and workers. To fulfill this commitment, OPG has established the OPG Corporate Safety rules, ensuring compliance with or exceeding the applicable health and safety legal obligations mandated by the Occupational Health and Safety Act (OHSA) and the applicable regulations (Occupational Health and Safety Act, R.S.O. 1990, c. O.1). The main purpose of OHSA is to provide the legal framework to achieve the goal of protecting workers from health and safety hazards on the job. Many regulations made under OHSA require compliance with standards published by the Canadian Standards Association (CSA) group; these standards define requirements for reducing the risk of workplace injuries.

Continuous improvement opportunities for OPG's Health and Safety Management System program are identified using a "Plan-Do-Check-Review" management cycle. The objective is to ensure conventional health and safety risks, work practices and conditions are appropriately managed to achieve a high degree of employee safety. Leveraging our HSMS, OPG seeks to continuously ensure excellence in everything we do. Our Compliance Assessment functions to monitor Key Performance Indicators (KPI) by conducting field assessments, document reviews and interviews with stakeholders to help identify systematic issues before they result in near-misses, injuries, and events. Compliance assessment objectives include confirming OPG's operations/activities are in alignment with expectations formally set forth by the HSMS and confirming OPG's operations/activities are being performed in conformance with applicable Occupational Health and Safety legal requirements.

To further enhance work safety, the Darlington NGS Joint Health and Safety Committee (JHSC) has been established to work co-operatively to improve health and safety in the workplace, as set out in the OHSA. One of Darlington NGS's goals is to have healthy people working safely in an accident-free environment.

The JHSC assists in achieving the goal by providing a forum for:

- Cooperatively resolving health and safety issues.
- Making recommendations for improvements.
- Providing visible leadership in actively promoting health and safety awareness.
- Ensuring that the Darlington NGS JHSC is in compliance with the legislated and corporate requirements for JHSCs.
- Promoting communication between workers, management and the JHSC on health and safety.
- Looking at environmental concerns in regards to worker health and safety.

In addition, a Building Trades Union JHSC has been established, which supports contractors supporting construction and project work on site; both unions work co-operatively to support their respective workers.

Moreover, the Internal Responsibility System (IRS) is a system applied consistently throughout OPG, where everyone has personal and shared responsibility for working together co-operatively, to prevent occupational injuries and illnesses. The duties for a healthy and safe workplace fall on every individual, to the degree they have authority and ability to do so. Each person is expected to take the initiative on health and safety issues, work to solve problems, and make improvements on an on-going basis. The IRS is based on the principle that employees themselves are in the best position to identify health and safety problems and identify solutions and outlines the appropriate resolution level for timely corrections.

2.8.2.1 WHMIS

Canada's requirements for the hazard classification and communication for workplace chemicals, Workplace Hazardous Materials Information System (WHMIS) were updated in 2015 to incorporate the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). All workplace chemicals must now meet the hazard classification and communication requirements established by WHMIS 2015. OPG is compliant with WHMIS 2015 and has processes in place for the management, handling, and storage of hazardous materials to ensure regulatory compliance and to ensure workers have information to safely work, store and dispose of hazardous materials in the workplace.

2.8.2.2 Training

Nuclear Conventional Safety Training and Qualification on Description on document describes required Initial and Continuing Conventional Safety Training and related qualifications for all major job families and contractors.

2.8.2.3 Environment Health and Safety Audits and Assessments

OPG-PROC-0044, *Environment Health and Safety Audits and Assessments* establishes the methodology, frequency, responsibilities, planning, and reporting requirements for internal and compliance audits on the effective implementation and maintenance of the Environment Health and Safety Managed Systems, in accordance with applicable ISO standards and other regulatory requirements.

2.8.2.4 Refurbishment Health and Safety Practices

Nuclear Refurbishment complies with program OPG-PROG-0005, *Environment Health and Safety Managed Systems* document for both OPG employees and contractors.

Nuclear Refurbishment engages contractors that have proven health and safety programs and experience. This is verified in a prequalification process that review industry experience, historical safety performance, implemented management system elements and prior OPG experience. With respect to Enterprise Project Contractors (EPC), OPG Nuclear Refurbishment is the "constructor" and the contractors will be the "employer" as defined in OHSA, and are governed by the requirements set therein. External construction and support staff work under the "employer" programs and procedures. This allows contractor front line supervisors and workers to work within the programs and procedures they are trained and experienced in, which improves performance and reduces human performance errors related to working with multiple programs and systems. The process aligns with the internal responsibility methodology fostered in the OHSA.

A guide has been developed and build into contracts related to the Nuclear Refurbishment program, which sets the expectations for conventional health and safety elements related to Refurbishment, thereby ensuring the contractor is fully aware of and will be held accountable to OPG's health and safety expectations. OPG reviews the contractor health and safety submissions against our expectations prior to approval and commencement of activities. The document also sets out common elements that will apply to all contractors within the Nuclear Refurbishment, such as:

- Safety performance metrics and key performance indicators.
- Problem/incident notification and investigation requirements.

- Common safety rules.
- Safety culture requirements.
- Communication requirements, and.
- Oversight and surveillance.

The Nuclear Refurbishment team recognizes that effective oversight throughout all stages of the program life cycle is paramount to the program's success. Health and Safety has a dedicated team of advisors who provide daily support and ensure contractors are held accountable to OPG's health and safety expectations.

2.8.3 Awareness

Safety Enhancements and Areas of Strength for the Future

Several health and safety improvement initiatives have been identified for Darlington NGS as part of the continuous improvement cycle of the HSMS. These initiatives remain on-going which include:

- Implementation of Fail-Safe Culture Change initiatives, which aligns with Industry best practice. Fail Safe identifies and strengthens defenses so when an event occurs, we have enough strong defenses in place to ensure the event occurs safely. It shifts our focus to learning; and proactively applies lessons to future work. OPG has streamlined our safe work planning process into one consolidated electronic database with Fail Safe built into the application. OPG has introduced hazard assessment tools including the energy wheel, to better identify hazards in the planning stage to eliminate, control and ultimately protect workers against workplace hazards.
- Continue to maintain the iCare Safety Culture initiatives in areas of Communications, Recognition, Risk Management, Human Performance & Coaching and Total Health Strategies. The initiative's aim is to revamp the delivery of safety messages, moving away from a directive of doing something just because it's required, to encouraging individuals to take actions out of genuine concern, expressing a desire to avoid/prevent injuries.
- Implementation of a Total Health Initiative supporting employees and their families in their efforts to achieve an optimal level of health, primarily through health education, health promotion, disease and injury prevention and crisis intervention. There is a continued focus on mental health and Musculoskeletal Disorder prevention with campaigns to raise awareness in these areas.
- The leading indicator safety performance metric, TCSCA will continue to be reinforced to focus on completing safety related actions in a timely manner. Focusing on safety related actions to ensure completion builds on the iCare safety culture.
- SIIR metric will continue to be reinforced to focus on prevention of serious injuries that have life-altering consequences.
- Implementation of a safety related work order strategy aimed at the timely repair/correction of identified equipment and plant conditions that pose safety risks.
- OPG's commitment to continuously improve performance is reflected by setting challenging targets for safety performance metrics.

Section 2.9

Environmental Protection

2.9 Environmental Protection

OPG's comprehensive environmental protection programs aim to continually minimize impacts from the station operation on the environment and human health. This is achieved by ensuring that there are multiple barriers in place to control and minimize emissions to the environment and to ensure all emissions are monitored.

Darlington NGS has in place environmental protection programs in accordance with CNSC regulatory document REGDOC-2.9.1, *Environmental Protection Policies, Programs and Procedures.* Given OPG's robust programs and processes, it is expected that Darlington NGS will continue to meet or exceed regulatory requirements and expectations within this SCA over the next licence term.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 13: SCA 9 – Environmental Protection

Number	Title
Effluent and Emissions Control (Releases)	
N-STD-OP-0031	Monitoring of Nuclear and Hazardous Substances in Effluents
NK38-MAN-03480-10001	Environment Manual
NK38-REP-03482-10001[1]	Derived Release Limits and Environmental Action Levels for Darlington Nuclear Generating Station
N-PROC-OP-0037	Environmental Approvals
Environmental Management System (EMS)	
OPG-POL-0021	Environmental Policy
OPG-PROG-0005	Environment Health and Safety Managed Systems
N-PROC-OP-0044[2]	Contaminated Lands and Groundwater Management
OPG-PROC-0126	Hazardous Material Management
N-PROC-OP-0038	Abnormal Waterborne Tritium Emission Response
Assessment and Monitoring	
N-PROC-OP-0025	Management of the Environmental Monitoring Programs
NK38-MAN-03443-10002	Darlington Environmental Monitoring Program
Environmental Risk Assessment (ERA)	
NK38-REP-07701-00001-R001[3]	Darlington Nuclear Environmental Risk Assessment

Notes:

1. Superseded by NK38-REP-03482-10001, *Derived Release Limits for Darlington Nuclear Generating Station* and NK38-REP-03482-10002, *Action Levels for Environmental Releases – Darlington Nuclear*, effective January 1, 2024.
2. Superseded by N-PROC-OP-0044 R005, *Contaminated Lands Management* and N-STD-OP-0046 R002, *Groundwater Protection and Monitoring Program*, effective December 2022.
3. Superseded by D-REP-07701-00001-R002, *2020 Environmental Risk Assessment for the Darlington Nuclear Site*.

2.9.1 Environmental Management System

OPG maintains an Environmental Management System (EMS), OPG-PROG-0005, *Environment Health and Safety Managed Systems*, which implements the requirements of OPG's Environmental Policy (OPG-POL-0021) and is consistent with the International Organization for Standardization (ISO) 14001 *Environmental Management System Standard.*

The objectives of the OPG Environmental Policy are to:

- Establish an EMS and maintain registration for this system to the ISO 14001.
- Work to prevent or mitigate adverse impacts on the environment, with a long-term objective of continual improvement in its EMS and its environmental performance.
- Strive to be a leader in climate change mitigation.
- Manage OPG's sites in a manner that strives to maintain, or enhance where it makes business sense, significant natural areas and associated species of concern. OPG will work with its community partners to support regional ecosystems and biodiversity through science-based habitat stewardship. Where disruption is required, OPG shall take reasonable steps to manage the residual impact to these areas and species.
- Set environmental objectives as part of its annual business planning process. Performance against these environmental objectives will be monitored and associated documented information will be maintained.
- Communicate its environmental performance to employees, governments, local communities, and other stakeholders.

The current OPG ISO 14001 EMS certificate, issued in 2021 following a successful audit by an external auditor, is valid for 3-years. The recertification audit is scheduled to take place in Q2 of 2024, with Darlington NGS as one of the sites undergoing an audit.

The EMS uses a risk-based approach to identify and assess areas of concern with respect to environmental management. Elements of OPG's activities, products, and services that interact or can interact with the environment are considered environmental aspects per OPG-PROC-0036, *Environmental Aspects Identification and Significance*. Significant environmental aspects, as determined by assessing risks and opportunities, are environmental aspects that have or can have a significant environmental impact.

Identified environmental aspects, including significant environmental aspects, are managed as appropriate through operational controls at the sites. Performance measures are established to ensure the controls perform as designed and are corrected and/or improved under the EMS framework.

Identification of the significant environmental aspects which apply to Darlington NGS allows for more focus on areas where there is the potential to have a negative impact on the environment. The significant environmental aspects that have been identified for Darlington NGS include the following:

- Spills (refer to Section 2.9.4 for details);
- Fish impingement/entrainment/spawning disruption (refer to Section 2.9.6 for details);
- Wildlife habitat: enhancement or disruption;

- Radiological emissions: production or reduction (refer to Section 2.9.4 for details);
- Non-radiological emissions: production or reduction (refer to Section 2.9.4 for details);
- Low or intermediate radiological waste: generation or diversion (refer to Section 2.11 for details);
- Non-radiological waste: generation or diversion (refer to Section 2.11 for details).

Continual improvement of Darlington NGS operations is an ongoing effort under OPG's ISO 14001-certified EMS. Opportunities for continual improvement may be identified through routine EMS audit activities, the performance improvement program, and strategic initiatives such as execution of OPG's Climate Change Plan and Reconciliation Action Plan (available at www.opg.com).

2.9.1.1 Biodiversity

Beyond the impact of operations, the Darlington NGS site has a strong commitment to Indigenous Nations and communities and the public and has numerous programs aimed at embracing the broader principles of biodiversity and habitat stewardship.

OPG's biodiversity conservation program OPG-STD-0119, *Biodiversity Conservation Standard,* meets the requirements of OPG-POL-0021, *Environmental Policy,* and aligns with OPG-PROG-0005.

Some highlights of the Darlington NGS's biodiversity efforts include:

- In 2017, Darlington NGS meadow and pollinator habitats were installed to improve habitat for local pollinators. Over 700 new plants, all of local ecotypes, were added in 2018 and 2019 based on recommendations from the Pollinator Partnership to improve floral diversity and seasonal availability.
- In 2020, a MOTUS tower was deployed on Bobolink Hill next to Coot's Pond, to study migratory birds, bats, and insects that have been electronically tagged and fly on or near the station. The MOTUS tower is a partnership between OPG and Birds Canada. The data collected supports federal migration research. It also provides valuable insights to OPG on which species fly on or near or site and helps to inform conservation stewardship around these species. Since deployment, nine bird species have been noted.
- The tree swallow nest box program is in its 25th year, and since 1998, over 900 chicks have successfully fledged their nests. The nest boxes, installed by Coot's Pond, provide breeding/nesting, foraging, shelter, and water habitat for Tree Swallows. Recent activities included nest box maintenance and bird banding of chicks and adults.
- In 2022, a turtle basking platform was built in partnership with the Courtice Secondary School and installed in Coot's Pond. The raft provides a safe basking habitat for painted turtles and reduces the chances of land predation. Painted turtles were observed using the platform.

Refer to Section 4.4.6 for additional details on OPG's biodiversity initiatives, environmental partnerships and programs.

2.9.1.2 Regulatory Compliance

The Darlington NGS site operates under numerous environmental regulations governing plant operations. The primary regulators from an environmental perspective are the CNSC and the Ministry of the Environment, Conservation and Parks (MECP).

At OPG, infractions are regulatory non-compliances that have moderate potential for regulatory actions and/or involvement. During the current licence term, there were nine infractions (as of February 29, 2024), most of which were related to Environmental Compliance Approvals (ECAs).

2.9.2 Environmental Risk Assessment

Consistent with REGDOC-2.9.1 and REGDOC-3.1.1, OPG is required to update the Darlington NGS site Environmental Risk Assessment (ERA) at least once every 5-years. The purpose of the ERA is to assess potential human health and ecological risks to receptors from exposure to radiological contaminants, conventional contaminants, and physical stressors present in the environment as a result of site operations. This is achieved through completion of a human health risk assessment and an ecological risk assessment. The results of the ERA inform the environmental monitoring program and effluent monitoring programs, as per CSA N288.4, *Environmental monitoring program at class I nuclear facilities and uranium mines and mills,* and CSA N288.5, *Effluent monitoring programs at class I nuclear facilities and uranium mines and mills*. These programs can also inform the ERA by providing information on effluent concentrations and loading, and by providing environmental data to assist in model calibration and validation.

The 2020 ERA, D-REP-07701-00001-R002, *2020 Environmental Risk Assessment for the Darlington Nuclear Site*, was issued in 2021 (and last revised in 2022) in accordance with CSA N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills*. The ERA focused on activities that occurred during the 2016 to 2019 period.

In April 2024, OPG prepared an Addendum to the 2020 ERA to support the renewal of the Darlington NGS PROL. D-REP-07701-00002 R000, *2024 Environmental Risk Assessment Addendum for the Darlington Nuclear Site*, serves as an interim update to the 2020 ERA ahead

of the next routine ERA update in 2026. The 2024 ERA Addendum focuses on activities that occurred during the years 2020 to 2022 (including some of 2023, where data was available at the time of preparation).

The 2020 ERA concluded that the Darlington NGS site is operating in accordance with approved limits and measures are taken to ensure regulatory compliance is maintained. In the 2024 ERA Addendum, OPG found that the Darlington NGS site continues to be operating in a manner that is protective of human and ecological receptors residing in the surrounding area. The 2020 ERA is available on www.opg.com and the 2024 Addendum will also be posted online.

Based on requests from the Williams Treaties First Nations (WTFNs), OPG is committed to facilitating WTFNs engagement on ERAs. A summary of key issues raised by Indigenous Nations and communities during engagement sessions is included in the 2024 ERA Addendum. OPG is sharing the 2024 ERA Addendum report with Indigenous Nations and communities, prior to finalization and submission to the CNSC, and will incorporate any feedback into this, and future assessments, as appropriate. OPG continues to work with Indigenous Nations and communities to develop comprehensive and ongoing engagement around ERAs.

2.9.3 Assessment and Monitoring

OPG maintains an Environmental Monitoring Program (EMP) in the vicinity of Darlington NGS in accordance with licence requirements. The EMP is implemented through N-PROC-OP-0025, *Management of the Environmental Monitoring Programs*, and complies with CSA N288.4-10, *Environmental Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills,* as demonstrated in NK38-MAN-03443-10002, *Darlington Environmental Monitoring Program*. The scope of Darlington's EMP encompasses protection of both the public and the environment from nuclear substances, hazardous substances, and physical stressors resulting from the operation of the Darlington NGS site.

OPG EMPs are designed to satisfy the following primary objectives of CSA N288.4:

1. Assess the impact on human health and the environment of contaminants and physical stressors of concern resulting from operation of OPG nuclear facilities.
2. Demonstrate compliance with limits on the concentration and/or intensity of contaminants and physical stressors in the environment or assess their effect on the environment.
3. Demonstrate the effectiveness of containment and effluent control and provide public assurance of the effectiveness of containment and effluent control, independent of effluent monitoring.
4. Verify the predictions made by the Environmental Risk Assessments (ERAs), refine the models used, and reduce the uncertainty in the predictions made by these assessments and models.

Additionally, environmental sampling and analyses for the Darlington EMP supports the calculation of annual public dose resulting from operation of Darlington NGS, as required by REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*.

OPG reports the results of its nuclear facility EMPs annually to the CNSC. The report is also made available to the public on www.opg.com.

2.9.4 Effluent and Emission Control

2.9.4.1 Radiological Emissions to Air and Water

The Darlington NGS site effluent monitoring program documented in N-STD-OP-0031, *Monitoring of Nuclear Hazardous Substances in Effluents*, and NK38-PLAN-03480-10001, *Darlington Effluent Monitoring Plan*, is compliant with CSA N288.5-22, *Effluent Monitoring Programs at Class I Nuclear Facilities and Uranium Mines and Mills.* The objectives of the effluent monitoring program are to:

- Demonstrate compliance with authorized release limits and any other regulatory requirements concerning the release of nuclear and hazardous substances from the source.
- Demonstrate adherence to internal objectives and targets set on release amounts, for purposes of effluent control.
- Confirm the adequacy of controls on releases from the source.
- Provide an indication of unusual or unforeseen conditions that might require corrective action or additional monitoring.
- Provide data to assess the level of risk on human health and safety, and the potential biological effects in the environment of the nuclear and hazardous substances of concern released from facility.
- Confirm predictions in the environmental impact statement made through the environmental review process.
- Provide assurance to the public on the effectiveness of effluent and emissions control.
- Provide data which, when combined with the results of environmental monitoring and modelling, can be used to test or refine the models used in the ERA or dose assessments.
- Address any other objective identified by the nuclear facility or licensed activity (e.g., demonstrating due diligence, meeting a stakeholder commitment, or other business reasons).

NK38-PLAN-03480-10001 is developed as a requirement of N-STD-OP-0031 and addresses design requirements, reporting requirements, and sampling/analytical procedures use, in alignment with CSA N288.5.

Derived Release Limits

Derived Release Limits (DRLs) are calculated using CSA N288.1, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities,* and submitted to the CNSC. The DRL for a given radionuclide is the release rate to air or surface water during normal operation of a nuclear facility that would cause an individual of the most highly exposed group around Darlington NGS to receive and be committed to a dose equal to the annual regulatory dose limit over the period of a calendar year. DRLs are used to establish controls on the releases of radioactive materials and are calculated for radionuclides of potential dose significance in effluent streams, to facilitate the control, reporting, and regulation of radionuclide emissions. The Darlington NGS DRL values are shown below in Table 14 and documented in NK38-REP-03482-10001, *Derived Release Limits for*

Darlington Nuclear Generating Station. For operational purposes, the airborne DRLs are divided into weekly amounts and waterborne DRLs into monthly amounts.

Table 14: Darlington Nuclear - Derived Release Limits

Release Category	Radionuclide	DRL (Becquerel/year)	Operational DRL (Becquerel/week)
Air	Tritium (HTO)	3.91×10^{16}	7.52×10^{14}
	Elemental Tritium (HT)	6.26×10^{17}	1.20×10^{16}
	Iodine (mixed fission products)	1.74×10^{12}	3.34×10^{10}
	Carbon-14	7.68×10^{14}	1.48×10^{13}
	Noble Gases[1]	3.46×10^{16}	6.66×10^{14}
	Particulate	5.51×10^{11}	1.06×10^{10}
	Gross Alpha	9.82×10^{10}	1.89×10^{9}
Release Category	**Radionuclide**	**DRL (Becquerel/year)**	**Operational DRL (Becquerel/month)**
Water	Tritium (HTO)	6.36×10^{18}	5.30×10^{17}
	Carbon-14	6.97×10^{14}	5.81×10^{13}
	Gross Alpha	4.39×10^{11}	3.66×10^{10}
	Gross Beta-Gamma	3.47×10^{13}	2.89×10^{12}

Notes:
1. Units are in Bq-MeV/year and Bq-MeV/week.

Action Levels

An Environmental Action Level (EAL) for environmental releases is an effluent monitoring level (concentration, activity, rate, etc.) that if exceeded triggers an investigation to determine whether a loss of control of the environmental protection program has occurred and to enable corrective action, if warranted. In 2017, following the recommendations of the CNSC, a standardized methodology for calculating and applying EALs at Class 1 nuclear facilities and uranium mines and mills was developed and documented in CSA N288.8-17, *Establishing and implementing action levels for releases to the environment from nuclear facilities*. The primary changes introduced by the standard are that the scope of the EALs must consider both hazardous and radioactive substances, and the EALs must be calculated based on the historical performance of the station. The Darlington NGS EALs, updated to reflect the guidance and methodology in this CSA standard, are shown in Table 15 and documented in NK38-REP-03482-10002, *Action Levels for Environmental Releases – Darlington Nuclear.* The updated EALs were implemented effective January 1, 2024. Exceeding an EAL requires notification and reporting to the CNSC, investigation of the cause, and corrective action as required.

Table 15: Darlington Nuclear – Action Levels for Environmental Releases

Release Category	Radionuclide	AL: Gaseous Releases (Becquerel/week)
Air	Tritium (HTO)	1.78×10^{13}
	Elemental Tritium (HT)	3.81×10^{13}
	Iodine	6.11×10^{6}
	Carbon-14	1.08×10^{11}
	Noble Gases[1]	3.29×10^{12}
	Particulate	4.51×10^{6}

Release Category	Radionuclide	AL: Liquid Releases (Becquerel/month)
Water	Tritium (HTO)	1.17×10^{14}
	Carbon-14	Not required[2]
	Gross Beta-Gamma	7.99×10^{9}

Notes:
1. Units are in Bq-MeV/week.
2. Qualified for exclusion from an AL – carbon-14 is currently only monitored for controlled batch releases of active liquid waste and dousing water.

During the current licence term, the emissions from the Darlington NGS site have consistently been orders of magnitude below DRL values as shown in

Figure 25 and

Figure 26. Note: The changes seen in 2023 for tritium oxide and elemental tritium emissions, while still very low (slightly above 1% of the DRL), are attributed to the Tritium Removal Facility, as described in further detail below.

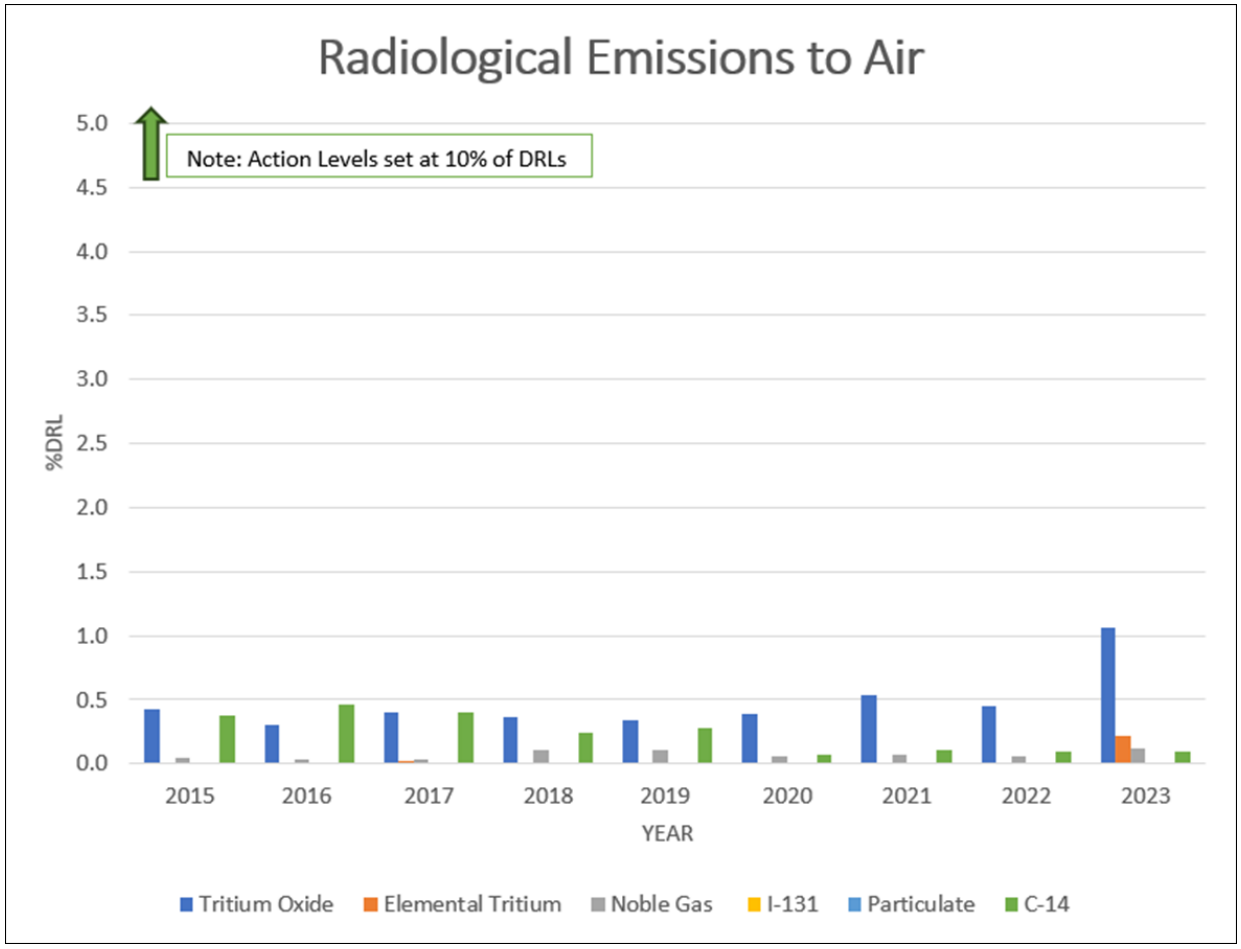


Figure 25: Radiological Emissions to Air

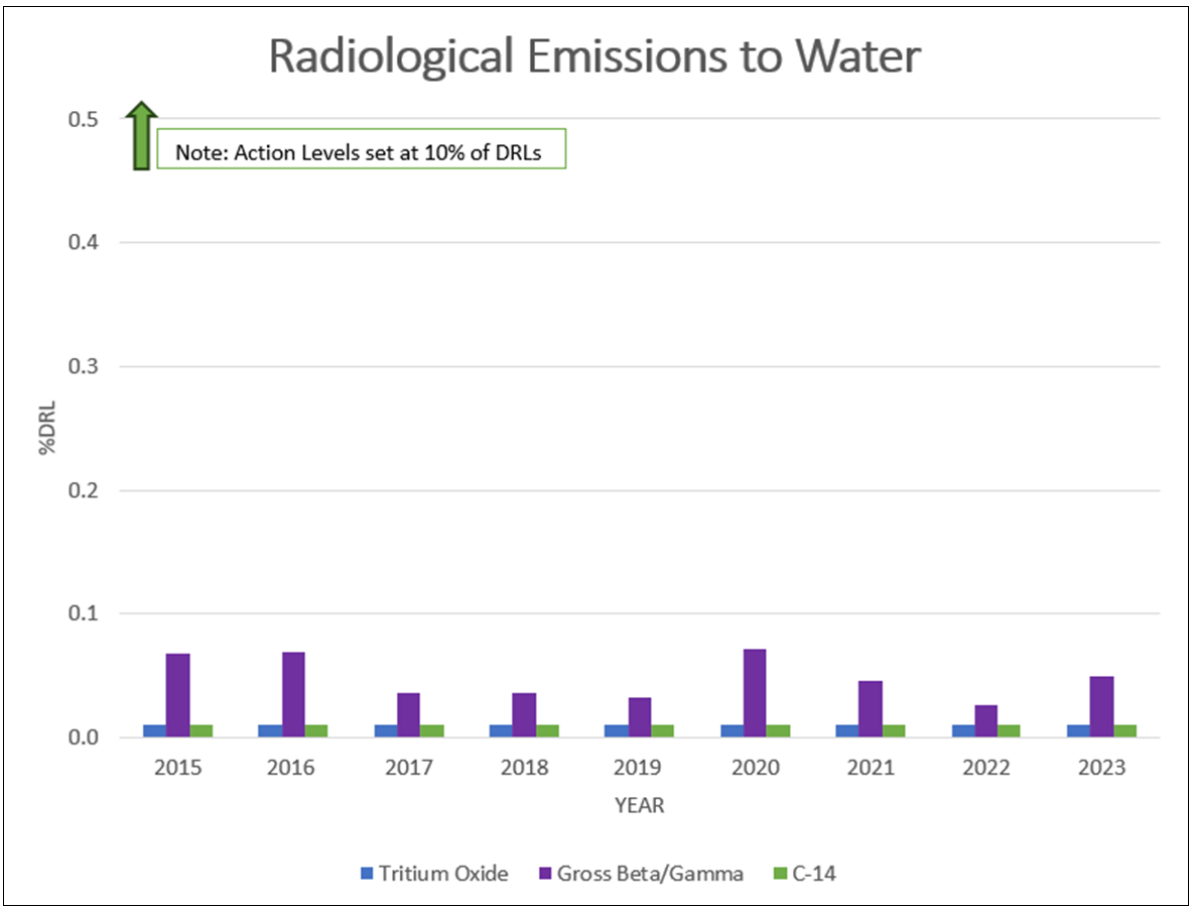


Figure 26: Radiological Emissions to Water

Powerhouse stack ventilation flows are monitored to measure the gaseous effluent releases (tritium, elemental tritium, iodine, carbon-14, noble gases, and particulate). The results are compiled weekly and compared to the applicable weekly DRL.

Waterborne radiological release data are compiled monthly and compared to monthly DRLs. Most radiological releases are routinely managed through the active liquid waste system and monitored prior to discharge.

During the current licence term, there was an exceedance of the weekly airborne tritium oxide (HTO) action level. This exceedance was attributed to an event at the Darlington NGS Tritium Removal Facility (TRF) due to issues with the tritium immobilization system. A Significant Issue Resolution Team was created, and corrective actions were taken to minimize further releases. Longer-term corrective actions are also in place, some of which include creating a cross-functional team to proactively address conditions in the TRF, implementing a design change to improve the robustness of the tritium immobilization system, improving leak check processes, and bolstering organizational support and prioritization of TRF challenges and equipment reliability.

2.9.4.2 Conventional Emissions

The Darlington NGS site also monitors conventional substances emitted to air and water as a result of site operations. Reports on emissions of conventional substances are prepared in accordance with provincial and federal regulatory requirements and submitted to provincial and federal agencies throughout the year.

Sulphur Dioxide, Nitrogen Oxides, and Carbon Dioxide Emissions

Darlington NGS has standby diesel generators to provide back-up electrical power to the station if required. These generators, which produce sulphur dioxide, nitrogen oxides and carbon dioxide emissions, are routinely tested to ensure availability. There were no regulatory non-compliances associated with air emissions from these generators during the licensing period.

Hydrazine and Ammonia

Hydrazine is used in the boiler feedwater systems to prevent corrosion. Ammonia is a resulting by-product. Hydrazine and ammonia are released to the environment when steam is vented to the atmosphere and from station water systems (to Lake Ontario). There were no regulatory non-compliances associated with hydrazine and ammonia emissions during the licensing period.

Ozone-Depleting Substances

Ozone-depleting substances (ODS) are used in refrigeration systems. Refrigerant leaks to air are minimized through routine inspections and maintenance of equipment. ODS releases between 10 kg and 100 kg are reported to Environment Canada in semi-annual halocarbon release reports. During the current licence term, there were six ODS releases.

2.9.4.3 Groundwater Protection and Monitoring Program

The Darlington NGS site has a Groundwater Protection Program (GWPP) and Groundwater Monitoring Program (GWMP), N-STD-OP-0046, *Groundwater Protection and Monitoring Program*, compliant with CSA N288.7-15, *Groundwater Protection Programs at Class I Nuclear Facilities and Uranium Mines and Mills*. Compliance with this standard came into effect on December 31, 2022.

The overall goal of the Darlington NGS GWPP is to protect the quality and quantity of groundwater by minimizing interactions with the environment from activities associated with the site, allowing for effective management of its groundwater resource. To meet this overall goal, the Darlington NGS site has a GWMP to provide timely data confirming that uncontrolled releases are not occurring and, if uncontrolled releases do occur, to signal when and where.

Water level elevation data collected as part of the Darlington NGS site's annual GWMP has shown that groundwater flow patterns remained consistent over the licensing period. The 2022 inferred shallow groundwater contour map is provided in

Figure 27 (NK38-REP-10140-10034, *2022 Darlington Nuclear Groundwater Monitoring Program Results*). Outside of the protected area, groundwater generally is inferred to flow from the north to the south, towards Lake Ontario. Inside the protected area and in the vicinity of the powerhouse, groundwater is inferred to flow west and north towards the Forebay. Further south of the powerhouse, groundwater is inferred to flow toward Lake Ontario.

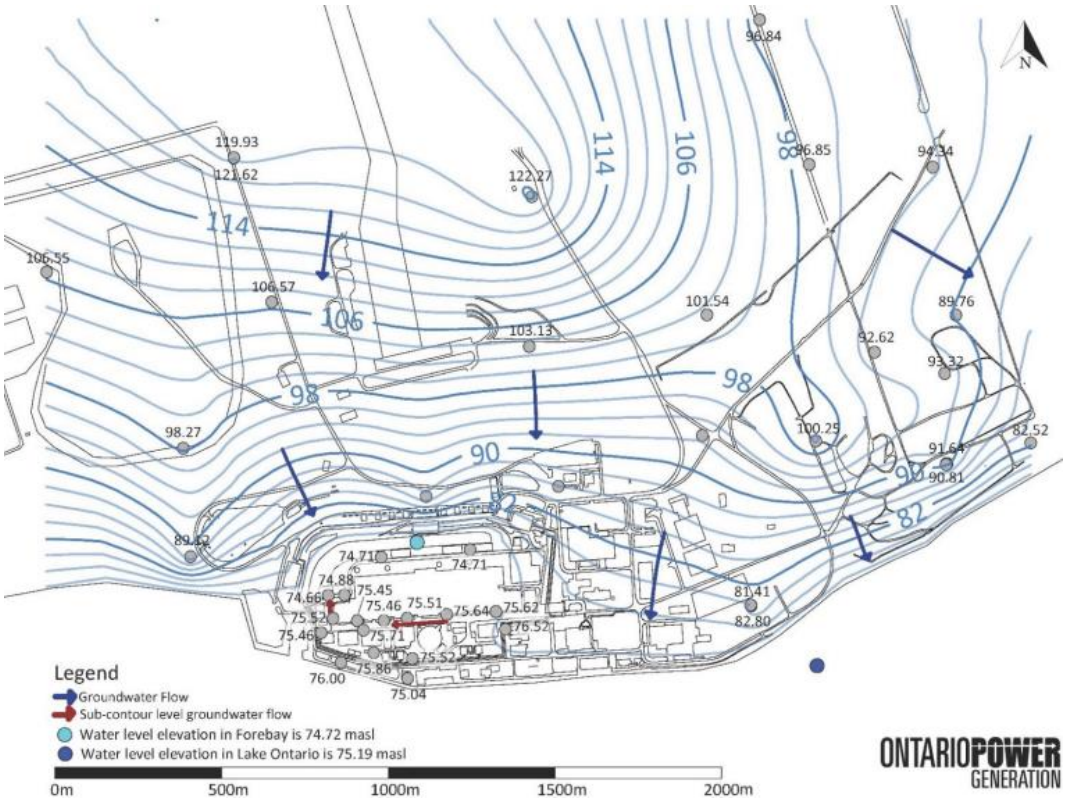


Figure 27: 2022 Inferred Shallow Groundwater Contour Map

On an annual basis, groundwater quality data is collected from monitoring wells located in key areas of the Darlington NGS site (in the protected area, in the controlled area, and at the Darlington NGS site perimeter). The majority of the samples are analyzed for tritium, with some samples also analyzed for petroleum hydrocarbons (PHCs) and benzene, toluene, ethylbenzene, and xylenes (BTEX).

With respect to tritium, results indicate that concentrations have remained relatively constant over time, which points to consistent environmental performance.

Elevated tritium concentrations in groundwater have been found in the Unit 2 area due to an injection water storage tank spill that took place in 2009. Since 2009, the groundwater tritium concentrations in that area have been steadily declining, indicating no new sources.

With respect to the Darlington NGS site boundary, tritium concentrations in groundwater are consistently low, indicating that the potential for adverse impacts to off-site groundwater quality from the Darlington NGS site is low to negligible. In 2022, the majority of perimeter monitoring wells reported tritium concentrations below the method detection limit. Municipal drinking water samples collected from downstream water supply plants as part of the annual OPG EMP were well below the Ontario Drinking Water Quality Objective for tritium of 7,000 Bq/L.

Darlington NGS site groundwater is also sampled to detect underground fuel oil pipeline leaks in key areas (for example, standby generator area). The results of PHC and BTEX sampling did not indicate any concerns during the licensing period.

2.9.4.4 Spill Management Program

The Darlington NGS site has a framework in place per OPG-STD-0152, *Spill Management* to manage spills, ensuring implementation of spill prevention, preparedness, response, clean-up, and remediation process in accordance with applicable regulations. At OPG, spills are classified as either Category A (Very Serious), Category B (Serious), Category C (Less Serious), or Category D (Exempted of Potential Spills). Spills are identified, classified, and reported following OPG-PROC-0041, *Environmental Event Identification, Classification, and Reporting*.

During the current licence term, there were no Category A or B spills. As of February 29, 2024, there were 13 recorded Category C spills. These spills typically involved refrigerant or oil.

Equipment deficiencies leading to the spill events were resolved via corrective action plans and documented in Annual Spills Risk Assessments. This includes an increase in equipment inspections (for potential leak risks), as well as an increase in preventative maintenance of refrigerant units.

Planned improvements were identified during a 2022 self-assessment on the spills program. It was determined that some updates to governance are required to ensure alignment. Actions are in place to address this.

2.9.5 Protection of People

One of the specific objectives of the ERA is to evaluate the risk to off site members of the public resulting from exposure to contaminants of potential concern and stressors related to the Darlington NGS site and its activities. The results of the ERA inform the EMP, which provides data to confirm that the Darlington NGS site is operating in a manner that is protective of people residing in the surrounding area.

The EMP monitors off-site air, water (municipal well, lake/stream), aquatic samples (fish, sediment, beach sand), and terrestrial samples (fruits, vegetables, eggs, poultry, milk, and animal feed). Data gathered from this program, along with emissions data, are used to assess the annual radiological dose to members of the public living or working in the vicinity of the Darlington NGS site.

OPG has also received recommendations from the Williams Treaties First Nations to add a new receptor to adequately assess the radiological dose for Indigenous populations who may live and/or work and/or harvest and consume wildlife, fish and/or plant resources close to the site. OPG will be starting to engage in early 2025 on the next Darlington site ERA and will seek to collaborate with Indigenous Nations and communities on including this a new receptor.

The most recent ERA for the Darlington NGS site concluded that there are no risks to human health as a result of the operation of Darlington NGS. Results of the public dose assessment are published in the annual EMP report. The annual EMP is submitted to the CNSC and made available to the public on www.opg.com.

The effective dose limit for members of the public as set out in the Radiation Protection Regulations, is 1,000 µSv/year. As shown in the logarithmic scale in Figure 28 and illustrated in Figure 29, dose to the public from operation of the Darlington NGS site is a very small fraction of both the annual legal dose limit and the annual natural background radiation in the area.

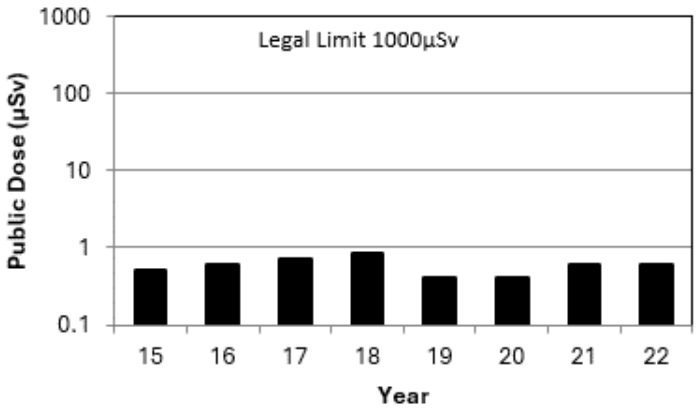


Figure 28: Public Dose Limits

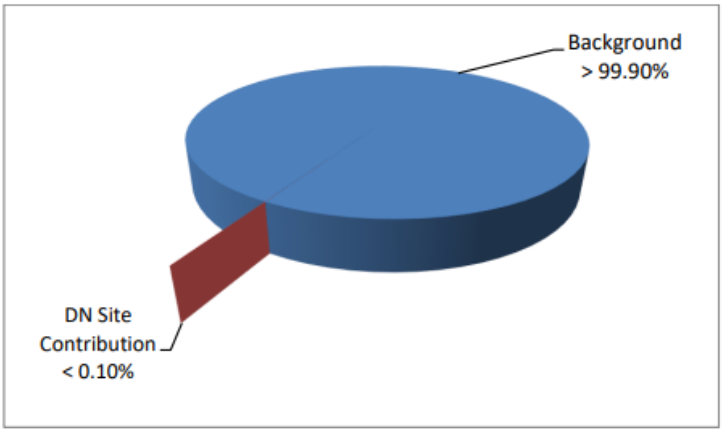


Figure 29: Background Radiation vs. Darlington NGS Site Contribution

2.9.6 Fish Impingement and Entrainment

Fish protection is integrated into the design and location of the intake of the Darlington NGS. The combined mitigation measures of the porous veneer lake bottom design, low approach velocities, and placement 800 m offshore, reduce the potential for impingement and entrainment of aquatic organisms as compared to an open channel shoreline intake design.

As part of the commitments of the Darlington NGS refurbishment follow-up monitoring program and as specified in the amended Darlington NGS Fisheries Act Authorization for refurbishment (Reference 2.9-1), OPG will conduct two years of consecutive fish impingement and entrainment monitoring after refurbishment of all units is completed.

During the current licence term, there were no impingement studies required or undertaken. The impingement and entrainment monitoring will commence in 2027 to align with completion of refurbishment. OPG recognizes that fish impingement and entrainment are important areas of interest to Indigenous Nations and communities, and commits to facilitating engagement and participation on the up-coming studies. Previous impingement studies verify that the intake design and location results in low levels of impingement that are not expected to increase substantially over time but that will fluctuate with natural variation and intake volumes (D-REP-07262-0509778, *Submission to DFO for an Authorization under the Fisheries Act for the Darlington Nuclear Generating Facility*).

During the Darlington Nuclear Refurbishment and Continued Operations Environmental Assessment, OPG committed to undertake entrainment monitoring prior to the commencement of refurbishment to characterize the station's entrainment of ichthyplankton (i.e., fish eggs and larvae) and benthic invertebrates. This year-long entrainment study, a condition of the Fisheries Act Authorization for Darlington NGS refurbishment, was completed during 2015-2016. The data from this study will also be used to establish a baseline to aid in predicting future operational effects from Darlington NGS post-refurbishment with all units operating.

Owing to the more intensive and year long duration, the 2015-2016 entrainment study, NK38-REP-07260-00005, *2015-2016 Entrainment Study: Final Report*, collected both previously documented and new species that were not previously collected in prior entrainment studies. New species included Deepwater Sculpin (a species at risk), Round Goby (a species listed in the Aquatic Invasive Species Regulation), Walleye, and Burbot (both species that are recreationally fished). The study did not capture any Round Whitefish eggs or larvae, suggesting that entrainment of Round Whitefish is not a significant risk to the species. Additionally, as an Environmental Assessment commitment, annualized entrainment of benthic invertebrates was estimated, which had not been done in the earlier studies.

The results reinforced that the experimental design of the entrainment sampling study improved the likelihood of capture relative to prior studies in 2004 and 2006. The detection of new species was, in part, attributed to longer sampling periods (encompassing day/night and seasonal variations) and larger sample volumes yielding greater sample sizes and increasing the likelihood of detectability. The study also concluded that entrainment is not significantly impacting local benthic invertebrate populations.

With respect to next steps, the authorization commits OPG to the completion of a two year impingement and entrainment monitoring program commencing in 2027, shortly after completion of the refurbishment phase and allowing for some time for the environment to readjust to all units operating.

2.9.7 Thermal Plume

The Darlington NGS refurbishment follow-up monitoring program required a study of condenser cooling water plume temperatures to verify that the activities would not adversely affect the survival of round whitefish eggs laid in the plume. Temperature monitoring was conducted in the plume and at a reference location in the winter of 2017/2018.

The results of the thermal plume study documented in NK38-REP-07250-00001, *Darlington Refurbishment Follow-Up Monitoring Program: Thermal Plume Monitoring 2017-2018*, showed that the predicted effect of the plume ranged from a relative survival gain of 0.1% to a loss of 0.4%. This is a negligible effect that is not biologically significant and well below the 10% loss threshold that CNSC requires to implement further mitigation measures. It was concluded that the operation of the site during the refurbishment period has not resulted in an adverse condition to the survival of round whitefish eggs laid in the plume. This confirms the prediction made in the Environmental Assessment, and no additional mitigation measures or monitoring are required during the refurbishment period.

Section 2.10

Emergency Management & Fire Protection

2.10 Emergency Management and Fire Protection

Darlington NGS has an effective nuclear, conventional and fire emergency preparedness and response programs that meets or exceeds regulatory requirements and related objectives. Emergency preparedness measures and fire protection response capabilities are in place at Darlington NGS to prevent and mitigate the effects of nuclear and hazardous substances releases, both onsite and offsite, and fire hazards to protect workers, the public and the environment.

The following subsections outline OPG's programs for Emergency Preparedness and Response:

- 10.1 – Conventional Emergency Preparedness and Response;
- 10.2 – Nuclear Emergency Preparedness and Response;
- 10.3 – Fire Emergency Preparedness and Response.

For specific areas within this SCA, the following subsections describe the objectives, key results from the current licence term, and planned improvements over the next licence term. These discussions also support that:

- Nuclear safety will be assured such that plant personnel, the public and the environment are protected.
- Staff are qualified and competent to respond to nuclear and fire events at the plant, and this will be maintained though the next licence term (e.g., refer to Section 10.2 regarding ERO performance).
- OPG continues to invest in Darlington NGS to support nuclear safety (e.g., via drills and exercises).
- Transparency and appropriate public consultations have been upheld and will continue (e.g., via public alerting provisions and public awareness campaigns for KI pill distribution).

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 16: SCA 10 – Emergency Management and Fire Protection

Document	Title
N-PROG-RA-0001	Consolidated Nuclear Emergency Plan
N-PROC-RA-0045	Emergency Preparedness Drills and Exercises
N-PROG-RA-0012	Fire Protection
NK38-REP-09701-10338	Fire Hazard Assessment of the DNGS Retube Waste Processing Building (RWPB)

2.10.1 Conventional Emergency Preparedness and Response

2.10.1.1 OPG Emergency Management

OPG-PROG-0030, *Ontario Power Generation Emergency Management Program*, ensures the security of its facilities and that strategies are in place that allow it to prepare for, respond to, and recover from emergencies that impact its operations or the public.

The objectives of the OPG Emergency Management (EM) program are to protect:

(a) The health and safety of employees, contractors, public and responders;

(b) The environment, OPG property and third party property;

(c) OPG's assets;

(d) OPG's reputation;

(e) Operational continuity.

The OPG Emergency Management program applies the all-hazards approach and Five Pillars of Emergency Management to facilitate: Prevention, Mitigation, Preparedness, Response and Recovery Efforts for all hazards and incidents that pose a risk to OPG's Emergency Management Program objectives. At OPG, incident management is carried out by several individual programs and initiatives spanning multiple Business Units.

2.10.1.2 Security Emergency Preparedness and Response

The Nuclear Security program supports the protection of nuclear assets at OPG. This program ensures security readiness and maximizes response capability to contain, mitigate, and terminate security events while minimizing the adverse impact on plant staff, operations and functions. OPG has a suite of documentation to support the defensive strategy and tactical plans for response. Details regarding the development and maintenance of OPGs defensive strategy such as supporting tactical deployment plans are classified as OPG Confidential - Security Protected or higher.

Additional details about the Nuclear Security program can be found in Section 2.12.

2.10.1.3 Cyber Emergency Preparedness and Response

OPG Cyber Security conducts regular assessments to support OPG Nuclear Security in addressing potential cyber security issues affecting the physical security at Darlington NGS.

Cyber Security related to Information Management is the responsibility of OPG Cyber Security Operations, Architecture and Governance. OPG maintains documentation on Information Technology Emergency Response which includes preparing, detecting and assessing, containing, eradicating and recovering from cyber incidents.

Refer to Section 2.12 for detailed information on the Cyber Security program.

2.10.1.4 Abnormal Waterborne Tritium Emission Response

N-PROC-OP-0038, *Abnormal Waterborne Tritium Emission Response*, provides direction for response to an abnormal waterborne tritium emission from OPG's nuclear sites, and provides guidance for staff to manage the required external notifications in a consistent and effective

manner. Specifically, it addresses notifications, default sampling, interfacing with external groups, response network, response facilities, drills and training to support this capability.

Radioactive Liquid Emission Response drills and exercises are conducted annually to demonstrate and assess OPGs ability to respond to simulated Abnormal Waterborne Tritium Emissions, including the effectiveness of response facilities, and the interface with external stakeholders.

On October 20, 2022, Darlington NGS conducted an evaluated drill which included participation by external agencies that receive notification from OPG. The purpose of the drill was to test the ability of Darlington NGS personnel to make initial contact promptly and effectively with internal departments and external agencies, notifying that a liquid emission had occurred, and to prepare personnel for the next stage of response. All objectives of the drill were successfully met, including projected tritium release times, and proper and timely notifications to external agencies. Some minor observations were identified to improve future response, including the creation of a dedicated information board.

2.10.1.5 Radioactive Materials Transportation Emergency Response Plan

The Radioactive Material Transportation (RMT) program, W-PROG-WM-0002, *Radioactive Material Transportation* describes the managed system for RMT at OPG Nuclear. The RMT program ensures safe, compliant, and efficient transportation of radioactive material.

Under this program N-STD-RA-0036, *Radioactive Material Transportation Emergency Response Plan*, identifies the OPG responsibilities and the concepts to enable an effective response to a transportation incident involving an OPG shipment of radioactive material. This plan also identifies the liaison and potential interface with external Emergency Response Organizations (ERO). This plan applies to off-site shipments only. On-site incidents are addressed through the site ERO implementing instructions.

A Darlington NGS Transportation Emergency Response Plan (TERP) table-top drill was conducted on October 20, 2023 (NK38-REP-03490-10162) as an opportunity for qualified personnel to maintain familiarity with their response instructions and understand the collaboration between roles. The drill was conducted to demonstrate the ability to respond to an off-site radioactive waste transportation emergency per Transport Canada regulations. This is covered under OPG's Emergency Response Assistance Plan (ERAP) for the transportation of dangerous goods and is a requirement under federal law.

This drill combined the efforts of qualified personnel from OPG and external agencies including the designated external contractor, Ministry of Environment, Transport Canada, and the Ontario Provincial Police. The use of drone technology will continue to be reviewed to improve response capabilities and personnel safety. There were no significant findings, and all drill objectives were met. Some minor observations were identified to improve future response, including revising response area maps.

2.10.2 Nuclear Emergency Preparedness and Response

2.10.2.1 Emergency Preparedness Program

OPGs Nuclear Emergency Preparedness program is documented in N-PROG-RA-0001, *Consolidated Nuclear Emergency Plan (CNEP).* This plan implements the requirements of REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response, Version 2,* and serves as the basis for the site-specific nuclear emergency preparedness and response arrangements at

OPG's nuclear generating stations. It describes concepts, structures, roles and processes to implement and maintain an effective OPG response in the unlikely event of a nuclear emergency that could endanger onsite staff, the public, or the environment. The objective of the program is to ensure OPG has adequate provisions for the preparedness and response capability that would mitigate the effects of accidental releases of radioactive material and ensure the health and safety of persons. The CNEP also provides a framework for interaction with external authorities and defines how OPG commitments under the Provincial Nuclear Emergency Response Plan (PNERP) are implemented. OPG acknowledges there is interest from Indigenous Nations and communities in the conduct of the Emergency Preparedness program and is taking steps to facilitate further engagement.

In the unlikely event of a nuclear emergency at Darlington NGS, OPG would perform the appropriate notifications to the Province, CNSC, and local municipalities in accordance with established procedures and requirements under the PNERP. The ERO takes actions to control and mitigate the emergency on-site and minimize off-site effects. Under the PNERP, the Province takes actions to notify and protect the public, including directing protective actions such as sheltering, potassium iodide ingestion, or evacuation. The local municipalities support the implementation of Provincial directions. OPG and a range of other organizations are integrated to ensure effective emergency measures are in place (Figure 30).

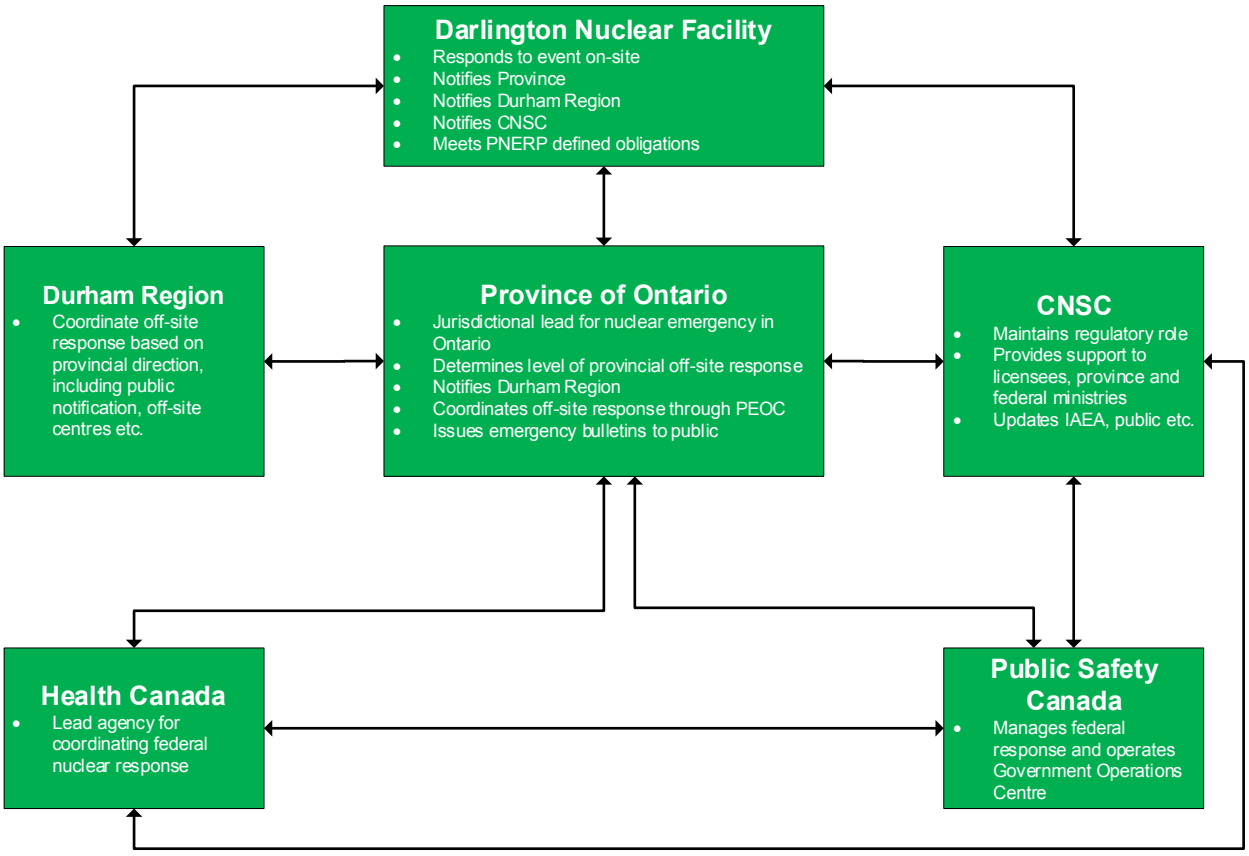


Figure 30: Emergency Response Agency Interactions

As per the PNERP and CNEP, a reportable event is:

1. An event affecting the reactor facility which would be of concern to the off-site authorities responsible for public safety.
2. Provincial and municipal duty staff should respond as per routine monitoring.

The PNERP, last revised in 2017, is undergoing a revision by Emergency Management Ontario (EMO) to align with international best practices. The review and update of the PNERP began in 2021 and is ongoing. OPG will review and provide comments on the final draft PNERP during the public consultation period. The Province will conduct a public consultation process with the objective of obtaining a Cabinet approved PNERP in 2024. OPG has reviewed and provided comments during the initial review period and will enhance its emergency plans to align with any PNERP requirements once issued. Once the revision is complete, EMO will revise the Darlington NGS Implementing Plan and OPG will enhance its emergency plans to align with any PNERP requirements once issued. OPG will also revise the CNEP as required to ensure continued alignment with PNERP requirements.

2.10.2.2 Nuclear Emergency Drills and Exercises at OPG

To ensure the capability to respond effectively to a nuclear emergency is sustained, OPG frequently conducts emergency preparedness drills and exercises which help to test and validate Darlington NGS emergency plans and procedures and provide the ERO with the opportunity to maintain performance in their roles.

Station-based radiological and nuclear emergencies are developed under the directive of N-PROC-RA-0045, *OPG Nuclear Emergency Response Organization Drills and Exercises*. They are intended to meet the requirements of N-PROG-RA-0001, *Consolidated Nuclear Emergency Plan,* and regulatory requirements established by the CNSC under REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response, Version 2.*

Darlington NGS drills and exercises serve the following purposes:

b) Develop and maintain the skills of the ERO.

c) Test the effectiveness of emergency plans and procedures, facilities, equipment, and training, and.

d) Demonstrate the adequacy of plans and preparedness to respond to events ranging from minor to severe accidents.

In February 2022, OPG executed “Exercise Unified Command” at Darlington NGS to test and demonstrate the effective integration of OPG emergency response plans with off-site agencies. The exercise included the participation of over 30 organizations and government agencies including the Province of Ontario, the Regional Municipality of Durham, the City of Toronto and the CNSC. The scope of the exercise included: accident assessment and response to both design basis and beyond design basis conditions, initial event categorization and notifications, event information communication, field radiation monitoring, dose predictions, public protective action decision making and communications, consultation around radioactive release decisions, public communications, and media interactions. Exercise Unified Command 2022 was successful in achieving the overall objective of testing the preparedness of OPG, and the interoperability with government agencies and local communities to respond to a severe event. Full scale interoperability exercises are conducted every 3-years at Darlington.

In September 2023, OPG executed another full-scale nuclear emergency response exercise at Pickering NGS. This exercise and scenario were designed to test emergency plan arrangements less commonly demonstrated including recovery operations. From this exercise, following lesson learned will be applied to Darlington NGS:

- Strategies to enhance drill realism, ensuring participants derive maximum benefit from the exercise.
- Enhancements to methodology for designing extended duration exercise scenarios and managing the associated complexities.
- Enhancements in guidance to staff during event recovery phase.
- Improvements in processes, equipment, and training identified during this exercise are already being implemented to better support our responders.

2.10.2.3 Equipment Important to Emergency Response

Equipment Important to Emergency Response (EITER) includes procedures and processes which identify the Systems, Structures, and Components (SSCs), as well as essential tools and equipment necessary to implement the CNEP. EITER procedures ensure maintenance is prioritized and contingency actions are taken when EITER designated equipment is taken out of service or becomes unavailable. EITER ensures OPG has the capability to implement the emergency plan through the readiness and availability of the EITER equipment, facilities, or through enacting compensatory measures or use of designated alternate facilities where the primary means may be unavailable. EITER requirements are integrated into the work management process for planned maintenance activities.

In 2020 OPG received recognition from WANO with an Industry Strength rating for the EITER program resulting from innovative practices for tracking, managing, and maintaining this equipment. Enterprise Emergency Management works closely with station staff to ensure EITER unavailability is reduced and equipment is restored quickly to service. In response to a self-assessment in 2020, a fleet-wide cross-functional Emergency Mitigating Equipment Excellence Team was established, driving improvements to EITER procedures, processes, training, accountabilities and clarified roles and responsibilities related to the management of this equipment.

EITER Improvements

A revision to the tracking system for EITER will provide automation and an improved visual representation of EITER performance. In addition, improved guidance documentation will guide the users to calculate EITER performance.

2.10.2.4 Potassium Iodide (KI) Pills

Ingestion of Potassium Iodide (KI) is one protective action that may be directed by Provincial authorities in the unlikely event of a nuclear emergency. OPG continues to provide the Regional Municipality of Durham with the necessary resources and support to pre-distribute KI in the 10km Detailed Planning Zone (DPZ), to meet the requirements of REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response, Version 2, and the Provincial Nuclear Emergency Response Plan (PNERP).* The KI pill inventory for the pre-distribution program is maintained separately from the emergency inventory that is maintained by the Province of Ontario. KI tablets pre-distributed within the DPZ are available at schools, childcare centres, health care

facilities and municipal services. Pre-distribution ensures that KI is available quickly for residents and businesses within 10 km of Darlington NGS. OPG also provides the ability for qualifying population outside the DPZ to request KI through an online portal. In the unlikely event of a nuclear emergency, additional supplies of KI are available at Reception Centres, Emergency Workers Centres and for the Ingestion Planning Zone (IPZ).

The Prepare to Be Safe website (preparetobesafe.ca) serves as a platform for KI pill Frequently Asked Questions (FAQs) and provides a means for businesses and residents within 50 km of Darlington NGS to request KI pills. Website information is translated into the most common languages spoken within 10 km (based on census data). New households and businesses in the 10 km DPZ are identified monthly by Canada Post and sent KI pills with supporting information included. Media campaigns are conducted three times per year to raise awareness of KI availability, focused on the public residing within the 10 km DPZ but extending into the IPZ, through various media (e.g., news releases, print advertisements, social media, and digital display boards). Durham Region has produced videos to raise general awareness about KI, one of which focused on the availability of KI within the 50 km IPZ.

OPG is committed to building long-term mutually beneficial working relationships and information sharing with other utilities, as well as organizations responsible for public health and emergency management coordination proximate to our operations. OPG continues to participate and support the CNSC-led Potassium Iodide Working Group (KIWG). Any recommendations and lessons learned from this working group will be adopted for Darlington NGS. OPG continues to monitor the changes in the updated regulatory requirements and PNERP, and OPG will maintain compliance. OPG continues to offer support to the KIWG on all matters as needed, including engagement and outreach with Indigenous Nations and communities.

2.10.2.5 Emergency Management Indigenous Nations and Communities and Public Engagement

OPG Emergency Management staff participate in various annual public engagement opportunities where nuclear emergency planning, preparedness and response are discussed. A variety of platforms are used to engage and inform the public, including in-person events (and public information centres), printed products (newsletters, fact sheets), website information, and various traditional and social media strategies. OPG communicates with our local residents as well as the public beyond our local communities through a number of these communication products and forums. Presentations are made every year to each to Darlington's Community Advisory Council and the Durham Nuclear Health Committee including overviews of Ontario's nuclear emergency response framework, OPG emergency preparedness structure, and key program updates as well as addressing various points of interest and questions.

OPG has also responded to requests from Indigenous Nations and communities for information and engagement with respect to emergency management. In May 2023, Emergency Management was invited to participate in a Métis Nation of Ontario community open house where various emergency preparedness, transportation and waste topics were discussed with attendees. OPG has been invited to attend this event again in June 2024 and looks forward to the opportunity to directly engage with the Métis Nation of Ontario. During OPGs 2023 open house at the Darlington Energy Complex (DEC), emergency management information was also made available to participants.

OPG understands that there is interest from Indigenous Nations and communities for further engagement on our Emergency Management programs. OPG is committed to taking steps to better understand the interests, identify opportunities and facilitate increased engagement with Indigenous Nations and communities through OPG's Emergency Management program.

2.10.2.6 External Hazard Assessment

Risk assessments of external hazards are addressed in OPG's *Risk and Reliability Program*, N-PROG-RA-0016 which is consistent with OPG Nuclear Safety Policy, Nuclear Management System and best practices in the industry. Probabilistic Safety Assessments are used to assess the magnitude and frequency of radiological risks to the public from accidents due to the operation of nuclear reactors. OPG's Darlington NGS Probabilistic Safety Assessment Report summarizes an overview of hazard screening method and the external hazard screening assessment.

External hazards are defined as hazards that are initiated outside the OPG exclusion zone or are hazards that are outside the plant's direct control. These hazards could be in the form of natural hazards (e.g., ice-storms, flood, etc.) or man-made hazards (e.g., a chlorine leak from a rail-car derailment, aircraft crash, etc.).

Initiating events for emergency preparedness planning can be non-nuclear and may result from situations and conditions external to the plant site. Potential events are screened based on frequency and consequence. OPGs designed emergency response capability and infrastructure is sufficiently flexible to be used for a broad range of events and disasters both within and beyond the design basis. For beyond design basis situations, the response infrastructure has the capability to draw upon additional external support resources to support OPGs response as needed.

2.10.2.7 Land Use

OPG Real Estate and Services personnel monitor land use policies and activities in proximity to OPG nuclear facilities. Enterprise Emergency Management (EEM) personnel support this activity, when required, to ensure planned activities have no adverse impact on the implementation of nuclear emergency plans.

The following is a list of Regional or Municipal Emergency Services within the 10-km area around Darlington NGS (Table 17):

Table 17: Regional or Municipal Emergency Services

Fire Emergency Stations	6
Regional Police Station	1 (plus one administrative police department)
Hospitals	1 Lakeridge Health Bowmanville Hospital

The following is a list of Transportation systems within 10-km around Darlington NGS (Table 18):

Table 18: Transportation Systems

Major Highways	401, 407, 418
Railway lines	Canadian National, south of Highway 401 and bisects the site Canadian Pacific, north of Highway 401
Naval Ports	Port of Oshawa East Pier

2.10.2.8 Remote Evaluation

OPG EEM has put a large focus on developing and sustaining a culture of innovation, resulting in several impactful initiatives being implemented successfully through annual Excellence Plans. To promote and sustain ERO performance through the pandemic, EEM implemented a remote drill evaluation solution to facilitate the continued execution of ERO drills in-person, at a time when the majority of industry had moved to conducting tabletop style drills. This solution has been recognized as an industry leading initiative and has been benchmarked externally through the WANO as well as several individual nuclear utilities.

OPG is committed to continuous improvement. EEM staff apply lessons learned from drills and exercises, self-assessments and our corrective action program and drive improvements to EP plans, procedures, equipment and ERO training.

2.10.2.9 Emergency Response Organization Performance

As part of an emergency preparedness excellence initiative, a new ERO performance process and tool were implemented in 2023 to provide an accurate picture of overall ERO performance. OPG also introduced additional opportunities for key members of the Darlington NGS ERO to demonstrate their skills and performance in executing Provincial emergency notification requirements in the simulator. As a result, performance has broadly improved across the ERO. In addition, OPG has qualified additional Darlington NGS ERO members for additional capacity beyond program requirements. These changes improve how ERO performance is measured, tracked, and reported to provide data-driven insights into performance strengths and areas requiring improvement. This ongoing ERO performance focus continues to be effective, and lessons learned are applied to other areas requiring improvement as needed.

2.10.2.10 Self-Assessments

Formalized self-assessments and industry benchmarking of Emergency Preparedness program elements are conducted annually to identify program improvement opportunities. Notably, in 2021 a self-assessment was conducted on the virtual activation and operation of the Crisis Management Communications Centre (CMCC). As a result, OPG revised its processes and procedures to include an option to activate the CMCC virtually. In 2023, a self-assessment review was conducted to assess the response of ERO members to the duty change process to validate that ERO turnover expectations are being met. Although the results were very positive, Enterprise Emergency Management implemented corrective actions and improvements to further reinforce its commitment to maintain a high level of emergency preparedness and response.

2.10.2.11 Station Performance Indictors

Emergency response performance indicators are monitored closely and reported quarterly to OPG leadership and the CNSC under REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*. These indicators are as follows:

- Radiological Emergencies Performance Index;
- ERO drill participation index;
- Emergency Response Resource Completion Index.

2.10.2.12 Radiological Emergencies Performance Index

This indicator monitors timely and accurate licensee performance in drills and exercises when presented with opportunities for categorization of emergencies, notification of offsite authorities, and providing information to local authorities to allow for timely development of protective action recommendations. It is the ratio, in percent, of timely and accurate performance of those actions to total opportunities. In 2021, as part of an emergency preparedness excellence initiative, OPG introduced additional opportunities for key members of the ERO to demonstrate their skills and proficiency in executing Provincial emergency notification requirements in the main control room simulator. As a result, the number of opportunities that is measured has increased dramatically as the result of an excellence initiative.

2.10.2.13Emergency Response Organization Drill Participation Index

The ERO drill participation index indicates what percentage of qualified ERO members have participated in drills, exercises, crew practices, practical evaluations, or actual events on a quarterly basis. This metric varies based on any relevant opportunities available in that quarter. It should be noted that OPG's requalification period is on an 18-month cycle, not 12 months.

2.10.2.14 Public Address System

The Darlington NGS Public Address (PA) system provides immediate notification and messaging to staff working on site of important information, including emergency conditions and associated actions. This includes emergency tones and verbal messaging indicating different types of emergencies which direct staff to take required actions. This system is aging and in 2023 experienced a notable degradation in system performance, including a reduction in coverage across the station to approximately 90% of full coverage.

OPG has undertaken a multi-phased project to assess and replace this system by bringing it into alignment with modern standards to improve the system maintainability, reliability, and performance. This project is expected to be in service by December 2026 with phase 1 implementation in 2025.

To recover the system's performance until the new system is in place, a team was formed, and a bridging strategy was implemented which resulted in the system being restored to 100% coverage within the station. A number of actions were taken to increase safety for all staff on site during this period, including posting of signage and a range of communications indicating system status, development of a text messaging application and implementation of pre-deployed and portable handheld radios which relay the PA system signal.

To provide confidence that the system continues to remain fully functional and to ensure that any issues are quickly identified and resolved, regular system testing is performed, and additional actions were taken to provide greater oversight of this system, including development of a system status dashboard and implementation of annual system health reporting.

2.10.2.15 Public Alerting

In the unlikely event of an emergency where the Province initiates protective actions under the PNERP, the need to shelter, evacuate or take other actions is communicated to the public as follows:

- Sirens: Mounted on poles, sirens emit a single tone alarm that can be heard outdoors. These sirens are located within 3 km of the Darlington NGS site.
- Telephone Dialing System: An automated telephone dialing system will deliver a recorded emergency message through landline home and business phone numbers within 10 km of the Darlington NGS site.
- Radio, Television, Social Media: Local radio and television stations, and social media, will broadcast information on public health, safety, and welfare. Instructions on what to do in the event of a nuclear emergency will be provided.
- Alert Ready: Canada's National Public Alerting System provides public alerts through radio, television, and on LTE connected and compatible wireless devices (i.e., cellular phones).

OPG provides resources and support to the Regional Municipality of Durham who owns, operates, and routinely tests the public alerting system including sounding the sirens each fall and spring.

Alert Ready officially launched in March 2015; at which time it distributed alerts solely through broadcasters. In April 2018, wireless providers were also required to implement the system and started distributing alerts via smartphones.

2.10.2.16 Evacuation Time Estimate

OPG provides updates to the Darlington Evacuation Time Estimates (ETE) every 5-years as new census data becomes available. An update to the Darlington ETE study using 2021 census data was issued in May 2023.

An industry-accepted methodology is used to complete this work. The ETE study takes into consideration the time required to evacuate the emergency planning zones defined in PNERP, as well as evacuations of schools, hospitals, and other residential institutions. This work is completed with support from the Province, local municipalities, police, and transit organizations. The results are made available to all relevant agencies. The study provides off-site emergency planners with projections on how long it may take for various sectors and emergency planning zones to evacuate if required, as defined in the PNERP. Variables such as time of day, day of week, road restrictions, special event assemblies and weather are assessed as to how those factors may impact the evacuation duration. The 2023 study resulted in increased time estimates compared to the previous 2018 Darlington ETE study. This is primarily a result of population increase, traffic pattern changes and updated planning assumptions.

2.10.2.17 Off-Site Support

Agreements

In May 2022, OPG and EMO endorsed a new 5-year agreement to support EMO in the planning, maintenance, and execution of the PNERP. This new agreement supports the Province who provide staff with expertise in nuclear and radiological science, hazard identification and risk assessment, emergency planning, drills, and exercises, maintenance of 24/7/365 nuclear emergency response capability, and nuclear education and emergency preparedness materials.

A 10-year Nuclear Emergency Mutual Aid Agreement between Canada's four major nuclear operators, (OPG, Bruce Power, Canadian Nuclear Laboratories and New Brunswick Power) was renewed in December 2022 which outlines emergency support that may be provided, and the processes involved in the unlikely event that a nuclear operator suffers a major emergency and requires mutual aid assistance.

Reception Centre and Emergency Worker Centre Support

OPG provides Monitoring and Decontamination Unit capability at Emergency Worker Centres and Reception Centres. Enterprise Emergency Management maintains equipment inventories at these designated offsite locations with the support of the local facility staff. OPG is continuously working with community partners and external stakeholders to improve off-site support.

Reception Centre exercises were conducted at Durham College Reception Centre in Oshawa in June 2018 and at Delpark Homes Centre in Oshawa in September 2019. More recently, in February 2022 an exercise was conducted at Orono Arena as an Emergency Workers Centre. During these three exercises, the OPG Monitoring and Decontamination Unit was activated and processed members of the public or emergency workers and their vehicles, and participation of community partners was present. Lessons learned from these exercises have been incorporated into OPGs and Durham Region processes and procedures.

In an effort to improve familiarization of local nuclear emergency planning and operations at Emergency Workers Centres and Reception Centres, OPG continues to collaborate with its off-site partners to conduct off-site centre drill and exercises and drive improvements to emergency plans and operations.

2.10.3 Fire Emergency Preparedness and Response

2.10.3.1 Fire Protection Program

OPG's comprehensive Fire Protection program consists of two elements: the Fire Protection programs group which provides oversight for regulatory compliance, and the Fire Protection Operations group (Emergency Response Team) which provides fire emergency response at Darlington NGS. Together, the overall Fire Protection program ensures that licensed activities do not result in unreasonable risk to the health and safety of persons and the environment due to fire.

OPG's Fire Protection program and its elements are outlined in N-PROG-RA-0012, *Fire Protection.* OPG's Fire Protection Program has been developed based on the requirements of CSA N293-12 (R2017), *Fire Protection for Nuclear Power Plants,* with the goals of:

- Minimizing the risk of radiological releases to the public as a result of a fire.
- Protecting station occupants from death or injury as a result of a fire.
- Minimizing economic loss resulting from damage to structure, equipment, and inventories as a result of a fire.
- Minimizing the impact of radioactive or hazardous material on the environment as a result of a fire.

To meet these four goals, the Fire Protection programs group establishes processes to ensure that all reasonable measures are taken to prevent fires, and to promptly detect and suppress any fires that may occur at the plant. These include but are not limited to:

- Combustible Material Safety Permits (CMSPs) and Ignition Source Permits (ISPs) to reduce the likelihood and severity of fire through the minimization and control of transient combustible materials and hot works.
- Impairment Manual for Fire Protection Systems to address impairments of fire protection and life safety systems and identify recommended compensatory measures to provide reasonable assurance that the affected impaired area will be unlikely impacted as result of a fire.
- Oversight of the inspection, testing, and maintenance of fire protection systems to ensure they operate as designed during the life of the systems.

Furthermore, the Fire Protection Programs group owns, maintains, and updates the station's Annual Plant Condition Inspection (APCI) Report, Fire Hazard Assessment (FHA) Report, Fire Safe Shutdown Assessment (FSSA) Report, and the Code Compliance Review (CRR) Report, to demonstrate regulatory compliance to the requirements of CSA N293 as stipulated in the PROL for Darlington NGS.

The latest 2023 APCI for Darlington NGS was completed by an independent, qualified third-party vendor. The vendor reported that there was sufficient evidence to conclude that OPG Fire Protection Program was being followed and effectively maintained to ensure compliance with the applicable requirements of CSA N293-12 (R2017), National Fire Code of Canada (NFCC), and National Building Code of Canada (NBCC).

A CCR was conducted in 2023 to verify the as-built conditions of the station complies with the applicable requirements of CSA N293-12 (R2017) and its referenced NFCC and NBCC.

Darlington NGS's Fire Protection Assessments, which consist of the FHA and Fire Safety Shutdown Assessment were completed in 2021 and submitted to the CNSC by the end of 2021 in compliance with the Darlington NGS PROL. In general, the 2021 FPA concluded that Darlington NGS is provided with effective design, construction, fire protection features and operational controls to mitigate the fire hazards present and maintain the fire, life and nuclear safety goals defined in CSA N293.

OPG Fire Protection programs is exploring the possibility of developing and implementing software(s) that could potentially enhance administrative oversight and control for major elements administered by the Fire Protection programs group, such as CMSPs, ISPs, and impairments. An expected feature of the software(s) is the automatic identification of fire-related impairments in an area where a CMSP or ISP is being requested. If implemented, the software(s) has the potential to assist the CMSP/ISP reviewer in understanding the aggregate fire risk in the area as part of the review and approval process, ensuring fire protection goals are not compromised.

2.10.3.2 Refurbishment

For the refurbishment project, N-PROG-RA-0012, *Fire Protection* is being followed. During refurbishment, OPG will:

- Prepare fire protection strategies.
- Perform FHA and FSSA for the islanding areas and refurbishment units.

- Act as Controlling Authority and fire protection subject matter expert for CMSPs.
- Act as ISPs issuer.
- Provide sufficient resources to response to first aid, firefighting, rescue and hazmat incidents in refurbishment units and operating units.

2.10.3.3 Emergency Response Team

OPG maintains an on-site, 24/7 Emergency Response Team (ERT) for manual fire suppression operations at the Darlington NGS site. The Darlington NGS ERT is currently a team consisting of full time and temporary Emergency Response Maintainers (ERMs) and light duty staff. At its disposal are: one incident command vehicle, two fire pumpers, one rescue, light and air apparatus, two response vehicles, five pickup trucks, one response cart for rapid deployment within the station, and four fire carts equipped with pump, aqueous firefighting foam supplies, and dry chemical extinguishers. The Darlington NGS ERT maintains a five-crew shift schedule to provide 24/7 fire protection coverage for the station, with day-support for related fire protection activities such as fire inspection rounds, fire watch, CMSP and ISP inspections. Individual ERMs of the ERT hold the same basic qualifications as professional firefighters at a municipal fire department, and the ERT as a group, and the ERMs as individuals also meet the requirements of internationally recognized NFPA 600, *Standard on Facility Fire Brigades, and* NFPA 1081, *Standard for Facility Fire Brigade Member Professional Qualifications* respectively.

A Memorandum of Understanding (MOU) is established between OPG and the Municipality of Clarington Emergency and Fire Services Department (CEFSD), to provide mutual aid agreements between OPG and Clarington. As part of this MOU, Clarington will respond to all fire emergencies at the Darlington NGS site and provides assistance as needed.

The Darlington NGS ERT participates in multiple annual drills ranging from site drills, contaminated casualty and hospitalization drill, Emergency Mitigating Equipment (EME) deployment drill, to live fire drills at the Wesleyville Fire and Rescue Academy to demonstrate ERT's training and technical capabilities at potential events. The latest drills in 2023 were deemed a success, and demonstrated the Darlington NGS ERT's ability to respond to realistic scenarios that may occur at the Darlington NGS site.

OPG's Wesleyville facility provides on-site training to both Darlington NGS and Pickering NGS ERT, including fire response, medical response, and other specialized training such as hazardous materials response and high-angle rescue. Unique features of the Wesleyville facility are the live-fire burn tower, power plant mock-ups, and industrial settings to conduct the high-angle rescue in realistic operational heights and configurations.

Wesleyville has also supplemented traditional emergency response training by facilitating aerial drone courses for OPG Emergency Services, municipal fire, police and transit. Additionally, local municipal fire departments and career colleges access Wesleyville in support of their internal recruit and incumbent training programs. Through joint training and inter-operability drills at Wesleyville, OPG strengthens relationships and collaboration between OPG and these off-site partners.

As part of its regular equipment upgrade initiative, Darlington NGS ERT recently acquired new Self-Contained Breathing Apparatus (SCBA) Air-Pak X3 for firefighting. The purchase of new SCBA will ensure that the ERMs are provided with new and up-to-date tools for their firefighting needs. The new Air-Pak X3s are also the same equipment used by Clarington Emergency and Fire Services Department, which allows for compatibility, interchangeability and flexibility during a joint Darlington NGS ERT and CEFSD response.

In the past four years, Darlington NGS ERT has been incorporating aerial drones from the OPG Security and Emergency Services (SES) Aerial Support Unit into its training. The aerial drones are used during training to film fire training evolutions and exercises for enhanced evaluation and feedback, as well as reconnaissance and surveillance tools in a variety of scenarios to minimize fire and radiation exposures to firefighters at the scene.

The OPG Aerial Support Unit (ASU) has been working with local fire and police for cross training at our fire academy, supporting public safety events in the surrounding towns. The ASU has been working with agencies from all over north America to establish a collaboration of efforts to start a program called Drones for First Responders (DFR). This will give all first responders a live view from the drone before the responders arrive on scene. The ASU has also been working with security and our regulator for anti-drone and detection technology. The ASU has been on standby and gone on several mutual aid calls for search and rescue and public safety related responses from Peterbourough Police, Port Hope Fire and Police, Clarington Fire and Durham Regional Police. The ASU has also been working with Ontario Tech. University to help the drone industry develop in the nuclear environment. The ASU has also just been training on how to operate and incorporate the Boston Dynamic robot dog “SPOT” into our program. This quadruped robot can mitigate risk for the fire fighters and assist in dangerous and time-consuming responses such as hazmat and confined space calls.

In recognition of the growing use of lithium-ion battery-powered vehicles, including the potential use of lithium-ion battery powered industrial trucks within the station, and the unique fire challenges they represent, Darlington NGS ERT has acquired an Electric Vehicle (EV) fire blanket as part of its fire response tools.

In February of 2022, Darlington NGS ERT participated in Exercise Unified Command, a tri-annual large-scale emergency and preparedness response exercise involving all three levels of government, utilities, and other stakeholders. The exercise was to assess the preparedness of OPG and other stakeholders to respond to a nuclear event at Darlington NGS. The exercise demonstrated the ability of Darlington NGS ERT, OPG, and our partners to respond effectively to a large-scale nuclear emergency at the Darlington NGS site.

A third-party evaluation was conducted of an OPG Industrial Fire Brigade Turbine Generator Fire Drill at Darlington NGS. Observations made during the On-Site Fire Drill showed that the exercise met all objectives incorporated into the fire scenario.

Section 2.11

Waste Management

2.11 Waste Management

The objective of the Darlington NGS Waste Management program is to ensure that adequate provisions are in place to limit the generation of radioactive and conventional waste and if created, control/manage its handling, storage, and disposal. This is done in an effort to ensure the safety of workers and the public; and continuously improve environmental performance in support of OPG's Environmental Policy.

There are two waste management programs that manage the elements of this SCA:

- OPG-PROG-0005, *Environment Health and Safety Managed Systems*; and,
- W-PROG-WM-0001, *Nuclear Waste Management.*

Both programs ensure that nuclear safety is a priority such that plant personnel, the public and the environment are protected and the impacts of plant operation to the public, workers, and the environment will be as low as reasonably achievable.

The *Environment Health and Safety Managed Systems* program, OPG-PROG-0005, describes how OPG's Environmental Management System (EMS) meets the requirements of the ISO 14001, *Environmental Management Systems* standard, including waste management activities. Standard OPG-STD-0156, *Management of Waste and Other Environmentally Regulated Materials*, is part of the EMS program and describes OPG's processes and procedures to address regulatory requirements with respect to waste management. OPG is subject to federal and provincial waste management regulations which include general waste management practices, transportation of dangerous goods, Polychlorinated Biphenyl (PCB) management, Ozone Depleting Substance (ODS) management, and CNSC requirements for nuclear facilities. The radiological waste content of OPG-STD-0156 is limited to low and intermediate level radioactive waste only.

The *Nuclear Waste Management* Program, W-PROG-WM-0001, is a mature and effective program applicable to all of OPG Nuclear. The objective of this program is to ensure adequate provisions are in place to limit the production of radioactive waste and to control its handling, storage, and disposal. Activities are performed in accordance with licensing basis standards and governing documents that prescribe controls and responsibilities to ensure the activities are carried out in a safe and effective manner by qualified personnel.

The program for the transportation of waste material is W-PROG-WM-0002, *Radioactive Material Transportation*, which addresses the radioactive material transportation shipments. This program ensures safe, compliant and efficient transportation of radioactive material from the site to its interim storage facility.

Waste management programs audits and self-assessments are conducted in accordance with OPG's Management System and internal governance requirements, to confirm that compliance obligations are addressed to identify opportunities for continual improvement.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 19: SCA 11 – Waste Management

Document	Title
OPG-PROG-0005	Environment Health and Safety Managed Systems
OPG-STD-0156	Management of Waste and Other Environmentally Regulated Materials
N-PROC-RA-0017	Segregation and Handling of Radioactive Wastes
W-PROG-WM-0003	Decommissioning Program
NK38-PLAN-00960-10001	Preliminary Decommissioning Plan - Darlington Nuclear Generating Station
NK38-PLAN-09701-10293	Operations & Maintenance Plan – Retube Waste Processing Building
NK38-REP-09701-10344	RWPB Safety Analysis Summary Report
NK38-REP-09701-10326	Darlington Retube Waste Processing Building – Safety Assessment
NK38-CORR-09701-0597849	RWPB Worker Dose During Normal Operation and Under Accident Conditions
NK38-REP-09701-10338	Fire Hazard Assessment of the DNGS Retube Waste Processing Building (RWPB)

2.11.1 Waste Management Practices

Waste is generated due to day-to-day operations of the plant. Station employees have three streams for waste disposal:

1. Bring waste to a collection area, where solid waste can be disposed as Active Waste, Likely Clean Waste, or Active Metal Waste.
2. Prepare the waste separately for drop-off to the Chemical Waste Collection Centre, commonly known as “Waste Handling”, according to storage and packaging requirements; and,
3. Contact Waste Handling for assistance in containing, securing, or picking-up large, heavy, or hazardous material.

Procedure N-PROC-RA-0017, *Segregation and Handling of Radioactive Waste*, provides direction to workers on the segregation and handling of potentially radioactive solid and liquid waste resulting from operation and maintenance activities.

Waste streams are handled and processed to ensure the safety of employees, the public, and the environment, while applying best practices to reduce and effectively segregate the generated waste.

After segregation and processing by Waste Handling, the generated waste paths can be classified as follows:

- Solid radioactive waste, which is shipped to a licenced waste management facility for incineration or long-term storage (compactable and non-processible).
- Radioactive oil, which is shipped to a licenced waste management facility for incineration.

- Radioactive liquid chemicals, which are either solidified on site and shipped to be stored at a licenced waste management facility or are shipped to be incinerated at a licenced waste management facility.
- Inactive solid conventional waste, which is shipped to public landfill or recycled.
- Inactive chemicals/liquid industrial waste, which is shipped to hazardous waste receiving company for incineration or disposal in hazardous landfill.
- PCBs, which are shipped to a licensed waste facility for incineration.

2.11.1.1 Interim Storage of Radioactive Waste

After radioactive waste has been processed at Darlington NGS, OPG's Nuclear Sustainability Services division manages it on an interim basis. Procedure W-PROC-WM-0025, *Waste Acceptance Criteria for Low and Intermediate Level Radioactive Waste,* defines the acceptance criteria for Low Level Waste (LLW) and Intermediate Level Waste (ILW) at the Western Waste Management Facility (WWMF), where Darlington NGS Low and Intermediate Level waste (L&ILW) is further volume reduced and stored on an interim basis. The LLW in storage buildings at WWMF is also further reduced at Western Clean-Energy Sorting and Recycling, where waste is sorted and segregated to reduce the LLW volume and optimize the use of waste storage space. Western Clean-Energy Sorting and Recycling is a CNSC-licensed facility located in Tiverton ON, operated by Energy Solutions.

Additionally, ILW from the reactor core components (i.e. pressure tubes, end fittings) associated with the Darlington refurbishment is stored, on an interim basis, at the Retube Waste Storage Building (RWSB) onsite. W-STD-WM-0002, *Waste Acceptance Criteria for Darlington Retube Waste Storage Building,* defines the waste that is stored under the Darlington Waste Management Facility (DWMF) licence WFOL-W4-355.00/2033.

High Level waste (HLW) consists of used reactor fuel. After at least 10-years of storage in the Irradiated Fuel Bay (IFB), used fuel is loaded into Dry Storage Containers (DSCs), transferred to DWMF, processed and stored under the facility waste management licence. W-PROC-WM-0082, *Eastern Waste Acceptance Criteria for Used Fuel Dry Storage Containers*, defines the criteria for the acceptance of a DSC which are stored at DWMF on an interim basis.

2.11.1.2 Long Term Disposal of Radioactive Waste

OPG remains committed to the safe and permanent disposal of nuclear waste.

The Nuclear Waste Management Organization (NWMO), in accordance with the federal Nuclear Waste Act (2002), is responsible for implementing Canada's plan for the safe, long-term management of used nuclear fuel. Under the NWMO's plan, a deep geological repository for used fuel is expected to be in-service in the mid-2040s.

Additionally, under the Federal Government's Integrated Strategy for Radioactive Waste (ISRW), the NWMO is also responsible for the long-term disposal of ILW. As per the ISRW, ILW is to be disposed in a deep geological repository with an expected in-service date by 2050.

Waste generators are responsible for LLW. OPG is planning a province-wide Learning Phase to seek a willing host for a LLW disposal facility, starting in 2024 with Indigenous Nations and communities followed by engagement with municipalities. As per the ISRW, LLW is to be disposed of in near surface disposal facilities with an expected in-service date by 2050.

As OPG's waste strategy for permanent disposal continues to evolve over the licence term. OPG will continue to engage with stakeholders and seek amendments to the associated licences as required.

2.11.2 Waste Characterization

The solid and liquid waste generated at Darlington NGS is characterized as either radioactive waste or inactive (non-radioactive) waste. The radioactive waste is further characterized as LLW, ILW, or HLW, while inactive (non-radioactive) waste is further characterized as conventional solid waste or hazardous chemical waste. For discussion of gaseous wastes (i.e. emissions) refer to Section 2.9.3.

LLW is radioactive waste that has a dose rate less than 10 mSv/h at 30 cm. To further segregate and reduce active waste volumes, OPG separates the LLW waste into three categories: incinerable, compactable, and non-processible LLW.

ILW is radioactive waste that has a dose rate of greater than or equal to 10 mSv/h at 30 cm. ILW largely consists of resins, filters and used reactor core components.

HLW is used nuclear fuel that has been withdrawn from a nuclear reactor following irradiation.

Procedure W-PROC-WM-0096, *Nuclear Waste Characterization*, documents the L&ILW characterization in alignment with international best practices and defines the requirements for preparing a waste characterization plan. L&ILW operations involves the safe handling, movement, processing, storage and monitoring of L&ILW.

2.11.2.1 Radioactive Solid Waste

Figure 31 shows the volume of station and refurbishment radioactive waste produced annually since 2015. In the past six years, refurbishment activities have contributed to approximately 66% of the total L&ILW generated at Darlington NGS (refurbishment waste was not tracked separately from station radioactive waste in 2016 and 2017). When refurbishment activities are completed in 2026, the volume of L&ILW generated annually is expected to be closer to pre-refurbishment averages.

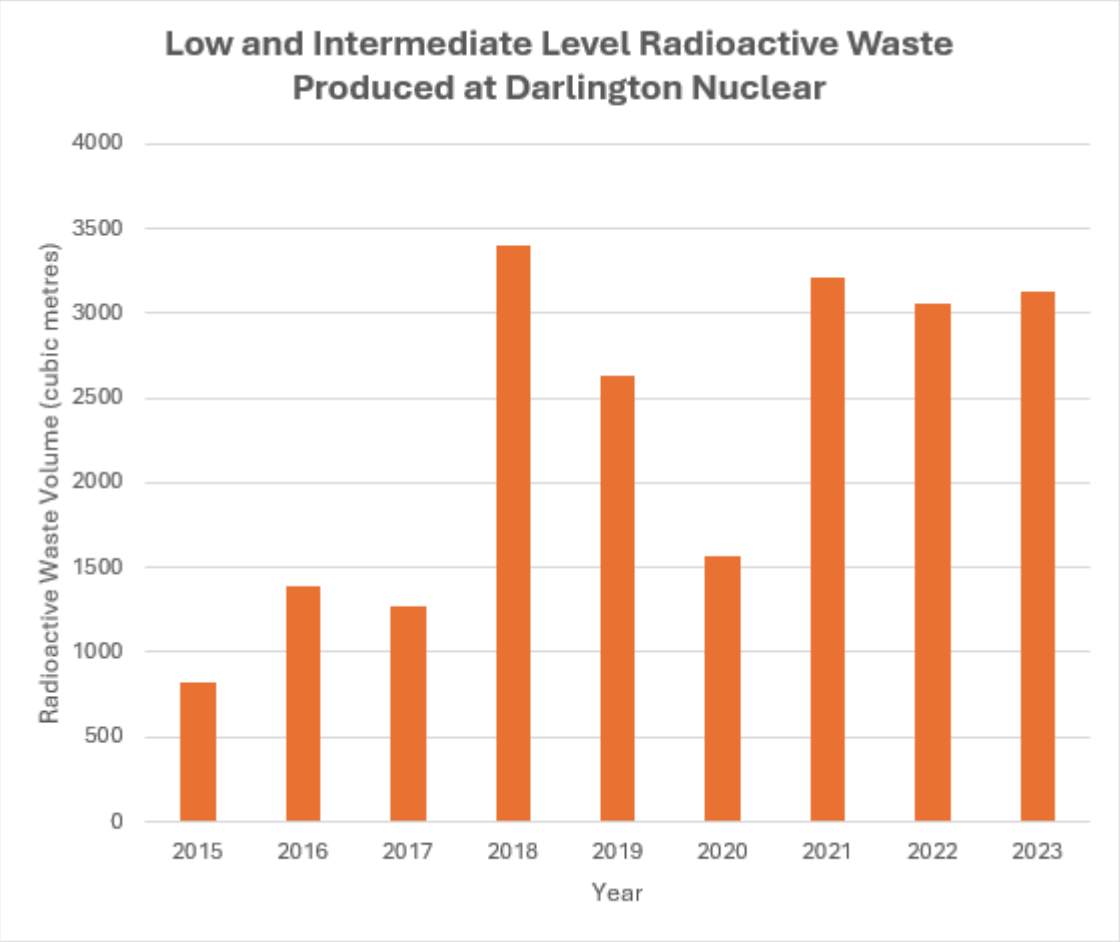


Figure 31: Low and Intermediate Level Radioactive Waste

2.11.2.2 High Level Waste

Approximately, 22,000 fuel bundles are transferred from the Darlington NGS IFB into DSCs each year and safely stored at DWMF. At the end of 2023, just over 900 DCSs are in storage at two storage buildings at the DWMF. The DWMF is licensed separately by the CNSC and considers the future needs of the Darlington NGS station. In 2023, construction of Storage Structure 3 (SS3) commenced and is planned to be in-service in 2025. A fourth storage structure is planned with an in-service date of approximately 2031.

2.11.2.3 Conventional Solid Waste

"Likely Clean" solid waste within the Unzoned Areas and Zone 1 is confirmed not to be contaminated. Any materials that can be recycled are segregated for that purpose. Solid waste is taken to designated waste collection stations.

For "Likely Clean" solid waste materials created in Zones 2 or 3, Unconditional/Conditional Transfer Permits are completed as required in preparation for shipment off-site. Materials that have the potential to be recycled are segregated for that purpose. Waste deemed to be active, trefoil symbols, trefoil tags, and any items with references to radioactivity are placed into the active waste stream regardless of the item's actual activity.

The conventional waste generated is confirmed to be free of contamination and is processed to a waste transfer station and then into a landfill or to a recycler. Conventional solid waste is also volume-reduced to minimize its environmental impact. Recyclable material collected and processed at Darlington NGS includes wood, cans, cardboard, paper, paper towels, plastic, asphalt, concrete, compost, metal, and glass.

2.11.2.4 Hazardous Chemical Waste

Hazardous waste generated at Darlington NGS includes chemicals and liquids such as cleaning agents, grease, oil, waste fuels, acids, batteries, and PCBs. The liquid and chemical wastes are generated from operations, maintenance, and outage activities. The volume of chemical drums on site is tracked and reported monthly with associated targets to ensure that the backlog is maintained at a low manageable level and that the waste is disposed as required by Ontario Regulation 347 requirements.

Oil and chemical waste handling is described in the document D-INS-79000-10001-R007, *Waste Disposal Guidelines for Oil and Chemical Wastes at Darlington*.

2.11.3 Waste Minimization

Darlington NGS has implemented initiatives to minimize and properly segregate waste. Waste minimization is a shared responsibility amongst all Darlington NGS employees. It consists of spreading awareness to all waste generators on the proper handling and segregation of waste, and implementing proper guidelines, instructions, and procedures. Waste minimization and segregation is part of work planning processes. Waste generators are to follow the concept of “Reduce, Reuse, Recycle”.

Darlington NGS’s waste minimization goals are two-fold: to minimize the volume of waste generated overall and to reduce the quantity of radioactive waste which is generated. The main initiatives that contribute to radioactive waste minimization are:

- Washable personal protective equipment: personal protective equipment worn inside the station is collected, washed and decontaminated by a licensed contractor for re-use.
- The “Likely Clean” program: segregates waste generated inside the Protected Area. “Likely Clean” waste cans are placed next to “Active Waste” cans and waste generated in Zone 3 areas that is believed to be uncontaminated is placed in the Likely Clean receptacles. Likely Clean waste is surveyed and, if free of contamination, is processed as conventional waste.
- "Active Metal" bins: the addition of these bins allows for the segregation of active metal (non processible waste) from other radioactive waste (incinerable and compactible). When active metal waste is mixed with incinerable and compactible waste the entire volume of waste is categorized as non-processible waste. Therefore, the segregation of active metal waste helps reduce non-processible radioactive waste.
- Low level waste with tritium levels less than 100 Maximum Permissible Concentration in air (MPCa) is sent to the tritium off gas room as part of the waste handling process. After off-gassing, the waste is treated as lower tritium activity waste.

OPG calculates the LLW diversion metrics on a monthly basis. A total of 6161 m^3 of LLW was diverted in 2023, with washable PPEs being the biggest contributor at 3136 m^3.

Radioactive waste is collected from designated areas throughout the station. Waste handlers separate the solid waste into conventional, radioactive, and hazardous waste streams. A new storing and segregating area was implemented in 2024, which helps reduce the LLW that is sent for disposal. Designated waste handlers process the waste to prepare and stage for shipment and/or final disposal. To reduce radioactive waste, plastic, wood and cardboard packing is removed from items entering the station, thus reducing the risk of packaging becoming contaminated LLW.

Site-wide communications on waste reduction expectations continue to improve behaviours and performance in waste reduction initiatives. Work groups are held accountable for waste reduction strategies and implement them in daily activities.

OPG has volume reduced reactor components from the Darlington NGS refurbishment and stored them in the RWSB. The RWSB went into service in 2017, via the DWMF waste licence. This waste consists of pressure tubes, end fittings, annulus spacers, calandria tubes and calandria tube inserts, all of which are ILW. It is stored in an inner container, referred to as the Retube Waste Container and an outer container, referred to as the Darlington Storage Overpack and will be stored until a permanent deep geological repository disposal facility becomes operational with the NWMO.

2.11.4 Decommissioning Plans

The purpose of the Decommissioning program, W-PROG-WM-0003, is to define the key program elements, objectives, roles and responsibilities and to ensure that, when retiring a licensed nuclear facility permanently from service and rendering it to a predetermined end-state condition, actions are taken in the interest of health, safety, environment, security, quality and economics. The program objective is to describe the requirements and processes to safely and cost effectively decommission OPG owned nuclear facilities and provide assurance that decommissioning work will be performed in accordance with the applicable regulatory requirements and Codes and Standards.

Planning for the eventual decommissioning of Darlington NGS is an ongoing process, taking place throughout each stage of the lifecycle. The current Preliminary Decommissioning Plan (PDP), NK38-PLAN-00960-10001 R003, *Darlington Nuclear Site Preliminary Decommissioning Plan*, was prepared in accordance with the requirements of the CSA standard N294-19, *Decommissioning of facilities containing nuclear substances*, and CNSC Regulatory Guides G-219, *Decommissioning Planning for Licensed Activities*, and G-206, *Financial Guarantee for the Decommissioning of Licensed Activities*, per the Darlington NGS licence and LCH. The PDP is updated and submitted as part of the Financial Guarantee submission every 5-years or when required by the Commission.

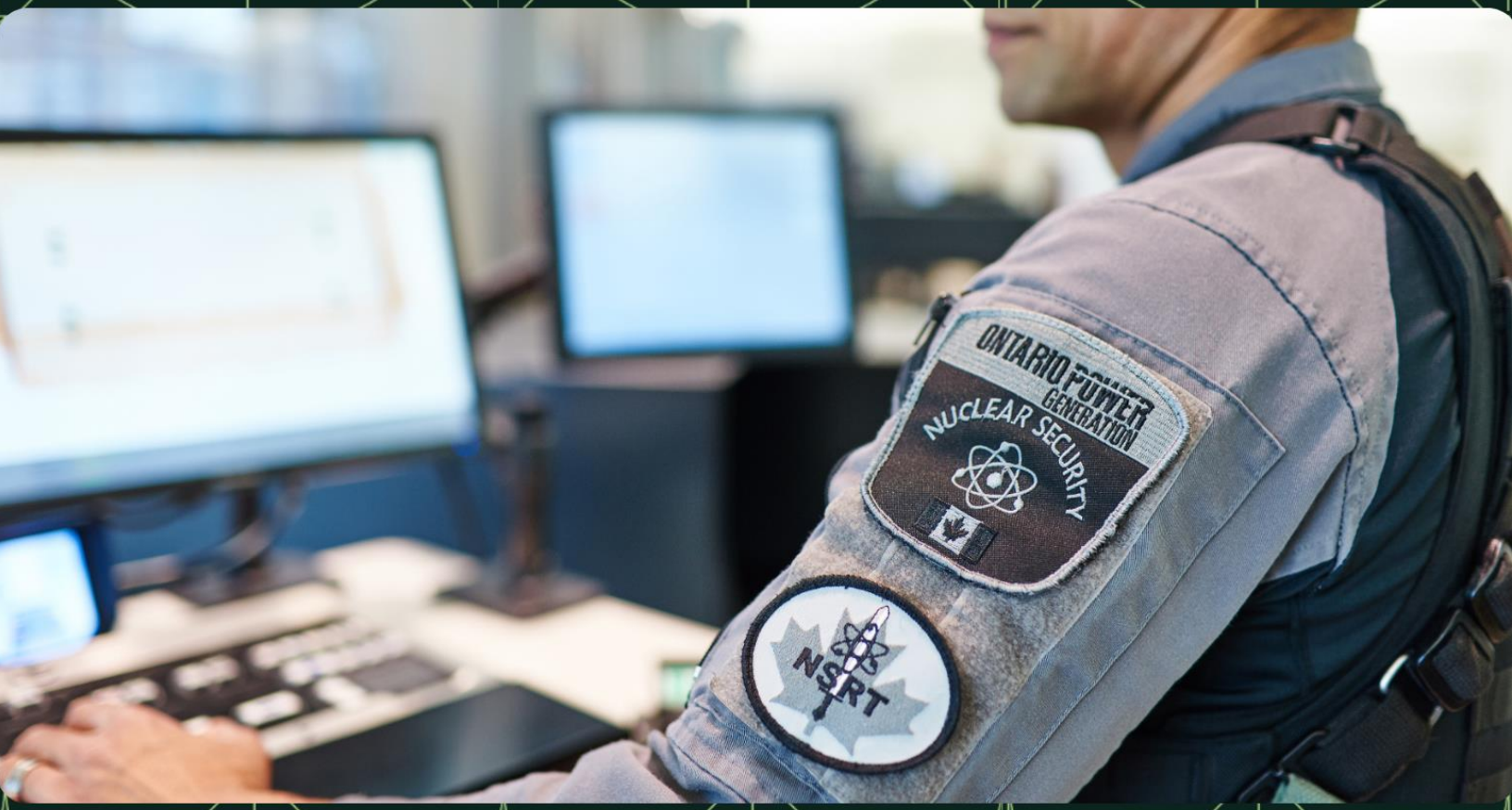
The PDP describes the activities that will be required to decommission Darlington NGS and restore the site for other OPG uses. It is also referred to as the Darlington Site PDP as it addresses the interfaces of the Darlington NGS with the DWMF. Details of the DWMF decommissioning are provided in the DWMF PDP. The Darlington NGS Site PDP demonstrates that decommissioning is feasible with existing technologies and it provides the schedule as well as the basis for estimating the cost of decommissioning.

OPG is planning to update the Darlington NGS Site PDP in support of the 2028 to 2032 Financial Guarantee submission. This revision of the PDP will meet the requirements of CNSC

regulatory documents REGDOC-2.11.2, *Decommissioning*, and REGDOC-3.3.1, *Financial Guarantees for Decommissioning of Nuclear Facilities and Termination of Licenced Activities*, and CSA standard N294-19 as well as any relevant domestic and international experience and best practices from the industry obtained in the previous 5-years will be incorporated into this revision.

Section 2.12

Security



2.12 Security

The objective of the Nuclear Security program at Darlington NGS is to ensure the safe and secure operation of the Nuclear Generating Station by supporting the protection of nuclear assets at OPG Nuclear in accordance with the legislative requirements of the Corporation, OPG-POL-0032, *Safe Operations Policy* and N-POL-0001, *Nuclear Safety and Security Policy*.

Through the use of equipment, personnel and procedures described in the fleetwide program governing document N-PROG-RA-0011, *Nuclear Security* program. OPG Nuclear Security ensures tactical readiness and maximizes response capability to prevent, contain, mitigate and terminate security events while minimizing the adverse impact on plant staff, operations and functions.

The Security and Emergency Services (SES) organization within OPG has accountably and responsibility for the effective management of security risk based on OPG risk tolerance, the Design Basis Threat (DBT) and required compliance with CNSC regulations and regulatory documents. The Nuclear Security program shall meet the expectations of N-CHAR-AS-0002, *Nuclear Management System*, by establishing, implementing, maintaining and improving a nuclear security management system with a focus on OPG high security sites that encompasses all licensing activities. This includes but not limited to Security Threat Identification and Risk Assessments, performed annually to identify credible threats to a specific site or facility. OPG is required to take any credible threats identified in a Threat Risk Assessment (TRA) into account in the design of the physical protection system. Requirements of this program include the following areas:

- Identify, assess, and understand security risk to staff and the public by conducting security TRAs and consider recommendations on an ongoing basis.
- Consider security risk during normal and abnormal operations and to potential emergency conditions.
- Anticipate potential risks with security strategies. Consider security threats faced by OPG, as a basis for establishing and continuing to improve the security management system.
- Maintain a proactive program which identifies key OPG assets and business interest.

The security program is based on credible risks and vulnerabilities, and as such, and in accordance with the Nuclear Security Regulations, has identified vital areas at Darlington NGS and implemented physical protection measures, including access control, and measures designed to delay unauthorized access taking into account the DBT and any other credible threat identified by the TRA. The OPG Nuclear Security Operations at Darlington NGS has continued to ensure uncompromised safety and security of employees, the public and the environment. The need to improve security performance is recognized and OPG is ensuring Security is held to the same high standards and intrusive oversight as all other organizations at OPG that impact nuclear safety. The OPG Nuclear Security organization operates under the leadership of the Vice-President, Security and Emergency Services, to ensure operational and regulatory requirements are continually met.

OPG Nuclear Security has progressed towards a more proactive approach to identifying program improvements that is evident in the implementation of a Security Excellence Plan that has established a Security Excellence Meeting (SEM) with the pillars of Our People, Our

Performance and Our Future. The Excellence Meeting process is a strategic model that has been proven to drive continuous improvement at the OPG station level.

OPG's Security program has moved from a Tier 3 level program to a Tier 1 level program with OPG's managed system. As such, a comprehensive and enhanced oversight body has been established, including a fleetwide functional peer team, which reviews performance and trends regularly. Security performance and results are reviewed and challenged at the Nuclear Executive Committee (NEC) on a regular frequency to continually drive performance. The process includes the use of N-PROC-RA-0023, *Fleetview Program Health and Performance Reporting*. In support of OPG's safety culture, Security continues to work toward improved performance in all elements of the Security program through a critical lens using effective and established managed processes, in addition to new initiatives.

OPG maintains open communication with the CNSC in forums such as the quarterly Security Director's meeting and the Nuclear Security Advisor Group (NuSAG) which includes security representatives from all Nuclear High Security Sites in Canada. The group is focused on ensuring nuclear security programs in Canada continue to meet future requirements, through the sharing of operating experience and the promotion of best security practices. OPG Security has also formed a Compliance Audit and Governance group, dedicated to unbiased, risk-based assessments of the Security Program. Through these internal self-assessments, OPG is able to monitor performance and trend worker behavior indicators, gather Key Performance Indicators (KPI) data for analysis and proactively identify latent organizational or process-based gaps more effectively.

In accordance with the Nuclear Security Regulations, OPG has identified the vital areas at Darlington NGS and has implemented physical protection measures, including access control, and measures designed to delay unauthorized access taking into account the DBT and any other credible threat identified by the TRA.

In accordance with the Nuclear Security Regulations, OPG Nuclear Security conducts a large-scale security exercise through a Performance Testing Program (PTP) audit at Darlington NGS every 2-years. The exercise tests and evaluates the integrated response capabilities of the Nuclear Security armed and unarmed elements against adversaries equipped within the DBT. This exercise is highly dynamic and realistic, incorporating laser systems to enhance realism. The CNSC observes and audits these exercises and may identify areas for improvement. OPG Security conducts a detailed after-action audit of the results, which has been provided to the CNSC. The combination of the internal audit and observations made by the CNSC are used in the development of the training objectives for each subsequent year. Darlington NGS conducted an exercise on March 9, 2023. OPG Nuclear Security has been operating with an onsite armed response force since January 18, 2010 and maintains a program in place to provide ongoing training for Armed Nuclear Security Officers (ANSO) (also referred to as the Nuclear Response Force) and unarmed Nuclear Security Officers (NSO).

The Security Training organization structure has realigned to report into the Nuclear Training Organization, which enables the incorporation of lessons learned and best practices from across OPG's departments and will support overall alignment. In accordance with the Nuclear Security Regulations and the Security Program, Security drills are regularly conducted to evaluate security physical protection systems including tactical deployment plans under realistic conditions to ensure regulatory compliance as well as to identify security improvements. OPG Security also maintains an ongoing Memorandum of Understanding (MOU) with the Durham Region Police Service (DRPS) for offsite tactical response support. OPG Security will continue

to operate at a high standard and meet the CNSC licensing requirements throughout the life of the Darlington NGS.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 20: SCA 12 – Security

Document	Title
8300-REP-61400-10003	Darlington Nuclear Generating Station Security Report
8300-PLAN-61400-10012	Darlington Nuclear Security Tactical Plan
N-PROG-RA-0011	Nuclear Security
TRAN-PLAN-03450-10000[1]	Transport Security Plan
NK38-REP-08160.3-00001	Threat and Risk Assessment
N-PROC-RA-0135	Cyber Security
N-STI-08161-10017	Cyber Essential Asset Identification and Classification
N-INS-08161-10011	Cyber Security Controls for Cyber Essential Assets
OPG-PROG-0042	Cyber Security

Notes:
1. OPG recommends TRAN-PLAN-03450-10000, *Transport Security Plan* be removed from the Darlington NGS LCH as the plan is no longer applicable as it was associated with transport licence TL-S-12861-07.01/2022 which is expired and will not be renewed.

2.12.1 Facilities and Equipment

The OPG Security Program ensures the possession, deployment and operation of required facilities and equipment at Darlington NGS comply with the Nuclear Security Regulations, and REGDOC-2.12.1, *High-Security Facilities, Volume II: Criteria for Nuclear Security Systems.*

The Darlington NGS Site Security Report describes in detail the physical security measures and systems and the security organization in place to ensure security of Darlington NGS employees, the public and the environment in accordance with the regulatory requirements. Changes to security systems are documented in the Site Security Report, as well as the Quarterly Security Report per REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants,* and are required to be submitted to the CNSC.

Personnel

Entry to the protected area at Darlington NGS requires all personnel to be searched for weapons and explosive substances at the Main Security Building (MSB), Auxiliary Security Building (ASB), or Refurbishment Project Office (RPO) in accordance with the Nuclear Security Regulations. The Darlington NGS search facilities are equipped with dedicated equipment for conducting security searches that meet REGDOC-2.12.1 Volume II requirements. Once personnel have passed the security search screening process, they are then required to use their proximity card and biometric hand scanners to activate the revolving door to enter the Protected Area.

Vehicles

All vehicles entering the protected area are searched for weapons, explosive substances and unauthorized persons in accordance with the Nuclear Security Regulations as well as contraband and prohibited items. All vehicles, upon entrance and exit from the Protected Area

are surveyed for Category I and II nuclear material using the Vehicle Radiation Monitor. Darlington NGS has physical protection measures against forced land vehicle penetration of the protected area. The measures are compliant with REGDOC-2.12.1 Volume II.

Powerhouse Doors

All exterior doors of the Darlington NGS powerhouse are hardened against forced entry, and the doors are equipped with a robust lock system to prevent unauthorized access to the powerhouse. The doors are checked daily by Nuclear Security Officers (NSOs) to ensure they are operating as designed.

Material Security

Searches are conducted on all packages and equipment entering the protected area for weapons, explosive substances and unauthorized persons in accordance with the Nuclear Security Regulations, as well as contraband and prohibited items.

Sealed sources and nuclear fuel are protected, stored and managed in compliance with REGDOC 2.12.3, *Security of Nuclear Substances: Sealed Sources and Category I, II and III Nuclear Material, Version 2.1* (Reference 2.12-1) and in accordance with the Nuclear Security Regulations. Sealed source security measures includes access control, detection of unauthorized access, locking hardware and key control, physical barriers, alarm response protocol, and inspection, maintenance and testing of security-related equipment. Recurring familiarization training has been implemented and conducted with all Nuclear Security Officer staff at Darlington NGS.

Physical Protection Systems

In accordance with REGDOC-2.12.1 Volume II, the Darlington NGS protected area is surrounded by a security fence equipped with devices intended to detect any attempt at unauthorized intrusion into the protected area, and to detect any tampering or component failures that could cause the system to malfunction. A delay system is built into the security fence that includes razor wire. The system is monitored at all times by NSOs in the Central Alarm Station (CAS). Alarms within the protected area are responded to by armed NSOs.

OPG employes Defence in Depth approach to the physical security protection system which is designed to deter, prevent, detect, assess, delay and respond. The various protection measures include but are not limited to:

- Perimeter/site security zone fencing and detection;
- Vehicle denial barriers;
- X-ray units;
- Radiation material detection equipment;
- Explosive detection equipment;
- Central Alarm Station monitoring;
- Lighting;
- Cameras.

On-site and off-site communication

In accordance with the Nuclear Security Regulations, OPG Nuclear Security has a primary communications system which is interoperable with Durham Regional Police Service (DRPS). the primary offsite responder. Redundant secondary communication systems are available to ensure lines of communication to the field and beyond can be established.

There are a number of initiatives underway to enhance security systems at Darlington NGS including hardware updates, upgrades to the CAS, and integration of the Entry Control System.

2.12.2 Response Arrangements

In accordance with the Nuclear Security Regulations, OPG has a written arrangement with the DRPS to provide off-site armed response force support to the Darlington NGS. The DRPS provides response capability for Darlington NGS in the event of identified security incidents.

OPG Nuclear Security has a tactical response plan for Darlington NGS that sets out clear expectations on how to maintain the security of the site and to ensure an effective response to security events including the unauthorized removal of nuclear or radioactive material or to the sabotage of nuclear facilities, as required by the Nuclear Security Regulations and REGDOC-2.12.1, *High Security Facilities, Volume I: Nuclear Response Force, Version 2*. The tactical plan implements the primary objective of Nuclear Security to make an effective intervention taking into account the CNSC DBT and any other credible threat identified by the TRA to the protected area. DRPS provide support to this tactical plan.

2.12.3 Security Practices

The OPG Nuclear Security organization has accountabilities and responsibilities for the delivery of security services to effectively manage security risks based on OPG risk tolerance levels, the DBT and required assurance of compliance with CNSC regulations.

Frontline Darlington NGS Security personnel consist of two roles, NSOs and ANSOs. NSOs perform all security functions for Darlington NGS primarily personnel, bulk material and vehicle searching, surveillance and patrolling, while ANSOs provide on-site armed support capable of dealing with situations outlined in the DBT in addition to core NSO duties. A defensive strategy is followed along with a tactical plan as required by the Nuclear Security Regulations and REGDOC-2.12.1 Volume I.

The OPG Security clearance process ensures personnel requiring access to OPG business units, locations, or access to OPG Confidential, OPG Confidential Exclusive or Security Protected information, do not pose a risk to the facilities, its employees, or company assets. Persons, including OPG employees and contractors, who require unescorted access to the Darlington NGS protected area must comply with the applicable requirements of Nuclear Security Regulations. Under OPG-PROC-0119, *Clearance Process,* and OPG-GUID-61400-0001, *Guide to Security Clearance*, each person requiring unescorted access must complete a Nuclear Site Access Security Clearance Form and be approved through the clearance process. These processes are in compliance with REGDOC-2.12.2, *Site Access Security Clearance*. A proximity card is given to each approved applicant, and the proximity card and biometric scans permit entry to and exit from the protected area, as per the Nuclear Security Regulations. Upon exit from the protected area, in accordance with the Nuclear Security Regulations, all personnel and vehicles are scanned for Category I or II nuclear substances.

Prescribed information is controlled and released only on a 'need to know' basis to those who possess the appropriate security clearance.

The trait of Vigilance was added to OPG's Nuclear Safety and Security Culture traits. OPG maintains vigilance as part of its defense-in-depth security strategy through requirements such as OPG's Supervisory Awareness Program, Continuous Behavioral Observation Program (CBOP). The program ensures all supervisors have the skill and knowledge to recognize behaviors that might constitute a risk to health and safety of employees, the plant and the general public.

2.12.4 Drills and Exercises

The OPG Security Program ensures the Nuclear Security Response Force conducts effective interventions, based on the DBT and any other credible threats identified through threat and risk assessments within the protected area. The objective is to prevent sabotage of the nuclear facilities or the sabotage and theft of Category I, II, or III nuclear materials.

To achieve this objective, the Nuclear Response Force is equipped with gear prescribed by REGDOC-2.12.2 Volume I, which includes tactical equipment, both lethal and less lethal options, and tactical personal protection equipment. A yearly maintenance program is in place to ensure firearms are maintained and armored to manufacturer specifications.

NSOs and ANSOs are required to qualify in specific training program elements and must requalify within established requalification periods as per REGDOC-2.2.4, *Fitness for Duty, Volume III: Nuclear Security Officer Medical, Physical, and Psychological Fitness*, and REGDOC-2.12.1, Volume I. N-TQD-603-00001, *Nuclear Security Training and Qualification Description,* establishes the training requirements for NSOs and ANSOs, including initial and subsequent requalification training requirements. OPG Security employs OPG's Training Information Management System (TIMS) to ensure the tracking and completion of required qualifications. The position of a Nuclear Security Training Coordinator is specifically used to implement and manage programs that support and adhere to nuclear security regulatory requirements, ensuring that employees meet qualifications and are recertified as necessary. The responsibilities of this position include ensuring the acquisition of essential documentation, as well as the required medical, physical, and psychological certifications for individuals before they can be authorized to act as nuclear security officers. Additionally, it involves safeguarding the requalification requirements for officers are continuously met.

The purpose of the training is to ensure officers are proficient at performing duties described in Nuclear Security Regulations and for armed officers REGDOC-2.12.1, Volume I. Examples of duties include, but are not limited to:

- Employing tactical strategies and movement.
- Managing larger scale high risk security incidents utilizing Incident Command response model.
- Search and control of persons, vehicles and shipments.
- Utilizing search equipment in the course of duties.
- Conducting patrols and responding to alarms.

OPG deploys a Security Training Team consisting of Tactical Trainers and Training Technicians who are responsible for developing and utilizing various training methods aimed at enhancing the competence and confidence of Security Officers. These methods include, but are not limited to:

- Dynamic physical drills for individual officers.
- Officers working in pairs and small teams.
- Demonstrations of skills.
- Equipment usage.
- Procedural adherence.
- Tabletop exercises, written exams, and the prescribed qualification testing procedures as per REGDOC-2.12.1 Volume I.

Additionally, Security Supervisors utilize on-crew trainers to ensure proficiency in specific aspects of officer's duties as well as conducting monthly drills and crew practice sessions to evaluate proficiency. These activities are reported, assessed and archived and are used to inform security training objectives.

2.12.5 Cyber Security

OPG has established an enterprise-wide cyber security program, which is outlined in OPG-PROG-0042, *Cyber Security*, to establish and maintain processes, procedures and controls to ensure OPG meets or exceeds regulatory requirements for cyber security, specifically CSA N290.7-14, Cyber Security for Nuclear Power Plants and Small Reactor Facilities standard. Moreover, OPG has implemented a Nuclear Cyber Security procedure, N-PROC-RA-0135, *Cyber Security* which identifies systems that are Cyber Essential Assets (CEA) and the requirements to protect them from internal and external cyber threats, up to and including the design basis threat. This program is under the purview of OPG's Nuclear Cyber Security section, which operates under the Corporate & Technology Services organization.

The cyber security program objectives address the following elements:

- Defensive strategy and security architecture: N-STI-08161-10001, *Defensive Cyber Security Architecture Standard* specifies the requirements for establishing a Defensive Cyber Security Architecture (DCSA) that is specifically tailored to the needs of OPG Nuclear Facilities including Darlington NGS. DCSA focuses on the arrangement of zones to establish defence-in-depth, and also specifies the requirements for boundary protection, secure communications and interconnections between zones, and common security control requirements that provide for protection across the facility.
- Policies and procedures: OPG-POL-0035, *Cyber Security Policy* requires OPG to establish and maintain a management system that reduces cyber risk, protects critical information and operational technology assets in accordance with internationally recognized cyber security standards while at a minimum maintaining compliance to regulatory and legal requirements. The policy supports the respective program, nuclear specific procedure and lower-level documents tailored to address specific clauses of CSA N290.7-14.
- Asset identification and classification: N-PROC-RA-0135 defines instructions for the identification of Cyber Assets and Cyber Essential Assets per the definitions defined by

CSA N290.7-14. Further, these assets are classified and prioritized using a graded approach for applicable cyber security controls commensurate to their significance and susceptibility.

- Roles and responsibilities: Roles and responsibilities for staff to meet program, process and lower-level document expectations are well defined under N-PROC-RA-0135.
- Security Controls: N-PROC-RA-0135 makes use of a graded approach to establish the necessary cyber security controls to protect Cyber Essential Assets.
- Awareness and Training: Qualifications and trainings are documented in training plan, N-PLAN-08161-00008, *Training Plan*. System Owners confirm that all cyber security activities performed on systems that they are responsible for are completed by competent individuals with the necessary qualifications.
- Cyber Asset Configuration Management and Life Cycle Approach: Applicable change control processes are listed under N-PROC-RA-0135 to ensure Cyber Essential Asset configuration management and life cycle management follows CSA N290.7-14.
- Coordination with other programs: Nuclear Cyber Security process, N-PROC-RA-0135 receives its authority from the enterprise-wide OPG-PROG-0042, *Cyber Security* program. Furthermore, N-PROC-RA-0135 is compliant with CSA N286-12, Management System Requirements for Nuclear Facilities, and interfaces with other nuclear processes to provide the necessary elements of a comprehensive cyber security program in OPG Nuclear.
- Incident response, reporting and recovery plan: N-PLAN-08161-00010, *Nuclear Cyber Security Incident Response Plan* provides guidance to cyber security incidents that potentially impact Nuclear Operational Technology digital assets supporting OPG Nuclear facilities.
- Program review and maintenance: OPG's Nuclear Cyber Security process emphasizes program review through monthly program performance updates, annual fleetview reports, continuous improvement through annual self-assessments, operating experience lessons, corrective actions, and updates to relevant CSA standards and CNSC regulations and REGDOCs. Furthermore, the process integrates lessons learned from cyber security incidents, audits, as well as supplemental drills/exercises.

Section 2.13

Safeguards & Non-Proliferation

2.13 Safeguards and Non-proliferation

Safeguards and Non-Proliferation refers to an international system of monitoring and verifying nuclear material and specified nuclear activities, administered in Canada by the CNSC and verified by the IAEA, to deter the diversion of nuclear material from legitimate peaceful activities. This system facilitates the IAEA to evaluate compliance with its obligations pursuant to its international safeguards agreements.

Canada has entered into a Safeguards Agreement and an Additional Protocol (hereafter referred to as "safeguards agreements") with the IAEA pursuant to its obligations under the *Treaty on the Non-Proliferation of Nuclear Weapons* (INFCIRC/140). The international *Treaty on the Non-Proliferation of Nuclear Weapons* is the cornerstone of Canada's efforts to promote its objectives of international disarmament, non-proliferation, and the peaceful use of nuclear energy. More specifically, Canada maintains obligations under the following Canada-IAEA safeguards agreements:

- *Agreement Between the Government of Canada and the International Atomic Energy Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons* INFCIRC/164; and,
- *Protocol Additional to the Agreement Between Canada and the International Atomic Energy Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons INFCIRC/164/Add.1.*

For Nuclear Power Plants in Canada, the non-proliferation program is limited to the tracking and reporting of foreign obligations and origins of nuclear material. The Additional Protocol contains further requirements for the provision of information and access, including the obligation to allow access to some locations on 24 hours' notice, and the obligation to provide information on and access to certain nuclear manufacturers and researchers, neither of which need involve nuclear material.

OPG is in compliance with these requirements to facilitate Canadian compliance with Canada's Safeguards agreements with the IAEA, and with OPG's obligations established in the *General Nuclear Safety and Control Regulations*.

Darlington NGS has an effective Safeguards and Non-Proliferation program that that ensures compliance with Canada's international safeguards obligations arising from the Canada/International Atomic Energy Agency safeguards agreements as well as other measures arising from the Treaty on the Non-Proliferation of Nuclear Weapons. This program consists of, in the following hierarchy:

- OPG's N-PROG-RA-0015, *Safeguards and Nuclear Material Accountancy* program is designed to establish, maintain, and verify compliance with Safeguards and Nuclear Material Accountancy requirements, ensuring all necessary measures are taken to facilitate Canada's compliance with international safeguards agreements and any other measures arising from the Treaty on the Non-Proliferation of Nuclear Weapons.
- N-STD-RA-0024, *Safeguards and Nuclear Material Accountancy Implementation* provides further direction to ensure OPG complies with its licence conditions, the Nuclear Safety and Control Act, the General Nuclear Safety and Control Regulations, and any other related regulations in support of Canada's safeguards and nuclear material accountancy agreements.

- N-PROC-RA-0136, *OPG Safeguards and Nuclear Material Accountancy Requirements* then captures specific requirements for the establishment and maintenance of the Safeguards program at OPG Nuclear; this procedure closely follows and where possible, exceeds the CNSC regulatory document, REGDOC-2.13.1, *Safeguards and Nuclear Material Accountancy.*

OPG's Safeguards and Nuclear Material Accountancy program is implemented in a manner to:

- Prevent damage, theft, loss, sabotage, or diversion of nuclear material.
- Timely detection of and reporting of damage, theft, loss, sabotage, or diversion of nuclear material.
- Establish and maintain a system(s) of accounting for nuclear material.
- Generate and submit nuclear material accountancy reports.
- Interface with IAEA personnel and support requests for information or site access.
- Provide operational and design information to support an integrate Safeguards approach appropriate for the facility.
- Facilitate the implementation, maintenance, and operation of Safeguards equipment and surveillance without undue interference.

These agreements, regulations, programs, standards, and procedures collectively provide a comprehensive system designed to fulfill the Safeguards and Non-Proliferation objective, as outlined in the safeguards agreements, 'the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by the risk of early detection.'

Throughout the current Darlington NGS licence, the OPG Safeguards program was successful in meeting all international Safeguards and Non-Proliferation agreements.

Since 2016, Darlington NGS received satisfactory results from all inspections performed by the IAEA (results can either be satisfactory or unsatisfactory), indicating that Darlington NGS has successfully met the Safeguards requirements. Darlington NGS provided satisfactory support to the IAEA including nuclear material accountancy and control, access and assistance to the IAEA, operational and design information, support for Safeguards equipment, and containment and surveillance. In addition, the Darlington NGS safeguards program is internally evaluated each year through self-assessments to ensure the continued health of the program, including the program remains in compliance with regulatory requirements and a satisfactory working level structure is in place to ensure success in meeting OPG obligations.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 21: SCA 13 – Safeguards and Non-proliferation

Document	Title
N-PROG-RA-0015	Nuclear Safeguards
N-STD-RA-0024	Nuclear Safeguards Implementation
N-PROC-RA-0136	OPG Safeguards and Nuclear Material Accountancy Requirements

2.13.1 Nuclear Material Accountancy and Control

Nuclear material accountancy involves activities which establish and report the quantities of nuclear material present within defined areas, as well as the changes in those quantities within defined time periods. This includes nuclear material measurement, record keeping, preparation and submission of accounting reports, and verification of accounting information.

All units of nuclear material have a unique identifier which is tracked and accounted for. For all non-exempted nuclear material, Darlington NGS has Material Balance Areas (MBAs), where inventory of nuclear material can be categorized and tracked, and key measurement points (KMPs) within those MBAs, where inventory of nuclear material can be measured. Any movements from one MBA to another are promptly reported to the CNSC and IAEA. Nuclear material movements within the same MBA are also tracked internally to ensure precise status. Inventory changes are input into Nuclear Material Accountancy software by staff qualified to move nuclear material. This software supports tracking and report generation. Reports of inventory status are submitted to the CNSC and IAEA as required by the licence conditions, which currently refer to REGDOC-2.13.1 and include:

- Inventory Change Documents;
- General Ledger;
- List of Inventory Items;
- Physical-KMP Inventory Summary;
- Obligated Material Inventory Summary;
- Reconciliation Statements.

To support accounting and reporting, additional information is provided by OPG to the CNSC and ultimately to the IAEA, including operational information, plant design information, and site procedures. Providing current operational data and upcoming plans allows CNSC and IAEA to compare and validate observations from installed measurement equipment to the inventory data provided. Transparency with plant design information and site processes prevent potential gaps in measurement points and methods.

Darlington NGS utilizes an electronic system to help track deadlines associated with CNSC/IAEA Safeguards requirements to ensure submissions are made on time in accordance with REGDOC-2.13.1. This system also supports historical traceability by documenting when submissions were made, in addition to record keeping of submitted files.

In accordance with N-PROG-RA-0015, *Safeguards and Nuclear Material Accountancy*, Darlington NGS shall disclose to the CNSC, the IAEA, or an IAEA inspector, any records required to be kept or any reports required to be made under a safeguards agreement. In accordance with the General Nuclear Safety and Control Regulations, Section 31, OPG shall file a report with the CNSC within 21 days of becoming aware of any inaccuracy or incompleteness in a record to be kept under the Act.

All communications with the CNSC and IAEA which contain sensitive information, such as nuclear material accounting, is performed using only secure means. To ensure timely communication and report submissions, procedures are kept in alignment with REGDOC-2.13.1 requirements and relevant staff are trained on these procedures to be aware of reporting requirements and timelines. Between 2015 and 2023 an average nearing 100

Safeguards Nuclear Material Accountancy submissions per year were submitted to the CNSC and IAEA.

2.13.2 Access and Assistance to the IAEA

The IAEA may require access to a given site for a variety of purposes pursuant to the Canada-IAEA safeguards agreements. Darlington NGS will grant prompt access to all locations within the licence to the IAEA and CNSC inspector(s), or to person(s) acting on behalf of the IAEA/CNSC, where such access is required to carry out an activity pursuant to a safeguards agreement. Site procedures are written to allow access for inspection at all operating hours. Initial access to areas for inspection will be attained within two hours of the IAEA arriving onsite provided it is safe to do so.

Typically, an OPG Single Point of Contact (SPOC) is assigned for all informal communications with IAEA/CSNC for Safeguards activities. A contact list including the SPOCs information is maintained and shared with the IAEA/CNSC to facilitate communication. The SPOC is trained in station processes related to Safeguards to help ensure effective and timely support. In the case where the OPG SPOC is unavailable, such as on night shifts, procedures are in place for staff on shift to make the same appropriate arrangements for the inspector(s) access during all station operating hours.

In granting access, Darlington NGS will provide:

- Health and safety services.
- Escorts for conventional and radiological safety.
- Technical or equipment assistance as required.
- Physical access equipment such as:
    - Ladders;
    - Scaffolding;
    - Lifting devices supplied as necessary.

Assigned Darlington NGS personnel will guide the IAEA and CNSC to ensure compliance with site procedures for the duration of the site access. Where necessary to ensure safe access, required training will be arranged as soon as practical.

IAEA and CNSC inspectors regularly perform site visits to review the status of monitoring equipment, accessible nuclear material inventory, submitted records, station design, procedures, and worker practices. Site visits are also required to perform maintenance of IAEA surveillance equipment, for example successfully completed IAEA replacement of Core Discharge Monitors with significant support from OPG. These inspections and maintenance prevent gaps in nuclear material safeguarding provisions.

Existing procedures have been in place for some time and have been reviewed against the safeguards agreements and Canadian regulations to ensure compliance; they have also been tested through many years of use at Darlington NGS site. During site visits, there are opportunities to share concerns and potential improvements to existing processes to make the OPG safeguards program, access and assistance more effective.

Similarly, Darlington NGS staff support trilateral meetings between OPG, CNSC and IAEA as forums to discuss the integrated Safeguards approach, process improvements, emerging trends, etc. With a culture of continuous improvement, site procedures are updated with any lessons learned. Should regulatory requirements be revised, thorough gap analysis is performed to identify any areas for improvement within existing site procedures. Site procedures are then promptly updated to maintain alignment, and where possible exceed, the latest regulatory requirements in force.

2.13.3 Operational and Design Information

The purpose of providing accurate and timely operational and design information to the CNSC and IAEA is to ensure adequate measures are in place to Safeguard nuclear material and ensure compliance with the non-proliferation Safeguards agreements. Operational and design information is used to ensure an appropriate, integrated approach for the site specifics is in place. It is also useful in understanding and validating observations from installed measurement equipment and provided nuclear material accounting reports. An appropriate site-specific safeguards approach is critical to assure that measures – such as nuclear material reporting, safeguards equipment and surveillance, and in person inspections – are sufficient to the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities.

Darlington NGS utilizes an electronic system to help track deadlines associated with CNSC and IAEA Safeguards requirements to ensure submissions are made on time. This system also supports historical traceability by documenting when submissions were made, in addition to record keeping of submitted files. It also enables oversight to closeout ensuring sufficient rigour and due process.

There are three primary reports provided by Darlington NGS to the CNSC and IAEA to capture relevant design and operational information required by REGDOC-2.13.1. The reports are Design Information Questionnaire (DIQ), Operational Program, and Additional Protocol.

The Design Information Questionnaire (DIQ) is an IAEA form which Darlington NGS completes with all applicable information, including:

a) The identification of the facility, stating its general character, purpose, nominal capacity and geographic location, and the name and address to be used for routine business purposes.

b) A description of the general arrangement of the facility, including site and building maps as needed, with reference to the form, location and flow of nuclear material and to the general layout of important items of equipment which are used to handle, produce or process nuclear material.

c) A description of features of the facility relating to nuclear material accountancy, containment and surveillance.

d) A description of the existing and proposed procedures at the facility for nuclear material accountancy and control.

e) Health and safety procedures that the IAEA shall observe and with which the inspectors shall comply at the facility.

Through Darlington NGS's internal routine electronic tracking (typically yearly), the DIQ is reviewed for any changes; any identified changes are included in a revision to the DIQ and it is resubmitted to the CNSC and IAEA. In addition, the Darlington NGS safeguards specialist maintains awareness of potential site developments that may necessitate updates and resubmission of the DIQ at any time. The OPG *Engineering Change Control* program, N-PROG-MP-0001, also requires design changes to be reviewed for potential impact to Safeguards in the early planning phase (for additional information on OPG's engineering change control program see Sections 2.1.5 and 2.5.1). Expected impacts are addressed collaboratively with CNSC and IAEA to maintain an adequate safeguards program. More specifically, design changes flagged for potential impacts to Safeguards are discussed with the Darlington NGS safeguards specialist and reported to the CNSC and IAEA for alignment prior to implementation. Direct communications from the design change team allows for detailed and applicable information to be gathered for accurate reporting; moreover, OPGs design change process requires rigorous documentation to capture all details that would be needed for Safeguards; relevant information as confirmed through documentation and discussion with the design change team, IAEA and CNSC (where applicable) is then included in the DIQ update.

To further ensure the accuracy of the submitted DIQ and the site-specific safeguards measures, the IAEA also performs routine Design Information Verifications (DIVs). During a DIV, the IAEA performs in person inspections of the provided DIQ information to verify it is accurate and sufficient to make decisions on the safeguard measures. The IAEA inspects various areas of the facility and asks many questions to confirm that there are no potential gaps in the safeguards approach or the DIQ. Much like any other IAEA inspection, there are opportunities for feedback and lessons learned, whereby the DIQ can be updated and resubmitted to ensure the highest standards are applied. The DIV is an important aspect of the DIQ.

The Operational Program is a CNSC form which Darlington NGS completes with all applicable information, including, but not limited to:

a) Any anticipated shutdown periods during the upcoming calendar year.

b) Information on expected transfers of nuclear material in the next calendar year.

c) Updates on current or upcoming projects of relevance to safeguards, such as the construction or decommissioning of a building, the commencement of projects involving nuclear material, changes to the types of nuclear material being possessed, etc.

The Operational Program is submitted annually as per REGDOC-2.13.1. Typically, quarterly updates are also provided to deliver confirmation of no change, or identify any changes.

Much like the DIQ preparation, the Darlington NGS safeguards specialist maintains awareness of site operating plans that may necessitate revision and resubmission of the Operational Program at any time. The Darlington NGS safeguards specialist gathers the required information from site contacts most applicable to the information; this ensures accurate information is provided from the source.

The Additional Protocol is an annual report which includes, but is not limited to:

a) Current drawings of the site, a general description of each building on the site, including its use and, if not apparent from that description, its contents.

b) General plans for the succeeding 10-year period relevant to the development of the nuclear fuel cycle (including planned nuclear fuel cycle-related research and

development activities) when approved by the appropriate authorities in Canada.

The information provided in the Additional Protocol assists the CNSC and IAEA in reviewing the site Safeguards approach, looking for gaps, or future areas of increased concern, to address.

In addition to the above three reports, Darlington NGS maintains communication with the CNSC and IAEA Safeguards divisions. Operational activities that could not be foreseen, such as sudden power loss, that may affect Safeguards are promptly reported to the CNSC and IAEA. Furthermore, OPG supports industry peer team meetings, benchmarking of other nuclear generating stations, and routine trilateral meetings with the IAEA and CNSC to discuss the Safeguards program; these are excellent environments to learn from each other and identify areas for improvement in the overall safeguards program.

OPG strives to be transparent with the CNSC and IAEA to ensure alignment and facilitate the objectives of the Safeguards and Non-Proliferation agreements.

2.13.4 Safeguards Equipment, Containment, and Surveillance

There are several IAEA Safeguards equipment installed at Darlington NGS to allow remote monitoring of necessary nuclear material movements within the station; for instance, cameras and radiation monitors which are strategically placed at critical transfer locations. Darlington NGS supports this equipment by providing the required services and operating safeguards equipment as specified by the IAEA; such services include power supplies, lighting, internet connections, etc. The installed equipment provides the IAEA with continuous detailed data of nuclear material movements. The IAEA use the information to compare against Darlington NGS's nuclear material accountancy reports to ensure all nuclear material movements are accounted for and used for legitimate purposes in accordance with the non-proliferation treaty.

IAEA equipment is labelled and sealed to deter interference, damage, or tampering. Site procedures and staff training clearly detail that tampering or disruption of IAEA surveillance equipment must be immediately reported to the CNSC. Tampering or disruption may take many forms including: physical damage, broken IAEA seal, power supply interruption longer than credited backup supply, reduction of lighting in areas of IAEA cameras, shielding of IAEA radiation measurement devices, high ambient temperature, etc. Where possible, duel switchable power supplies are provided for increased reliability and online maintenance.

Additional critical support parameters, such as the minimum required ambient lighting for IAEA cameras or a specified range of ambient temperature for IAEA computers, have requirements captured in site procedures and training, reinforce expectations to perform all due diligence to satisfy these bounds.

The IAEA conducts remote monitoring to ensure functionality of surveillance equipment, as well as in-person inspections to verify no tampering has occurred. OPG personnel also perform periodic inspections to confirm no visible tampering of IAEA equipment.

Darlington NGS shall not make changes to any aspect of a facility, facility operation, equipment or procedures that would affect implementation of safeguards measures except with prior approval of the CNSC, or a person authorized by the CNSC.

From 2012 to 2023 there were a total of five events reportable to the CNSC related to Safeguards Equipment, Containment and Surveillance. In each case, immediate action was

taken to resolve the condition. Where practical, reoccurrence control actions were implemented following the event.

Besides the reported events, there were no observations of adverse equipment support identified by the IAEA. Such observations can be made by IAEA remote monitoring of equipment, site inspections and maintenance. Visual inspections of accessible Darlington NGS IAEA equipment were performed at least once per year since 2017 by both OPG and IAEA. In all cases no visible signs of equipment/seal damage or tampering was found.

In the spirit of continuous improvement, annual Safeguards self-assessments have been completed by OPG since 2016. The self-assessments identified minor areas for improvement and created actions to address them to keep standards high. In all instances, the self-assessment concluded that the Darlington NGS Safeguards program was healthy, which is expected to continue.

2.13.5 Import and Export

The scope of the non-proliferation program at Darlington NGS is limited to the tracking and reporting of foreign obligations and origins of nuclear material. Import and export of controlled nuclear substances, equipment and information as identified in the Nuclear Non-proliferation Import and Export Control Regulations, is not currently permitted under the Darlington NGS site licence and any application is made in accordance with applicable regulations.

Section 2.14

Packaging & Transport

2.14 Packaging and Transport

Darlington NGS has an effective packaging and transport program that meets or exceeds all applicable regulatory requirements and related objectives. Packaging and transport of nuclear substances are conducted safely.

The program document, W-PROG-WM-0002, *Radioactive Material Transportation* (RMT), establishes the program and necessary controls for safe, regulatory compliant and efficient transportation of radioactive material at OPG. The RMT program establishes procedures for the handling, packaging, shipment, and receipt of radioactive materials. The program also addresses emergency response to transportation accidents. OPG's response in the event of a transportation accident involving radioactive material is documented in N-STD-RA-0036, *Radioactive Material Transportation Emergency Response Plan*.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 22: SCA 14 – Packaging and Transport

Document	Title
W-PROG-WM-0002	Radioactive Material Transportation
N-STD-RA-0036	Radioactive Materials Transportation Emergency Response Plan

2.14.1 Package Design and Maintenance

OPG controls the design of its radioactive materials packagings and performs maintenance on the packagings to ensure compliance with the *Packaging and Transport of Nuclear Substances Regulations* (PTNSR).

Each OPG radioactive materials transportation packaging (with the exception of one-time use packagings) is subject to an annual maintenance outage. Packaging maintenance is performed in a dedicated facility - the Transportation Package Maintenance Building at the Nuclear Sustainability Services (NSS) - Western Waste Management Facility.

Each packaging is maintained in accordance with a packaging-specific procedure. Maintenance tasks include disassembly of major components, visual inspections of critical features and components such as fasteners, and replacement or refurbishment of worn parts. The containment system of each Type B or Type A packaging is tested to ensure its effectiveness.

Modifications to OPG's existing radioactive materials transportation packagings are a rare occurrence due to the maturity of the designs. Although several of OPG's packagings are greater than 15-years old, all packagings have been maintained in good condition without any reduction in safety or operability.

An improved version of the OPG Trillium Transportation Package, designated as Trillium TP-03, will be added to the OPG fleet in 2025 to increase the fleet's capacity to transport spent ion exchange resins and intermediate level waste from the Darlington, Pickering, and Bruce Power stations. The design of the Trillium TP-03 was developed in accordance with OPG's *Design Management* (N-PROG-MP-0009) and *Engineering Change Control* (N-PROG-MP-0001) programs.

OPG plans to update its Type B package safety analysis reports, the associated CNSC design approval certificates, and lower category regulatory compliance reports to demonstrate compliance with the International Atomic Energy Agency *Regulations for Safe Transport of Radioactive Material, 2018 Edition* by 2027.

2.14.2 Packaging and Transport Program

The objective of the RMT program is to ensure that shipments of radioactive material for which OPG is the consignor are prepared and offered for transport in a manner that is compliant with the *Transportation of Dangerous Goods Regulations* (TDG) and the PTNSR. The RMT program also establishes the necessary
controls for safe and compliant transportation and handling aspects of radioactive material within OPG's control where OPG is the consignee or when OPG Class 7 carriers are used. This is done to ensure the safety of workers, the public, and the environment.

The RMT program is owned by the Low & Intermediate Level Waste Operations and RMT department within the NSS division of OPG. The overall structure of the program is defined in W-PROG-WM-0002. As per this document, it is the responsibility of the station organization *"to ensure that radioactive shipments are characterized, classified, packed, shipped, and received in accordance with approved procedures and applicable regulations."* To ensure regulatory compliance, NSS issues and maintains a set of procedures and instructions that provide information on the correct means of handling, loading, and offering of radioactive material for shipment, including W-PROG-WM-0002, W-PROC-WM-0033, *Radioactive Shipments* and W-PROC-WM-0040, *Type A and Less Package Receiving, Handling and Shipping*.

The TDG regulations require that anyone who handles (i.e., loads, unloads, receives, classifies or ships) radioactive material in preparation for transport must be adequately trained or under the direct supervision of someone who is. Within OPG, evidence that an employee is adequately trained for their function is demonstrated by holding a valid Class 7 Certificate of Training issued by the RMT section. To meet their responsibilities to the RMT Program, each work group must maintain an adequate complement of trained Class 7 Handler/Receivers and Class 7 Shippers. Each work group must receive sufficient oversight from their line management to ensure compliance with RMT procedures. In addition, all Type A or Type B radioactive shipments and shipments requiring a Licence to Transport must be approved by an RMT Transportation Officer prior to leaving site.

There have been hundreds of radioactive material shipments to and from the Darlington NGS site during the current licensing period and none have been involved in any accidents or any other dangerous occurrences.

2.14.3 Registration for Use

Users of Type B packages must register with the CNSC and acknowledge that they have the necessary instructions to properly prepare the package for shipment. The objective of the user registration process is to ensure that OPG applies for and obtains confirmation from the CNSC that OPG has been registered as a user for the package of certified design. OPG's process for registration for use of packages of certified design is specified in W-PROC-WM-0006, *Radioactive Materials Transportation Records*.

Currently OPG is a registered user for 11 different package designs. These packages include OPG's intermediate level waste and tritiated heavy water transportation packages, and packages from external agencies and companies for used fuel samples, Cobalt-60, and Molybdenum-99. OPG has never used a package of a certified design without being a registered user.

3.0 Facility-Specific Information

This section highlights the facility-specific information associated with Darlington NGS Power Reactor Operating Licence (PROL) 13.03/2025.

3.1 Tritium Removal Facility

The Tritium Removal Facility (TRF) and Heavy Water Management Building (HWMB) reduces the tritium content of heavy water inventories for Darlington NGS and all Ontario CANDU reactors. This is accomplished through distillation, ion exchange and particulate filtration as well as extraction and immobilization of the tritium isotope for storage in a secure vault. The reduction of tritium reduces the radiation dose to OPG personnel and minimizes the tritium emissions to the environment. The facility also maintains isotopic purity requirements for heavy water at Darlington NGS. Maintaining isotopic purity of heavy water helps with the fission process by slowing down neutrons and therefore optimizing fuel burn-up.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 23: Tritium Removal Facility

Document	Title
NK38-OPP-03600	Darlington Nuclear Operating Policies and Principles
D-INS-39000-10003	TRF Planned Outage Management
N-PROG-AS-0008	Heavy Water Management Plan

Since 2015, the TRF has removed approximately 157.5 million Curies (5.81e+18 Bq) of tritium. During the current licence term, several initiatives were completed to improve and ensure continued detritiation capability:

- The HWMB (West Annex) was commissioned and placed into service, increasing OPG's heavy water storage capacity by 1900 Mgs. The addition of this facility allows for flexibility with refurbishment, Pickering end of commercial operation/refurbishment activities as well as support for Bruce Power's Major Component Replacement activities.
- Wet scrubbers were placed into service. The function of a wet scrubber is to remove tritiated water vapour from an air stream. Key indicators of success include:
    - The HWMB wet scrubber reduced the tritium emission during the Unit 1 moderator drain by 95% compared to the previous Unit 3 drain without the scrubber.
    - The recombiner wet scrubber reduced the tritium emission by 80% during the 2023 TRF outage during warm up activities of the high tritium distillation and low tritium distillation columns.
- The cryogenic refrigeration compressor conditioning monitoring system was put into service. This will allow time between cryogenic refrigeration system-only outages being extended from 10,000 hours to 15,420 hours. The main purpose of the cryogenic refrigeration system is to provide refrigeration to maintain the distillation processes.

- A helium-3 tool was commissioned and placed into service. This allows the harvesting of stored immobilized tritium containers for helium-3 which is an inert decay product of tritium. In addition to eliminating tritium as a waste by product, helium-3 is anticipated to be a valuable input to the fusion industry and has uses, today, in Magnetic Resonance Imaging, super-cooling systems that support quantum computing, and border security to detect radioactive materials. OPG produces one third of the global supply.
- In 2021, the detritiation factor returned to the design value as a result of the use of deep evacuations to remove impurities in the cryogenic refrigeration system. As a result, the TRF is able to process an increased volume of water.
- The 2023 TRF outage was executed event free and ahead of schedule using lessons learned from the 2021 outage.
- The health of the heavy water program allowed a timely response to an Industry peer's unit transient and support their return to service. OPG coordinated and supplied a total of ~78 Mg of D2O in drums within a 2-week window.

The TRF team is developing and supporting plans for Pickering Units 1 & 4 end of commercial operation and Units 5-8 refurbishment.

A decision to extend the TRF operation through 2060 has been made to align with Darlington NGS operations. Reliability improvements and life extension activities will be incorporated into each planned TRF outage.

A major component replacement project team has been established and initial scopes of each proposed refurbishment outage from 2026 onward have been developed. The six refurbishment outages will begin in 2026 to 2038 with an estimated duration of 6 to 10 months each. These outages will address equipment reliability, redundancy and maintainability. Planned improvements include:

- Hydrogen compressor replacement.
- Cryogenic refrigeration system turbine oil skid system replacement.
- Low pressure service water line replacement.
- Fisher bellows valve replacements (~76 valves).
- Auxiliary system improvements (i.e. drain and purge, tritium immobilization).
- TRF simulator – the current simulator is task based and not all scenarios contain the cryogenic physics required to allow for live plant manipulation. A $1.5M investment is being made into the simulator to improve physics and allow for improved initial and continuing training as well as a more realistic means of practicing first of a kind evolutions.

3.2 Refurbishment

The Darlington NGS refurbishment project is a multi-year, multi-phase, project that is enabling Darlington NGS to continue safe and reliable operation through 2055. The project includes the replacement of life-limiting critical components, the completion of upgrades to meet regulatory requirements, and the rehabilitation of components in Darlington NGS's four units.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 24: Refurbishment

Document	Title
NK38-NR-PLAN-09701-10001, Sheet: 0003	Darlington Refurbishment Return to Service Program Management Plan
NK38-INS-09701-10006	Nuclear Refurbishment Unit Readiness for Service
N-PROC-MP-0090	Engineering Change Control Process

Progress to date (Figure 32):

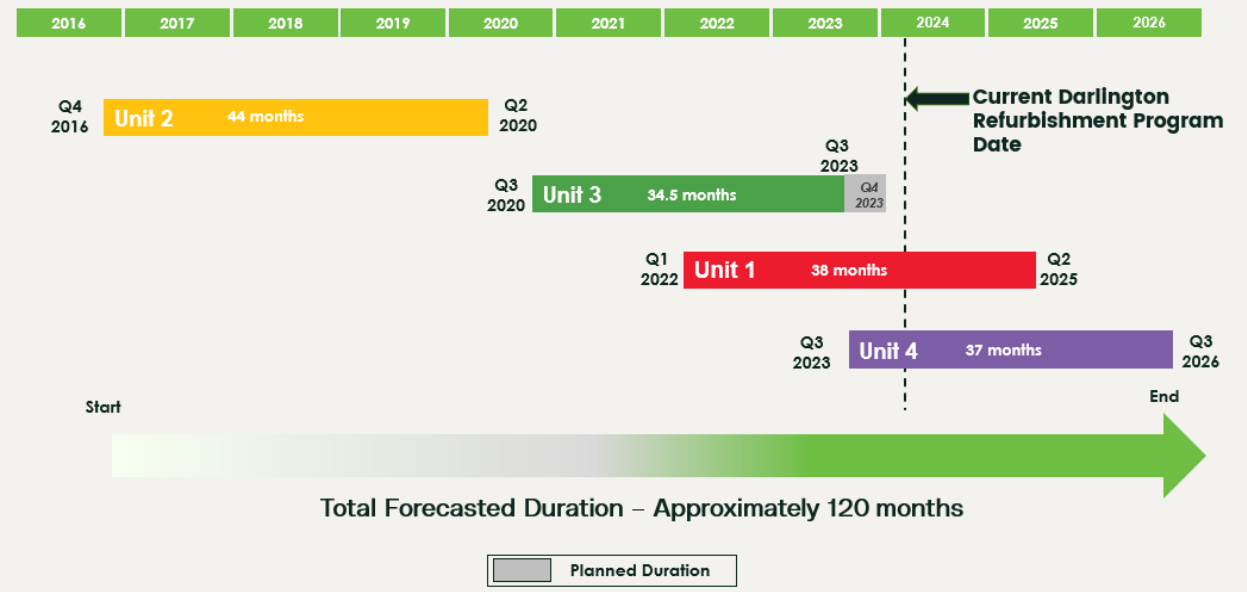


Figure 32: Refurbishment Progress

Two of the four units have been refurbished and returned to service:

- Unit 2 was successfully returned to service on June 4, 2020. Completion of this first unit represented a significant achievement for the project and provided considerable experience and lessons learned for the subsequent units.
- Unit 3 was successfully returned to service on July 17, 2023. Overall, Unit 3 was completed with marked performance improvements and efficiencies versus Unit 2 with a 56% reduction in Medically Treated Injuries, 36% reduction in Collective Radiation Exposure and 43% reduction in quality events. Other highlights are included in Figure 33:

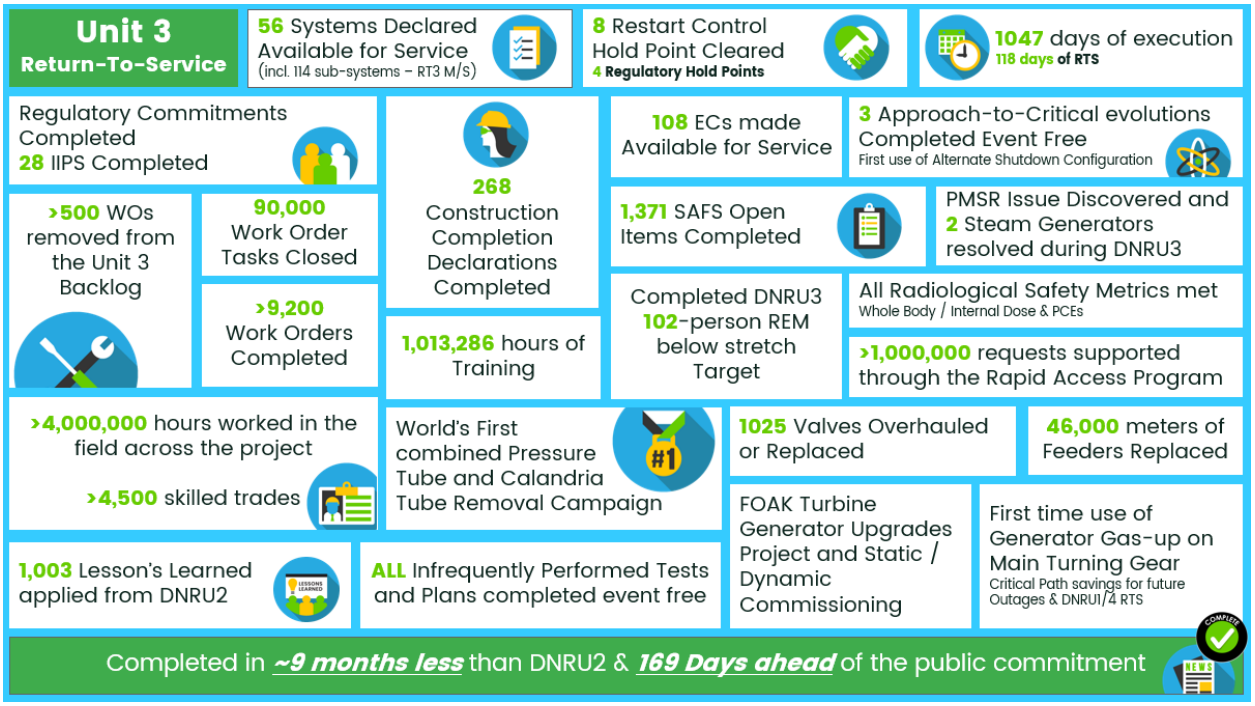


Figure 33: Unit 3 Return-To-Service

- Unit 1 refurbishment activities are progressing, currently in the final segment, which involves loading fuel, tieing the unit back to station containment and final unit start-up and reactor physics testing. This final segment is progressing as planned, with fuel load targeting completion in Q2 2024. Overall, Unit 1 is on track to be returned to service in Q2 of 2025.
    - Restart Control Hold Point (RCHP) 1 of 8 was completed on December 20, 2023, and was shortly followed by the refill of the Moderator System in late December 2023.
    - The second RCHP was completed on April 29, 2024. This also marks the completion of Regulatory Hold Point (RHP) 1 of 4, a significant milestone in the return to service process.

- Unit 4 refurbishment commenced on July 19, 2023, shortly after the return to service of Unit 3, and is the last of four units undergoing refurbishment at Darlington NGS. Refurbishment activities are progressing on schedule, safely and successfully with completion of the defueling of the reactor in September 2023. The unit is progressing through the disassembly segment (2nd segment), forecasting completion in Q3 2024, and the overall schedule is on track to be returned to service in Q3 of 2026.

3.2.1 Major Projects and Improvements

While the primary focus of refurbishment is the replacement of the reactor core components, there has also been a considerable number of initiatives and improvements completed to ensure Darlington NGS's continued safe operation. These improvements are outlined in the Integrated Implementation Plan (IIP) and focus on enhancing the station's safety and reliability.

The IIP presents the scope and schedule for the implementation of actions resulting from environmental assessments, integrated safety reviews, addressing code gaps, component condition assessments, and integrated aging management programs. Overall, 541 of 622 of the IIP refurbishment and continuing operation commitments have been completed up to Q1 2024.

Key station improvements that have been implemented includes (but not limited to):

- Fuel channels, feeders, calandria tubes, and end fitting replacements: the full scope of this project includes replacement of fuel channel and calandria tube assemblies, feeders, feeder cabinet insulation, and instrumentation tubing associated with the feeders. Design improvements have also been incorporated to the feeder material and bend fabrication as the original design exhibited susceptibility to Flow Accelerated Corrosion, a known degradation mechanism.
- Auxiliary Shutdown Cooling (ASDC): installation of two completely diverse auxiliary shutdown cooling pumps per unit. These pumps serve as backup to the main shutdown cooling pumps to protect against common cause failures. The two ASDC pumps and their support services are independent, diverse, and physically separated from the main SDC pumps.
- Replacement of the Shutdown System (SDS) trip computers: the current SDS trip computers relied on older technology that was becoming increasingly difficult to maintain, and spare parts availability was limited. The new computers retain much of the existing software and the core functionality of the current system, including trip setpoints and trip timing but also improves human-user interface and human factors considerations.
- Replacement of In-core Flux Detectors: the Reactor Regulating System (RRS) in combination with the Liquid Zone Control is required to monitor and control the bulk and spatial neutron flux power distribution. This project has involved the replacement of aged Flux Detectors for SDS1, SDS2 and RRS in each unit based on performance indicators to ensure flux tilt is within limits.
- Implementation of a Containment Filtered Venting System (CFVS): this system provides controlled and filtered emergency venting of the containment to prevent over-pressurization and ensure containment integrity. The CFVS minimizes releases to the environment, reduces the content of flammable gases, and filters out radioisotopes with high removal efficiencies.
- Shield Tank Overpressure Protection modification: this modification enhances the relief capacity of the shield tank surrounding each unit's calandria vessel limiting containment over-pressurization.
- Enhancements to the Powerhouse Steam Venting System (PSVS): these enhancements include duplication of the programmable controller logic of the current PSVS to improve reliability and protect plant systems following a steam line break. These modifications are aimed at reducing plant risk and improving operational flexibility.
- Installation of a third Emergency Power Generator (EPG3): this generator is designed to withstand a seismic event greater than the Design Basis Earthquake and increases emergency power reliability when one EPG is not available.
- Implementation of alternate and independent water supply to the Primary Heat Transport (PHT) system: this is achieved through the installation of Emergency Mitigating

Equipment and a permanent line from the Emergency Service Water to the PHT system to act as an emergency heat sink.

- The replacement of the Primary Heat Transport Liquid Relief Valves: this modification addresses valve opening and closing times to eliminate water hammer effects while maintaining overpressure protection requirements.
- Upgrades to the Turbine and Generator Controls: the work scope includes replacement of analogue Steam Turbine Electronic Controls system, with a dual or triplicated redundant digital control system and provisions of generator rotor monitoring. Replacement of the entire Turbine Supervisory System and the installation of a full scope maintenance simulator.
- Main Output Transformers (MOTs) and Unit Service Transformers (USTs) Replacements: the original MOTs and USTs had been in service for over 25-years and OPG has been completing proactive replacements due to obsolescence of spare parts and aging. In conjunction with these replacements, the original deluge systems is being replaced with improved designs to meet new fire protection requirements. The new deluge system includes replacement of legacy piping and supports and extending sprinkler coverage.

These projects have been undertaken to enhance the reliability and safety of Darlington NGS, ensuring its continued safe operation.

3.2.2 Conventional Safety Performance

Safety is a top priority for OPG. OPG has one of the lowest injury rates in the Canadian electricity sector. In order to maintain this excellent safety performance, OPG continues to set challenging targets for its day-to-day operations. At the end of Q1 2024, the Program reported a Total Recordable Injury Frequency (TRIF) of 0.21 against its internal target of 0.40, reflecting three medically treated injuries in Q1 2024.

OPG sets very challenging targets for all aspects of its operations and the Program. This expectation has resulted in a Program safety performance that is significantly better than the overall construction industry average as illustrated in Table 25, below. As of Q1 2024, the Program is approaching over 53 million hours worked with one Lost Time Injury, which occurred in May 2019. OPG employs a variety of leading indicators to ensure that issues are addressed before incidents occur. OPG's practice of proactively tracking events/safety incidents where no injuries occur, but where there is potential for harm, is one example of a leading indicator. OPG carefully logs and reviews each of these incidents and implements corrective actions to reduce the likelihood of future incidents. Additionally, a Quality of Safety Practices (QSP) metric was implemented in 2023 as a monitoring metric to assess safety practices in real time. The QSP metric score is calculated by using Observation and Coaching (O&C) data related to high-energy hazards based on the percentage that meet or exceed expectations compared to all high-energy hazard O&Cs. In addition, the Safe Work Planning Assessment (SWPA) is being piloted to assess the quality of direct controls implemented to address high-energy hazards within safe work plans. The implementation of the SWPA is expected by the first quarter of 2024.

Table 25: Conventional Safety Performance (includes OPG and Vendor)

Historical Actuals										IHSA[2]
Measure	**OPG Target**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**Ontario Construction Industry 2023**
TRIF[1] (Total Recordable Injury Frequency)	0.40	0.64	0.49	0.39	0.52	0.35	0.25	0.29	0.19	4.24
Lost Time Injuries	0	0	0	0	1	0	0	0	0	N/A

Notes:
1. TRIF is the average number of fatalities, Lost Time Injuries, medical treatment injuries and restricted work injuries per 200,000 hours worked.
2. Infrastructure Health & Safety Association (IHSA) rating is the most current safety rating for the Ontario Construction Industry (current as of 2023 year-end).

3.2.3 Radiological Safety Performance

OPG's Radiological Protection (RP) program continues to meet regulatory requirements and industry standards. All workers are in compliance within regulatory dose limits and OPG's more stringent internal targets. OPG's dose performance is industry leading. This performance is a result of OPG's robust nuclear safety culture and OPG's *As Low as Reasonably Achievable* (ALARA) radiological safety principles. Lessons learned on Unit 2 and Unit 3 have been incorporated into training and enhanced radiological safety measures on Unit 1 and Unit 4. The Program's ALARA committee continues to monitor and challenge RP performance to ensure ALARA principles result in lower doses to workers.

Table 26 provides a summary of the radiological safety performance and includes both OPG and vendor employees. The statistics are specific to Refurbishment only. Due to the nature of the work, such as reactor component replacements, a higher person-mSv dose is expected compared to the Station statistics. The actual dose remains lower than the forecasted targeted dose, representing a lower radiological exposure.

Table 26: Radiological Safety Performance

	2021 Year End		2022 Year End		2023 Year End	
	Actual	**Target**	**Actual**	**Target**	**Actual**	**Target**
Unit 3 Collective Radiation Exposure (person-mSv)	10280	13790	3370	6330	550	950
Unit 1 Collective Radiation Exposure (person-mSv)	N/A	N/A	7220	9840	4751	5000
Unit 4 Collective Radiation Exposure (person-mSv)	N/A	N/A	N/A	N/A	4269	4750

3.2.4 Quality Performance

Refurbishment of the Darlington NGS units involves many thousands of removal and installation activities, which are required to be executed with a high degree of precision. Many of the

installation activities involve precision fit tasks and highly technical welding. The quality management program is used to identify issues during refurbishment execution by focused surveillance of vendor performed work.

Incorporation of lessons learned has improved industrial and radiological safety, tooling, schedule management, organizational alignment, enhanced safety and Foreign Material Exclusion planning and oversight. A culture of continuous improvement has resulted in the collection and implementation of lessons learned and continues to drive performance in Unit 1 and Unit 4 return to service. The most significant improvement elements from Unit 3 include Operational Transfer Plans, and Refurb Outage Control Centre Change Management.

3.2.5 Collaboration

In 2015, long-term agreements were made to revitalize Ontario's nuclear feet at both OPG and Bruce Power to ensure the Province has the reliable baseload power it needs. Throughout these projects, our focus on collaboration has led to the sharing of lessons learned, innovations, resources, and tooling and equipment, resulting in more efficient and successful projects for both companies (Figure 34).

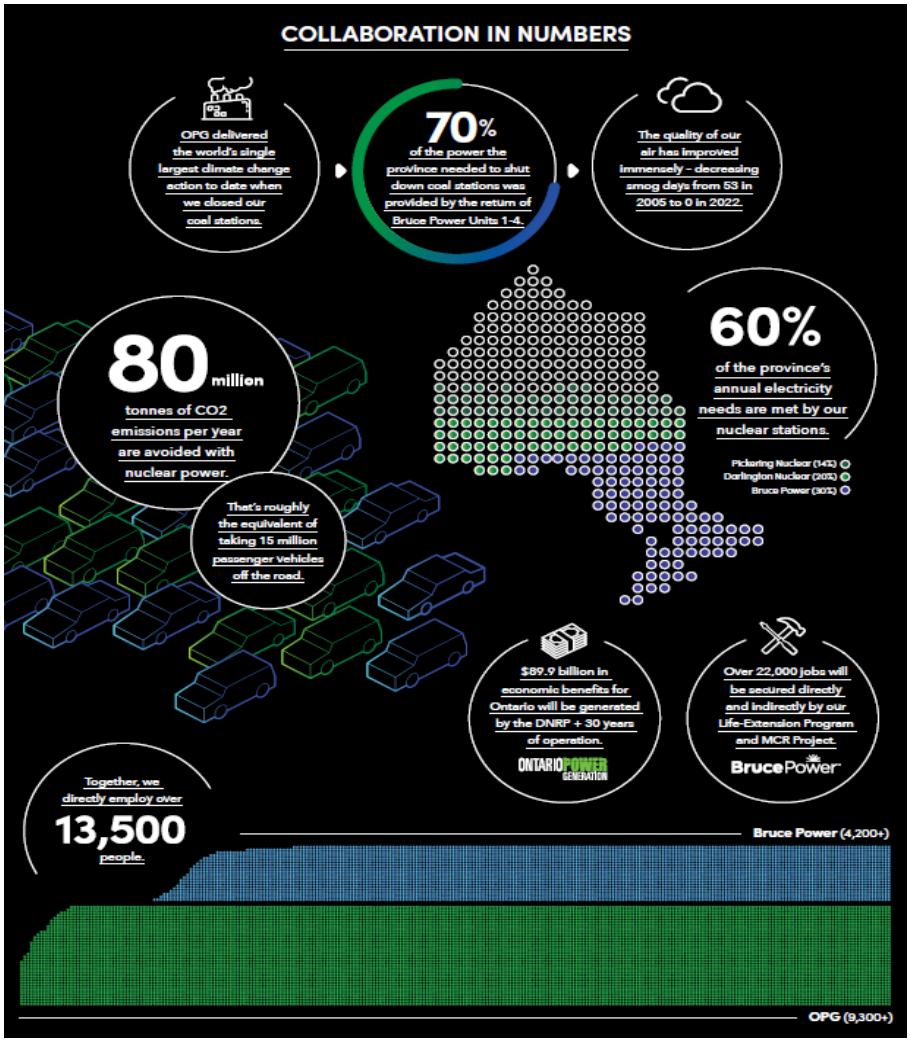


Figure 34: Collaboration in Numbers

3.2.6 Recognition

The refurbishment project continues to garner significant external attention. Numerous requests for visits and/or tours of Darlington NGS and the Retube and Feeder Replacement Mock-up and Training Facility at the Darlington Energy Complex, as well as invitations to speak/present on a wide range of project-related topics.

The following organizations visited Darlington NGS for primary benchmarking purposes to gain insight into improvement opportunities:

- CNCAN Romania;
    - Focus on best practices, return to service protocols, Lessons Learned/Enterprise Business Extensions and Cable Surveillance Program Human Performance.
- Emirates Nuclear Energy Corporation;
    - Focus on overall Refurbishment structure and execution.
- EDF Energy;
    - Focus on overall Refurbishment structure and execution.
- KHNP Korea Nuclear Research Institute;
    - Focus on development and deployment, operations and maintenance, Operator training, commissioning and regulatory support.

3.2.7 Next Steps – Return-to-Service

Return-to-Service Protocol

Return-to-Service (RTS) involves returning the reactor and associated nuclear and non-nuclear systems to commercial operation. Darlington NGS must demonstrate that all regulatory requirements have been met and that the associated work has been completed to the satisfaction of the CNSC through an RTS protocol which establishes the administrative process to be used to clear the following four RHPs:

- RHP 1: Prior to fuel load;
- RHP 2: Prior to Guarantee Shutdown State removal;
- RHP 3: Prior to exceeding 1% full power; and,
- RHP 4: Prior to exceeding 35% full power.

Each of these hold points require regulatory verification to confirm operational readiness of the plant safety systems to satisfy regulatory requirements for staged progress through the commissioning phases up to full power operation. A completion assurance document is the deliverable presented to the CNSC when seeking approval to release an RHP. It provides evidence of the completion of commitments required to support the release of the hold point.

The RTS Program Management Plan, NK38-NR-PLAN-09701-10001, Sheet: 0003, *Darlington Refurbishment Return to Service Program Management Plan* describes the processes, procedures, and organization that will be used during the Darlington NGS Refurbishment Project to manage the modification and restart activities. This plan identifies eight internal

Restart Control Hold Points (RCHPs) that will be the focus of the run-up activities leading up to full power and unit availability for commercial operation.

Unit 1 RTS

Completion of 51 Systems Available for Service (SAFS) declarations will support RTS and the removal of each of the eight RCHPs milestones, including four RHPs. In 2023, 14 SAFS were completed in support of clearing the first RCHP and to permit the refilling of the Moderator System. The refill of the Moderator System was completed in Q4 2023. Upon the completion of eight SAFS in Q1 2024, the second RCHP was achieved in April 2024, followed by the first Regulatory Hold Point. This marks a significant milestone as the RTS activities progress in 2024.

Unit 4 RTS

Completion of 51 SAFS declarations is planned and will support RTS and the removal of each of the eight RCHPs, including four RHPs. The refurbishment of Unit 4 began on July 19, 2023, and RTS activities are scheduled to begin in 2025.

3.3 Periodic Safety Review (PSR)

The Darlington Periodic Safety Review (D-PSR) was completed in accordance with Licence Condition 3.4 of Darlington NGS PROL 13.03/2025. The D-PSR is a subsequent review which builds on previous OPG Integrated Safety Review (ISR)/PSR work such as: (1) the Pickering PSR2 (programmatic components applicable to Darlington NGS) and (2) the Darlington NGS ISR, performed in support of refurbishment and life extension. The D-PSR was conducted in accordance with the D-PSR Basis Document, NK38-REP-03680-11844, *DNGS Periodic Safety Review Basis Document*, and the requirements of CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*. The planning basis for the D-PSR covers the period of operation of Darlington NGS units from November 2025 to November 2035.

As per REGDOC-2.3.3, the D-PSR was conducted in four phases:

1. Preparation of the D-PSR Basis document.
2. Conduct of safety factor reviews and identification of gaps and strengths.
3. Analysis of the gaps and identification of potential safety enhancements for Darlington NGS in the global assessment process; and,
4. Preparation of a plan for the implementation of safety enhancements.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 27: Integrated Implementation Plan

Document	Title
N-INS-03680-10001[1]	Darlington NGS Integrated Implementation Plan (IIP) Change Control and Closeout Process

Notes:
1. N-INS-03680-10001 has been superseded by N-PROC-MA-0109, *Periodic Safety Review (PSR)*.

3.3.1 D-PSR Basis Document

The first phase of the D-PSR process was the development of the D-PSR basis document, NK38-REP-03680-11844, for acceptance by the CNSC. The D-PSR Basis Document defined the approach for completing the D-PSR, specifically the:

- Proposed operating strategy of the facility.
- Scope and methodology, including conduct of safety factor reviews and identification of compliances and gaps.
- Process for categorizing, prioritizing, tracking and resolving gaps arising from the Safety Factor reviews.
- Conduct of the global assessment.
- Methodology for developing the Integrated Implementation Plan (IIP).
- Applicable current versions of Laws, Regulations, Codes and Standards (LRCSs).
- Major milestones, including the freeze date for document revisions; and,
- Project management and quality management processes to be followed.

3.3.2 Safety Factor Reviews

The second phase of the D-PSR process was the completion of safety factor reviews. Safety factor reviews cover all aspects important to the safety of an operating nuclear power plant. In accordance with REGDOC-2.3.3, there were 15 Safety Factors used in the D-PSR review, as shown in Table 28 below:

Table 28: Safety Factors

Subject Area	Safety Factor	
The Plant	SF1	Plant Design
	SF2	Actual Condition of Structures, Systems and Components Important to Safety
	SF3	Equipment Qualification (Environmental and Seismic)
	SF4	Aging
Safety Analysis	SF5	Deterministic Safety Analysis
	SF6	Probabilistic Safety Analysis
	SF7	Hazards Analysis
Performance and Feedback from Operating Experience	SF8	Safety Performance
	SF9	Use of Experience from other NPPs and Research Findings
Management	SF10	Organization, the Management System and Safety Culture
	SF11	Procedures

Subject Area	Safety Factor	
	SF12	Human Factors
	SF13	Emergency Planning
Environment	SF14	Radiological Impact on the Environment
Radiation Protection	SF15	Radiation Protection

The results of the safety factor reviews were documented in 15 safety factor reports which address the review tasks derived from REGDOC-2.3.3 and document the results of the assessments of Darlington NGS with respect to applicable modern LRCSs and OPG program effectiveness reviews. The safety factor reports were submitted to the CNSC for review and included the:

- Scope of the review.
- Applicable elements of the D-PSR assessment basis (review tasks and applicable LRCSs).
- Review methodology.
- Assessment of compliance with review tasks.
- Effectiveness review of OPG programs supporting compliance assessments.
- Review findings (compliances, strengths, gaps and improvement opportunities).
- Impacts on other safety factor reviews (interdependencies); and,
- Overall assessment of the safety factor.

3.3.3 Global Assessment

The third phase was the global assessment which provided an overall evaluation of the safety of the plant and assessed the acceptability of Darlington NGS for continued operation over the period of the D-PSR.

The global assessment process consists of the following elements:

a) *Identification and consolidation of Gaps and Strengths from the Safety Factor Reports:* The strengths and gaps from the 15 safety factor reports and CNSC findings were consolidated and grouped by topic area to support the global assessment.

b) *Development of Global Issues:* Gaps of a common nature were consolidated into global issues to facilitate the assessment of safety impact and to identify and assess practical and effective resolutions. The global issues were tabularized, tracking sources of the issues, to facilitate further review and assessment.

c) *Assessment of the interfaces between various Safety Factors and aggregate impact of Global Issues:* The aggregate impact of the global issues was assessed and the interaction between the issues was identified. New global issues were also identified as part of this consolidation review, where applicable.

d) *Prioritization of Global Issues and Gaps:* D-PSR global issues and associated gaps were prioritized with respect to their importance to nuclear safety to determine the safety significance level associated with each global issue. This supported the resolution

evaluation method and the outcome of the resolution process. This methodology is consistent with OPG prioritization processes used in previous ISRs, PSRs and industry practice. The safety significance level considered deterministic and probabilistic safety analysis impact, as appropriate. Probability levels selected for delineation between categories were based on significance, as applied in previous ISRs and PSRs. These values account for overall safety impact and align, where appropriate, with requirements and limits in relevant safety standards. The relationship between safety significance level and impact on nuclear safety is shown in Table 29 below:

Table 29: Safety Significance Level and Impact on Nuclear Safety

Safety Significance Level	Impact on Nuclear Safety
1	High
2	Medium
3	Low
4	Very Low

e) *Development of Resolutions/Dispositions of Global Issues and Gaps:* Resolution options were developed and assessed using risk informed decision-making techniques. The development of the resolution utilized the following strategy:

- Defence-in-depth elements were considered during the assessment of potential dispositions;
- Overall safety significance guided the resolution process when developing resolutions;
- For global issue resolution, the process was as follows:
    - Evaluate the global issue to understand safety basis and intent of the requirement;
    - Consider possible options for resolution/mitigation. Consider safety significance and defence-in-depth elements;
    - Evaluate options with respect to effectiveness, cost, schedule, practicality. For potential plant modifications, this required an evaluation of the safety impact, both deterministic and probabilistic. If it was not practicable to fully resolve a global issue, other mitigation options were considered for enhancements.
    - Evaluate the practicality of a proposed resolution in terms of cost, resources, schedule, and relation to the overall safety impact;
    - Propose recommended resolution/mitigation;
    - Document the decision-making process.
- Items of high or medium impact on nuclear safety (safety significance Levels 1 and 2) required a more in-depth analysis to clearly establish the issue and potential impact, and to develop the proposed recommended resolution/mitigation.
- Items of very low impact on nuclear safety (safety significance Level 4) were generally deemed acceptable deviations, and while these items were not tracked

beyond the global assessment, they were shared with the accountable organizations for consideration as potential enhancement initiatives for future work program planning purposes. A similar treatment was applied for items of low impact on nuclear safety (safety significance Level 3) for which a practicable solution was not readily evident.

- Proposed resolutions were categorized as i) programmatic (changes to procedures and programs), ii) engineering (plant modifications or maintenance), or iii) analytical (e.g., safety or hazard analysis), to facilitate binning of potential work. In some cases, the proposed resolutions entailed work from more than one of these categories.
- In some cases, the development of resolutions/dispositions to the global issues was part of an OPG or industry initiative currently underway or planned. The resolution and development of options required more detailed analysis and assessment, extending beyond the timelines for submission of D-PSR. In these instances, the status of the initiative and plans were included in the disposition. The work was included in the global assessment to facilitate continued tracking.
- Where a global issue/gap was closed, due to work done in the interim or for other reasons, the rationale was documented, and the global issue/gap was set to resolved and closed.

f) *Assessment of Defence-in-Depth and aggregate impact of Acceptable Deviations:* After evaluating a range of resolutions for global issues, and determining a recommended resolution, the impact on defence-in-depth, considering both deterministic and probabilistic elements, was evaluated to assess the aggregate impact on overall safety. This overall assessment was an important element in supporting the enhancement plans and the planned operational strategy over the period of the D-PSR. For each of the five levels of defence listed below, the defence-in-depth Assessment considered the overall plant as well as the identified strengths, acceptable deviations, and the proposed resolutions to the global issues listed in the global assessment.

Level 1: Prevention of abnormal operation and failures;

Level 2: Control of abnormal operation and detection of failures;

Level 3: Control of accidents within the design basis;

Level 4: Control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of severe accidents;

Level 5: Mitigation of radiological consequences of significant releases of radioactive materials.

g) *Ranking Global Issues:* All global issue resolution statements were ranked from 1 through 35, in accordance with overall safety significance. The ranking considered factors such as the priority previously determined (i.e., safety significance level), the contribution to defence-in-depth, the source of the issue and the degree of non-compliance with the D-PSR assessment basis.

h) *Expert Panel and OPG Senior Management review of proposed Resolution Statements:* The results of the global assessment were reviewed by a panel of industry experts independent of the global assessment team. The enhancements identified in the D-PSR Global Assessment Report (GAR), with their priority and safety basis, were then

presented to OPG Senior Management for approval. This review ensured alignment with the proposed resolutions, their basis and context, and is the means to obtain concurrence that the proposed enhancements are practicable and effective. This also allowed the senior management team to consider potential realignment of overall priorities based on the insights from the D-PSR.

i) *Assessment of overall acceptability of operation of the plant over the period considered in D-PSR:* As a final step in the assessment process, the team assessed the overall acceptability of operation of the plant over the period considered in D-PSR. This entailed a review of the results of the safety factor reviews, a consideration of enhancements planned (both newly identified in D-PSR and from other station plans) and a consideration of plant performance and initiatives underway.

j) *Preparation of the Global Assessment Report:* Preparation of the GAR was conducted to summarize the assessments and document the global assessment.

The results of the global assessment are documented in the D-PSR GAR, NK38-REP-03680-11938, *Darlington NGS Periodic Safety Review (D-PSR): Global Assessment Report*, which was submitted to the CNSC for review. The GAR presents the results, assesses the overall defence-in-depth of the plant, and documents the conclusions, corrective actions, and enhancements to be considered. It includes a ranked list of the global issues with identified actions, with rationale for the ranking using an established decision support methodology. Residual global issues and acceptable deviations are noted in the GAR, summarizing the assessed aggregate impact on safe operations. However, these items are not tracked further beyond the GAR or carried forward into the Integrated Implementation Plan (IIP). The GAR includes a statement of OPG's assessment of the overall acceptability of operation of the plant. Reviews and approval of the report were conducted as required under the OPG management system.

3.3.4 Integrated Implementation Plan

The fourth and final phase was the preparation of the IIP, which involved transforming the proposed resolution statements resulting from the global assessment into Resolution Actions with supporting IIP Actions. The IIP Actions described in NK38-REP-03680-11940, *Darlington NGS Periodic Safety Review (D-PSR): Integrated Implementation Plan,* include initiatives derived from the safety factor reviews and the GAR and existing initiatives that were integral to the overall assessment. The initiatives summarized in the IIP were mapped to the CNSC Safety and Control Areas as per REGDOC-2.3.3.

The IIP includes a schedule that is established to manage the completion of the resolution actions, and the supporting IIP Actions, with baseline target completion dates, progress reporting requirements, and plan risk management for the period of the D-PSR. The IIP includes a tabularized listing of the safety enhancement initiatives, their assigned owners, and their planned implementation date. The IIP was accepted by the CNSC in March 2024 (Reference 3.3-1).

A structured oversight organization is in place to assign accountability for the overall IIP and IIP Action ownership, and to ensure that the IIP phase is resourced to mitigate risks and enable program success. An action tracking and management system is in place for OPG and Regulatory Oversight to ensure actions are completed per the baseline schedule. The reporting, completion, change management, and close-out of the resolution and IIP actions are managed through the PSR process per N-PROC-MA-0109, *Periodic Safety Review (PSR)*.

3.3.5 D-PSR Results

Through the safety factor review process, 99 D-PSR gaps identified from various sources (e.g., safety factor reports and expert panel review) were integrated into the global assessment. These gaps were consolidated and grouped based on topical similarities into 23 global issues. This consolidation facilitated the analysis of interfaces between Safety Factors and the aggregate impact of global issues. Each global issue was prioritized with respect to nuclear safety and assigned a corresponding Safety Significance Level.

Following prioritization, proposed resolution plans were developed for each global issues that identified resolutions to address the associated gaps. Proposed resolution plans were then ranked to determine activities that will be the most effective in enhancing safety of the plant.

Resolution plans proposed for several global issues are already in progress, and many of the global issues Resolution Plan 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. None of the global issues identified an immediate safety concern that requires additional planned or urgent action to be taken outside of the D-PSR process.

A summary of the significance of the 23 global issues is outlined below:

- One global issue related to the replacement of the heat transport system liquid relief valves was assessed to have a high impact on nuclear safety and was therefore 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, NK38-REP-03680-10185, *Darlington NGS Integrated Implementation Plan*, to track the replacement of these valves to completion.
- One global issue related to Aging Management was assessed to have a medium impact on nuclear safety and was therefore assigned Safety Significance Level 2. The Resolution Plan for this global issue leverages existing OPG processes for aging management and the completion of this Resolution Plan will support the continued safe operation of Darlington NGS during the D-PSR timeframe.
- 13 global issues related to specific requirements in modern codes and standards were assessed to have a low impact on nuclear safety and were therefore assigned Safety Significance Level 3. Actions have been identified as part of the applicable Resolution Plan to adopt requirements in modern codes and standards where it is practical to do so in order further align Darlington NGS with modern standards.
- Eight global issues related mostly to OPG governance, specific requirements in modern codes and standards, or administrative gaps were assessed to have a very low impact on nuclear safety and therefore assigned Safety Significance Level 4. Based on their significance, the majority of the gaps associated with these global issues were assessed as acceptable deviations. However, the resolution plans do include actions to address a subset of gaps associated with these global issues, which reflects OPG's focus on continuous improvement.

In addition, as part of the Safety Factor review, 12 Strengths in Darlington NGS design, operations, and performance were identified. The methodology and the list of Strengths were reviewed by an Expert Panel with extensive knowledge of the D-PSR project and the design and operation of Darlington NGS. The Strengths were used in the Defence-in-Depth

Assessment to demonstrate the extent to which the safety requirements of defence-in-depth are fulfilled and to support mitigation of the global issues.

As part of the global assessment, a Defence-in-Depth Assessment was performed which supported extended operation at Darlington NGS by demonstrating the extent to which the safety requirements of defence-in-depth are fulfilled at Darlington NGS. The overall assessment was an important element in supporting the proposed enhancement plans and the planned operational strategy over the period of the D-PSR.

The results of the Defence-in-Depth Assessment were as follows:

- The Defence-in-Depth Assessment confirmed that effective Level 1 barriers are ensured through the original conservative design, supplemented by design improvements implemented since initial operation, comprehensive programs in place 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 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 continues to be strong and effective for Darlington NGS.

- The assessment of Defence-in-Depth Level 2 confirmed that the provisions in place at Darlington NGS are mature and robust. Implementation of measures to ensure compliance with modern requirements for inspections and maintenance, and improvements to the Deterministic and Probabilistic Safety Assessments, further enhance the Level 2 barrier at Darlington NGS.

- The assessment of Defence-in-Depth Level 3 confirmed that effective provisions for the control of accidents within the design basis are provided at Darlington NGS. Operators have indications and alarms, as well as the capability to perform actions from the Main Control Room and Secondary Control Areas, for this purpose. The review confirmed that Darlington NGS has strong Level 3 barriers due to the high quality of the design, supported by a robust set of safety analyses which is further enhanced through the implementation of CNSC REGDOC-2.4.1, *Safety Analysis – Deterministic Safety Analysis*, and best practices from CSA N290.17-17, *Probabilistic Safety Assessment for Nuclear Power Plants*.

- The assessment of Defence-in-Depth Level 4 confirmed that Darlington NGS has additional design features and procedural provisions which are in place and are adequate to address severe accident conditions. Darlington NGS Units 1-4 have complementary design features for Beyond Design Basis Accidents (BDBA). Operating Manuals and Abnormal Incident Manuals include Emergency Mitigating Equipment Guidelines to prevent accident progression. Severe Accident Management Guidelines (SAMG) for mitigating accident progression in the very unlikely event of a BDBA have been implemented. Furthermore, a mature emergency response infrastructure is in place, and the requisite qualified staffing and expertise are maintained. A significant number of improvements have been implemented since initial operation specifically to reinforce Defence-in-Depth Level 4. 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.

- The assessment of Defence-in-Depth Level 5 confirmed that extensive plans and procedures are in place at Darlington NGS to ensure capability and readiness to respond to a nuclear emergency, with the support of a coordinated effort from various response organizations. The implementation of SAMG, post-accident monitoring capability, installation of Containment Filtered Venting System, and implementation of OPEX from Fukushima have also significantly improved the existing robust barriers for the Defence-in-Depth Level 5.

The Defence-in-depth assessment concluded that Darlington NGS Units 1-4 design and operation have effective barriers in all levels of Defence-in-Depth and that significant enhancements have been implemented since the plant was put into service.

Proposed resolution plans were developed to address the 23 global issues with consideration of safety benefit and practicability. The proposed resolution plans for each of the 23 global issues consisted of the following Resolution types:

- Resolution Statement: An activity intended to address the global issues. There were 35 resolution plans categorized as Resolution Statements covering 10 global issues (some global issues had more than one Resolution Statement).
- No Further Action: Activities which had already been completed or had actions already underway outside of D-PSR to address the related GI or where information had been found that addressed the global issues have been categorized as requiring No Further Action within the D-PSR. 21 proposed resolution plans were categorized as No Further Action during the global assessment.
- Acceptable Deviation: The global assessment categorized proposed resolutions as acceptable deviations when it was determined that the proposed resolution had Low/Very Low Safety Significance or when practicable resolutions were not readily evident. 13 proposed resolution plans were categorized as acceptable deviations during the global assessment. There were 209 D-ISR Issues classified as acceptable deviations in the previous ISR, of which 143 acceptable deviations were identified as applicable to D-PSR. In addition, 13 D-PSR Gaps were classified as acceptable deviations. In total, 156 acceptable deviations from D-ISR and D-PSR were considered for their aggregate impact on Darlington NGS design and operation in support of the Defence-in-Depth Assessment.
- Cross-Reference: The global assessment categorized proposed resolutions that were covered by another resolution as Cross-Reference. Five proposed resolution plans were categorized as Cross-Reference during the global assessment.

The global assessment process resulted in 10 global issues that have 35 proposed Resolution Statements with a defined activity. The resolution plans associated with the remaining 13 global issues do not have Resolution Statements and fit into one of the other categories defined above. Resolution Actions were developed by senior industry experts, meeting with responsible OPG area experts, to define completion and success criteria. When complete, these Resolution Actions will address the associated Resolution Statement. Actions were independently reviewed and approved by OPG senior leadership, to ensure that actions would satisfy the completion criteria and success criteria, and that implementation timelines would be met by responsible Action Owners. The Resolution Actions, and their supporting IIP Actions, form the scope of the D-PSR IIP, NK38-REP-03680-11940.

Of the 35 Resolution Statements, 25 have been excluded from the D-PSR IIP because they are either already being tracked in the D-ISR IIP, NK38-REP-03680-10185, covered by an existing action, or were completed following the finalization of the D-PSR GAR. The D-PSR IIP provides the rationale for excluding the 25 Resolution Statements. The remaining 10 Resolution Actions, and the supporting 17 IIP Actions, which define the scope of the D-PSR IIP are scheduled with target completion dates ranging from Q4 of 2023 to Q4 of 2028. The status and progress of the Resolution and IIP Actions is reported to the CNSC annually in IIP progress reports. The latest progress report for the D-ISR IIP, NK38-REP-03680-10185, was submitted in February 2024 (Reference 3.3-2).

3.4 Isotope Irradiation Program

Darlington NGS Power Reactors are utilized to support the radioisotope industry in both the medical and food safety fields.

Darlington NGS Power Reactors' reliability, high neutron flux, online fueling and capacity to produce isotopes in high quantities make power reactors an ideal source of neutrons for large scale radioisotope production. The predictable and reliable nature of Darlington NGS Power Reactors enables dependable supply for isotope markets and provides opportunity to expand offerings to new isotope markets.

OPG, and its family of companies, produce isotopes by leveraging reactor neutrons. The reactor cores are analyzed to be safe in this configuration and processes and procedures are in place to ensure safe handling and hand-off of the resultant isotopes to OPG's strategic partners.

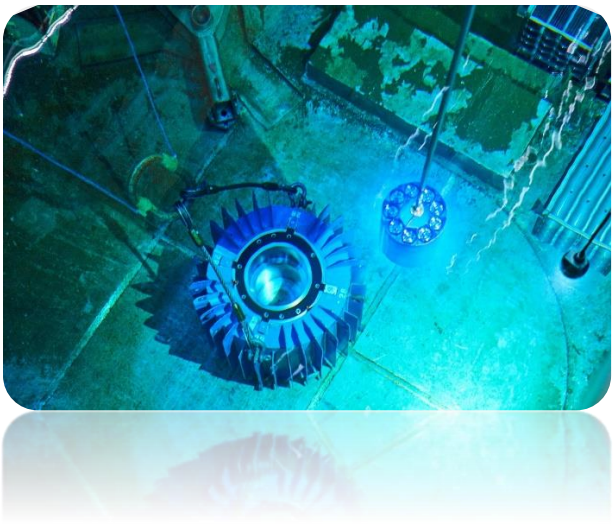
Darlington NGS's support for safe production of isotopes includes the planned production of Cobalt-60 (Co-60), Molybdenum-99 (Mo-99), and Yttrium-90 (Y-90) and there is potential for additional growth in this fast-changing and life-saving field.

Results and Planned Improvements

With scientific advancements in medical and industrial sectors, OPG is investing in innovative technologies to expand isotope production capabilities into valuable resources that benefit our society.

Cobalt-60 (Co-60)

In April 2023, OPG submitted an application to the Commission to amend the Darlington NGS PROL in order to produce Co-60, an isotope used in medical device sterilization and in food production (Reference 3.4-1). About 40% of the world's single-use medical devices, such as syringes, gloves, implants and surgical instruments, are irradiated and sterilized with Co-60. Similar to its use in sterilizing medical devices, Co-60 is useful in sterilization of food products, removing pathogens and parasites. Pending the Commission's decision by summer 2024, Co-60 production is planned to start with the initial harvest expected in 2028.



Molybdenum-99 (Mo-99)

In October 2021, the Darlington NGS PROL was amended to authorize OPG to possess, transfer, process, package, manage and store Mo-99 radioisotope and its associated decay isotopes. As of Q3 2022, OPG completed installation activities during the Unit 2 planned outage following the removal of the two Regulatory Hold Points. In 2024, OPG continues to progress with commissioning activities, with support from its wholly owned subsidiary and its strategic business partner, utilizing the Target Delivery System (TDS) to facilitate production of Mo-99 in Darlington NGS Unit 2. The unique design of the Darlington NGS's CANDU reactors allows for Mo-99 to be harvested from Darlington NGS without interrupting the generation of clean energy. Commercial operation is targeted to commence in Q3 2024 making Darlington NGS the first commercial-scale reactor in North America to produce Mo-99, securing a stable domestic supply of this isotope.

Mo-99 is valuable because its daughter isotope, technetium-99m, is the most widely used radioisotope in the world. It is used in 80% of all nuclear medicine imaging procedures to help diagnose cancer, heart disease and other ailments.

The OPG documents in the table below require written notification of change per Darlington NGS Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 30: Mo-99 Isotope Irradiation Program

Document	Title
NK38-OM-30550	Darlington Operating Manual – Target Delivery System (TDS)
NK38-MMP-30550-13	Target Delivery System Flask Hoisting and Handling Procedure
N-REP-03500-0839983	Integrated Nuclear Safety and Operational Assessment of the Target Delivery System in Darlington

Yttrium-90 (Y-90)

On February 26, 2024, OPG submitted an application to the Commission to amend the Darlington NGS PROL in order to produce the radioisotope Y-90 (References 3.4-2 and 3.4-3). Utilizing the TDS, Y-90 is planned to be harvested from Darlington NGS.

Pending the Commission's decision, Y-90 production is expected to begin by mid-2025 and the irradiated Y-90 will be sent to the vendor's facility to package and distribute to more than 30 countries globally for use in minimally invasive, targeted radiation therapy to destroy cancer cells and shrink tumors.

Overall, the reliability of Darlington NGS's CANDU reactors and expanding the breadth of ways that isotopes can be generated will be a key component to strengthening the radioisotope supply chain for the coming decades.

4.0 Additional Matters of Regulatory Interest

This section addresses the requirements and/or of the following regulations made under the NSCA:

- General Nuclear Safety and Control Regulations, paragraphs 3(1)(l) and (m), and sections 29 to 32;
- Class I Nuclear Facilities Regulations, paragraph 3(j);
- Canadian Nuclear Safety Commission Cost Recovery Fees Regulations;
- CNSC REGDOC-3.2.2, *Aboriginal Engagement*.

4.1 Environmental Assessment

OPG undertook an Environmental Assessment (EA) under the *Canadian Environmental Assessment Act* for the mid-life refurbishment of the four Darlington NGS reactors and continued operation of the plant to approximately 2055, NK38-REP-07730-10002, *Environmental Impact Statement Darlington Nuclear Generation Station Refurbishment and Continued Operation*.

The Environmental Impact Statement (EIS) and its 15 associated Technical Supporting Documents (TSDs) for the EA were submitted to the CNSC in 2011 (Reference 4.1-1). The EA concluded that refurbishment and continued operation of Darlington NGS, taking into account mitigation measures, was not likely to cause significant adverse environmental effects. This conclusion was confirmed in the CNSC's Record of Proceedings, Including Reasons for Decision (Reference 4.1-2).

In 2013, OPG applied for the renewal of Darlington NGS' operating licence, including refurbishment (Reference 4.1-3), and provided an addendum to the original application for renewal in 2015 (Reference 4.1-4), the current licence was granted.

Mitigation and Follow-up Activities

Follow-up and monitoring program activities were identified in the EA to verify that the environmental effects of refurbishment and continued operations are as predicted, and to confirm that the proposed mitigation measures are effective (and thus determine if additional or new mitigation measures are required).

The mitigating measures and follow-up program activities were included in the scope of the Darlington NGS Integrated Implementation Plan (IIP) and are also being tracked through this plan, NK38-REP-03680-10185, *Darlington NGS Integrated Implementation Plan,* (Reference 4.1-5).

With respect to mitigation (in-design and additional mitigation), six of the nine actions have been completed in their entirety and the remaining three are on track for completion. The six completed actions relate to:

- Offsetting for fish impingement and entrainment losses (IIP-EA-001).
- Demonstrating that the implementation of good industry management practices are effective in minimizing air/soil/water quality effects on humans and biota (IIP-EA-002).

- Reducing traffic disruption during peak periods and maintaining safe traffic conditions both on-site and off-site during the Refurbishment phase (IIP-EA-003).
- Monitoring and consulting municipalities on land-use policies and future developments proposed in the vicinity of the Darlington NGS site with focus on sensitive land uses (e.g. hospitals, schools) which may result in incompatible uses and effects on implementation of the emergency plans (IIP-EA-004).
- Protecting and avoiding the potential Van Camp cemetery which has potential archaeological and cultural heritage resource interest (IIP-EA-007); and
- Maintaining emergency response procedures to protect the health and safety of people and the environment in the context of specific Accident & Malfunctions scenarios (IIP-EA-008).

The following three mitigation actions remain open, though certain elements of each have been completed:

- IIP-EA-005 (Socio-Economics) relates to informing neighbours and the public of the refurbishment project and on-going activities of the Darlington NGS operations. This includes annual activities from 2014 to 2025.
- IIP-EA-006 (Socio-Economics) relates to minimizing the disruption of recreation facilities and amenities on the Darlington NGS site, which includes maintaining public access to the Waterfront Trail. This will include undertaking a Recreational User Survey of the Darlington NGS site recreation facilities for two seasons in one year after the restart of all reactors and reviewing the survey results. These activities are anticipated to be completed in 2026.
- IIP-EA-009 (Accidents & Malfunctions) relates to design modifications for various systems. The open item is for the provision of an alternate and independent supply of water to the primary heat transport system. This is anticipated to be completed by 2026 (based on each unit's refurbishment outage restart).

Three of six EA follow-up activities have been completed in their entirety. These relate to:

- Characterizing the conventional chemical (i.e., non-radiological) parameters present in Darlington NGS effluent streams (IIP-EA-010);
- Confirming the effectiveness of mitigation measures to protect stormwater quality in the area subject to refurbishment activities (i.e., Protected Area) (IIP-EA-011); and,
- Confirming the liquefaction potential of foundation materials in the Protected Area is acceptably low (IIP-EA-015).

The following three EA follow-up program activities remain open, though certain elements of each have been completed:

- IIP-EA-012 (Aquatic) relates to confirming the accuracy of the predictions made in the EA concerning changes in lakewater temperatures in the vicinity of the Condenser Cooling Water (CCW) discharge, and their associated possible effects on survival rates for round whitefish embryos. The open activities for this IIP objective are to (1) conduct thermal monitoring after the restart of all reactors (continued operations phase), and (2) report on monitoring data collected during continuous operations and assess the likely

effects on the survival of round whitefish embryos. These activities are anticipated to be completed by 2027.

- IIP-EA-013 (Aquatic) relates to impingement and entrainment, including characterizing early life stages of fish and macro invertebrates being entrained and fish impinged by station operations, monitoring at a level capable of detecting fish Species at Risk and aquatic species of conservation concern, and determining the total fish and macro invertebrate losses and associated impact. An entrainment study assessing impacts to fish and macro invertebrates was conducted in 2015 prior to refurbishment with the submitted report reviewed and approved by the CNSC and Fisheries and Oceans Canada (DFO). The open activities for this IIP objective are incorporated into OPG's amended Fisheries Act Authorization (FAA) for Darlington NGS (Reference 4.1-6). The combined IIP and FAA open activities are to prepare a sampling plan for fish impingement and entrainment in 2026, conduct associated 24-month impingement monitoring in 2027 and 2028, and entrainment monitoring in spring 2027- spring 2029, and submit a report to DFO (copied to the CNSC) documenting the findings of each study by March 31, 2030.
- IIP-EA-014 (Accidents & Malfunctions) relates to updating the station Probabilistic Risk Analysis (PRA) to confirm that the assignment of probabilities appropriately represents the Safety Improvement Opportunity (SIO) changes. The anticipated completion date of this action is 2026.

For information on OPG's comprehensive environmental protection programs, including monitoring through existing programs, refer to Section 2.9.3.

4.2 Indigenous Engagement

OPG is directed by a corporate wide Indigenous Relations policy that provides a framework for meaningful engagement with Indigenous Nations and communities and for the support of community programs and initiatives through its Corporate Citizenship Program.

The purpose of the policy is to work with Indigenous Nations and communities proximate to Darlington NGS and those that express interest in our operations at Darlington NGS. Engagement includes dialogue on Darlington NGS-related plans and activities, eliciting feedback and fostering opportunities through partnership and collaboration.

OPG is committed to engaging with Indigenous Nations and communities regarding nuclear operations and future projects. OPG's Indigenous Relations Policy provides a framework for engaging with Indigenous peoples and providing support for community programs and initiatives while respecting Aboriginal and Treaty rights which are recognized and affirmed under s.35 of Constitution Act, 1982. OPG also takes guidance from the CNSC, as outlined in REGDOC-3.2.2, that provides information for licensees on carrying out Indigenous engagement activities.

4.2.1 Power Reactor Operating Licence (PROL) Renewal and Duty to Consult

From OPG's perspective, the continued operation of Darlington NGS does not create any new adverse impacts on Aboriginal and/or Treaty rights held by local Indigenous Nations and communities but does extend the known impacts and the ongoing mitigation efforts. OPG is committed to continue working with Indigenous Nations and communities to inform OPG's

understanding of how activities carried out under a renewed PROL may impact Aboriginal and/or Treaty rights and address those impacts, as appropriate.

OPG is committed to meaningful engagement, building awareness of Indigenous perspectives and knowledge, and while the Duty to Consult has not been formally delegated by the Crown, OPG endeavours to meet the standard of meaningful consultation and engagement. Meaningful engagement takes time and investment of resources, and OPG is committed to working with the Indigenous Nations and communities to develop culturally reflective frameworks and respectful protocols that incorporate the unique priorities, and capacity needs of each Nation.

Engagement on Darlington NGS PROL renewal is focused on the Williams Treaties First Nations (WTFN) in whose Treaty and traditional territory Darlington NGS is located, as well as other Indigenous Nations and communities that express an interest. Over the course of OPG's engagement with the WTFN, the perspective that all life is connected has been shared and has helped frame OPG's approach to understanding various plant and animal species – particularly those that are viewed as "invasive species" by the western world. Gleaning Indigenous Knowledge is a privilege that is earned through meaningful relationship building, and it is gradually shared as trust is developed. OPG respects the principles of ownership, control, access, and possession (OCAP)® and works to ensure that any data and information shared with OPG remains under the control of the Indigenous Nation or community that provided it. OPG continues to engage with the rightsholders surrounding Darlington NGS to build an understanding of Indigenous Knowledge, values, and worldviews to better understand how Indigenous perspectives can be incorporated into methodologies and practices. Through these engagements, OPG aims to not only share information on our operations but to develop awareness of the potential impacts on the Aboriginal and Treaty rights of the Indigenous Nations and communities, as well as ways to avoid, mitigate and/or accommodate those impacts, as required.

As was committed to during the License to Construct Hearing #1 in January 2024, OPG will support the development of an Indigenous Knowledge Study (IKS), led by WTFN members Mississaugas of Scugog Island, Curve Lake, Hiawatha and Alderville. The initial focus will be on the Darlington New Nuclear Project area and will extend to Darlington and Pickering NGS, and in time, to WTFN shared and treaty territory. This IKS will also help to inform OPG regarding cumulative effects of nuclear development in the territory as well as a Rights Impact Assessment and an enhanced monitoring program featuring WTFN participation.

OPG has established Framework Agreements with the Curve Lake First Nation, Hiawatha First Nation, the Mississaugas of Scugog Island First Nation, the Six Nations of the Grand River, and as of April 2024, with Alderville First Nation. The framework agreements allow for dedicated time and capacity funding to support ongoing, regular engagement on OPG's nuclear and renewable generation operations. Where a need for capacity support is identified to support project-specific engagement, OPG is open to exploring options.

In addition to the Indigenous Nations and communities noted above, Darlington NGS has provided PROL renewal information and invited the following Indigenous Nations and communities to engage on OPG's licence renewal application and any other engagement opportunities of interest:

- Rama First Nation;
- Beausoleil First Nation;

- Georgina Island First Nation;
- Métis Nation of Ontario Region 8;
- Mississaugas of the Credit First Nation;
- Mohawks of the Bay of Quinte;
- Kawartha Nishnawbe.

4.2.2 Indigenous Community Meetings

OPG engages with the Indigenous Nations and communities with whom there are established Framework Agreements on a regular basis to discuss station operations, environmental reporting, employment/procurement opportunities and other topics viewed as priorities by the communities. For those Nations and communities with whom there are no established agreements, OPG shares information and is open to engaging as requested and as interest and schedules allow.

Darlington NGS PROL specific Indigenous Engagement - August 2023 to February 2024:

- All Indigenous Nations and communities identified were provided with initial information regarding the Darlington NGS PROL Renewal and the offer to have further discussions and engagement was extended in December 2023.
- Introductory Darlington NGS PROL Renewal Presentation and discussion meetings occurred with Curve Lake and Hiawatha First Nation (August 10, 2023) and Mississaugas of Scugog Island First Nation (August 22, 2023).
- In September 2023, representatives from OPG's Darlington relicensing team were invited and spent the day with representatives and Elders from Curve Lake First Nation.
- Update meetings on the Darlington NGS PROL Renewal process were held with Curve Lake First Nation and Hiawatha First Nation on October 24, 2023 and January 23, 2024; and with Mississaugas of Scugog Island First Nation on February 8, 2024.

The information sharing and preliminary engagement that has occurred to date has generated productive discussions about the PROL application, including the early identification of interests and concerns from Indigenous Nations and communities. In consideration of the interests and concerns OPG has heard to date, OPG's immediate next steps include the circulation of the Draft Darlington NGS PROL Relicensing Indigenous Engagement Plan to identify Indigenous Nations and communities. OPG welcomes Indigenous Nations and communities' review and input, so that the approach can be tailored to best fit community needs and interests.

OPG acknowledges that there are multiple ongoing and proposed activities that OPG is requesting Indigenous Nations and communities' engagement on, amongst requests from other proponents and regulators. OPG has also heard the importance of establishing an engagement framework after a licensing decision is made. OPG is steadfast in its commitment to supporting meaningful engagement during and after the licencing application process and will work in collaboration with Indigenous Nations and communities to identify approaches to engagement that is considerate of the engagement context and the interests of each Indigenous Nation and community.

As engagement continues, there will be upcoming opportunities for site visits, workshops and information sessions will be extended, or as interest is expressed by Indigenous Nations and communities.

OPG will endeavor to respond to any questions, concerns or comments from Indigenous Nations and communities, and intends to continue and improve upon its engagement activities supported by existing and future Framework Agreements, as well as the PROL renewal Indigenous Engagement Plan.

4.2.3 Commitment to Reconciliation

OPG is committed to taking concrete and measurable actions to advance reconciliation with Indigenous peoples and to report regularly on the company's activities and progress in achieving established goals.

In the fall of 2021, OPG launched the Reconciliation Action Plan (RAP), which outlined the commitment to advancing reconciliation with Indigenous peoples under the pillars of leadership, relationships, people, economic empowerment, and environmental stewardship. The RAP is a public document that serves as a roadmap to reconciliation and the 2021 edition included 38 specific actions and commitments with clear deliverables and timelines spanning between 2022 and 2031. An annual report was published in the fall of 2022 which noted that the first-year goals were achieved through much work, dedication, and collaboration with communities.

The RAP is being updated and published in Q2 2024 with over 20 new commitments that were developed through internal discussions and input from Indigenous Nations, communities, and businesses. Included in the RAP update, will be a report on our 2023 results, including:

1) OPG placed 32 Indigenous Opportunities Network (ION) candidates in roles for a grand total of 125 placements in the industry since late 2018 when we first started taking candidates into the program. Our goal this past year was to place at least 20 candidates and we achieved 60 percent placements above our initial target. In 2024 our goal is to more than double our placements and reach a new goal of 50 candidates placed within the energy sector.
2) OPG has expanded opportunities for Indigenous businesses to participate in nuclear procurement. As a result, the nuclear qualified vendors list now includes 3 Indigenous businesses, surpassing the initial target of 2.
3) Since 2021, we have met $237.4 million of the $1 billion economic impact target for Indigenous communities and businesses over 10-years (by 2031).
4) In 2022, OPG's Supply Chain mandated criteria for Indigenous content on supplier bids and awards higher scores to businesses that can demonstrate positive Indigenous relations (employment and business partnering).
5) In 2023, OPG created an Indigenous Engagement Vendor Scorecard in collaboration with Mississaugas of Scugog Island and Curve Lake First Nations. This scorecard identifies criteria for vendors to meet in the areas of Indigenous procurement, capacity building, Indigenous employment, and cultural training, with points awarded according to defined performance metrics.
6) The Indigenous Circle is an Employee Resource Group (ERG) that provides an internal network for Indigenous employees of OPG. Established in 1992, the Indigenous Circle promotes awareness about the diversity of Indigenous people both

within OPG and externally through involvement in special events, career fairs, and other programs. Annually in June, the Indigenous Circle hosts National Indigenous Peoples Day celebrations across OPG sites. Between 2021 and 2024, OPG partnered with INDspire's Building Brighter Futures Program on the John Wesley Beaver Memorial Scholarship, resulting in 20 awards of $10,000 each offered to Indigenous post-secondary students across Ontario. OPG also hosts events to commemorate National Day for Truth and Reconciliation and Treaty Week and all staff are invited to participate, learn, and build their awareness of Indigenous culture and how to demonstrate reconciliation.

7) OPG is actively seeking input from the WTFNs and the OPG Indigenous Circle throughout the design process for the new OPG Headquarters in Oshawa. This feedback will be used to infuse elements of local Indigenous culture into the architecture and landscape of the new headquarters.

8) OPG leadership encourages and supports staff to engage with and visit Indigenous Nations and communities to gain firsthand knowledge and develop relationships. For example, throughout the summer of 2023, OPG staff were present at the various pow wows held in various First Nations. Further, in the fall of 2023 OPG staff had the privilege of visiting Curve Lake First Nation and the Petroglyphs Provincial Park to participate in a community tour and deepen their understanding of the local culture and values and OPG staff were invited to attend and participate in two Harvester's Symposiums held by Curve Lake First Nation, where community members were in attendance and information was made available about OPG's nuclear operations.

4.3 Financial Guarantee, Nuclear Liability Insurance and Cost Recovery

Financial Guarantee

The objective of OPG's financial guarantee is to ensure that sufficient funds are estimated, collected, and administered for the management of liabilities associated with operating and decommissioning of all its nuclear facilities. The financial guarantee is prepared for all OPG owned or leased facilities and makes specific financial provisions for the decommissioning of the Darlington NGS. The Darlington NGS preliminary decommissioning plan, NK38-PLAN-00960-10001, *Darlington Site Preliminary Decommissioning Plan* forms the basis for establishing and maintaining an acceptable Financial Guarantee.

In addition to the decommissioning program, OPG's Financial Guarantee also covers financial provisions for the long-term management (storage and eventual disposal) of all operational and decommissioning wastes (Used Fuel, Low Level Waste, and Intermediate Level Waste).

OPG's financial guarantee is prepared and maintained on a 5-year cycle in accordance with the requirements set out in CSA Standard N294, *Decommissioning of facilities containing nuclear substances* and CNSC Regulatory Document, REGDOC 3.3.1, *Financial Guarantees for Decommissioning of Nuclear Facilities and Termination of Licensed Activities*. OPG also provides an annual financial guarantee report to the CNSC detailing the status of the guarantee including the amounts accumulated in segregated funds and the value of the Provincial guarantee (when required). The report compares the amount of the liabilities and the financial resources available to discharge the obligations.

The financial guarantee provisions for Darlington NGS demonstrate that the current level of funding is adequate for decommissioning the station and returning the site to an end state agreed with the Regulators. CNSC access to these funds is provided by the *CNSC Financial Security and Ontario Nuclear Funds Agreement Access Agreement* between the CNSC, OPG and the Province of Ontario, and, as required, the *Provincial Guarantee Agreement* between the CNSC and the Province of Ontario. In December 2022, the Commission accepted OPG's proposed 2023-2027 consolidated financial guarantee as documented in Record of Decision DEC 22-H104 in Reference 4.3-1.

OPG will continue to provide annual Financial Guarantee reports to the CNSC detailing the status of the guarantee, including the amounts accumulated in segregated funds.

Nuclear Liability Insurance

OPG is required, under the Nuclear Liability and Compensation Act (NLCA), to maintain financial security in an amount equal to $ 1 billion for its Darlington NGS in 2024. The following four figures provide certificates of insurance that verifies the financial security OPG has secured as required by the NLCA for 2024.

Marsh

Certificate of Insurance

No.: **2024-4** Dated: **February 29, 2024**

This document supersedes any certificate previously issued under this number

This is to certify that the Policy(ies) of insurance listed below ("Policy" or "Policies") have been issued to the Named Insured identified below for the policy period(s) indicated. This certificate is issued as a matter of information only and confers no rights upon the Certificate Holder named below other than those provided by the Policy(ies).

Notwithstanding any requirement, term, or condition of any contract or any other document with respect to which this certificate may be issued or may pertain, the insurance afforded by the Policy(ies) is subject to all the terms, conditions, and exclusions of such Policy(ies). This certificate does not amend, extend, or alter the coverage afforded by the Policy(ies). Limits shown are intended to address contractual obligations of the Named Insured.

Limits may have been reduced since Policy effective date(s) as a result of a claim or claims.

Certificate Holder:	**Named Insured and Address:**
Canadian Nuclear Safety Commission Headquarters **280 Slater Street P.O.Box 1046 Station B** **Ottawa, ON K1P 5S9**	**Ontario Power Generation Inc.** **700 University Avenue, H18-J18** **Toronto, ON M5G 1X6**

This certificate is issued regarding:
Darlington Nuclear Generating Station

Type(s) of Insurance	Insurer(s)	Policy Number(s)	Effective/ Expiry Dates	Sums Insured Or Limits of Liability	
NUCLEAR LIABILITY	Nuclear Risk Insurers Limited - Licensed	L18CAN2099/2024	Jan 01, 2024 to Jan 01, 2025	Limit of Liability	CDN 600,000,000 45% of total limit of liability

Notice of cancellation:
The insurer(s) affording coverage under the policies described herein will not notify the certificate holder named herein of the cancellation of such coverage.

Marsh Canada Limited
120 Bremner Boulevard
Suite 800
Toronto, ON M5J 0A8
Telephone: (647)-3543154
Fax: -
[redacted]

Marsh Canada Limited
By: [redacted]

Figure 35: Nuclear Liability Insurance – Marsh – Certificate of Insurance

Marsh

Certificate of Insurance

No.: 2024-5 Dated: March 01, 2024

This document supersedes any certificate previously issued under this number

This is to certify that the Policy(ies) of insurance listed below ("Policy" or "Policies") have been issued to the Named Insured identified below for the policy period(s) indicated. This certificate is issued as a matter of information only and confers no rights upon the Certificate Holder named below other than those provided by the Policy(ies).

Notwithstanding any requirement, term, or condition of any contract or any other document with respect to which this certificate may be issued or may pertain, the insurance afforded by the Policy(ies) is subject to all the terms, conditions, and exclusions of such Policy(ies). This certificate does not amend, extend, or alter the coverage afforded by the Policy(ies). Limits shown are intended to address contractual obligations of the Named Insured.

Limits may have been reduced since Policy effective date(s) as a result of a claim or claims.

Certificate Holder:	Named Insured and Address:
Canadian Nuclear Safety Commission Headquarters 280 Slater Street P.O.Box 1046 Station B Ottawa, ON K1P 5S9	Ontario Power Generation Inc. 700 University Avenue, H18-J18 Toronto, ON M5G 1X6

This certificate is issued regarding:
Darlington Nuclear Generating Station : issued for ELINI (unlicensed carrier)

Type(s) of Insurance	Insurer(s)	Policy Number(s)	Effective/ Expiry Dates	Sums Insured Or Limits of Liability	
NUCLEAR LIABILITY	Euro Liab. Ins for the Nuc. Ind. (ELINI)	24EL/0036	Jan 01, 2024 to Jan 01, 2025	Limit of Liability	CDN 270,000,000

Notice of cancellation:
The insurer(s) affording coverage under the policies described herein will not notify the certificate holder named herein of the cancellation of such coverage.

Marsh Canada Limited
120 Bremner Boulevard
Suite 800
Toronto, ON M5J 0A8
Telephone: (647)-3543154
Fax: -
[redacted]

Marsh Canada Limited
By: [redacted]

Figure 36: Nuclear Liability Insurance – Marsh – Certificate of Insurance

401 Bay Street, Suite 1600, Toronto, ON Canada M5H 2Y4

CERTIFICATE OF INSURANCE

This is to certify to: Canadian Nuclear Safety Commission
280 Slater Street P.O. Box 1046 Station B, Ottawa, ON, K1P 5S9

The policies of insurance as herein described have been issued to the Insured named below and are in force at this date.

Name of Insurer:	**Name and Address of Insured:**
Nuclear Insurance Association of Canada 401 Bay St., Suite 1600 Toronto, ON M5H 2Y4	Ontario Power Generation Inc. and its subsidiaries 700 University Ave., Toronto, ON M5G 1X6

TYPE OF INSURANCE	LIMITS OF LIABILITY	DEDUCTIBLE	POLICY NUMBER	POLICY PERIOD*
Nuclear Energy Liability Policy Operators Form No. 610 (1016) - Darlington Nuclear Generating Station (Power Reactor Class) - Claims Expense Form No. 620 (04/16)	$330,000,000 $33,000,000	Nil	OF105	Jan.1, 2024 to Jan. 1, 2025, 12:01 AM Standard Time at the Location of the Insured

*NIAC Operators Form is continuous until cancelled. Policy Period refers to the current annual continuation certificate in force.

The insurance afforded is subject to the terms, conditions and exclusions of the applicable policy. This Certificate is issued as a matter of information only and confers no rights on the holder and imposes no liability on the Insurer. The Insurer will endeavour to mail to the holder of this Certificate 30 days' written notice of any material change in or cancellation of these policies but assumes no responsibility for failure to do so.

The Nuclear Insurance Association of Canada's collective liability is limited to **55.0000%** of the Limit of Liability of $600,000,000 under Operators Form No. 610 (1016) and $60,000,000 under Claims Expense form No. 620 (04/16).

Issued at: Toronto, Ontario

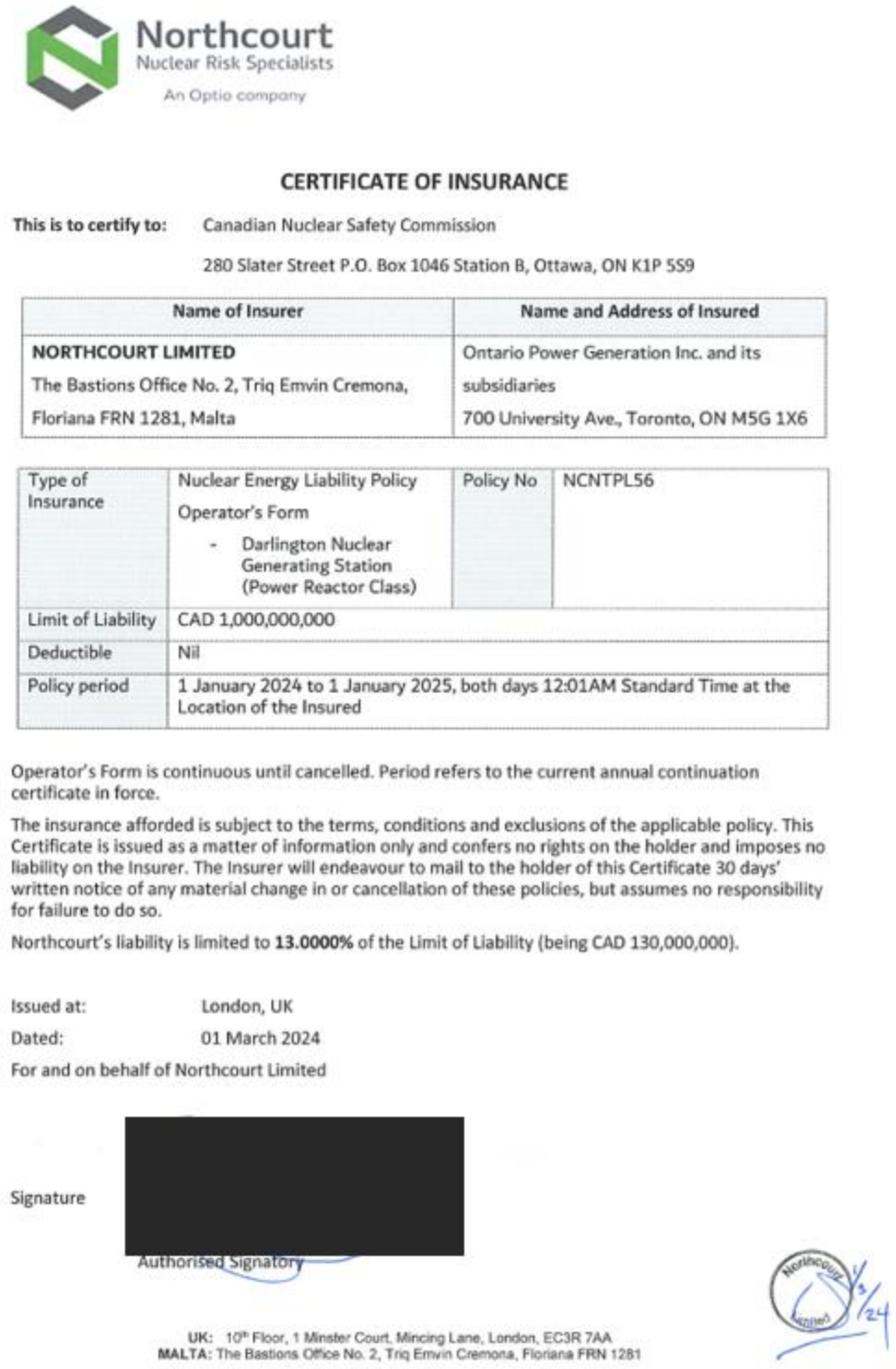
NUCLEAR INSURANCE ASSOCIATION OF CANADA

[redacted]

Authorized Representative

Dated: March 1, 2024

Figure 37: Nuclear Liability Insurance – NIAC – Certificate of Insurance



Northcourt
Nuclear Risk Specialists
An Optio company

CERTIFICATE OF INSURANCE

This is to certify to: Canadian Nuclear Safety Commission

280 Slater Street P.O. Box 1046 Station B, Ottawa, ON K1P 5S9

Name of Insurer	Name and Address of Insured
NORTHCOURT LIMITED The Bastions Office No. 2, Triq Emvin Cremona, Floriana FRN 1281, Malta	Ontario Power Generation Inc. and its subsidiaries 700 University Ave., Toronto, ON M5G 1X6

Type of Insurance	Nuclear Energy Liability Policy Operator's Form - Darlington Nuclear Generating Station (Power Reactor Class)	Policy No	NCNTPL56
Limit of Liability	CAD 1,000,000,000		
Deductible	Nil		
Policy period	1 January 2024 to 1 January 2025, both days 12:01AM Standard Time at the Location of the Insured		

Operator's Form is continuous until cancelled. Period refers to the current annual continuation certificate in force.

The insurance afforded is subject to the terms, conditions and exclusions of the applicable policy. This Certificate is issued as a matter of information only and confers no rights on the holder and imposes no liability on the Insurer. The Insurer will endeavour to mail to the holder of this Certificate 30 days' written notice of any material change in or cancellation of these policies, but assumes no responsibility for failure to do so.

Northcourt's liability is limited to **13.0000%** of the Limit of Liability (being CAD 130,000,000).

Issued at: London, UK

Dated: 01 March 2024

For and on behalf of Northcourt Limited

Signature [redacted]

Authorised Signatory

UK: 10th Floor, 1 Minster Court, Mincing Lane, London, EC3R 7AA
MALTA: The Bastions Office No. 2, Triq Emvin Cremona, Floriana FRN 1281

Figure 38: Nuclear Liability Insurance – Northcourt – Certificate of Insurance

Cost Recovery

Pursuant to the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*, the CNSC prepares a Regulatory Activity Plan for Class I nuclear facilities and calculates an estimated annual fee payable for that fiscal year using the estimated full cost of the plan. OPG pays the CNSC's fees on a quarterly basis.

4.4 Public Information and Disclosure Program

OPG recognizes that members of the public, stakeholder groups, and local communities have an interest in the Darlington NGS operations. This may include operations, licensing activities, health, safety and security of persons, employees and the environment.

OPG believes in open and transparent communication in a timely manner to maintain positive and supportive relationships and confidence of key stakeholders and the public. OPG's *Nuclear Public Information Disclosure and Transparency Protocol*, posted on OPG's website, describes our communication principles and information requirements and reporting.

The following OPG document requires written notification of change per Licence Conditions Handbook, LCH-PR-13.03/2025-R005:

Table 31: Licensee Public Information Program

Document	Title
N-STD-AS-0013	Nuclear Public Information and Disclosure

OPG's Corporate Relations and Communications organization adheres to standard N-STD-AS-0013, *Nuclear Public Information and Disclosure,* as it describes consistent standards and procedures for all public disclosure of both material and non-material information. Public information and disclosure involves the provision to inform, in a timely and transparent manner, accurate information to stakeholders and the public in the vicinity of OPG's nuclear facilities regarding events, activities and operations. The standard is a regulatory requirement developed in accordance with CNSC REGDOC-3.2.1 *Public Information and Disclosure.*

OPG's public information program has been recognized as a strength by national and international utility peers. To ensure continuous improvement, OPG will annually evaluate the effectiveness of N-STD-AS-0013 and implement findings. Strategies include:

- Interviews/focus groups/surveys with key stakeholders, community members, community groups/committees.
- Self-Assessments.
- Reviews of documentation/reports, including media coverage and Salesforce reports.
- Public opinion/opinion leader polling, research polling.
- Consultation with public and key stakeholders on a variety of Corporate Relations strategies including community and key stakeholder programming.

In addition, OPG continues to benchmark current practices amongst other industries.

The public information program proactively provides information to the public and stakeholders on Darlington NGS's operations.

The primary focus area for engagement activities, in addition to the public at large, includes two municipalities proximate to the Darlington NGS site including the host community (Clarington) and adjacent community within 10 km of the project (the City of Oshawa). The 10 km radius is consistent with the Darlington NGS *Detailed Planning Zone* for nuclear emergency planning purposes, an area where residents are most familiar with nuclear plant operations and regularly receive station information and operational updates.

OPG ensures the public and stakeholders with a potential interest in Darlington NGS operations and performance, are provided with relevant information and have the opportunity to share their views and perspectives. Information is communicated in a number of ways based on their interests and preferred means of communication.

Darlington NGS Stakeholders and audiences may include but are not limited to:

- Residents in the vicinity of the Darlington NGS and the public.
- Established community committees such as the Darlington Community Advisory Council and the Durham Nuclear Health Committee.
- Local businesses and business organizations, such as boards of trade and chambers of commerce.
- Private/public community organizations and special interest groups.
- Non-Governmental Organizations.
- Nuclear industry associations/organizations and regulatory bodies.
- Media.
- Federal, provincial, regional, and municipal agencies and officials with a regulatory role or project interest.
- OPG employees and retirees.

4.4.1 Communication Methods

Communication methods are the approaches and activities used to distribute information, and to solicit feedback and input. The methods employed are specific to the issues and matters that arise and include:

Advertisements and Letters: Public notifications are prepared and distributed to announce upcoming hearings and other licensing activities, via a press release (as required), stakeholder letter(s), web communications, the OPG community newsletter (Neighbours) and advertisements in local print media (as required).

Website: The OPG website is updated on a regular basis as new information becomes available. The website serves as a vehicle to provide access to information, as well as a mechanism to receive input from interested persons as an enhancement of the public outreach program.

Toll Free Information Line: The 1-800 toll free line for Darlington NGS continues to be maintained. Messages are checked and responded to on weekdays and any required follow-up is completed in a timely manner.

Media Relations: Ongoing liaison with respect to operations and licensing activities is initiated and maintained by OPG with reporters and news editors for both electronic and print media.

OPG Employee Communication Activities: The employee communication program includes articles written in OPG-wide and Darlington NGS-specific employee media. Staff presentations and information sessions are also held. In addition, an intranet site is maintained to facilitate communication with employees.

Key Stakeholder Briefings: Briefings are conducted to present information and provide an opportunity to have questions and comments addressed. Regular updates are presented to municipal representatives, established community committees including the Darlington and Pickering Community Advisory Committees, Durham Nuclear Health Committee, and other key stakeholders on a frequency commensurate with various activities and milestones. Feedback from these meetings is recorded for response and issues management.

Workshops: Key stakeholders with a high level of interest in operations or other station activities may be invited to participate in workshops that involve meaningful discussions with the opportunity to provide substantive input.

Public Information Sessions: Information sessions (in person or virtual) advertised broadly and open to any participants provide an opportunity to learn more about Darlington NGS and the licensing phases/activities and provide comments and/or have questions answered by members of the OPG team.

Information Centre: Darlington NGS continues to operate an information centre, as referenced below.

Social Media: OPG maintains a presence on social media (Facebook, Twitter, Linked In and Instagram) and shares information through these media.

4.4.2 Station Reporting

OPG regularly and proactively provides information to the public on its facility activities. For operational status changes or unscheduled operations that may cause public concern or media interest, OPG follows the *Public Information and Disclosure Protocol* to notify key community stakeholders in a timely manner as outlined in Section 4.4. The purpose of the protocol is to ensure contacts in the emergency agencies (fire, police, and emergency management) and local government organizations are kept aware and are able to respond accurately if they receive questions from constituents. OPG maintains a duty on-call organization 24 hours a day, seven days a week.

On a quarterly basis, OPG publicly posts performance reports on station operations on OPG's website and shares this document electronically with key stakeholders. Additionally, since 2014, OPG issues a quarterly Environment Report in an easy to read and understandable format.

4.4.3 Welcoming Visitors

Darlington NGS maintains an Information Centre to host public, community groups and students. Visitors can find information on operations, technology, future plans and current issues, and staff are available to have conversations and answer questions. Students are offered curriculum-based educational presentations, introductions to CANDU technology and STEM-based activities.

OPG encourages community groups to use the Information Centre for events unrelated to the industry. The meeting room and event space were built to help build greater ties to the community. By creating a meeting space, organizations otherwise unrelated to the industry gain a comfort and familiarity with the technology.

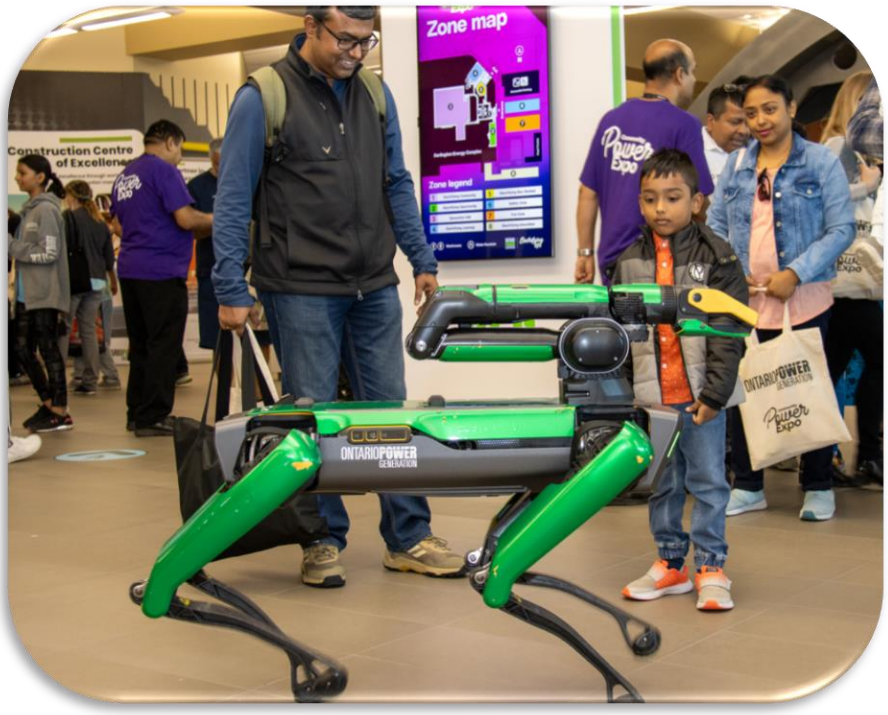
4.4.4 Community Outreach

Outreach activities to interested groups and communities may include:

- Station tours, bus tours, presentations, reactor mock-up tours and virtual tours to community groups, key stakeholders, industry partners, students and the general public.

Community Power Expo at Darlington NGS

- Three times a year, OPG publishes a Neighbours Newsletter which is distributed to approximately 250,000 residents and businesses within 10 km of the Darlington and Pickering stations. The newsletter is posted on opg.com and distributed at community events.
- Annually, OPG hosts a Community Power Expo, which is widely advertised with a focus on the nearby community. Staff from OPG and various industry partners are present to answer questions and provide information to participants. In 2023 the annual event hosted more than 3,500 people from across the Durham Region.



Darlington NGS's Corporate Relations team continues to provide quality programs within our host communities. Our annual March Break and Tuesdays on the Trail programs reached thousands of community members throughout the winter and summer months.

4.4.5 Community Committees

OPG works with established local community committees on matters of interest and concerns related to our operations and projects. Updates on the status of licensing activities are provided to the committees.

- The Darlington Community Advisory Council meets regularly to exchange information

with community leaders and local residents, who in turn provide advice to senior OPG staff on issues of environmental, economic and public concern.

- OPG has representatives on the Durham Nuclear Health Committee and OPG staff make regular presentations on a variety of environmental, community outreach and operational issues. This committee is chaired by the Durham Region Medical Officer of Health.

OPG meets often with stakeholder groups, elected officials, and municipal representatives, as well as with stakeholder groups that have an interest in nuclear, safety, energy, climate change, and/or environmental issues.

Community Responsibility

As the province's largest electricity generator, OPG had the responsibility to not only keep the lights on for families, hospitals and essential businesses during the COVID-19 pandemic, but also a social responsibility to do everything we could to help meet our communities' most vital health care needs. Throughout the pandemic, OPG provided essential support across the province, including donations of supplies to frontline healthcare workers and food distribution centres, among others.

4.4.6 Environmental Partnerships and Programs

Darlington NGS is committed to biodiversity work on OPG property and on public lands within the host communities. Darlington NGS's biodiversity program continues to provide plantings, pollinator gardens, and numerous other initiatives. Since 2000, OPG has planted more than 8.7 million trees throughout the province, and we continue to help create hundreds of acres of new grasslands and wetlands.

To further enhance local sustainability efforts, OPG has a long-standing partnership with Courtice Secondary School. Within this unique partnership, students work closely with OPG to support regional ecosystems and biodiversity through science-based habitat stewardship. Many projects including pollinator plantings, building of bee hotels, turtle rafts and bird nest boxes have been accomplished over the years.

Since 2011, OPG has been a lead partner in the Bring Back the Salmon program with the Ontario Ministry of Natural Resources, and the Ontario Federation of Anglers and Hunters. OPG's support contributes to all four pillars of the Bring Back the Salmon program but is weighted towards fish production. The program originally began at Pickering NGS, however Darlington NGS began participating in the program in 2019. Since then, each year, the Darlington NGS Information Centre houses a hatchery and partners with a local school as part of the program. In 2023, the five-month hands-on lesson on Atlantic Salmon and the biodiversity of the Lake Ontario watershed, introduced students and teachers to the Atlantic Salmon species, their history in Ontario, and the restoration efforts to bring back a healthy and self-sustaining population to Lake Ontario.

OPG's Nuclear Operations hold a Gold Level Conservation Certification from the Wildlife Habitat Council (WHC). This achievement recognizes the specific efforts of our biodiversity programs, which aim to protect and nurture species and their habitats wherever the company operates. The WHC certifies conservation programs on corporate lands around the world and promotes environmental management through various partnerships and education.

Community Recognition

- United Way Durham, Region McLaughlin Award – 2016;
- Community Care Durham, Corporate Leadership Award – 2016;
- Greater Oshawa Chamber of Commerce, Sustainability Award – 2019;
- Greater Oshawa Chamber of Commerce, Business Excellence Award – 2021;
- Whitby Chamber of Commerce, Business Achievement Award - Excellence in Governance Strategy Award – 2021;
- Whitby Chamber of Commerce, Business Achievement Award (50 + People) – 2021;
- City of Oshawa, Business Excellence Sustainability Award – 2023.

4.4.7 Employee Communications

The OPG Employee Communication division at Darlington NGS works to keep employees informed on station, fleet-wide company, and industry issues in a timely, accurate and consistent manner by working collaboratively with station leadership and staff to develop and implement strategic station-wide communications programs.

These comprehensive programs support Darlington NGS's vision of working together, as well as overall business objectives, work programs and goals to effectively drive improvements and support the safe and reliable operations of the plant. Additionally, the messages used within these communication programs help to foster alignment, engagement, and teamwork amongst the intended audiences.

The Communications team develops annual communications strategies to support Darlington NGS's business plans and vision, major on-site projects, initiatives, and events. They include selected services and materials designed to achieve communication goals. This ensures consistent communications have a positive, long-term impact on workforce alignment and engagement using a reliable two-way information exchange by way of the supervisory chain and meaningful face-to-face communication with direct reports, as well as more informal and formal online information channels. Darlington NGS site communications anchor and reinforce key messages through multiple channels, including but not limited to face-to-face meetings, intranet websites, site-wide emails, in-station TV screens, and videos.

The team leads a number of initiatives throughout the year to measure and gauge the effectiveness of the strategies to promote a process of continual learning and improvement.

External evaluators and review teams continue to recognize the positive contributions of internal communications on the culture at Darlington NGS.

5.0 References

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1.0-2.	OPG letter, B. Duncan to M. Leblanc, “Darlington NGS – Additional Information in Support of Application for Renewal of Darlington’s Power Reactor Operating Licence (PROL) 13.01/2015”, January 30, 2015, CD# NK38-CORR-00531-17206.
1.0-3.	OPG letter, A. Grace to A. Mathai, “Darlington NGS – Response to CNSC Staff’s Request for Implementation Plans or Justification for Identified Documents to be Guidance in the Darlington Licence Conditions Handbook”, March 19, 2024, CD# NK38-CORR-00531-25234.
Section 2.2 References	
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Section 2.4 References	
2.4-1.	OPG letter, W.M. Elliott to M. Santini and F. Rinfret, “OPG Safety Analysis Improvement and REGDOC-2.4.1 Compliance”, July 11, 2014, CD# N-CORR-00531-06620.
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2.4-3.	OPG letter, D. Townsend to G. Frappier, “Progress Update on Category 3 CANDU Safety Issues – Implementation of Risk Control Measures”, June 18, 2020, CD# N-CORR-00531-20185.
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Section 2.12 References	
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Section 3.3 References	
3.3-1.	CNSC letter, A. Mathai to A. Grace, “Darlington NGS – Periodic Safety Review (D-PSR) – CNSC Staff Acceptance of the Integrated Implementation Plan (IIP)”, March 25, 2024, e-Doc# 7248767, CD# NK38-CORR-00531-25314.
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4.1-2.	CNSC letter, L. Levert to D. Reiner, “Record of Proceedings – Environmental Assessment on the Refurbishment and Continued Operation of the Darlington Nuclear Generating Station”, March 14, 2013, e-Docs# 4105438, CD# NK38-CORR-00531-16265.
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Appendix A: Commonly Used Acronyms

Acronym	Word
AAs	Adjuster Assemblies
ABFP	Auxiliary Boiler Feed Pump
ACU	Air Cooling Unit
ADL	Administrative Dose Limits
AIA	Authorized Inspection Agency
AIMs	Abnormal Incident Manuals
AIR	Accident Injury Rate
AL	Action Level
ALARA	As Low as Reasonably Achievable
AMP	Aging Management Plan
ANDE	Advanced Non-Destructive Evaluation
ANO	Authorized Nuclear Operator
ANSO	Armed Nuclear Security Officers
AOO	Anticipated Operational Occurrences
APCI	Annual Plant Condition Inspection
ARRR	Annual Risk and Reliability Report
ASB	Auxiliary Security Building
ASDC	Auxiliary Shutdown Cooling
ASR	Accident Severity Rate
ASTGMS	Automated Source Term Gamma Monitoring System
ASU	Aerial Support Unit
ASW	Auxiliary Service Water
BDBA	Beyond Design Basis Accident
BDBE	Beyond Design Basis Earthquake
CA	Condition Assessment
CANDU	CANada Deuterium Uranium
CAS	Central Alarm Station
CBOP	Continuous Behavioral Observation Program
CC	Corrective Critical
CC/CN	Corrective Critical and Non-Critical
CCW	Condenser Cooling Water
CEA	Cyber Essential Assets
CEFSD	Clarington Emergency and Fire Services Department
CEO	Chief Executive Officer
CFAM	Corporate Functional Area Manager
CFSI	Counterfeit, Fraudulent and Suspect Items
CFVS	Containment Filtered Venting System
CIGAR	Channel Inspection and Gauging Apparatus for Reactors
CIS	Components Important to Safety
CMCC	Crisis Management Communications Centre
CMSP	Combustible Material Safety Permits
CN	Corrective Non-Critical
CNEP	Consolidated Nuclear Emergency Plan
CNO	Chief Nuclear Officer
CNR	Canadian National Railway

Acronym	Word
CNSC	Canadian Nuclear Safety Commission
CO	Closed Out
CofA	Certificate of Authorization
COG	CANDU Owners Group
CPI	Chemistry Performance Index
CRC	Corporate Relations and Communications
CRE	Collective Radiation Exposure
CRO	Control Room Operator
CRR	Code Compliance Review
CRS	Cryogenic Refrigeration System
CRSS	Control Room Shift Supervisor
CSA	Canadian Standards Association
CSCA	Common Secondary Control Area
CSIs	CANDU Safety Issues
CSP	Critical Safety Parameter
CT	Calandria Tube
CT-LISS	Calandria Tube-Liquid Injection Shutdown System
CW	Circulating Water
D4F	Darlington for the Future
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DBT	Design Basis Threat
DC	Deficient Critical
DC/DN	Deficient Critical and Non-Critical
DCC	Digital Control Computers
DCSA	Defensive Cyber Security Architecture
DEC	Darlington Energy Complex
DFO	Department of Fisheries and Oceans
DFR	Drones for First Responders
DIQ	Design Information Questionnaire
D-ISR	Darlington Integrated Safety Review
DLA	Dynamic Learning Activity
DMS	Dose Management System
DN	Deficient Non-Critical
DPRS	Durham Region Police Service
D-PSR	Darlington PSR
DPZ	Detailed Planning Zone
DRL	Derived Release Limit
DSA	Deterministic Safety Analysis
DWMF	Darlington Waste Management Facility
DWP	Demineralized Water Plant
EBP	Electronic Based Procedures
ECA	Environmental Compliance Approvals
ECC	Engineering Change Control
ECI	Emergency Coolant Injection
ECL	Exposure Control Levels
ECO	End of Commercial Operation
ED&I	Equity, Diversity, and Inclusion

Acronym	Word
EEM	Enterprise Emergency Management
EFADS	Emergency Filtered Air Discharge System
EFDR	Event Free Day Reset
EHC	Electrohydraulic Converter
EITER	Equipment Important to Emergency Response
EM	Emergency Management
EME	Emergency Mitigating Equipment
EMEGs	Emergency Mitigating Equipment Guidelines
EMO	Emergency Management Ontario
EMP	Environmental Monitoring Program
EMS	Environmental Management System
EOC	Emergency Operations Centre
EOP	Emergency Operating Procedure
EPC	Engineer, Procure, Construct (Section 2.1.5)
EPC	Enterprise Project Contractors (Sections 2.5.5.1 and 2.8.2.4)
EPD	Electronic Personal Dosimeter
EPG	Emergency Power Generator
EPR	Environmental Protection Reviews
EPRI	Electric Power Research Institute
EPS	Emergency Power Supply
EQ	Environmental Qualification
EQA	Environmental Qualification Assessment
EQP	Equipment Performance Index
ER	Equipment Reliability
ERA	Environmental Risk Assessment
ERAP	Emergency Response Assistance Plan
ERI	Equipment Reliability Index
ERM	Emergency Response Maintainers
ERO	Emergency Response Organization
ERT	Emergency Response Team
ESA	Emergency Shift Assistant
ESC	End Shield Cooling
ESL	Equipment Status Log
ESM	Equipment Status Monitoring
ESP	Environmental Stewardship Pickering
ESW	Emergency Service Water
ETE	Evacuation Time Estimates
EV	Electric Vehicle
FAA	Fisheries Act Authorization
FAAGM	Fixed Area Alarming Gamma Meter
FAATM	Fixed Area Alarming Tritium Monitors
FAQ	Frequently Asked Questions
FFAA	Fuelling Facility Auxiliary Area
FH ER	Fuel Handling Equipment Reliability
FHA	Fire Hazard Assessment
FINCH	Fully Instrumented Nominal Channel Power
FMD	Fuelling Machine Duct
FSSA	Fire Safe Shutdown Assessment

Acronym	Word
GFP	Gaseous Fission Product
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
GIE	Global Innovation Effectiveness
GOSP	Governance, Oversight, Support and Perform
GSS	Guaranteed Shutdown State
GVO	Generator Voltage Output
GWPP	Groundwater Protection Program
HFE	Human Factors Engineering
HLW	High Level Waste
HoW	Hours of Work
HP	High Pressure
HPM	Health Physics Manager
HSMS	Health and Safety Management System
HTS	Heat Transport System
HTS-AMS	Heat Transport System Aging Management Strategy
HVAC	heating, Ventilation and Air Conditioning
HWMB	Heavy Water Management Building
I/O	Input/Output
IAEA	International Atomic Energy Agency
IAM	Integrated Aging Management
ICFDs	In-Core Flux Detectors
IESO	Independent Electricity System Operator
IFBs	Irradiated Fuel Bays
IHSA	Infrastructure Health & Safety Association
IIP	Integrated Implementation Plan
ILW	Intermediate Level Waste
INPO	Institute of Nuclear Power Operations
ION	Indigenous Opportunities Network
IPB	Isolated Phase Bus
IPZ	Ingestion Planning Zone
IRIS	Industry Reporting and Information System
IRS	Internal Responsibility System
ISAR	Industrial Safety Accident Rate
ISO	International Standards Association
ISP	Ignition Source Permits
ISRW	Integrated Strategy for Radioactive Waste
IST	Industry Standard Toolset
IUCs	Instrument Uncertainty Calculations
IWST	Injection Water Storage Tank
JHSC	Joint Health and Safety Committee
JIT	Just-in-Time
KI	Potassium Iodide
KIWG	Potassium Iodide Working Group
KPI	Key Performance Indicators
L&ILW	Low and Intermediate Level Waste
LBLOCA	Large Break Loss of Coolant Accident
LCH	Licence Conditions Handbook

Acronym	Word
LCMP	Life Cycle Management Plan
LLW	Low Level Waste
LOCA	Loss of Coolant Accident
LP	Low Pressure
LPSW	Low Pressure Service Water
LRF	Large Release Frequency
LWPRB	Local Work Protection Review Board
LZC	Liquid Zone Control
M&D	Monitoring & Diagnostics
MBA	Material Balance Areas
MBFP	Main Boiler Feed Pump
MCCP	Minimum Complement Coordinator Program
MCQ	Multiple Choice Question
MCR	Main Control Room
MDE	Margin Design Earthquake
MIV	Mispositioning Index Value
MOT	Main Output Transformer
MOU	Memorandum of Understanding
MPO	Main Power Output
MSB	Main Security Building
MSLB	Main Steam Line Break
MVC	Main Vacuum Chamber
NBCC	National Building Code of Canada
NEC	Nuclear Executive Committee
NFCC	National Fire Code of Canada
NGS	Nuclear Generating Station
NLCA	Nuclear Liability and Compensation Act
NPCS	Negative Pressure Containment System
NPP	Nuclear Power Plant
NSA	Nuclear Safety Analysis
NSCA	Nuclear Safety and Control Act
NSO	Nuclear Security Officers
NSRB	Nuclear Safety and Review Board
NSS	Nuclear Sustainability Services
NSSCMP	Nuclear Safety and Security Culture Monitoring Panel
NuSAG	Nuclear Security Advisor Group
NWMO	Nuclear Waste Management Organization
O&C	Observation and Coaching
ODS	Ozone-depleting Substances
OHSA	Occupational Health and Safety Act
OPEX	Operating Experience
OPG	Ontario Power Generation Inc.
OSL	Operator Shift Log
OSRs	Operational Safety Requirements
P&IC	Pressure and Inventory Control
PA	Public Address
PAWCS	Post Accident Water Cooling System
PB	Pressure Boundary

Acronym	Word
PCB	Polychlorinated Biphenyl
PdM	Predictive Maintenance
PDP	Preliminary Decommissioning Plan
PDS	Plant Damage States
PEOC	Provincial Emergency Operations Centre
PFU	Predicted Failure Unavailability
PHC	Plant Health Committee
PHT	Primary Heat Transport
PI	Performance Improvement
PIEs	Postulated Initiating Events
PIP	Periodic Inspection Program
PM	Preventative Maintenance
PMMR	Preventative Maintenance Modification Request
PMRB	Preventative Maintenance Review Board
PMT	Post-Maintenance Test
PNERP	Provincial Nuclear Emergency Response Plan
PO&C	Performance Objectives & Criteria
PRD	Pressure Relief Duct
PROL	Power Reactor Operating Licence
PRV	Pressure Relief Valve
PSA	Probabilistic Safety Assessment
PSR	Periodic Safety Review
PSVS	Powerhouse Steam Venting System
PTNSR	Packaging and Transport of Nuclear Substances Regulations
PTP	Performance Testing Program
PULSW	Powerhouse Upper Level Service Water
QSP	Quality of Safety Practices
R&D	Research and Development
RAP	Reconciliation Action Plan
RC	Release Category
RCF	Radiation Calibration Facility
RCHP	Restart Control Hold Point
RCW	Recirculated Cooling Water
RHP	Responsible Health Physicist (Sections 2.2.3, 2.7.2, 2.7.3 and 2.7.4)
RHP	Regulatory Hold Point (Sections 3.2 and 3.2.7)
RIHs	Reactor Inlet Headers
RMI	Reactivity Management Index
RMT	Radioactive Material Transportation
ROR	Regulatory Oversight Report
RP	Radiation Protection
RPO	Refurbishment Project Office
RPPE	Radiation Personal Protective Equipment
RRS	Reactor Regulating System
RTS	Return-to-Service
S&L	Safety and Licensing
SA	Severe Accident
SAA	Severe Accident Analysis
SAFS	Systems Available for Service

Acronym	Word
SAMGs	Severe Accident Management Guidelines
SAT	Systematic Approach to Training
SCAs	Safety and Control Areas
SCBA	Self-Contained Breathing Apparatus
SCDF	Severe Core Damage Frequency
SCO	Station Containment Outage
SCR	Station Condition Record
SDC	Shutdown Cooling
SDS	Shutdown System
SEFDRs	Site Event Free Day Resets
SEM	Security Excellence Meeting
SES	Security and Emergency Services
SG	Standby Generator
SHT	System Health Team
SIIR	Serious Injury Incidence Rate
SIS	Systems Important to Safety
SM	Shift Manager
SMC	Site Management Centre
SMRs	Small Modular Reactors
SOE	Safe Operating Envelope
SOR	Shutoff Rod
SOT	Staying on Top
SPI	Safety Performance Indicators
SPOC	Single Point of Contact
SPOCAI	Smart Performance Objective & Criteria Artificial Intelligence
SPS	Sewage Pumping Station
SPVs	Single Point Vulnerabilities
SREs	System Responsible Engineers
SSC	Systems, Structures, and Components
SSCs	Structures, Systems, and Components
SST	System Service Transformer
SWPA	Safe Work Planning Assessment
SYSImp	System Importance
TCSCA	Timely Completion of Safety Corrective Actions
TDS	Target Delivery System
TERP	Transportation Emergency Response Plan
TG	Turbine Generator
TGD	Transportation of Dangerous Goods Regulations
TIMS	Training Information Management System
TLD	Thermoluminescent Dosimeter
TPARs	Technical Procedure Action Requests
TRA	Threat Risk Assessment
TRF	Tritium Removal Facility
TRIF	Total Recordable Injury Frequency
TSSA	Technical Standards and Safety Authority
U0 CRO	Unit 0 Control Room Operator
USCA	Unit Secondary Control Area
UST	Unit Service Transformer

Acronym	Word
VB	Vacuum Building
VBO	Vacuum Building Outage
VR	Virtual Reality
WANO	World Association of Nuclear Operators
WBC	Whole Body Counts
WHC	Wildlife Habitat Council
WHMIS	Workplace Hazardous Materials Information System
WO	Work Order
WPCP	Water Pollution Control Plant
WPPI	Work Protection Performance Index
WTP	Water Treatment Plant
WWMF	Western Waste Management Facility

Appendix B: System Design and Performance

The subsections in this Appendix contain descriptions and performance details of specific station systems, including details on nuclear safety functions. Significant projects, modifications, and initiatives have been undertaken throughout the current licence term for continuous improvement in the reliability and performance of the Structures, Systems and Components (SSCs), with continued prioritization of safe station operation. These improvements resolve issues such as equipment obsolescence, aging management, maintenance and operator burden, spare parts availability, and applicable performance or design issues identified through performance monitoring and trending. Successful completion of the improvements results in reliable SSC performance throughout the extended life of the station and positive long-term trends in system health. Execution of projects and modifications is planned and completed for each applicable Unit through the applicable work management processes including Darlington NGS Refurbishment, outages, or on-line work. Throughout the subsections in this Appendix, the improvements listed for each system include completed, in-progress, and planned improvements for the current and upcoming licence term.

Safety Related System Tests are performed at their specified schedules for applicable systems and components to ensure all safety functions are reliable and meeting the design and operating requirements. The Preventative Maintenance (PM) program is also in place such that the required maintenance and testing for critical equipment is completed at the specified intervals.

Operational Safety Requirements (OSRs) are in place for applicable systems with safety functions and are in the LCH (refer to Section 2.3 for the list of OSRs). The starting point of the OSR is the determination of the Safety Limits, which are derived from the analysis limits used in safety analysis (NK38-SR-03500-10002, *Darlington Nuclear 1-4 Safety Report: Part 3 – Accident Analysis*). The Safety Limits are used to define the hardware functional requirements and limiting system parameter values in the hardware subsystems. The Safety Limits are also used to ensure there is sufficient margin to the nominal actuation setpoints to account for instrument error and uncertainty.

System performance monitoring is an ongoing process which is planned and completed for every system. The rigour and frequency of each task is applied commensurate with the safety criticality and performance requirements of the system. Critical system performance monitoring tasks performed by System Responsible Engineers (SREs) include:

- Completion of System Health Reports at required frequency for each system. Methodology is in place for classification of system tiers and scoring mechanisms.
- Screening for maintenance work including PM and other work orders/requests for repairs and improvements. Scoping and prioritization of work execution is regularly monitored, and considered for system health improvements and continued safety adherence.
- Performance Improvement (PI) database checks to ensure system operating parameters are within the required ranges. SREs communicate with Control Room Operators (CROs) and Authorized Nuclear Operators (ANOs) as required, for verification of abnormal system trends.
- Monitoring & Diagnostic Center has been implemented to perform additional monitoring on specific PI trends. It utilizes advanced pattern recognition software to build operational profiles, and monitor the condition and performance of SSCs.

- System walkdowns for field observation of system components and parameters.
- Monitoring and trending of the Station Condition Record database, including reportable events per REGDOC-3.1.1.
- ENGAGE software has replaced older software with an enhanced user interface, to facilitate efficient monitoring of PM status and system health report action items.
- Review of station briefing packages and equipment failure review packages for any engineering inputs and support required.

B.1 Special Safety Systems – Emergency Coolant Injection System

The Emergency Coolant Injection (ECI) system is one of the four Special Safety Systems at Darlington NGS. The purpose of the ECI system is to automatically provide make-up water to the Primary Heat Transport (PHT) system following a postulated Loss of Coolant Accident (LOCA). ECI is not required to operate during normal plant operation, but must be in a poised standby mode.

During poised mode, the common ECI System remains pressurized by a recirculating pump that recirculates water through the entire system up to the ECI Injection Valves. Unit ECI System is required to detect LOCA conditions and send signals to start common ECI pumps, open Instrumented Steam Relief Valves for rapid cooldown, start the Standby Generators (SGs), and open ECI Injection Valves.

Short-Term Injection Mode will be initiated in the event of a LOCA large enough that the PHT D2O Pressure and Inventory Control System cannot make up the losses. Short-Term Injection is the mode of operation during which the cooling water is drawn from the Injection Water Storage Tank (IWST). On receipt of a low water level signal from the IWST or sufficient water level signal from the Recovery Sump, Long-Term Injection Mode will be initiated by the Operator. Long-Term Injection is the mode during which the cooling water is drawn from the Fuelling Machine Duct (FMD) and the Pressure Relief Duct (PRD).

Post Accident Water Cooling System (PAWCS) is a safety support system required for long term post-LOCA operation to provide a heat sink for continued heat removal from the fuel in the reactor, and to maintain the water temperature in the FMD and PRD below 65°C. During normal plant operation and during early stages post-LOCA, PAWCS remains in a poised standby state.

As part of system performance monitoring, the Recharge Dashboard is a tool that is used for monthly trending of hydraulic leaks and accumulator recharges.

Completed projects, modifications, and initiatives for the ECI System and PAWCS include:

- PAWCS heat exchangers replacement.

In-progress and planned projects, modifications, and initiatives for the ECI System and PAWCS include:

- OH180 hardware replacements through reverse-engineering of existing communication modules, Input/Output (I/O) boards, and power supplies.
- ECI System and PAWCS motor operated valves and air operated valves replacement.
- ECI System 4kV Motor replacements for eight low pressure ECI System pumps.

- ECI System Group II pressure transmitters replacement.
- ECI System Injection Valves overhaul.
- ECI System flow orifices and feeders replacement.
- Power operated valve/Motor operated valve replacement project which includes ECI recovery isolators and other ECI valve replacements.

B.2 Special Safety Systems – Negative Pressure Control System

The Containment System is one of the four Special Safety System at Darlington NGS. Its purpose is to prevent the release of radioactivity to the environment in excess of regulatory release limits for the site following certain postulated accidents and also during normal operation of the station. The Containment System limits the overpressure transient resulting from a LOCA so as to maintain the integrity of containment, and to quickly return the containment pressure to sub-atmospheric in order to minimize short term releases. This is done by providing a physical barrier to the release of radionuclides, by maintaining containment pressure sub-atmospheric to minimize uncontrolled releases, and by limiting the magnitude and period of any overpressure transient following accidents. Operational procedures for Negative Pressure Containment System (NPCS) elaborate on different operating conditions such as shutdown state, poised state and operating state.

The containment at Darlington NGS is maintained at 3.5 kPa sub-atmospheric. In case of a LOCA, high pressure radioactive airborne particles would overcome the weight of the Pressure Relief Valves (PRV) surrounding the Main Vacuum Chamber (MVC) in the vacuum structure by establishing a flow path from station common containment to the Vacuum Building (VB) via the PRD. Since the VB is maintained at 8 kPa(a), it will take all airborne particles into it to prevent from radioactive release to the public domain. If the MVC pressure continues to rise, it will initiate the dousing system, a self-actuated system, by the pressure rise in the Vacuum Structure resulting in water spray to condense the air for pressure reduction.

The Emergency Filtered Air Discharge System (EFADS) is a part of the NPCS having following functions:

- Maintain containment at a suitable sub-atmospheric pressure in the long-term following a LOCA or less severe accident that will result in increased containment pressure and high activity release into the containment; and,
- Maintain containment at sub-atmospheric pressure in the long-term following an earthquake.

The following graphs (Figure 39) demonstrate the leak tightness of the Darlington NGS Containment from tests that were performed in the past. They include; (i) Station Containment Outage (SCO) / Vacuum Building Outage (VBO) leakage tests, currently completed at a 12-year frequency per the Darlington NGS Licence Conditions Handbook, and (ii) Online Containment leak rate tests performed every 6 months. These results clearly show that the Containment / Structural leakage is below the action and OP&P limits. Hence, the integrity of the containment is well maintained.

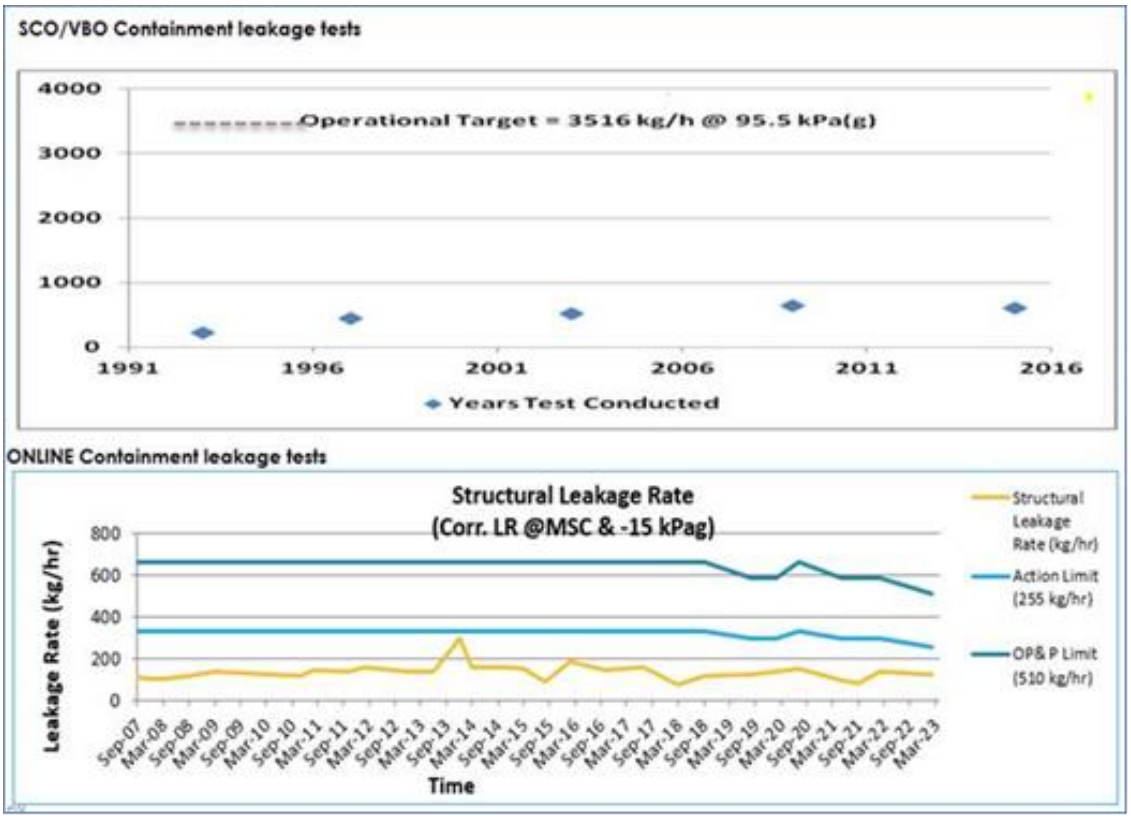

Figure 39: Containment Leakage Tests

Completed projects, modifications, and initiatives for the NPCS include:

- Containment Button-Up System activity monitors replacement. This modification has resulted in a significant reduction of spurious signals.
- Installation and commissioning of the Containment Filtered Venting System.
- Post Accident Radiation Monitoring System replacement which is the monitoring interface of EFADS.

In-progress and planned projects, modifications, and initiatives for the NPCS include:

- OH180 hardware replacements through reverse engineering of existing boards.
- Radiation Protection (RP) teledosimetry penetration upgrade with EQ fiber optic penetration module installation. This modification installs new cable penetration modules with fiber optic and copper conductors to increase data capacity of the Audio Video Teledosimetry System going into the vault.
- MVC pump skid replacement with stainless steel parts to reduce aging and degradation caused from corrosion.
- Upper Vacuum Chamber pump replacement.
- Dousing water heater and controller replacement.
- Hydrogen Ignitor relays replacement.

B.3 Special Safety Systems – Shut Down Systems

Shutdown Systems (SDS) are required to automatically initiate reactor shutdown before the Safety Limit associated with any trip parameter is exceeded. SDS1 and SDS2 are two of the four Darlington NGS Special Safety Systems, providing independent and diverse means of reactor shutdown following Design Basis Accidents (DBAs). The provision of two fast, independent, diverse and highly reliable shutdown systems is in accordance with the requirements stated CSA N290.1-13, *Requirements for the shutdown systems of nuclear power plants.*

The following DBAs, evaluated in the Safety Report: Part 3 - Accident Analysis, result in automatic activation of the SDSs:

- Large Loss of Coolant Accidents
- Transition Loss of Coolant Accidents;
- Small Loss of Coolant Accidents;
- Electrical Failures;
- Control Failures;
- Feedwater System Failures;
- Steam Supply System Failures;
- Moderator System Failures;
- Failures in the Shutdown Cooling System and in the Shutdown Cooling System Rooms;
- Common Mode Events;
- The remaining DBAs occur on a time scale long enough to credit the operator to reduce the power manually using the Reactor Regulating System (RRS), or to manually activate the SDSs.

Completed projects, modifications, and initiatives for the SDS1 and SDS2 include:

- SDS1 Shutoff Rod (SOR) clutch relay cards and RRS logic modules replacements. This completed modification improves reliability and prevents inadvertent dropping of SORs in the reactor core.
- SDS1 clutch relay card power supply replacement.

In-progress and planned projects, modifications, and initiatives for the SDS1 and SDS2 include:

- SDS1 and SDS2 EQ Ion Chamber Detectors replacement;
- SDS1 and SDS2 Flux Detectors replacement;
- SDS1 and SDS2 Ion Chamber Amplifiers and Neutron Overpower Amplifiers replacement;
- SDS1 and SDS2 flow orifices (with their respective pressure tubes and feeders) replacement;
- SDS1 and SDS2 Trip Computer and Display/Test Computer replacement;

- SDS1 SOR drive mechanisms spare procurement and SOR potentiometers replacement;
- SDS2 process transmitters replacement;
- Liquid Injection Shutdown System poison ball level alarm replacement.

B.4 Reactor Regulating System and Liquid Zone Control

The RRS in combination with the Liquid Zone Control (LZC) is required to monitor and control the bulk and spatial flux power distribution across all 14 zones of a CANDU reactor. Under normal operation or reactor power outages, the RRS and LZC must be capable of monitoring reactor power and controlling it within operational limits per CSA N290.4, *Requirements for Reactor Control Systems of CANDU Nuclear Power Plants,* and the Darlington NGS OP&Ps. To meet the operational limits, the RRS is capable of automatically reducing power in the event of an adverse perturbation that directly or indirectly impacts reactor power. The power reduction can either be minor (setback) or major (stepback) depending on the severity of the perturbation. This power reduction provides an increase in heat sink availability as described in the Safety Report Accident Analysis.

The operational safety requirements for RRS drive the safe operating envelope of the RRS and LZC systems. The stepback and setback functions for the RRS require surveillance requirements, as found in the OSR, to minimize the frequency of serious process failures. In addition, the safety limits from the fuel and physics OSR and the moderator OSR, drive various safety surveillance requirements in the RRS. In relation to fuel and physics OSR, the following systems must be monitored:

- Fully Instrumented Nominal Channel Power (FINCH): to ensure the reactor's maximum thermal power is within licence limits, Simulation of Reactor Operation error is within limits, and neutronic power error is within limits.
- In-Core Flux Detectors (ICFDs): to ensure flux tilt is within limits.
- Rod and liquid positions: to ensure safe operations.

In relation to the moderator OSR, the automatic poison addition system must be monitored to ensure the hardware meets design requirements.

Completed projects, modifications, and initiatives for the RRS and LZC systems include:

- Logic Modules replacement for Adjuster Assemblies (AAs), control absorbers and shutoff rod assemblies. The new models contain dual internal power supplies and ensure no spurious rod drives in or out of the core. Control Modules for AAs and control absorbers were also replaced.
- AA maintenance covers were designed to facilitate the removal of AA rods to ensure pressure boundaries during AA rod removal/installation activities.
- LZC valve digital positioners installation to replace old analog positioners.

In-progress and planned projects, modifications, and initiatives for the RRS and LZC systems include:

- RRS Ion Chamber Detectors replacement with a new model made by imaging and sensing technology.

- RRS ICFDs replacement.
- RRS Ion Chamber Amplifiers and ICFD Amplifiers replacement.
- AAs replacement for Cobalt-60 Project, to replace titanium/stainless steel rods with Cobalt rods. This modification is critical for the future production of the Cobalt-60 medical isotope, and will continue to meet the function of flux shaping the core.
- RRS flow orifices, pressure tubes and feeders replacement.
- Reactor monitoring Resistance Temperature Detector replacement for reactor inlet headers, FINCH lines, and channel outlet temperatures.
- Redesign of Liquid Zone pump discharge check valves to improve opening time and eliminate sticking has been initiated.
- Start-up Instrumentation installation during Refurbishment, to allow core monitoring for reactor power under -6 decades.

B.5 Electrical Power Systems – Class I

The purpose of the Class I Power System is a System Important to Safety, and its purpose is to provide a highly reliable supply of DC power to the following load categories:

- 250 Vdc
    - Inverters used for 120/208 Vac and 347/600 Vac Class II power.
    - DC pump motors (DC Lubricating Oil pump and DC Seal Oil pump).
- 125 Vdc
    - Station service circuit breaker control (13.8 KV, 4.16 KV and 600 V circuit breakers trip/close circuits) and protection loads.
- 48 Vdc
    - Channelized safety-related loads (Group 1 Special Safety and Safety Related instrumentation loads for all three channels).
    - Group 2 Special Safety and Safety Related instrumentation loads for the 3rd channel.
    - Process/Electrical Control and logic loads (OH180 Programmable Controllers).

In-progress and planned projects, modifications, and initiatives for the Class I Power System include:

- Class I Batteries replacement will improve reliability and utilize newer models as battery manufacturing has improved in addressing battery leakage issues.
- Class I Rectifiers replacement.
- Class I Ground Fault Detectors replacement.

B.6 Electrical Power Systems – Class II

The purpose of the Class II Power System is to provide a highly reliable supply of AC power to the following load categories:

- Group 1 Special Safety and Safety Related loads for all three channels.
- Group 2 Special Safety and Safety Related loads for the 3rd channel.
- Computers and instrumentation (e.g., Digital Control Computers (DCC) X and Y, Common processes computer, sequence of events monitoring computer.
- Equipment protection/logic loads.
- Emergency lighting and emergency Class I/II Equipment Room Ventilation.

In-progress and planned projects, modifications, and initiatives for the Class II Power System include:

- Uninterruptable power supplies replacements.
- 120/208 Vac Motor Starter replacements.
- 120/208 Vac Switchgear (Unit 0) refurbishment.

B.7 Electrical Power Systems – Class III

The purpose of the Class III Power System is to provide electrical power to specified Class III loads which ensure that, following a loss of Class IV power, the reactor is safely shutdown, the reactor decay heat is removed, the status of steam supply is monitored, and the release of radio nuclides from the containment, if any, is limited. The Class III power system must also supply specific Class III economic loads which are required to minimize the economic consequences of a loss of Class IV power.

The Class III Power System is divided into; Common System, Class II Power Sources, Unit System, and Station Class III Transfer System. Each of these sub-systems is designed to include the “odd” and the “even” divisions for both power distribution systems and control; to provide redundancy and to ensure security for particular systems. Each division is electrically independent of the other, and physically separated. Electrical independence and physical separation for odd and even division equipment is necessary to minimize the probability of equipment failure due to a common mode event.

In-progress and planned projects, modifications, and initiatives for the Class III Power System include:

- OH180 hardware replacements for the Class III transfer schemes and circuit breaker control.
- Circuit breakers and motor protection relays addition for Shutdown Cooling pump motors to allow for additional shutdown cooling capability.
- Unit 0 Switchgear refurbishment, including circuity breakers, buses, transformers, and relays associated with both nuclear safety loads and important economical loads.

- Electrical Signature Analysis online monitoring system implementation for Class III 4.16kV buses, to improve reliability of the electrical motors and provide monitoring to assist in preventing failures.

B.8 Electrical Power Systems – Class IV

The purpose of the Class IV Power System is:

- To supply AC Station Service power to the Class IV service loads (e.g., lighting and receptacles) and process systems (e.g., boiler-feed water system) at 13.8 kV, 4.16 kV, 347/600 V, and 120/208 V distribution voltage levels.
- To provide power directly to the Class III distribution system, during normal operation.

The purpose of the Class IV Transfer Scheme is:

- To transfer the unit auxiliaries supplied from the System Service Transformer (SST) to the Unit Service Transformer (UST) during a unit start-up.
- To transfer the unit auxiliaries supplied from the UST to the SST:
    1. Manually when a loss of the UST is pending or
    2. Automatically following actual (or impending) loss of the UST supply.

In-progress and planned projects, modifications, and initiatives for the Class IV Power System include:

- Unit 0 Switchgear refurbishment.
- LED lighting replacements to improve lighting levels in various station areas including Unit 0 offices and shops, new fuel areas in Fuelling Facility Auxiliary Areas (FFAAs), FMD, Unit hallways and pump houses, Powerhouse, and outdoor system buildings such as SG, Emergency Power Generator (EPG), Emergency Power Supply (EPS), Condenser Cooling Water (CCW).
- Transformer (10MVA) control cabinet wiring system replacement, which is associated with significant loads such as the CCW pump and Boiler Feedwater pump.

B.9 Electrical Power Systems – Standby and Emergency Power Generators

The SG System consists of four 100% capacity gas turbines capable of automatic black starting. Each SG is rated for a minimum continuous output of 22.375 MW (at 40°C inlet temperature), a generator power factor of 0.8, and at a terminal voltage between 95% and 105% of the rated 13.8kV. When operating at an air inlet temperature of 15°C or less, the minimum continuous output is 26 MW.

The SGs make up part of the Standby Class III System. The purpose of the SGs is to provide power to the Standby Class III in the event of a loss of Class IV power and/or LOCA. In both cases, all four SGs are expected to start up automatically and run up to synchronous speed. In the event of a loss of Class IV, the first ready SG will synchronize to either the odd or even Class III transfer bus and pick up all nuclear safety loads. One SG is required to be available to pick up the minimum required Standby Class III loads. Similarly, the second ready SG will synchronize to the other bus and pick up all of the economic (non-nuclear) loads. Two SGs are

capable of supplying the entire Standby Class III load for the station. The recommended operating practice is that two SGs are maintained available at all times.

The EPG System consists of three 100% capacity gas turbines capable of starting without external power (black starting). EPG1 is rated at 6.8 MW gross (6.5 MW net) and 4.0 MVAR at 0.8 power factor. EPG2 and EPG3 are rated for 8.0 MW and 6.0 MVAR at 0.8 power factor. The EPGs are capable of supporting Safety Related Emergency Loads (Group 2) connected to the EPS System following a postulated common mode incident within the reapplication time of 30 minutes. EPGs are seismically qualified to Design Basis Earthquake (DBE) Category-C, i.e. the specified performance capability must be retained following a seismic event.

Completed projects, modifications, and initiatives for the SG and EPG Systems include:

- EPG3 installation and improvements to EPS availability. Additional design enhancements were made to EPG3 based on initial operational performance and monitoring, mainly regarding the compressed air supply.
- EPG1 and EPG2 replacements completed with new and upgraded generators to match EPG3.
- SG Control retrofit including replacement of control system components, software, and logic.

In-progress and planned projects, modifications, and initiatives for the SG and EPG Systems include:

- SG Protection Relays replacement with digital multifunction relays to replace the older electro-mechanical relays;
- SG Fuel System duplex fuel filter bypass relief valve replacement to address fuel leak issues.

B.10 Electrical Power Systems – Main Power Output

The purpose of the Main Power Output (MPO) System is to transmit the power from the generator terminal output 22kV to the 500kV Ontario Bulk Electric System Grid. The purpose of the Generator Voltage Output (GVO) system is:

- To transmit the generator output to the low voltage terminals of the Main Output Transformer (MOT).
- To supply power to the high voltage terminals of the UST, through taps off the GVO system.
- To provide voltage source for protective relaying, voltage regulation, synchronizing, metering and other functions, through the use of instrument transformers.
- To limit, by means of generator stator neutral grounding equipment, the phase-to-ground fault currents to a low value and to provide a signal source for protective relaying.

In-progress and planned projects, modifications, and initiatives for the MPO System include:

- MOT and UST replacements.

- MPO protection relays replacement with microprocessor-based multifunction relays, to improve grid reliability and station power supply reliability. Furthermore, dynamic disturbance monitoring is to be installed on the MPO system as part of this project per North American Electric Reliability Council standards for transmission and generation systems.
- Revenue Metering replacement, including current and capacitor voltage transformer replacements at both the MOTs and SSTs, along with updates to the metering cabinets. Completion of this project is critical for Revenue Metering System compliance with the Independent Electricity System Operator (IESO) market rules and Measurement Canada regulations.
- Isolated Phase Bus (IPB) upgrade project through critical component replacements.
- Sulfur hexafluoride synchronizing breakers refurbishment at Bowmanville Substation, including gasket replacements, grading capacitor replacements, and hydraulic mechanism overhaul.
- Transformer control cabinet wiring system replacement, including disconnect switches, relays, control power transformers, terminal blocks, and wiring.
- Phasor Measurement Unit technology for Unit Generators, as this technology will enhance reliability and resiliency of the grid. This technology allows for more comprehensive and accurate data to be supplied to the IESO, and will enable detailed health assessments of local and wide-area power systems.

B.11 Instrumentation and Control – Digital Control Computers

Instrumentation and Control at Darlington NGS is primarily implemented by the DCC system. The DCC system is Safety Related, and its purpose is to control and monitor various plant process systems in the reactor unit.

Completed projects, modifications, and initiatives for the DCC System include:

- I/O chassis 48V power supplies replacement to resolve previous issues with equipment redundancy.
- Replacements of printed circuit boards with reverse engineered or new boards, including for the I/O Controller and Contact Input Scanner.

In-progress and planned projects, modifications, and initiatives for the DCC System include:

- Replacements of printed circuit boards with new reverse engineered Watchdog Timer boards.
- Display Subsystem replacement including display generators, CRT displays, light pens, printers, and all interconnecting cabling. Refer to Figure 40 and Figure 41 below for comparisons of the legacy and new equipment in Unit 2.
- Analog input points expansion with purpose of adding 15 analog input points and associated cabling for each DCC.
- DCC hardware future replacements such as I/O subsystem, I/O power supplies, power distribution units and filters, terminals, and keyboard electronics, along with major DCC software upgrades.

Figure 40: Old CRT display (left) and new touchscreen display (right)

Figure 41: Old display generator (left) and new video display generator (right)

B.12 Instrumentation and Control – Control Facilities

The purpose of the Control Centres is to provide a facility and an environment necessary for the equipment in the area to function, and for personnel to be capable of operating plant equipment. Control centres are those areas which contain the instrumentation, controls, and protection necessary for the operation and monitoring of equipment. Examples are the Main Control Centre, the Local Control Equipment Rooms, and Local Control Rooms.

The control centre is located in the Central Service Area. It contains the Main Control Room (MCR), Control Equipment Rooms for each unit, a Common Services Equipment Room, Fuel Handling Control Equipment Rooms, and a Work Control Area. The MCR is the centralized on-site facility where the site's nuclear units are monitored and operated. The MCR is staffed at all times with licensed operators, and MCR control panels are checked each shift. The MCR contains a control panel and console for each generating unit, the fuel handling control panels, the common services control panel, and the unit and common electrical control panels.

Each unit has a Unit Secondary Control Area (USCA) and a Unit Electrical Secondary Control Area. These are used to shut down, cool down and monitor the nuclear steam supply should the MCR become un-inhabitable. A Common Secondary Control Area (CSCA) contains instrumentation and control necessary to accomplish the same functions for common process systems under these circumstances. The CSCA further provides a location for the Secondary Emergency Operations Centre from which the overall station operations can take place and be coordinated, along with communication with outside agencies.

From a health, safety and security perspective, there is a MCR Breathing Air System to provide breathing air at controlled pressure to the MCR during a potential toxic gas release event. Darlington NGS has made seismic routes (designated pathways) available to provide assured and unimpeded access from MCR to Secondary Control Room areas and other designated areas, following a seismic event or common mode event.

The majority of changes impacting the control room are controlled by the Engineering Change Control process, with a couple of notable exceptions, including business LAN equipment, and some facilities modifications such as the furniture in the Emergency Operations Centre (EOC).

Completed projects, modifications, and initiatives for the Control Facilities include:

- Door locks installation on the MCR and Secondary Control Areas for enhanced security. In order to gain entry, individuals are required to be on a “vital areas” list.

In-progress and planned projects, modifications, and initiatives for the Control Facilities include:

- MCR Annunciation system modification to address legacy design issues as per IIP-OI 034.
- MCR Breathing Air system replacement with Powered Air Purifying Respirator (PAPR) system, consisting of a personal battery powered air pump and filter system connected to a helmet and hood. These systems have been used successfully during Unit Refurbishments.
- MCR Turbine-Generator (TG) controls change as a result of the TG control system replacement.
- MCR Fuel Handling monitor and keyboard configuration modification to improve user interface for Fuel Handling Operations.
- MCR furniture replacement to allow for improved workflow, productivity, ergonomics, and communication between ANOs/CROs.

B.13 Emergency Response Facilities

Emergency facilities are equipped with the necessary equipment to implement emergency response actions as required. This includes voice communications equipment, including back-up, and other equipment which may include fax machines, personal computers, status boards, area radiation monitoring equipment, radiation survey kits, fire-fighting gear and equipment, off-site monitoring vehicles, and meteorological monitoring data read-out equipment. Other support facilities have phone communications equipment, including back-up fax machines and radios as appropriate.

The station telephone system is the primary telephone system with the main emergency response facilities having external trunk lines to provide adequate back-up communications

capability. Fax machines equipped with station Private Business Exchange and trunk lines are available. OPGs nuclear stations have an emergency radio communications system with dedicated frequencies. On-site and off-site field teams are equipped with cell phones and/or portable radios. Base radio stations are available at several on-site locations such as the MCR.

OPG emergency response facilities are linked to the Provincial Emergency Operations Centre (PEOC), municipal EOC and regional EOC through landline phone and other communication systems as required to allow information transfer. OPG has also established reliable contingency communication systems. (e.g., Satellite phones). Fixed and portable equipment lists for tasks such as firefighting, accident assessment, process monitoring, radiation monitoring, and meteorological monitoring, are included in site-specific documents.

For the response to an emergency event, the MCR is the first on-site facility to become involved with the response. The EOC is an on-site facility adjacent to the MCR, under the direction of the Shift Manager, where site shift staff assemble to manage and coordinate event response. This facility is also dedicated as the Shift Manager's office and is maintained in a poised state. The power supply to the EOC is station Class IV power. An alternate location for the EOC is located in the Common Secondary Control Area. Facility checks are routinely conducted in this area for emergency response supplies and equipment.

The EOC has a telephone system as the primary communication method, along with backups and alternate lines for redundancy. An efficient communication line between the Shift Manager in the EOC and the Emergency Response Manager in the Site Management Centre (SMC) is established. The SMC is a dedicated emergency response facility where on-call management, technical, and support staff assemble to manage and coordinate the site-wide response to a radiological emergency. Furthermore, a callback line is available and poised for communication with the PEOC during emergency response. Overall, the communication systems and processes are in place to allow for efficient communication between personnel in critical roles during response to an emergency, and ensures safety of all personnel and the public.

Emergency cabinets available to the EOC provide a dedicated supply of emergency equipment to support the response to an emergency. All emergency cabinets are sealed with a blue security seal and an inventory list is located in each cabinet. There are emergency cabinets available for a number of different functions including emergency supplies, RP equipment, in-plant survey team, assembly areas, and emergency flashlights.

In the case of response to Beyond Design Basis Earthquakes (BDBEs), equipment such as laptops, fax machines and radios are available at Darlington NGS to assist the Emergency Response Organization to fulfill their requirements and to communicate with off-site agencies. BDBE radio communications are also available in the EOC, SMC, and throughout the station.

In the event of an extreme external event that requires essential staff to be sequestered at site, 72-hour emergency supplies provide the necessary food, water, hygiene and sleeping requirements until outside aid is brought in. In addition, Radiation Personal Protective Equipment (RPPE) is stocked and maintained at the Darlington NGS site in quantities that consider a response to an emergency with no off-site aid for up to 72 hours. The RPPE is located in regular inventory locations and maintained in accordance with OPG's inventory control procedures and processes. Distribution of 72-hour supplies is intended for extreme emergency situations, and only at the direction of the Shift Manager, Emergency Response Manager or Emergency Recovery Director.

OPG has established processes and defined procedures to monitor, test, and maintain emergency response facilities and equipment to ensure operability 24 hours a day, 7 days a week. This includes testing and facility walk-through frequencies, and covers the different types of documents and equipment. Specific requirements, configuration management and contingency actions for emergency management facilities are contained in applicable facility manuals. The Equipment Important to Emergency Response (EITER) procedures include the framework to assure that when EITER is removed from service (including control facilities) for maintenance or is in a degraded condition, the correct restoration priority is assigned, and any required compensatory measures are implemented. EITER includes systems, structures, and components, as well as essential tools and equipment necessary to implement this emergency plan.

Enterprise Emergency Management maintains facility checks for emergency preparedness equipment and supplies for the CSCA, EOC and SMC. These checks are completed at regular intervals and reported to the CNSC. If an EITER equipment deficiency is discovered by any staff on site, a defined process is outlined to ensure notifications are made, and the equipment and facility condition are documented and returned to service.

Completed projects, modifications, and initiatives for the Emergency Response Facilities include:

- EOC renovation to improve the layout and function of the facility. Equipment replacement included televisions, monitors and computers, LAN cables, and the addition of a second Plant Information computer, along with aesthetic updates such as carpets, paint, and furniture. Refer to Figure 42 below for the renovated EOC.

In-progress and planned projects, modifications, and initiatives for the Emergency Response Facilities include:

- Public Address System upgrade modification is a critical improvement being made to the EITER and will result in improved audibility across the site.

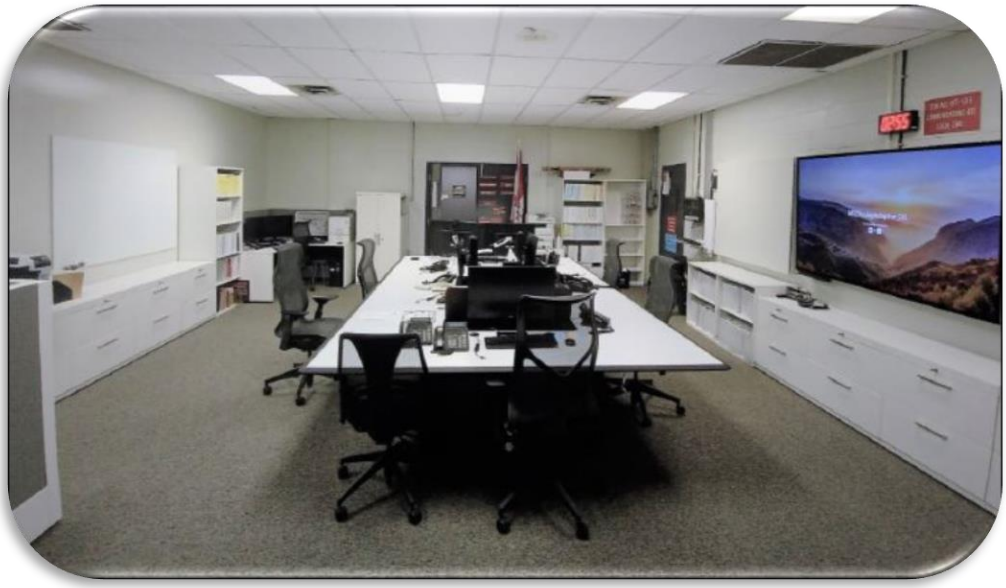

Figure 42: Darlington NGS Emergency Operations Centre (EOC)

B.14 Steam Supply Systems – Feedwater, Main Steam and Steam Bypass

The Boiler Feed System is provided to supply hot, pressurized demineralized water to the steam generators under all operating conditions, including start up and shutdown. Each of the four Units of the powerhouse is provided with a Main Steam System, which is comprised of the Main Steam Supply System and the Steam Generator Steam Relief System. The purpose of the Main Steam Supply System is to carry steam from the steam generators to the turbine-generators under normal operating conditions when electric power is generated. Additionally, the steam is supplied to other miscellaneous systems per requirements.

The turbine bypass system enables the reactor power to be maintained at 70 percent even though the turbine-generator may be tripped, on turning gear or operating at a load lower than 70 percent. The system accomplishes this by absorbing the main steam flow when it cannot be admitted, either wholly or partially, to the turbine.

Completed projects, modifications, and initiatives for the Feedwater, Main Steam and Steam Bypass systems include:

- Feedwater System seismic reinforcement improvements to meet requirements for mitigation of BDBE. Upgrades were made to anchorage and supports for the Deaerator storage tank and Boiler Feed high pressure heaters.

In-progress and planned projects, modifications, and initiatives for the Feedwater, Main Steam and Steam Bypass systems include:

- Auxiliary Boiler Feed Pump (ABFP) mechanical seal replacements and addition of gland injection cooling loop to reduce seal failures caused by high temperatures.
- Main Boiler Feed Pump (MBFP) and ABFP reverse rotation detection system replacements.
- Main Steam System EQ pressure transmitters replacement.
- Procuring spares for critical components (valves, pumps, and pump motors) to enable periodic overhauls and replacement.
- Steam Generator level control valves replacement, and additional modifications to upgrade the associated hand controllers and ABFP/MBFP recirculation controllers.
- Valve replacements including ABFP pressure control valves, Condenser steam discharge valves, and Inter-Unit Feedwater Tie valves.

B.15 Steam Supply Systems – Turbine and Generator

Darlington NGS incorporates a defense-in-depth design approach for the Turbine, Generator and Auxiliaries systems. The Turbine and Auxiliaries system consists of the turbine set; 1 High Pressure (HP) turbine and 3 identical Low Pressure (LP) turbines coupled in series. Live steam flows from the Steam Generators to the HP turbine via 4 control valves and 4 stop valves. After exiting the HP turbine, the wet steam, is partly dried in 4 pre-separators before it enters the 2 moisture separator reheaters. The reheated steam exists the moisture separator reheaters, and flows through 6 intercept and 6 stop valves before it enters the LP turbines. The steam is then expanded before it enters the Condenser where it is condensed. The Turbine Auxiliaries include the turbine Turning Gear, Turbine Bearings, Lubricating Oil, Lube Oil Purification, Gland Seal, and Turbine Supervisory Systems.

The Generator System consists of a 4-pole synchronous generator, the excitation system, Seal Oil System, Stator Cooling Water System, Hydrogen Cooling System and Slipring Dehumidification system. The generators utilize single pass water-cooled stator and direct hydrogen-cooled rotor design. Generator stator coolant flows from the slipring end to the turbine end through the stator bars and some coolant flows through the terminal bushings. Pressurized hydrogen gas is circulated by two fans mounted on either end of the generator rotor.

Completed projects, modifications, and initiatives for the TG systems include:

- Tube bundles in all seal oil heat exchangers across all four Units.
- Replaced TG Auxiliary Lube Oil Pump motor across all four Units.
- Replaced lube oil temperature control valves on each Unit.

In-progress and planned projects, modifications, and initiatives for the TG systems include:

- Turbine and Generator upgrade.
- Turbine and Auxiliaries system modifications as part of the TG Upgrade project during each Unit Refurbishment including: Turbine Electronic Control upgrade, PRV piston ring modification, HP Turbine Layup modification, Electrohydraulic Converter (EHC) modification, Main Output Control and Protection Equipment Room control panel modifications, field instrumentation modifications, Jacking Oil pump and Turning Gear operation project, and Auxiliary Turning Gear cables upgrade.
- Generator and Auxiliaries system modifications as part of the TG Upgrade project during each Unit Refurbishment, including: Stator Rewind, End shield and shaft seal housing modification, Excitation system modification, Hydrogen Cooling skid upgrades, Seal Oil skid upgrades, Stator Cooling Water skid upgrades, Turbine and Auxiliary Instrumentation and Controls System, Turbine Trip and Protection System, EHC modification, TG supervisory system, and Data Acquisition Computer.
- A pilot program to test ultrasonic greasing on reheat drains and second stage reheat drains pump motors.
- Fire Resistant Fluid pump upgrade.

B.16 Plant Auxiliary Systems – Liquid Chlorination System

The Liquid Chlorination System utilizes the properties of 12 wt% sodium hypochlorite (NaOCl) and calcium thiosulphate to mitigate the damage caused by Zebra Mussels and other organic material in the span of the Emergency Service Water (ESW) and Low Pressure Service Water (LPSW) systems, without exceeding an effluent total residual chlorine concentration of 10 ppb (parts-per-billion). The system normally operates from the end of May to the middle of November. Start and end dates vary based upon the requirements listed in the Environmental Compliance Approval, approved by the Ministry of Environment Conservation and Parks.

The Liquid Chlorination System is continually reviewed for improvements to equipment and monitoring practices. Monitoring is completed every shift, including checking the total residual chlorine levels and adjusting the levels as required. Spare parts for the system will also be evaluated and updated as required based on past demand, new operating experience, and any obsolescence issues that arise.

Completed projects, modifications, and initiatives for the Liquid Chlorination System include:

- ESW and LPSW chlorination upgrade to enable continuous chlorination of Units 0 and 1 to 4 simultaneously for more effective prevention of zebra mussel and biofilm growth.
- Permanent Dechlorination building and system installation to ensure that the station water discharge does not exceed 10 ppb total residual chlorine.
- Dechlorination chemical change from sodium bi-sulphate to calcium thiosulphate to remove hazards when working with sodium bi-sulphate.

B.17 Plant Auxiliary Systems – Water Treatment Plant

The Water Treatment Plant (WTP) is used to process water from Lake Ontario into a high purity demineralized water. The WTP is continuously run and monitored by an operator. The operator is displayed information on the key aspects of the plant, such as inflow, outflow, station demand, water storage level, and effluent conditions. Certain conditions of the water such as pH and conductivity are monitored remotely.

The WTP must have enough capacity to support: continuous condensate make-up at 0.125% unit steam flow (USF = 4.72 x 10^6 kg/h) for four units, continuous blowdown of the steam generators at 0.3% USF for four units, emergency blowdown of the steam generators at 3% USF, and miscellaneous process uses in the station distributed by the HP Demineralized Water System at a nominal flow of 15 L/s and an infrequent maximum flow of 30 L/s. It must also include sufficient storage capacity for various different operating states including normal operation, unit startup and unit shutdown. Standards and requirements are in place for chemistry of the effluent from the WTP.

In-progress and planned projects, modifications, and initiatives for the WTP include:

- A new Demineralized Water Plant (DWP) is under construction to replace the function of the existing WTP which has been in service since 1987. A contractor partner will design, build, finance, operate, maintain, and own the new DWP that will supply ultra-pure demineralized water 24 hours a day, 7 days a week, 365 days per year for the extended life of Darlington NGS. The new DWP has a target available for service date of the end of Q2-2024.

B.18 Plant Auxiliary Systems – Circulating Water

The Circulating Water (CW) system is a Safety Related System, and its purpose is to provide a continuous supply of lake water to cool the unit steam condensers under all operating conditions, transient conditions, and during steam dumping to the condenser. A flow of water shall be circulated to condense the steam exhausted from the main turbine for the four units. A critical requirement of the system is to control circulating cooling water to the unit main steam condensers in order to remove waste heat during reactor operation and to improve thermal efficiency of the unit.

The maximum design flow rate required for all four units operating is 126 m^3/sec (10.5 m^3/sec per pump). The lake water enters the Forebay through the Intake tunnel and then the Station through bar screen/travelling screen pairs. The bar screens prevent larger debris from entering, while travelling screens, having finer mesh, screen out small fish and algae. The travelling screens are normally stationary; they start to rotate to allow cleaning by jets of water supplied from the screen wash pumps. The trash removal screen separates debris from the water and

discharges it in the trash bin. The Frazil Ice Protection System prevents frazil ice from forming on the bar screens and travelling water screens.

Completed projects, modifications, and initiatives for the CW System include:

- CW System Travelling Screens replacement to resolve degradation due to corrosion observed during inspection of the underwater parts.
- CCW travelling screens bubbler lines replacement to increase diameter of lines for the purpose of preventing lines from being plugged by zebra mussels.

In-progress and planned projects, modifications, and initiatives for the CW System include:

- CW Trash Removal System pump discharge check valves replacement.
- Frazil Ice and Discharge Gate replacements.
- CCW Piping Expansion Joints replacement.
- CW Pumps Vibration Monitoring System upgrades.
- Several proactive component replacements such as valves, relays, motors, vacuum priming pumps, trash screens, and piping in various parts of the system.

B.19 Plant Auxiliary Systems – Compressed Air

The Compressed Air system provides different types of air for various applications throughout the plant. The Compressed Air system is a combination of three different air systems: Instrument Air, Service Air and Breathing Air. Instrument Air provides dry and oil free compressed air to various instruments and services in the station at a required pressure and quantity. Service Air provides compressed air to various parts of the station to progress various maintenance, service and operational functions. The Breathing Air system provides safe breathable compressed air to personnel accessing contaminated or potentially contaminated areas of the station. The air delivered to the user conforms in general composition to the composition of normal air of the lower atmosphere. The oxygen content does not at any time fall below 19% v/v.

Completed projects, modifications, and initiatives for the Compressed Air System include:

- Instrument Air system mass flow meter replacements for flow measurements into Containment (Units 1, 3, 4).
- Breathing air system compressor installations for Refurbishment and upcoming VBO.
- Service air system installation of new compressors which provide higher capacity and additional flow beyond the existing compressors.
- Service water return piping for Service Air compressors replaced and upgraded to stainless steel.
- Breathing air purge tool implementation for more efficient purging of Breathing Air system following maintenance activities.

In-progress and planned projects, modifications, and initiatives for the Compressed Air System include:

- Compressor replacement project in place to replace older air compressors in multiple locations within the Instrument Air, Service Air, and Breathing Air systems.

B.20 Plant Auxiliary Systems – Active/Inactive Drainage and Sewage

Drainage Systems are composed of three sub systems; Inactive Drainage, Active Drainage and Sewage. Under normal operating conditions, the Inactive Drainage System shall collect the inactive liquid waste from floors, equipment, roof drains and open gutters, and shall transfer it to the inactive drainage sumps. Waste collected in the drainage sumps shall then be transported to the Treatment system prior to discharge into to the lagoon and further to the Lake Ontario. Drainage above 107.5 m elevation shall be discharged to the lake via the LPSW shaft.

The function of Active Plant Drainage System is to recover, segregate and transfer active liquid waste generated throughout the station to the Active Liquid Waste Collection System. The active liquid waste will be segregated prior to routing to appropriate collection tanks according to sump analysis. Batches of liquid waste with gross beta-gamma activity exceeding 37 MBq/m^3 (10-3 Ci/m^3) and non-chemical wastes from decontamination will be transferred to decay/treatment tank. The treatment system is designed to treat batches of active liquid waste with toxic levels exceeding the derived toxicity limits and/or the Municipal and Industrial Strategy for Abatement limits and also with gross beta-gamma activity exceeding 37 MBq/m^3 (10^{-3} ci/m^3) using a combination of filters and ion exchangers. The treated effluent returns to the Active Liquid Waste Collection System where it is sampled to ensure it meets requirements and discharged to Lake Ontario.

Under normal operating conditions, the sewage system collects the discharge by gravity from all washrooms, wash fountains, sinks inside the workshops, drinking fountains, and all showers (excluding the emergency showers). Sewage collected by gravity drainage at the various sump pumps, shall be pumped to the gravity sewer system where it will drain to either the east Sewage Pumping Station (SPS) or to the west SPS. The collected sewage in the East SPS shall be pumped north through a forcemain to an outlet manhole and gravity sewer north of the Canadian National Railway (CNR) at Holt Road from which it will drain westerly to the Courtice Water Pollution Control Plant (WPCP) where it will be treated and discharged to Lake Ontario. The collected sewage in the West SPS shall be pumped north through a forcemain to an outlet manhole and gravity sewer north of the CNR on Park Road from which it will drain westerly to the Courtice WPCP where it will be treated and discharged to Lake Ontario.

Completed projects, modifications, and initiatives for the Drainage and Sewage Systems include:

- Inactive Drainage collection header modification (Unit 3 only) to add bypass header connection for purpose of allow access for maintenance to be performed without a system outage.
- Relocation of underground Inactive Drainage line (Unit 0 only) to accommodate for the Heavy Water Management Building (HWMB) West Annex.
- Inactive Drainage Lagoon Aeration System implementation.
- Additional Data Logger installation (Unit 4 only) to increase redundancy for flow measurement and effluent monitoring of inactive drainage being discharged from the station.
- Active Drainage System and D_2O Liquid Recovery (HWMB West Annex) tie-in.

- Active Liquid Waste collection tanks high and low level setpoint changes to prevent stagnant water being left in tanks (decrease low level setpoint) and improve efficiency of the system by processing more water per discharge (increase high level setpoint). As a result, pump operating life will also be increased by requiring less frequent start up.
- Conductivity Transmitter and Cell replacements.
- SPS and Forcemain additions to connect to the municipal sewer system.

In-progress and planned projects, modifications, and initiatives for the Drainage and Sewage Systems include:

- Active Liquid Waste ion exchange column spent process change to optimize the usage of existing resin columns.
- Active Liquid Waste sumps to have an additional pump installed to provide alternate means to pump out sump during maintenance and to increase reliability.
- Inactive Drainage sump pump replacement, to replace existing submersible pumps with outboard pumps.
- Inactive Drainage level switches relocation to improve accuracy of annunciation.
- Active Liquid Waste tank liner replacement.
- Active Liquid Wast tanks chemical addition station to improve current manual chemical addition process.
- Sump level switch upgrade for Sewage system which will create a more consistent duty cycle for the pumps.
- Additional sump pump for drains sewage to create an alternate path for urgent pump out and maintenance purposes.

B.21 Plant Auxiliary Systems – Auxiliary Service Water and Safety Related System – Emergency Service Water

The ESW System is classified as a Safety Related System and as a Group 2 Safety System. During normal station operation, the purpose of the ESW System is to act as the source of firewater for the station, and to act as a source of service water and make-up water for a number of systems. For DBA conditions, the ESW System acts as a back-up source of water for cooling and make-up to systems that may have lost their normal supply because of the accident.

The basic nuclear safety function of the ESW System is to assist in the removal of decay, residual or process heat by providing cooling water (supply and return) or make-up water (supply only) to specified systems when their normal sources of supply might be interrupted as a result of certain design basis events. Additionally, it is to ensure prevention of subsequent process failure and release of radioactivity to the public. To ensure consistent ESW System reliability, the system is designed to operate during normal station operation, rather than being dormant (i.e. to supply some regular station loads).

Auxiliary Service Water (ASW) System has no nuclear safety requirements. ASW is supplied by the ESW System in the Central Service Area , the FFAA East and the FFAA West. It is a cooling

water system for cooling of the various continuous and intermittent loads, or for miscellaneous process uses in the Central Service Area, the WTP, the Technical Support Building and the FFAA East and West.

Completed projects, modifications, and initiatives for the ESW and ASW Systems include:

- Vibration Monitoring System upgrade on ESW pumps.
- Restoration of ESW and Fire Water margins by installing Emergency Mitigating Equipment (EME) hose manifolds on the ESW System and implementation of auto-isolation of the ASW System during a Main Steam Line Break (MSLB) signal.
- ESW buried piping line replacement during 2015 VBO, and cathodic protection system installation to extend lifetime of the piping.
- ESW tie-ins for BDBE modifications, such that EME pumps can provide makeup water to Steam Generators and Moderator.
- ASW Containment isolation valves replacement (Units 3 and 4 only).

In-progress and planned projects, modifications, and initiatives for the ESW and ASW Systems include:

- Major piping replacements during Refurbishment for line to the Vault Coolers and Main Supply Headers.
- ESW to PHT system permanent pipe connection to inject ESW for Beyond Design Basis Accidents (i.e. emergency heat sink).
- ESW supply and return line replacement for USCA Air Cooling Units (ACUs);
- ESW 4kV pump motors replacement.
- ESW piping Expansion Joints replacement.
- ESW travelling screen, motor, bubbler, and strainer replacements.
- Isolation valves addition on ASW supply lines to Breathing Air and Service Air compressors, to allow for improved efficiency in maintenance or replacement of compressors.

B.22 Plant Auxiliary Systems – Heating, Ventilation and Air Conditioning

The purpose of the ventilation system is to remove heat, provide general ventilation, minimize cross-contamination inside the station and minimize the release of contaminants to the environment. The system provides separate cooling and ventilation for SDS2 Equipment and Group 2 Instrument Rooms, steam protected rooms and automatic steam venting in the powerhouse in the event of a steam or feedwater line break. The system also provides intake process air for Breathing Air Compressors.

The purpose of the air conditioning system serving the Main Control Centre in the central service area at elevation 115.0 m is to provide a suitable environment for the proper operation and long service life of the computers, electrical and electronic equipment therein, comfortable working conditions for the operating personnel, and to provide emergency smoke removal capabilities.

Completed projects, modifications, and initiatives for the Heating, Ventilation and Air Conditioning (HVAC) Systems include:

- Powerhouse Units HVAC Systems outside air temperature switches upgrade.
- Powerhouse Steam Venting System (PSVS) modification.
- Powerhouse Ventilation fire damper replacement.

In-progress and planned projects, modifications, and initiatives for the HVAC Systems include:

- Powerhouse ACU replacements.
- ACU replacement for Secondary Control Area.
- Glycol Chiller temperature control valves replacement.
- Station Glycol header installation.
- PSVS actuator overhauls.
- MCR HVAC backup Instrument Air compressor/dryer replacement.
- Common Service Area major ventilation systems upgrade.
- Ventilation and Air Conditioning fans replacement.

B.23 Plant Auxiliary Systems – Low Pressure Service Water

The LPSW System is a unitized, once-through type, cooling water system which uses strained Lake Ontario water for cooling various continuous and intermittent loads. Water is drawn from the station's forebay, and after passing through the various loads, is returned to the lake via the CCW discharge duct.

Completed projects, modifications, and initiatives for the LPSW System include:

- LPSW Travelling Screens replacement to resolve corrosion issues for components below surface of water.
- Advanced Algae Warning System development, which has the capability to provide Operations with an alert 72 hours in advance if there is a higher risk of an algae run due to inclement weather patterns. A procedure is also in place for operation of this system.
- Replacement of LPSW pressure control valves.
- Conducted a full LPSW outage on each Unit to replace isolation valves for critical loads.

In-progress and planned projects, modifications, and initiatives for the LPSW System include:

- LPSW booster pumps replacement.
- Several valve replacements within LPSW System including for the Screenwash, Vault Cooler supply, Moderator Temperature Control, Recirculation Cooling Water supply, IPB LPSW isolation, Turbine Hall supply, and Shutdown Cooling isolation.
- Piping replacement for several section of LPSW System piping, including Back Up Bearing Tank standpipe, Small Bore piping, and piping around main LPSW pressure control valve.
- LPSW 4kV Motors refurbishment.

- LPSW pump discharge Expansion Joints replacement.
- LPSW Pump rebuild to address degradation mechanisms such as corrosion by utilizing stainless steel parts for applicable sub-components.

B.24 Plant Auxiliary Systems – Powerhouse Upper Level Service Water

The Powerhouse Upper Level Service Water (PULSW) System is a Safety-Related and Group 1 system. The purpose of the PULSW is to take water from the LPSW in order to provide cooling water to specific equipment, where either the freezing of D_2O is a concern or higher pressure cooling water is required. The equipment serviced by the PULSW are Heat Exchangers, some of which are safety related and/or seismically qualified, or environmentally qualified for a MSLB. An additional safety related aspect of the PULSW is that, following loss of Class IV Power, there are designated loads that are serviced by the PULSW using Class III Power.

The nuclear safety functions of the PULSW System are to:

- Remove decay heat.
- Support the operation of other Safety-Related Systems.
- Maintain Containment Boundary integrity where its piping penetrates through containment.
- Provide post accident monitoring.

PULSW outages have been completed successfully on each unit. This configuration allowed for a significant amount of work to be completed on the PULSW system as the upstream supply was drained. Major equipment such as temperature control valves, isolation valves, discharge check valves, and piping were replaced during the outages. PULSW outages are planned to take place every 12-years, which will continue to allow replacement of critical components such as piping and valves to ensure continued equipment reliability.

Completed projects, modifications, and initiatives for the PULSW System include:

- Shutdown Cooling (SDC) heat exchangers replacement
- Vapour Recovery System Dryers strainer additions to allow for clearing of fouling (e.g. zebra mussels, corrosion products, silt).

In-progress and planned projects, modifications, and initiatives for the PULSW System include:

- PULSW piping replacements for supply and return piping to the SDS heat exchangers, including replacement of various field run copper line sections with stainless steel.
- Temperature and flow control valve positioners replacement for several valves across the PULSW system.
- PULSW 4kV pump motors replacement.
- PULSW Temperature Control Valve full valve replacement.
- PULSW isolators for SDC.

B.25 Plant Auxiliary Systems – Recirculated Cooling Water

The Recirculated Cooling Water System (RCW) System is a Safety-Related and Group 1 system. The RCW System is a unitized closed loop cooling system, containing demineralized water as the working fluid. The purpose of the system is to supply cooling water to certain vital equipment requiring treated water; at a temperature above the freezing point of D_2O, at a pressure sufficiently high to prevent localized boiling in certain heat exchangers, and of a quality sufficiently high to minimize corrosion, fouling and activation by radiation. In addition, following a loss of Class IV power, the RCW System provides continued cooling water flow from a pressurized storage tank (i.e. head tank) to the Heat Transport Bleed Cooler, by gravity. When Class III power is established the RCW System provides cooling water flow to a smaller set of loads that are essential to remove residual heat. Heat rejection from the RCW System is to the LPSW System.

The nuclear safety functions of the RCW System are to remove decay heat by supporting the operation of designated safety-related systems, maintain containment boundary integrity where its piping penetrates through containment, and to provide post-accident monitoring.

During Refurbishment on Units 1, 2 and 3, inspection and cleaning of multiple RCW heat exchangers has occurred. Inspections of these heat exchangers have shown favourable results with no tube plugging required after approximately 30-years in service. Cleaning of these heat exchangers have shown improved results pertaining to heat transfer efficiency. Similar inspections of these heat exchangers will occur during the Refurbishment of Unit 4. Heat exchangers that are not inspected during the Refurbishment outages will continue to be inspected in future unit outages and tracked as part of the Heat Exchanger Program.

Completed projects, modifications, and initiatives for the RCW System include:

- RCW valve replacements for various pneumatic valves and temperature control valves within the system.

In-progress and planned projects, modifications, and initiatives for the RCW System include:

- Temperature transmitter relocation for improvement in reliable temperature control of the RCW System.
- Controller replacements for RCW System

Appendix C: Activities and Nuclear Substances to be Encompassed by the Licence

The information below is provided to satisfy the requirements of Section 3(1)(b) of the *General Nuclear Safety and Control Regulations*.

Activities to be Licensed:

The application for renewal of PROL 13.03/2025 contains information for the activities to be licensed. These activities include those currently licensed in PROL 13.03/2025:

i. operate the Darlington NGS which includes the Darlington NGS Tritium Removal Facility housed within the Heavy Water Management Building at a site located in the Municipality of Clarington, in the Regional Municipality of Durham, in the Province of Ontario;

ii. possess, transfer, use, package, manage and store the nuclear substances that are required for, associated with, or arise from the activities described in i.;

iii. import and export nuclear substances, except controlled nuclear substances, that are required for, associated with, or arise from the activities described in i.;

iv. possess and use prescribed equipment and prescribed information that are required for, associated with, or arise from the activities described in i.;

v. possess, transfer, process, package, manage and store the nuclear substances associated with the operation of the Darlington NGS Tritium Removal Facility;

vi. possess, transfer, process, package, manage and store Molybdenum-99 radioisotope and its associated decay isotopes.

Additional activities requested to be licensed include activities associated with the production of isotopes. Requests to amend the Darlington NGS PROL to include these activities were submitted in References C-1, C-2 and C-3 and these requests are pending Commission decision.

List of Nuclear Substances:

Table 32 below is provided to satisfy the requirements of Section 3(1)(c) of the *General Nuclear Safety and Control Regulations*.

Nuclear Substances Identified:

- Natural Uranium (as fuel bundles);
- Depleted Uranium (as fuel bundles);
- Depleted Uranium (in components, e.g. shielding);
- Irradiated Uranium (as spent fuel bundles that contain fission and activation products including actinides, such as Pu-239);
- Molybdenum-99 (Mo-99) radioisotope (and its associated decay isotopes), and Zirconium target cladding;
- Heavy Water (D_2O, DTO);
- Tritium as gas (DT, T_2), and Tritium as solid (Titanium Tritide);

- Enriched Uranium (in components).

The maximum quantity is interpreted as the maximum amount that can be accommodated in inventory as per design by Darlington NGS (including the TRF for its operation). The data provided are current as of April 2024.

Table 32: List of Nuclear Substances

Nuclear Substance	Form and Location	Maximum Quantity
Natural Uranium	Solid as Fuel Bundles: New Fuel Inventory, New Fuel Transfer Mechanisms, Fuelling Machine Heads, Service Area Rehearsal Facility, Pressure Testing Facility.	10838 bundles *
Irradiated Uranium	Solid as Spent Fuel bundles: All Bays – Storage Bays, Reception Bays, Wet Cask Bays. All Reactor cores – Units 1,2,3,4	461492 bundles * (note 1) 24960 bundles
Depleted Uranium	Solid as Fuel Bundles: New Fuel Inventory, Spent Fuel Discharged to Bays.	*Included in above totals marked with asterisk
Depleted Uranium in components (e.g. shielding)	Solid. Located within the Darlington protected area for use as needed.	1620.32 kg (note 2)
Nuclear substances associated with the production of Mo-99: • Mo-99 radioisotope and its associated decay isotopes • Zirconium target cladding	Mo-98 is irradiated to form Mo-99 in the Darlington NGS reactor core. The material to be irradiated is always encapsulated in the form of target capsules and inserted and removed from the core by the Isotope Irradiation System.	The quantity of activated Mo-99 will not exceed 8766 TBq. The quantity of activated Zirconium target cladding will not exceed 369 TBq.
Heavy Water	Liquid (D_2O, DTO)	6388 Mg (storage capacity)
Tritium	Gaseous (DT, T_2)	7.88 e+16 Bq (2.13 MCi) (note 3)
Tritium	Solid (Titanium Tritide)	2.73 e+19 Bq (737 MCi)
Enriched Uranium in Components (e.g. fission chambers)	Solid. Located within the Darlington protected area for use as needed	1.683 g (note 4)

Notes:
1. Full storage bay and reception/Wet Cask Handling Bay (WCHB) floor based on bay and module dimensions.
2. This is the current inventory. There is no design maximum and inventory may change (may increase) based on operational needs.
3. Value per the Safety Report, Part 3 (Rev 6).
4. This is the current inventory. There is no design maximum and inventory may change (may increase) based on operational needs.

Appendix 3 References	
C-1.	OPG letter, R. Geofroy to D. Saumure, “Darlington NGS – Application for Darlington Nuclear Generating Station Power Reactor Operating Licence 13.03/2025 Amendment for Production of the Cobalt-60 Radioisotope”, April 28, 2023, CD# NK38-CORR-00531-23462.
C-2.	OPG letter, A. Grace to D. Saumure, “Darlington NGS - Application for Amendment to the Darlington NGS Power Reactor Operating Licence 13.03/2025 for Additional Isotope Production”, February 26, 2024, CD# NK38-CORR-00531-25141.
C-3	OPG email, L. Moraru to M. Young, “Darlington NGS – Redacted Application for Amendment to the Darlington NGS Power Reactor Operating Licence 13.03/2025 for Additional Isotope Production”, May 14, 2024, CD# NK38-CORR-00531-25215.

Appendix D: List of Hazardous Substances

The purpose of this Appendix is to document a list of hazardous materials at the Darlington NGS with respect to a licence application requirement under *Class I Nuclear Facilities Regulations* SOR/2000-204.

Under *Class I Nuclear Facilities Regulations* SOR/2000-204, Licence Applications, General Requirements, S. 3.,

An application for a licence in respect of a Class I Nuclear Facility, other than a licence to abandon, shall contain the following information in addition to the information required by Section 3 of the *General Nuclear Safety and Control Regulations*.

- (e) the name, form, characteristics and quantity of any hazardous substances that may be on the site while the activity to be licensed is carried on.

Table 32 contains a list of the hazardous substances.

Table 33: List of Hazardous Substances

Name	Form	Characteristics	Quantity (inventory)	Quantity (in system)
Aluminex	Liquid	Corrosive acid	5 totes, 1000 L each	Consumed in system
Ammonia	Liquid (20%)	Toxic, corrosive base	maximum two totes x 1,020 kg/tote	225 kg as 20% ammonia for station
Argon	Liquified gas	Asphyxiant	1,500 gal tank (liquid argon)	Used as needed
Carbon dioxide gas	Compressed Gas	Mildly toxic, asphyxiant in high concentrations, heavier than air.	12,700 kg	14.4 m^3
Ethylene Glycol	Liquid	Toxic	2 drums, 205 L each	1000 L per unit estimated
Gadolinium Nitrate Hexahydrate	Solid, mixed with D2O	Toxic, severe irritant	~4 containers of 5 kg each	Combined all units: Liquid Injection Safety System: 132 kg Poison Addition Tanks: ~ 5 kg
Helium gas	Compressed Gas	Compressed gas, simple asphyxiant, lighter than air	12 tubes, total 2832 m^3 for station	Normally none. Used when needed.

Name	Form	Characteristics	Quantity (inventory)	Quantity (in system)
			3 tubes, total 708 m^3 for Tritium Removal Facility Additional trailer on site, capacity 3000 m^3	
Hydrazine (35% solution)	Liquid	Corrosive base, Toxic	Feedtrain + Emergency Coolant Injection + Recirculating Cooling Water (RCW) is 1,890 kg as 35% hydrazine for station	Maximum eight totes x 850 kg/tote
Hydrogen gas	Compressed Gas	Flammable Compressed Gas, lighter than air	800 m^3 in multi tube H_2 trailer 900 m^3 in six storage cylinders as backup	4 X 650 m^3 = 2600 m^3 nominalized to atmospheric pressure
Hydrogen gas	Compressed Gas	Flammable Compressed Gas, lighter than air.	Warehouse ~ 15 cylinders @ 197ft^3 Addition station combined: 24 cylinders @ 197 ft^3 when full.	Combined: ~ 60 ft^3
IX resin Cation	Solid	Toxic, irritant	~ 30 containers of 0.5 ft^3 bag and 2 bags in each container	Combined all units: 40 ft^3
IX Resin Anion	Solid	Toxic, irritant	~ 36 containers of 0.5 ft^3 bag and 2 bags in each container	Combined all units: 72 ft^3
IX resin: De-oxygenating Resin	Solid	Toxic, irritant	Not normally in stock; order per demand: 15 containers of 1 ft^3 bag	Combined all units 60 ft^3
IX resin: Lithiated mixed bed resin	Solid	Toxic, irritant	~ 40 containers of 0.5 ft^3 bag and 2 bags in each container	Combined all units: Primary Heat Transport (PHT) system: 48 ft^3 RCW: 28 ft^3

Name	Form	Characteristics	Quantity (inventory)	Quantity (in system)
				End Shield Cooling (ESC): 72 ft^3
IX resin: Neutral Mixed Bed Resin-	Solid	Toxic, irritant	~ 250 containers of 0.5 ft^3 bag and 2 bags in each container	Combined all units: Moderator 160 ft^3 Irradiated Fuel Bay: 720 ft^3 Liquid Zone Control: 40 ft^3 Stator Cooling Water: 8 ft^3 Primary Heat Transport: 40 ft^3 D2O Cleanup system: 36 ft^3 Active Liquid Waste: 120 ft^3
Lime	Solid (powder) made into paste with water.	Corrosive base	Bulk tank – paste 45,400 kg	Consumed in system
Lithium Hydroxide monohydrate	Solid, made into solution for addition	Corrosive base	~ 23 bottles of 0.5 kg each	Combined all units (in liquid): PHT: ~1944 g ESC: 36000 g RCW: ~70 g
Lubricating oil and seal oil Teresso #46	Liquid	Non-toxic during normal use	1,640 L	Estimated 2,800 L of oil in the system piping
Morpholine	Liquid	Combustible liquid, toxic, corrosive base	8 totes x 800 kg/tote	200 kg as 45% morpholine for station
Nitrogen gas	Compressed gas	Asphyxiant	32,000 L bulk supply, approx. 40 cylinders (304 ft^3)	N/A. Used when needed.
Nitrogen liquid	Compressed Liquid	Cryogenic hazard	32,000 L bulk supply	N/A. Used when needed.

Name	Form	Characteristics	Quantity (inventory)	Quantity (in system)
Oxygen gas	Compressed Gas	Strong oxidizer - increases flammability of flammable or combustible material	2 oxygen cylinders (335 ft^3 each) for moderator cover gas, 2 cylinders for Liquid Zone Control gas. 4,780 m^3 bulk storage at TRF.	Approx. 1,340 ft^3
Reolube Turbofluid 46XC Fire Resistant Fluid	Liquid	Mildly toxic	17 drums @ 205 L = 3,500 L	40,000 L (10,000 per unit)
Sodium Hypochlorite 12%	Liquid	Corrosive acid, oxidizer – increases flammability of flammable or combustible material	2 x 27,000 L storage tanks in Water Treatment Plant; 4 x 4,000 L tanks, one in each Low Pressure Service Water pumphouse; 2 x 4,500 L tanks in Emergency service Water	N/A. Diluted into system water.
Sodium Meta-bisulphite 38% aqueous	Liquid	Corrosive acid, toxic	6 x 1,000 US Gallon Storage Tanks	N/A. Diluted into system water.
Sodium Hydroxide	Liquid	Corrosive base	46,000 L max tank volume (connected to system)	Consumed in system
Sulphur Hexafluoride	Compressed Gas	Compressed Gas, mildly toxic	2 1A cylinders, 1.55 ft^3 each, total 3 ft^3	ZERO most of the time. 6 ft^3 during testing.
Sulphuric Acid	Liquid	Toxic and corrosive	38,600 L max tank volume (connected to system)	N/A. Diluted into system water.

Name	Form	Characteristics	Quantity (inventory)	Quantity (in system)
Transformer Fluid - Oil (litres)	Liquid	Non-toxic during normal use.	Currently not in stock.	4,650 L per transformer x 16 = 74,384 L = 75 m^3 plus 1,353 m^3 = 1,428 m^3 total
Transformer Fluid - Silicone (litres)	Liquid	Non-toxic during normal use.	Currently not in stock.	4,650 L per transformer x 22 = 102,278 L
Type 1 heating fuel oil, "Stove Oil", Diesel Fuel	Liquid	Combustible Liquid, toxic	Standby Generator: Total of 4 tanks. Approx. 3720 m^3 of fuel oil in all 4 tanks. Emergency Power Generator: ~ 660,000 L in 6 tanks	N/A. Consumed by equipment.
Standby Generator Lube oil Teresso 32	Liquid	Non-toxic during normal use	300 L/tank (1,200 L total)	Short pipe runs. Negligible amount.
Standby Generator Lube Oil Turbo Oil 2380	Liquid	Non-toxic during normal use	3,420 L in each Standby Generator building (13,680 L total)	Short pipe runs. Negligible amount.

Appendix E: Permits, Certificates and Other Licences

The following are CNSC licences that control other nuclear substances at Darlington NGS.

Waste Facility Operating Licence

Darlington Waste Management Facility, WFOL-W4-355.00/2033

Nuclear Substance and Radiation Devices Licences

Industrial Radiography (812), 12861-1-25.5

Consolidated Use (815), 12861-2-25.3

Basic Servicing (822), 12861-17-25.2

Dosimetry Service Licence

Dosimetry Service, 12861-11-25.9

Class II Nuclear Facilities and Prescribed Equipment Licences

Class II Irradiator (635), 12861-18-26.7

Import/Export Licences

Import:

Import Licence, IL-A4-27071.0/2024
Import Licence, IL-A2-A4-26400.0/2024
Import Licence, IL-A2-A4-26401.0/2024

Import Licence, IL-A2-A4-27029.0/2026

Import Licence, IL-A2-29788.0/2028
Import Licence, IL-A4-29770.0/2028
Import Licence, IL-A2-A4-27029.1/2028

Export:

Export Licence, EL-A4-27070.0/2024
Export Licence, EL-B3-27315.0/2024

Export Licence, EL-A4-26398.0/2025
Export Licence, EL-A3-A4-27530.0/2025

Export Licence, EL-A4-27030.0/2026

Summary of Regulatory Commitments, Regulatory Obligations and Regulatory Management Actions Made/Concurrence Requested

CD# NK38-CORR-00531-25450 P

Submission Title: **Darlington NGS – Application for Renewal of the Darlington Nuclear Generating Station Power Reactor Operating Licence 13.03/2025**

Regulatory Commitments (REGC):

No.	Description	Date to be Completed
	None.	

Regulatory Management Action (REGM):

No.	Description	Date to be Completed
	None.	

Regulatory Obligation Action (REGO):

No.	Description	Date to be Completed
	None.	

Concurrence Requested: None