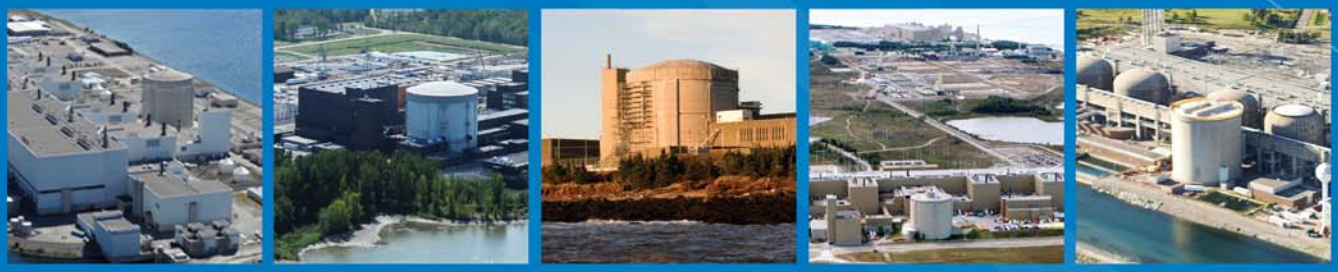
Canada's Nuclear Regulator

Regulatory Oversight Report for Canadian Nuclear Power Plants: 2015



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Regulatory Oversight Report for Canadian Nuclear Power Plants: 2015

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Cover images: Canadian nuclear power plants
From left to right:
Darlington Nuclear Generating Station (Bowmanville, Ontario)
Gentilly-2 Nuclear Generating Station (Bécancour, Québec)
Point Lepreau Nuclear Generating Station (Point Lepreau, New Brunswick) Bruce A and Bruce B Nuclear Generating Stations (Tiverton, Ontario) Pickering Nuclear Generating Station (Pickering, Ontario)

EXECUTIVE SUMMARY

Each year, the Canadian Nuclear Safety Commission (CNSC) produces a report on the safety performance of Canada's nuclear power plants (NPPs). This *Regulatory Oversight Report for Canadian Nuclear Power Plants: 2015* (the 2015 NPP Report), provides the CNSC staff's assessment of the Canadian nuclear power industry's safety performance during 2015 and details the progress of regulatory issues and initiatives up to April 30, 2016.

In 2015:

- Five NPPs had operating licences.
- Nineteen reactor units were operational.
- Gentilly-2, Pickering Unit 2 and Pickering Unit 3 remained in safe storage.

Overall performance highlights

Through site inspections, reviews and assessments, CNSC staff concluded that the NPPs operated safely during 2015. The evaluations of all findings for the safety and control areas (SCAs) show that, overall, NPP licensees made adequate provisions for the protection of the health, safety and security of persons and the environment from the use of nuclear energy, and took the measures required to implement Canada's international obligations on the peaceful use of nuclear energy.

The following observations support the conclusion of safe operation:

- There were no serious process failures at the NPPs.
- No member of the public received a radiation dose that exceeded the regulatory limit.
- No worker at any NPP received a radiation dose that exceeded the regulatory limits.
- The frequency and severity of non-radiological injuries to workers were minimal.
- No radiological releases to the environment from the stations exceeded the regulatory limits.
- Licensees complied with licence conditions concerning Canada's international obligations.
- No NPP events above Level 0 on the International Nuclear and Radiological Event Scale (INES) were reported to the International Atomic Energy Agency (IAEA).

Table 1 summarizes the 2015 safety performance of Canada's NPPs, presenting the SCA ratings for each nuclear generating station, the industry average ratings for each SCA and the integrated plant ratings that determine overall safety performance. The SCA rating categories are "fully satisfactory" (FS), "satisfactory" (SA), "below expectations" (BE) and "unacceptable" (UA). A "satisfactory" rating indicates the licensee's safety and control measures are effective, while a "fully satisfactory" rating indicates they are highly effective. A "below expectations" rating indicates the safety and control measures are marginally ineffective, while an "unacceptable" rating indicates the safety and control measures are significantly ineffective.

Table 1: Canadian nuclear power plant safety performance ratings 2015

Safety and control area	Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average*
Management system	SA	SA	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA	SA	SA
Operating performance	FS	FS	FS	FS	SA	SA	FS
Safety analysis	SA	SA	FS	FS	SA	SA	SA
Physical design	SA	SA	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA	SA	SA
Radiation protection	SA	SA	FS	FS	SA	SA	SA
Conventional health and safety	FS	FS	FS	FS	SA	FS	FS
Environmental protection	SA	SA	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA	SA	SA
Waste management	FS	FS	FS	FS	SA	SA	FS
Security	FS	FS	SA	SA	SA	SA	SA
Safeguards and non-proliferation	SA	SA	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA	SA	SA
Integrated plant rating	FS	FS	FS	FS	SA	SA	SA

* The industry average of all operating NPPs in Canada

All NPPs in Canada received SCA ratings of either “fully satisfactory” or “satisfactory”. There were 19 “fully satisfactory” ratings across the stations, a net increase of five compared to the 14 “fully satisfactory” ratings reported in 2014. The operating performance rating for Bruce A and Pickering, the safety analysis rating for Darlington and Pickering, the conventional health and safety rating for Darlington and Pickering, and the waste management rating for Pickering all improved to “fully satisfactory” in 2015 from “satisfactory” in 2014. Both Darlington and Pickering had their ratings for the security SCA decrease from “fully satisfactory” in 2014 to “satisfactory” in 2015.

The industry average was “satisfactory” for 11 SCAs and “fully satisfactory” for three SCAs, the same as the previous year. While the number of stations rated at “fully satisfactory” in the operating performance SCA increased by two in 2015, the security SCA returned to “satisfactory’ in 2015 from a “fully satisfactory” in 2014. The “fully satisfactory” ratings for waste management and conventional health and safety remained unchanged from 2014.

The integrated plant rating in 2015 was “fully satisfactory” for Bruce A, Bruce B, Darlington and Pickering. (Compared to 2014, Bruce A and Pickering improved to “fully satisfactory” from “satisfactory”, while Darlington and Bruce B remained at “fully satisfactory”.) Gentilly-2 and Point Lepreau received a “satisfactory” integrated plant rating. None of the plants received an integrated plant rating of “below expectations” or “unacceptable”.

Performance highlights of each NPP

Bruce A and Bruce B Nuclear Generating Station

The 2015 integrated plant rating for Bruce A was "fully satisfactory", an improvement over the "satisfactory" rating achieved in 2014. For Bruce B the rating was "fully satisfactory, unchanged from 2014.

While most SCA ratings were "satisfactory", the CNSC noted "fully satisfactory" performance for both Bruce A and Bruce B in the following areas:

- operational performance
- conventional health and safety
- waste management
- security

For Bruce A, the "fully satisfactory" ratings for conventional health and safety, waste management and security remained unchanged from 2014. The operational performance rating improved from "satisfactory" in 2014 to "fully satisfactory" in 2015.

For Bruce B, the "fully satisfactory" ratings for operational performance, conventional health and safety, waste management and security remained unchanged from 2014.

Operating performance at both Bruce A and B was highly effective; Bruce Power had no unplanned reactor trips in 2015 for both stations.

A two-part public hearing for the Bruce A and B licence renewal was held in February and April 2015. In May 2015, the Commission renewed the operating licences issued to Bruce Power as a single licence for both Bruce A and B, valid from June 1, 2015 to May 31, 2020. In its May 2015 licence renewal decision, the Commission authorized the operation of Bruce A and B, Units 1 to 8, up to a maximum of 247,000 equivalent full-power hours (EFPH).

Darlington Nuclear Generating Station

The 2015 integrated plant rating for Darlington was "fully satisfactory", unchanged from 2014.

While most SCA ratings were "satisfactory", CNSC staff noted "fully satisfactory" performance in the following areas:

- operational performance
- safety analysis
- radiation protection
- conventional health and safety
- waste management

Regarding the five SCAs listed above, the ratings for conventional health and safety as well as safety analysis improved from "satisfactory" in 2014 to "fully satisfactory" in 2015. The ratings for the other three SCAs remained unchanged from the previous year. The security rating for Darlington returned to "satisfactory" in 2015 from "fully satisfactory" in 2013 and 2014.

The radiation protection program put in place by Ontario Power Generation (OPG) at Darlington was again rated as "fully satisfactory" and initiatives continue to be implemented to ensure the continuous improvement of this program. Radiation protection at Darlington includes a highly effective as low as reasonably achievable (ALARA) program, which is based on industry best practices.

A two-part public hearing for the Darlington licence renewal was held in August and November 2015. In December 2015, the Commission renewed the operating licence issued to OPG for the operation of Darlington, valid from January 1, 2016 until November 30, 2025.

On April 13, 2016, the Federal Court of Appeal dismissed the appeal on the Federal Court decision to dismiss the application for judicial review for the environmental assessment (EA) decision on the refurbishment and continued operation of the Darlington Nuclear Generating Station.

The appeal was brought in November 2014 by Greenpeace Canada, the Canadian Environmental Law Association, Lake Ontario Waterkeeper and Northwatch. They claimed that the Federal Court erred in rejecting their application for judicial review because the Responsible Authorities who conducted the assessment unreasonably excluded severe low probability nuclear accidents from the scope of the assessment and unreasonably failed to give adequate consideration to the long term management of nuclear fuel waste that the Darlington Facility will generate.

The Federal Court of Appeal did not agree. In its decision, among other points, the court stated that "…the CNSC is much better placed than a reviewing court to factually assess and determine what types of possible accidents are likely to occur at a nuclear power plant and how to conduct the assessment of the environmental impacts of potential accidents. It is therefore inappropriate for a reviewing court to second-guess these determinations through a detailed re-examination of the evidence as the appellants would have us do in the instant case." [60]

Pickering Nuclear Generating Station

The 2015 integrated plant rating for Pickering was "fully satisfactory", an improvement from 2014.

While most SCA ratings were "satisfactory", the CNSC noted "fully satisfactory" performance in five areas:

- operating performance
- safety analysis
- radiation protection
- conventional health and safety
- waste management

Of the five SCAs listed above, the ratings for operating performance, safety analysis, conventional health and safety, and waste management improved from "satisfactory" in 2014 to "fully satisfactory" in 2015.

The remaining SCA ratings for Pickering were unchanged from 2014 with the exception of the security SCA rating, which returned to "satisfactory" in 2015 from "fully satisfactory" in 2013 and 2014.

OPG's radiation protection program at Pickering continued to be rated as "fully satisfactory" and initiatives have been implemented to ensure the continuous improvement of this program. Radiation protection at Pickering includes a highly effective ALARA program that is based on industry best practices.

Gentilly-2 Nuclear Facility

The 2015 integrated rating for Gentilly-2 was "satisfactory", unchanged from 2014.

All SCA ratings for Gentilly-2 were "satisfactory". The plant was in a safe shutdown state throughout 2015.

The Commission approved amendments to the power reactor operating licence for Gentilly-2 in May 2015. The amendments replaced references to S-99, *Reporting Requirement for Operating Nuclear Power Plants* [1] with those of REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [2]. The approved amendments also reduced reporting requirements for Gentilly-2 to those applicable to REGDOC 3.1.1, commensurate with the level of risk of a reactor in a safe shutdown state.

In March 2015, Hydro-Québec submitted a revised decommissioning plan and decommissioning cost study to reflect the decision to permanently shut down the reactor instead of refurbishing it. CNSC staff provided comments to Hydro-Québec on these documents in January 2016.

Point Lepreau Generating Station

The 2015 integrated plant rating for Point Lepreau was "satisfactory", unchanged from 2014.

The safety performance rating for conventional health and safety was the same as in 2014. All other SCAs received a "satisfactory" rating in 2015.

The draft site-specific seismic hazard assessment was completed at the end of 2014. The licensee posted the executive summary of the assessment on its website. In May 2015, CNSC staff received the final seismic hazard assessment from NB Power. The CNSC, Natural Resources Canada, and Environment and Climate Change Canada (ECCC) staff completed their respective reviews of these assessments in mid-January 2016 and were satisfied with their results and related follow-up.

The conventional health and safety program at Point Lepreau was rated as "fully satisfactory". The accident severity rate at Point Lepreau remained at zero in 2015, while the accident frequency was below the industry average.

Response to Fukushima Daiichi accident

During 2015, CNSC staff continued to verify that licensees are on track to implement safety enhancements in response to the Fukushima Daiichi accident. The Fukushima action items (FAIs), as specified in the *CNSC Integrated Action Plan on the Lessons Learned from the Fukushima Daiichi Nuclear Accident* (the CNSC Integration Action Plan), address safety improvements aimed at strengthening defence in depth and enhancing onsite emergency response. As of March 2016, all short-, medium- and long-term FAIs were closed for all Canadian NPP licensees (per the established closure criteria). CNSC staff will continue to monitor FAI implementation at Canadian NPPs through related station-specific action items as part of the established compliance verification program.

On February 29, 2016, the CNSC published its assessment of the *IAEA Director General Report on the Fukushima Daiichi Accident* (the DG-IAEA Report) [3]. The purpose of this assessment

was to benchmark the observations and action items identified in two CNSC documents – the *CNSC Fukushima Task Force Report* and the CNSC Integrated Action Plan – against the DG-IAEA Report. This is to ensure that post-Fukushima actions implemented by licensees of Canadian nuclear facilities are in line with and address the lessons learned identified in the DG-IAEA Report.

This assessment affirmed that the CNSC has been and continues to be on the right path with respect to continuous enhancements to safety, commensurate with maintaining the high level of nuclear safety achieved in Canada.

As a follow-up to the DG-IAEA Report, the CNSC is applying its lessons learned and observations, such as in developing post-accident recovery guidelines, which speak to offsite measures as they relate to the transition from an emergency exposure situation to an existing exposure situation and then to recovery.

Darlington new nuclear project

The nuclear power reactor site preparation licence (PRSL) for the Darlington new nuclear project was issued by the Commission for a period of 10 years – from August 17, 2012 to August 17, 2022.

As required by the *Canadian Environmental Assessment Act* (1992), prior to any licensing decision, for a PRSL, an environmental assessment (EA) of the project was required. The EA was carried out by the Joint Review Panel (JRP) in 2011. This EA and the PRSL were challenged through an application, by Greenpeace Canada, Lake Ontario Waterkeeper, Northwatch and the Canadian Environmental Law Association, for judicial review before the Federal Court of Canada.

On April 28, the Supreme Court of Canada issued its decision to not hear the appeal filed by Greenpeace Canada, Lake Ontario Waterkeeper, Northwatch and the Canadian Environmental Law Association with respect to the environmental assessment and the site preparation licence for the proposed new nuclear power reactors at the existing Darlington Nuclear Generating Station.

The decision to not hear the appeal means that the Federal Court of Appeal's decision on the legality of the environmental assessment and the licence stands. That is, the Federal Court of Appeal found that the Joint Review Panel's environmental assessment was fully compliant with the Canadian Environmental Assessment Act.

The final result in this case is a validation of the Canadian Nuclear Safety Commission's competence as an expert nuclear regulator that conducts proper and legal environmental assessments, and ensures the safety of the public and the environment.

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REGULATORY OVERSIGHT REPORT FOR CANADIAN NUCLEAR POWER PLANTS: 2015

1 Overview

The Canadian Nuclear Safety Commission (CNSC) is the federal government body that regulates the use of nuclear energy and materials to protect health, safety, security and the environment; to implement Canada's international commitments on the peaceful use of nuclear energy; and to disseminate objective scientific, technical and regulatory information to the public. Licensees are responsible for operating their facilities safely and are required to implement programs that make adequate provision for meeting the CNSC's mandate.

Each year, CNSC staff assess the overall safety performance of the Canadian nuclear power industry – looking at both the industry as a whole and the performance of each nuclear power plant (NPP). This assessment is summarized in this *Regulatory Oversight Report for Canadian Nuclear Power Plants: 2015* (the 2015 NPP Report).

This assessment aligns with the regulatory oversight of NPPs using the licensing basis (as defined in INFO-0795, *Licensing Basis Objective and Definition* [4]), which comprises the legal requirements of the *Nuclear Safety and Control Act* (NSCA), the regulations made under the NSCA, the conditions set out in operating licences, applicable standards and regulatory documents, and the safety and control measures in licence applications and licensees' documents. It is supported by information obtained through inspections, site surveillance activities, field rounds, document assessments, desktop reviews and performance indicator data.

This report makes comparisons and shows trends where possible. It also highlights emerging regulatory issues and development activities at the industry level and for each licensed station. The information given in this area includes updates on licensing, licence conditions handbooks (LCHs), projects and initiatives, and public communications.

The 2015 NPP Report includes:

- an overview of the nuclear power industry throughout Canada
- the safety performance assessments and ratings for the overall nuclear power industry and for each licensed station, covering the 2015 calendar year
- detailed information on licensing and other regulatory issues pertaining to the industry as a whole as well as each licensed station, covering an extended period of January 1, 2015 to April 30, 2016 (to permit the most up-to-date view of the issues)
- updates on activities conducted by the industry as a whole and by licensees in response to the *CNSC Integrated Action Plan on the Lessons Learned from the Fukushima Daiichi Nuclear Accident* [5]

This report also contains an update on improvements performed by Ontario Power Generation (OPG) and the CNSC's regulatory oversight with respect to the new nuclear project at the Darlington Nuclear Generating Station, an update on the neutron overpower

protection methodology, and updates on the risk improvement plan and aging management program at the Pickering Nuclear Generating Station.

Also included are nine appendices, a glossary and a list of references. New to this year's report is appendix A, which provides details on the five-year trend for inspections, event reviews and other compliance activities for each station.

Note: This report uses the terms NPP, plant and station interchangeably.

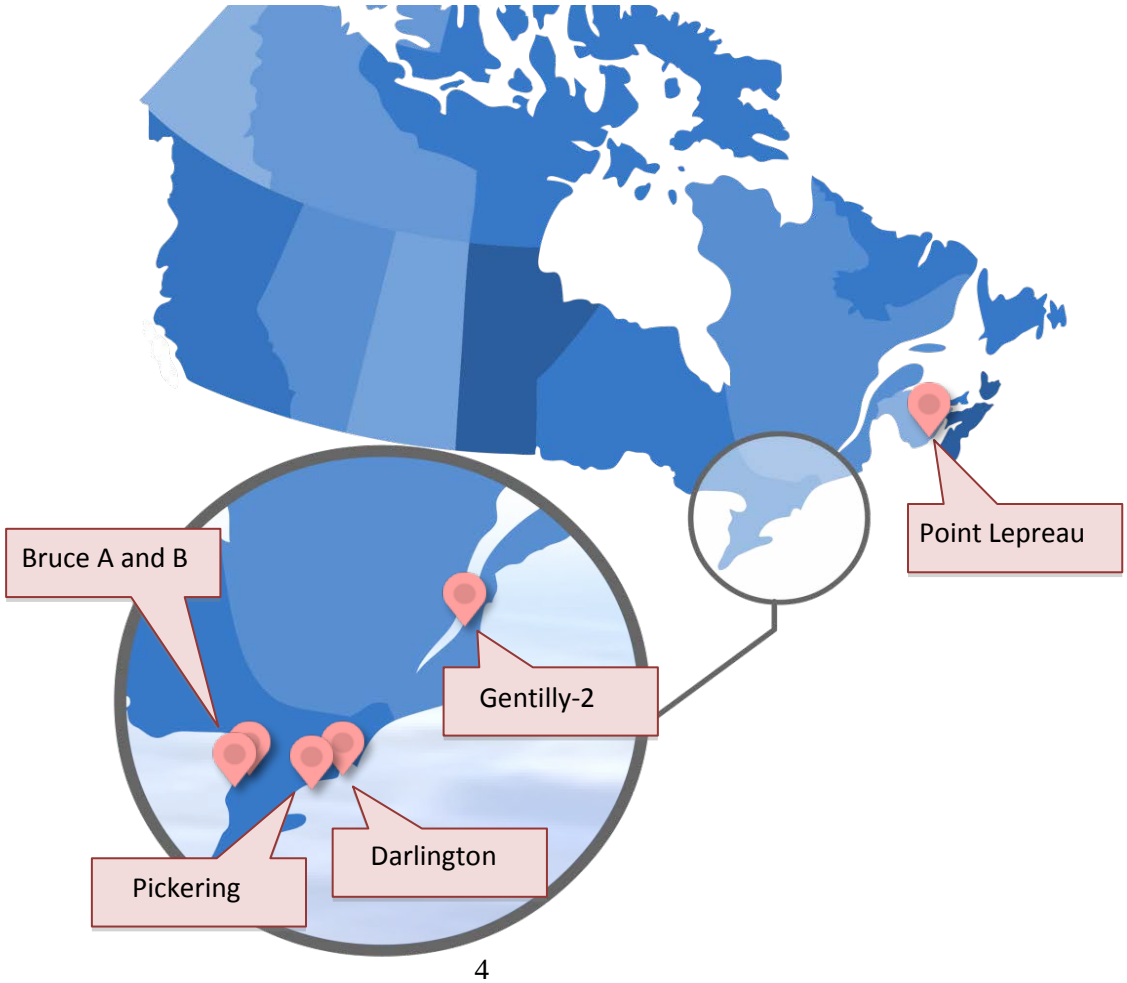
Canada's nuclear power plants

There are five NPPs with operating licences in Canada, located in three provinces (as shown in figure 1), and operated by four separate licensees. These NPPs range in size from one to eight power reactors, all of which are of the CANDU (CANada Deuterium Uranium) design. This design was originally developed by the Canadian Crown corporation Atomic Energy of Canada Limited (AECL), and is licensed to the SNC-Lavalin Group Inc. through its wholly owned subsidiary, Candu Energy Inc.

A total of 19 reactor units were operational in 2015, with Gentilly-2, Pickering Unit 2 and Pickering Unit 3 remaining in safe storage.

In addition to showing the geographic location of each NPP in Canada, figure 1 provides data for each plant, including the generating capacity of the reactor units, their initial startup dates, the names of the licensees and the expiry dates of the operating licences.

Figure 1: Locations and data for Canadian nuclear power plants



NPP	Licensee	Location	State of reactor units	Gross capacity per unit (MWe)	Startup[1]	Licence expiry
Bruce A	Bruce Power Inc.	Tiverton, ON	Four operating	805	1977	May 31, 2020
Bruce B	Bruce Power Inc.	Tiverton, ON	Four operating	872	1984	May 31, 2020
Darlington	Ontario Power Generation Inc.	Darlington, ON	Four operating	935	1990	Nov. 30, 2025
Pickering	Ontario Power Generation Inc.	Pickering, ON	Six operating, Two defuelled and in safe storage	Units 1, 4: 542 Units 5-8: 540	Units 1, 4: 1971 Units 5-8: 1982	Aug. 31, 2018
Gentilly-2	Hydro-Québec	Bécancour, QC	One defuelled and in safe storage[2]	675	1983	Jun. 30, 2016
Point Lepreau	New Brunswick Power Corp.	Lepreau, NB	One operating	705	1982	Jun. 30, 2017

[1] For multi-unit NPPs, this indicates the startup of the first reactor unit
[2] Gentilly-2 ended commercial operation in 2012 and completed the transition to safe storage in 2014

Regulatory oversight

The CNSC regulates the nuclear sector in Canada, including NPPs, through licensing, reporting, verification and enforcement. For each NPP, CNSC staff conducts inspections, assessments, reviews and evaluations of licensee programs, processes and safety performance.

The Power Reactor Regulatory Program involves the direct efforts of 230 CNSC staff, plus support from other members of the organization. This total effort includes 31 CNSC employees who are located onsite at all NPPs with operating reactors. Among their many tasks, they perform inspections and audits, monitor safety performance and provide regulatory oversight.

Licensing

A two-part public hearing for the Bruce A and B licence renewal was held in February and April 2015. In May 2015, the Commission renewed the operating licences issued to Bruce Power as a single licence for both Bruce A and B, valid from June 1, 2015 to May 31, 2020.

A two-part public hearing was also held for the Darlington licence renewal in August and November 2015. In December 2015, the Commission renewed the operating licence issued to OPG for the operation of Darlington, valid from January 1, 2016 to November 30, 2025.

The Gentilly-2 licence was renewed in June 2011 for a five-year period (effective until June 30, 2016); however, Gentilly-2 ended commercial operation on December 28, 2012. In 2015, the CNSC and Hydro-Québec staff began the preparatory work and activities required for the renewal of the Gentilly-2 decommissioning licence CMD. At the time of writing, the Commission hearing was scheduled for May 5, 2016.

The Commission was kept informed of events and activities at NPPs through public proceedings comprising six status reports on power reactors, three event initial reports (EIRs) and presentations. (See section 2.2.4 for details on these presentations.)

CNSC staff conducted several Aboriginal engagement activities in 2015, including consultations with a number of Aboriginal communities in relation to the Darlington and Bruce Power operating licence renewals. CNSC staff also identified a number of First Nation and Métis groups who may be interested in participating the CNSC's regulatory review process regarding the Hydro-Québec licence application to continue decommissioning activities at the Gentilly-2 facility. (Specific details on the licensees' efforts in this area are included in section 2.2.4.)

Compliance verification program

The safety performance of NPPs presented in this report was determined using the results of activities planned through the CNSC compliance verification program (CVP). In 2015, these activities included surveillance and monitoring conducted by full-time, onsite inspectors, announced and unannounced inspections supported by subject matter experts, and desktop reviews by a wide range of technical specialists. These activities were performed through an effective combination of document review, workplace observation and worker interviews. All compliance verification activities were fully documented and recorded the objective evidence that forms the basis of the compliance results.

Table 2 shows the compliance activities conducted by CNSC staff by station and for the industry as a whole. There were more than 17,049 person-days of effort by CNSC staff in conducting inspections, event reviews and other compliance activities in 2015. This effort was comparable to the 2014 value of 17,411 person-days.

Table 2: Compliance activities for stations and industry for 2015

Compliance activities effort (person-days)	Bruce A and B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry total
Inspections	1,030	1,079	1,460	147	1,030	4,746
Event reviews	198	128	132	4	58	520
Other compliance activities *	3,899	2,141	3,453	416	1,874	11,783
Total effort (person-days)	5,127	3,348	5,045	567	2,962	17,049

* Includes verification activities such as station walk-downs and reviews of licensee-submitted documents and reports.

The five-year trend in compliance activities is given in appendix A.

At its foundation, the CVP consists of a collection of compliance verification activities covering the 14 safety control areas (SCAs) conducted with varying frequency over a rolling five-year period. This collection shapes the baseline and is used to systematically and comprehensively verify whether licensees are complying with all of the safety and control measures established as the basis for the licensing of their station.

Approximately 100 to 150 applicable compliance verification activities are selected for the each year's compliance plan. The annual plan is then validated by CNSC technical specialists and licensing staff using a risk-informed approach that considers the status, performance history, and conditions and challenges of each station to ensure appropriate regulatory oversight and safety performance evaluation. Where necessary, additional reactive compliance verification activities are added that focus on known or potential licensee challenges. Additional supplemental compliance verification activities may also be added as necessary during the year in response to new or emerging licensee challenges.

The goal is to ensure that the CVP for NPPs is always timely, risk-informed, performance-based and tailored to individual stations.

Enforcement

The CNSC uses a graduated approach to enforcement to encourage and compel compliance and deter future non-compliances.

When non-compliance (or continued non-compliance) has been identified, CNSC staff assess the significance of the non-compliance and determine the appropriate enforcement action (based on the CNSC's graduated approach to enforcement). Each enforcement action is a discrete and independent response to non-compliance.

Measures used to encourage/compel compliance and deter further non-compliances include:

- informing licensee/discussion
- written notices
- requests under the *General Nuclear Safety Regulations* section 12(2)
- orders
- increased regulatory scrutiny
- licensing actions
- administrative monetary penalties
- decertification
- prosecution

Enforcement actions can be applied independently or in combination with other actions. Regulatory judgment must be applied, and multiple factors taken into account, to determine the most appropriate enforcement strategy for any given situation. If the initial enforcement action does not result in timely compliance, other actions will be used.

Safety and control area framework

CNSC staff use the Safety and Control Area Framework (SCAFramework) in evaluating each licensee's safety performance. The SCA framework includes 14 SCAs, each SCA is sub-divided into specific areas that define its key components. (See appendix B for a complete list of the SCAs and specific areas used in this report.)

In response to RD/GD-99.3, *Public Information and Disclosure* [6], licensees implemented public information and disclosure programs to disseminate objective scientific, technical and regulatory information to the public, detailing anticipated effects on the health and safety of persons and the environment of their activities under the SCA framework. (Specific details on the licensees' efforts in this area are included in section 2.2.3.)

Safety performance assessment

This report presents safety performance ratings for each SCA at each NPP. The ratings are based on the CVP activities. In generating the performance ratings, CNSC staff considered more than 800 findings. The vast majority of the findings (99.5 percent) were assessed as being either compliant, negligible or of low safety significance – in other words, they had a positive, insignificant or small negative impact on the assessment of

the specific area. The remainder (less than 0.5 percent) had a negative effect on the assessment of a specific area. (These findings of medium safety significance are discussed in section 3 of this report.) The findings were categorized into appropriate SCAs and assessed against a set of CNSC-developed performance objectives and criteria.

The assessment presented in this report includes an integrated plant rating for each NPP. The rating is a general measure of the overall safety performance at each NPP. It is determined by combining the ratings of the 14 individual SCAs.

Reporting requirements

In April 2014, the Commission approved REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [2], to replace S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1]. This new regulatory document was implemented on January 1, 2015 through an amendment to the individual NPP operating licences. This report therefore refers to REGDOC-3.1.1 for licensee reporting to the CNSC.

As described in REGDOC-3.1.1, all operating NPPs in Canada are required to submit to the CNSC the following reports:

Scheduled reporting

- quarterly report on safety performance indicators
- quarterly report on nuclear power plant pressure boundaries
- quarterly report on nuclear power plant personnel
- quarterly report on operational security
- annual report on environmental protection
- annual report on research and development
- annual report on risk and reliability
- annual report on fuel monitoring and inspection

Other scheduled specific periodic reports

- updates to facility descriptions and final safety analysis report
- probabilistic safety assessment
- site environmental risk assessment
- station security report
- proposed decommissioning plan

REGDOC-3.1.1 also states that operating NPPs must submit to the CNSC reports on any unplanned situations and events. These reports are posted by the licensees on the Web pages noted below:

- OPG: opg.com/generating-power/nuclear/stations/Pages/Reports.aspx
- Bruce Power: brucepower.com/2015-s99-reports/2015_s99-reports/

- NB Power: nbpower.com/en/about-us/regulatory/nuclear/nuclear-events/
- Hydro-Québec : hydroquebec.com/production/centrale-nucleaire/evenements.html

During 2015, NPP licensees reported to CNSC staff on 258 events and submitted 98 scheduled reports as a result of the requirements of REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [2]. None of the event reports resulted in findings of medium or high safety significance, and all findings were either low safety-significant, negligible or compliant. Three events were reported to the Commission as event initial reports (EIRs) in 2015. (See details in sections 2.2.4 and 3 for more details).

2 Industry safety performance and regulatory developments

This section presents the details of safety performance and regulatory developments for the Canadian nuclear power industry as a whole.

Specifically, it provides the CNSC's integrated assessment of the industry's safety performance in each of the 14 safety and control areas (SCAs):

- management system
- human performance management
- operating performance
- safety analysis
- physical design
- fitness for service
- radiation protection
- conventional health and safety
- environmental protection
- emergency management and fire protection
- waste management
- security
- safeguards and non-proliferation
- packaging and transport

The overall performance of the industry is determined by calculating an industry average rating for each SCA. (See appendix B for the definitions, performance objectives and specific areas of each SCA. The definitions of the performance ratings and the rating methodology used in this report can be found in appendix C.)

CNSC staff evaluated how well licensees' programs met regulatory requirements and expectations; contributed to protect the overall health, safety and security of persons and the environment; and helped implement Canada's international commitments on the peaceful use of nuclear energy. These evaluations were based on findings made throughout the year during inspections, desktop reviews, field rounds and follow-ups on licensee progress on enforcement actions.

CNSC and the adopted World Association of Nuclear Operators (WANO) performance indicators (PIs) are included in this section to illustrate various trends. CNSC safety performance indicators (SPIs) are defined in REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [2].

While useful for trending the performance of an individual station, comparing data between stations in any particular year is difficult because many factors – such as the number of operating units, design, unit capacity or governing documents – contribute to differences in SPI data.

Detailed information on various regulatory developments and issues for the nuclear power industry can be found in section 2.2. In recognition of the complexity and ongoing nature of many regulatory issues, the reporting period for section 2.2 covers January 2015 to April 2016.

2.1 Overall safety assessment

2.1.1 Management system

This SCA covers the framework that establishes the processes and programs required to ensure that an organization achieves its safety objectives, continuously monitors its performance against those objectives, and fosters a healthy safety culture. The industry average for management system was "satisfactory", unchanged from the previous year.

Based on the information assessed, CNSC staff concluded that the management system SCA at NPPs met all applicable regulatory requirements.

Management system ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
SA	SA	SA	SA	SA	SA	SA

The management system SCA encompasses the following specific areas:

- management system
- organization
- change management
- safety culture
- configuration management
- records management
- management of contractors
- business continuity

Management system

All NPP licensees are required to develop and implement a management system that adheres to the requirements of CSA standard N286-05, *Management system requirements for nuclear power plants* [7]. The oversight activities conducted by CNSC staff revealed some deficiencies in this area. In particular, improvements are needed at Point Lepreau to maintain an effective management system. CNSC staff continue to closely oversee the implementation of a corrective action plan at Point Lepreau.

Organization
The organization structure established by each NPP is documented per management system requirements. The documentation includes descriptions of roles and responsibilities for all licensed activities. Roles and responsibilities are verified during CNSC compliance activities.

Change management
Programs for change management have been implemented at all sites. There were no significant observations from compliance verification activities to report in this specific area for 2015.

Safety culture
Licensees conduct periodic safety culture self-assessments at planned intervals at their facilities, typically every three years. CNSC staff will continue to monitor these assessments and the associated follow-up actions. There were no significant findings or compliance verification activities to report in this specific area for 2015.

Configuration management
Configuration management is a systematic approach to identifying, documenting and changing the characteristics of a facility's structures, systems and components. It also ensures conformance is maintained between design requirements, physical configuration and facility configuration information.

The overall configuration management baseline program for all NPPs has been implemented. Implementation of the configuration management program requires improvements and continued support in other ongoing processes, such as engineering change control, performance monitoring, maintenance, aging management, and problem resolution and identification. The overall evaluation for configuration management across the industry is satisfactory.

Management of contractors
Oversight activities conducted by CNSC staff identified minor deficiencies with the qualification of contractors, roles and responsibilities for contractor oversight, and documentation regarding the procurement of goods and items from suppliers with ISO 9001 certification. (Further information on these issues can be found in sections 3.1.1.1, 3.3.1.1 and 3.5.1.1.) Licensees provided corrective action plans and timelines to address the deficiencies. CNSC staff are monitoring the implementation of corrective actions.

Records management
Licensees maintained and retained the documented information required by regulations. However, during compliance activities, CNSC staff observed that the quality of the records produced for different activities was not always ensured. (Further information on these issues can be found in sections 3.2.1.1, 3.4.1.12 and 3.5.1.12.) Licensees provided corrective action plans and timelines to address the issues. CNSC staff are monitoring the implementation of corrective actions.

Business continuity
All licensees have adequately prepared their business continuity plans to ensure the minimum shift complement at their facilities is not affected by labour actions, severe weather or other disruptions.

2.1.2 Human performance management

This SCA covers the activities that enable effective human performance through the development and implementation of processes that ensure licensees have sufficient personnel in all relevant job areas – and that these personnel have the necessary knowledge, skills, procedures and tools to safely carry out their duties. The industry average rating for human performance management in 2015 was "satisfactory", unchanged from the previous year.

Based on the information assessed, CNSC staff concluded that the human performance management SCA at NPPs met all applicable regulatory requirements.

Human performance management ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
SA	SA	SA	SA	SA	SA	SA

Human performance management encompasses the following specific areas:

- human performance program
- personnel training
- personnel certification
- initial certification examinations and requalification tests
- work organization and job design
- fitness for duty

Human performance program

All NPP licensees utilize a human performance program to minimize human and organizational errors. CNSC staff determined, through compliance verification activities, that licensees have implemented and continued to improve their comprehensive human performance programs. CNSC staff confirmed that the licensees met their regulatory requirements in this specific area during 2015.

Personnel training

All Canadian NPPs use training systems based on the systematic approach to training. Implementation of these systems for the many training programs at each facility met regulatory requirements. Identified weaknesses in the implementation of the training systems are being addressed by the licensees in accordance with their corrective action plan process and do not represent an increased risk to nuclear safety.

Personnel certification

All licensees are required to have certified shift supervisors, control room operators and health physicists. All licensees maintained sufficient numbers of personnel for the certified positions in 2015. CNSC staff are satisfied that NPP licensees' programs certify the competency of personnel at Canadian NPPs to perform their duties safely.

Table 3: Number of certifications per station and certified positions

Station	Reactor operator	U0O[a, b]	Shift supervisor[e]	Health physicist	Total
Bruce A					
Actual	44	19	16	4	83
Minimum	30	10	10	1	51
Bruce B					
Actual	53	23	19	4	99
Minimum	30	10	10	1	51
Darlington					
Actual	57	19	19	2	97
Minimum	30	10	10	1	51
Pickering 1,4					
Actual	36		22	3[c]	61
Minimum	20		10	1	31
Pickering 5-8					
Actual	54		22	3[c]	79
Minimum	30		10	1	41
Gentilly-2					
Actual				3[d]	3
Minimum				1	1
Point Lepreau					
Actual	11		8	3	22
Minimum	5		5	1	11

Notes:

a. The reactor operator and Unit 0 operator (U0O) positions form the control room operator cadre.

b. There are no U0O positions at Pickering Unit 1, Pickering Unit 4, Pickering Units 5–8 or Point Lepreau. The corresponding cells are therefore left empty.

c. Three health physicists are certified for both stations.

d. The three health physicists are the only positions at Gentilly-2 requiring certification.

e. At multi-unit stations, the shift supervisor number is the total of certified shift managers plus certified control room shift supervisors.

Initial certification examinations and requalification tests

The initial certification examinations and requalification tests conducted at all NPPs met regulatory requirements for initial certification and renewal of certification of workers in 2015.

Work organization and job design

Minimum shift complement

Licensees are required, in accordance with the *General Nuclear Safety and Control Regulations*, to ensure the presence of a sufficient number of qualified workers to safely carry on the licensed activity. For NPP licensees, this means they must maintain a minimum shift complement at all times in accordance with their power reactor operating

licences. In 2015, licensees continued to ensure the presence of a sufficient number of qualified workers at their respective facilities.

Fitness for duty

A draft version of REGDOC 2.2.4, *Fitness for Duty* [8], was published for public consultation in 2015. This document sets out comprehensive fitness for duty requirements at high-security sites, including medical fitness, psychological fitness, occupational fitness, and alcohol and drug testing. CNSC staff will review the comments received from stakeholders and update the draft document before seeking the Commission's approval.

Hours of work

All licensees have procedures that specify station requirements related to the hours of work and processes in place to enable them to monitor compliance with the hours of work limits. Overall, licensees met the hours of work requirements and CNSC staff will continue to monitor all licensees' compliance with the hours of work limits.

A renamed draft of REGDOC 2.2.4, *Managing Worker Fatigue* [8] was published for a second round of public consultation in 2015. This draft regulatory document sets out requirements for managing worker fatigue and sets limits on hours of work for the purpose of nuclear safety. CNSC staff will review the comments received from stakeholders and update the draft regulatory document before seeking the Commission's approval.

2.1.3 Operating performance

This SCA includes an overall review of the conduct of licensed activities and the activities that enable effective operating performance. The industry average rating for operating performance in 2015 was "fully satisfactory", an improvement on the "satisfactory" rating from the previous year.

Based on the information assessed, CNSC staff concluded that NPP licensees operated their facilities safely and met or exceeded all applicable regulatory requirements.

Operating performance ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
FS	FS	FS	FS	SA	SA	FS

Operating performance encompasses the following specific areas:

- conduct of licensed activity
- procedures
- reporting and trending
- outage management performance
- safe operating envelope
- severe accident management and recovery

- accident management and recovery

Conduct of licensed activity

Nineteen reactors continued to operate in Canada throughout 2015, unchanged from the previous year. Pickering Units 2 and 3 as well as Gentilly-2 are in safe storage. There were no serious process failures at any of the NPPs.

Unexpected reactor power reductions (or transients) can indicate problems within a plant and place unnecessary strain on its systems. Table 4 below summarizes the number of unplanned reactor power transients in Canadian NPPs caused by stepbacks, setbacks and reactor trips where the trip resulted in a reactor shutdown. (Stepbacks and setbacks are gradual power changes intended to eliminate potential risks to plant operations.)

In 2015, all unplanned transients were controlled properly and, where necessary, power reduction was initiated by the reactor control systems. The CNSC will continue to monitor the trends associated with this indicator.

Table 4: Number of unplanned transients, 2015

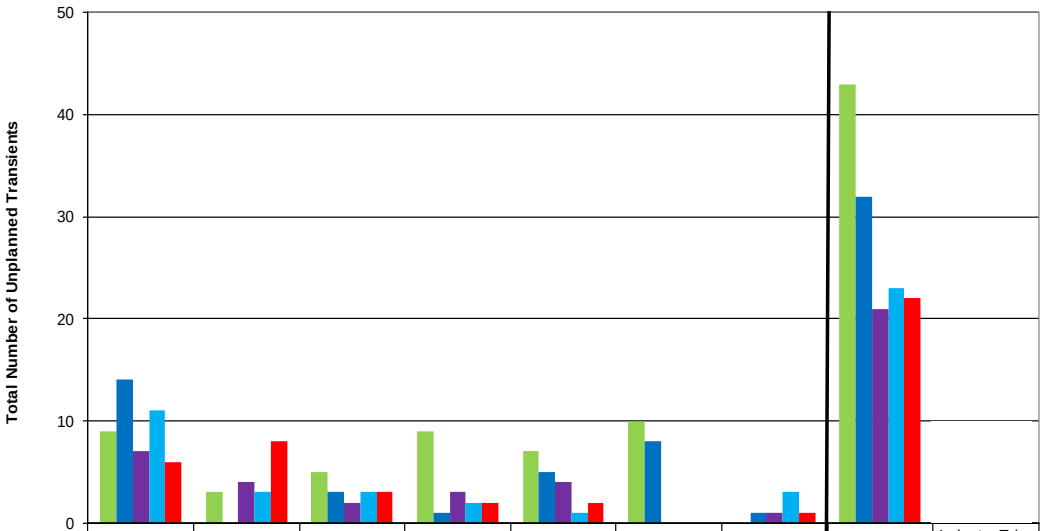
NPP	Number of operating reactors	Number of hours of operation	Un-planned reactor trips[1]	Step-backs	Set-backs	Total unplanned transients[2]	Number of trips per 7,000 operating hours[3]
Bruce A	4	31,208	0	1	5	6	0.00
Bruce B	4	30,548	1	0	7	8	0.23
Darlington	4	27,718	1	0	2	3	0.25
Pickering 1, 4	2	13,868	0	n/a[4]	2	2	0.00
Pickering 5-8	4	28,704	1	1	1	3	0.24
Gentilly-2	n/a[5]	n/a[5]	n/a[5]	n/a[5]	n/a[5]	n/a[5]	n/a[5]
Point Lepreau	1	8239	0	0	1	1	0.0
Industry total	19	140,285	3	2	18	23	0.15

Notes:

1. Automatic reactor trips only; does not include manual reactor trips or trips during commissioning testing.
2. Unplanned transients consist of unplanned reactor trips, stepbacks and setbacks.
3. Nuclear power industry performance target is less than 0.5 reactor trips per 7,000 operating hours.
4. Stepbacks are not implemented at Pickering 1 or 4 (due to plant design).
5. Gentilly-2 in safe storage during 2015.

Figure 2 shows the individual station and industry trend in the number of unplanned transients from 2011 to 2015. For two stations, the number of unplanned transients decreased in comparison to 2014; for two stations it remained unchanged and for two stations it increased. For the industry as a whole, the total number of unplanned transients decreased by one compared to 2014.

Figure 2: Trend details for the number of unplanned transients for stations and industry, 2011-15



	Bruce A	Bruce B	Darlington	Pickering 1, 4	Pickering 5-8	Gentilly-2	Point Lepreau	Industry Total	Industry Trips per 7,000 Hours
2011	9	3	5	9	7	10	n/a	43	0.53
2012	14	0	3	1	5	8	1	32	0.30
2013	7	4	2	3	4	n/a	1	21	0.34
2014	11	3	3	2	1	n/a	3	23	0.38
2015	6	8	3	2	2	n/a	1	22	0.15

Note: Cells labelled “n/a” indicate periods when the Gentilly-2 and Point Lepreau reactors were shut down for the year. The shutdown at Point Lepreau was for refurbishment and the shutdown at Gentilly-2 was due to the end of commercial operation.

Figure 3 on the following page shows the number of unplanned reactor trips per 7,000 operating hours for the Canadian nuclear power industry in comparison to the international nuclear power industry values published by the World Association of Nuclear Operators (WANO).

The reactor trip rate decreased from 2014 to 2015 – from 0.38 to 0.15 – and remains within the industry performance target of 0.5 unplanned trips per 7,000 operating hours. The industry average was one unplanned reactor trip per 46,762 hours, about 70 percent better than the specified performance target of less than 0.5 reactor trips per 7,000 hours of operation (or one trip per 14,000 hours).

Figure 3: Trend details for the number of unplanned reactor trips per 7,000 operating hours, compared to WANO values, 2011-15

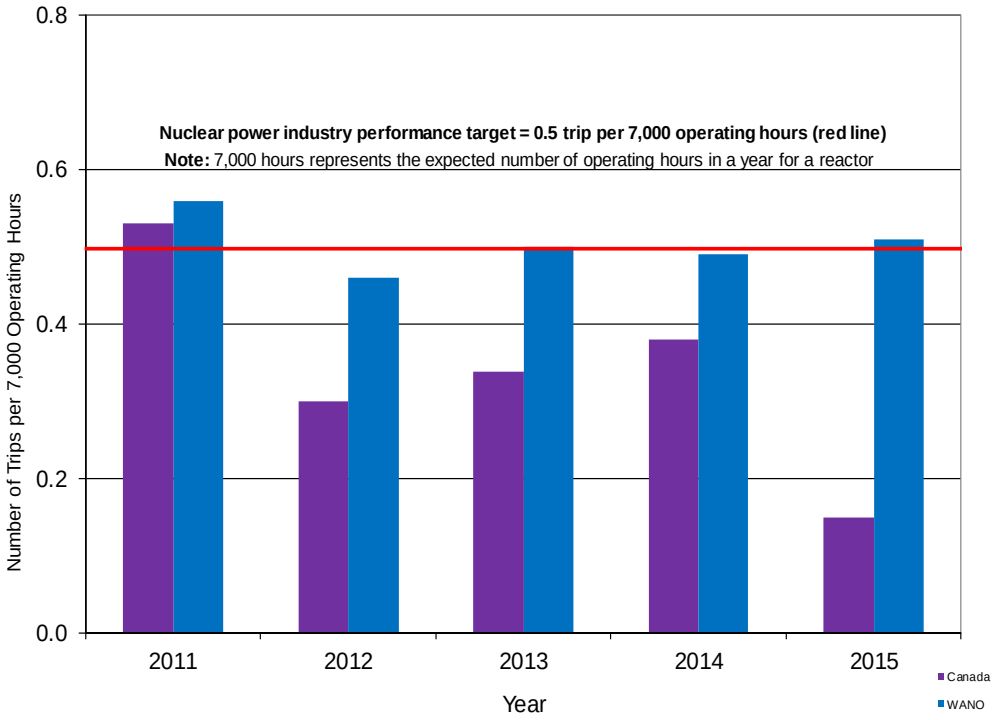
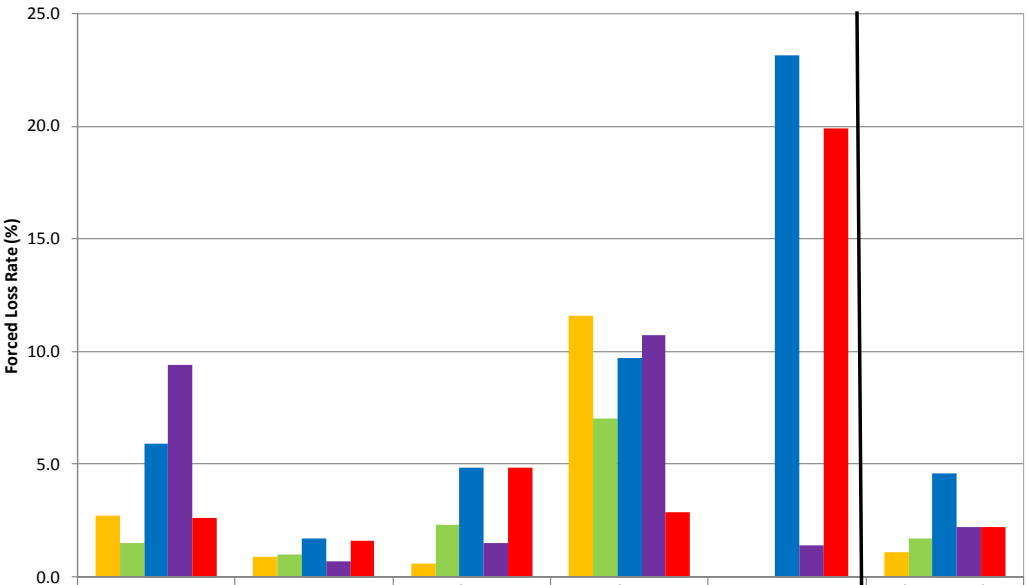


Figure 4 shows the forced loss rate (FLR) for Canadian NPP licensees and the industry, and presents the median value for the industry (consistent with WANO methodology). The purpose of this indicator is to monitor industry progress in minimizing outage time and power reductions that result from unplanned equipment failures, human errors or other conditions during the operating period (excluding planned outages and their possible unplanned extensions). This indicator reflects the effectiveness of plant programs and practices in maintaining systems available for electrical generation.

As shown in figure 4, the FLR for two stations decreased during the year, while for three stations the FLR increased. Overall, the industry FLR remained unchanged between 2014 and 2015, remaining at 2.2 percent.

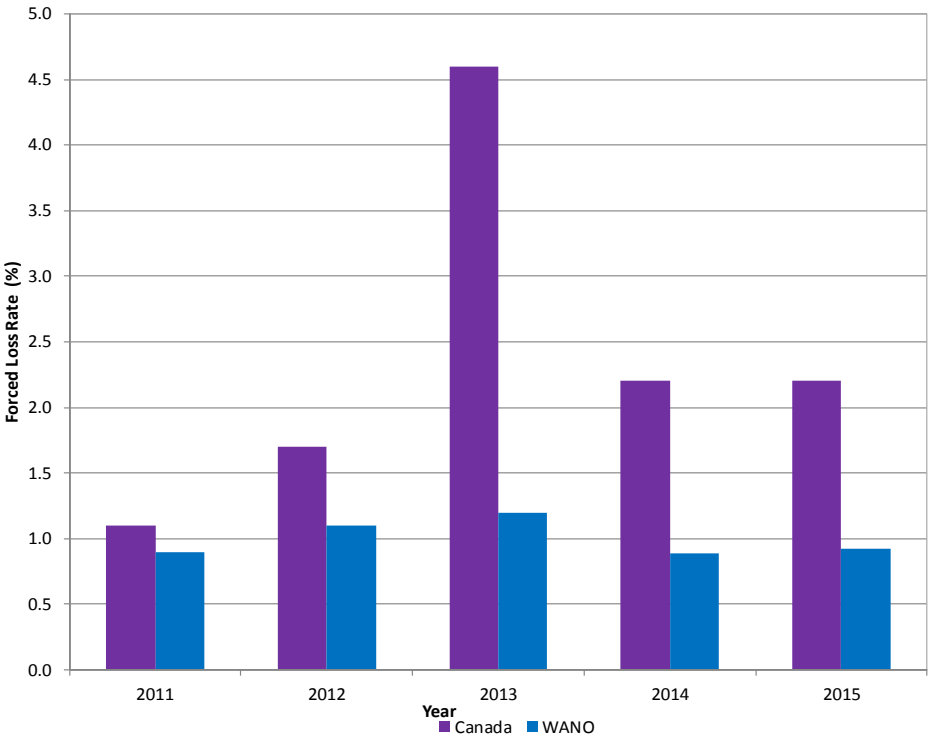
Figure 4: Trend details for forced loss rate for stations and industry, 2011–15



	Bruce A	Bruce B	Darlington	Pickering	Point Lepreau	Industry Median
2011	2.7	0.9	0.6	11.6	N/A	1.1
2012	1.5	1.0	2.3	7.0	N/A	1.7
2013	5.9	1.7	4.8	9.7	23.2	4.6
2014	9.4	0.7	1.5	10.7	1.4	2.2
2015	2.6	1.6	4.9	2.9	19.9	2.2

Figure 5 shows the FLR for the Canadian nuclear power industry in comparison to the international nuclear power industry values published by WANO. The Canadian nuclear power industry values are higher than the world median values. The reason for the difference between the world and Canadian industry values is not clearly understood, but could be due to differences in reactor technologies and the number of operating reactors in each group (19 for Canada versus more than 400 reporting units for the WANO values). In all cases, the forced outages and outage extensions were managed safely and in accordance with regulatory requirements.

Figure 5: Trend of forced loss rate compared to WANO values, 2011–15



2.1.4 Safety analysis

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

For NPPs, safety analysis is primarily deterministic in demonstrating the effectiveness of the fundamental safety functions of "control, cool and contain." Risk contributors are considered by using probabilistic safety assessments. Appropriate safety margins should be applied to address uncertainties and limitations of safety analysis approaches.

In 2015, the industry average for the safety analysis SCA was "satisfactory", unchanged from the previous year. Based on the information assessed, CNSC staff concluded that the safety analysis SCA at NPPs met all applicable regulatory requirements.

Safety analysis ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
SA	SA	FS	FS	SA	SA	SA

Safety analysis encompasses the following specific areas:

- deterministic safety analysis

- probabilistic safety analysis
- criticality safety
- severe accident analysis
- management of safety issues (including R&D programs)

Deterministic safety analysis

CNSC staff reviewed the licensees' activities under this SCA, to confirm the ongoing compliance with regulatory requirements.

Safety analysis improvement program

Each licensee has developed an implementation plan for upgrading their deterministic safety analysis to demonstrate compliance with the requirements of REGDOC-2.4.1, *Deterministic Safety Analysis*, [9]. This is a continuation of earlier work to implement RD-310, *Safety Analysis for Nuclear Power Plants* [10], which was replaced by REGDOC-2.4.1 in 2014.

REGDOC-2.4.1 implementation allows the deterministic safety analysis to be updated in a systematic and staged manner. CNSC staff have reviewed licensees' REGDOC-2.4.1 implementation plans and found these acceptable.

CNSC staff continue to provide feedback to licensees on their ongoing safety analyses within the framework of REGDOC-2.4.1 implementation. One area of focus is the common-mode events deterministic safety analysis, which contains some features new to the analysis of CANDU reactors. As the activities of the licensees' implementation plans are progressed to enhance the safety case of each facility, the current deterministic safety analysis remains adequate for the continued support of the safe operation of CANDU reactors.

Impact of aging on the safety analysis

Aging changes certain characteristics of the reactor heat transport system, resulting in a gradual reduction of the safety margins unless compensatory measures are taken and implemented. As the reactor ages, the impact of simultaneous aging effects in various structures, systems and components on the overall safety case of the NPP needs to be assessed and the existing safety margins quantified.

Licensees have aging management programs in place that include systematic monitoring of aging-related parameters important to safety analysis, along with assessment of the impact of the change in reactor conditions on existing safety margins. CNSC staff reviewed the Bruce Power and OPG programs to monitor, assess and mitigate the impact of heat transport system aging on safety analysis and found them satisfactory. As Point Lepreau was refurbished and returned to service in 2012, there are currently no aging related concerns with its heat transport system.

Large break loss-of-coolant accident: Composite analytical approach

In late 2013, OPG, NB Power and Bruce Power submitted their proposed composite analytical approach (CAA) for CNSC staff review. The CAA is a safety analysis methodology to support the recategorization to a lower risk level of CANDU safety issues AA 9, PF 9 and PF 10 for large break loss-of-coolant accidents (LBLOCA). (See appendix D for more details on these CANDU safety issues.) The CAA uses modern techniques for assessing and accounting for uncertainties as well as more advanced pipe-

failure frequency and rupture-progression models. It is intended to demonstrate that larger safety margins exist for LBLOCA than shown in traditional safety analysis results.

CNSC staff acknowledged that concerns raised in most of the key areas are not impediments to the use of CAA, and that a clear path forward for resolution has been established with associated activities currently being undertaken by industry. Industry is preparing a plan and schedule to address all CNSC concerns. Overall, industry continues to progress with activities toward CNSC staff acceptance of the CAA methodology.

Bruce Power has taken the lead in this regard and plans to submit a licence application using CAA that may address many CNSC comments. Bruce Power expects to complete this licensing analysis by end of 2019. OPG and NB Power plan to cooperate with Bruce Power in generic aspects of this project; OPG intends to follow with its own CAA-based analysis after Bruce Power. NB Power may also consider submitting a CAA-based analysis in the future.

While industry is working on the CAA methodology and CNSC staff continue to review industry submissions, the licensing basis of Canadian stations for the LBLOCA scenario will continue to be based on traditional safety analysis results and the CNSC's LBLOCA interim regulatory position. Safety analysis results are based on conservative assumptions, which include an instantaneous opening of the large break. The interim regulatory position established a set of action levels and acceptance criteria for all NPPs. In the event of LBLOCA discovery issues uncovered during this interim period, the latest results from the application of the CAA methodology may be used as part of a risk-informed decision-making process to assess the safety significance of the discovery issues.

Large break loss-of-coolant accident: Safety margins

Past research discovery findings related to assumptions and input data used in the safety analysis for the unlikely event of an LBLOCA have been assessed by the licensees. The licensees have determined that adequate safety margins remain and that there are no negative safety impacts on continued operation. CNSC staff acknowledge that licensees have met the reporting requirements for these discovery findings.

Independent technical panel on shutdown system effectiveness criteria

In 2015, CNSC staff completed a review of the technical basis for a new set of derived acceptance criteria (DAC) for design basis accidents. The new DAC were developed by industry in accordance with REGDOC-2.4.1, *Deterministic Safety Analysis* [9]. G-144, *Trip Parameter Acceptance Criteria for the Safety Analysis of CANDU Nuclear Power Plants* [11], is no longer applicable and has been superseded by REGDOC-2.4.1.

The new DAC maintains the safety margins outlined in the licensing basis. However, if any updated analyses lead to changes to the safe operating envelope (SOE), licensees will notify CNSC staff in accordance with the requirement set out in their licence conditions handbook (LCH).

The new DAC addressed long-standing issues related to fuel behaviour under accident conditions, which allowed licensees to request for a recategorization of CANDU safety issue PF18 ("fuel bundle/element behaviour under post dryout"). As a result, in April 2016, CNSC staff recategorized PF18 from Category 3 to Category 2. (See appendix D for definitions of these categories.) The CANDU safety issue CMD is scheduled to be presented to the Commission in August 2016.

Probabilistic safety assessment

The CNSC's regulatory requirements with regard to probabilistic safety assessments (PSAs) have been integrated into REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [12].

OPG is progressing toward a whole-site PSA at Pickering, while the other nuclear generation stations will use the lessons learned from this pilot project to determine their paths forward.

Severe accident analysis

Severe accident management and multi-unit modelling

All severe accident-related Fukushima action items (FAIs) for all Canadian NPPs were closed. (See appendix H for descriptions of the FAIs.)

In response to FAI 3.1.1, all Canadian NPPs have developed and implemented severe accident management guidelines (SAMG). CNSC staff desktop reviews and evaluations of the station-specific SAMGs for a single-unit Point Lepreau station and multi-unit Pickering station were completed. These reviews confirmed that the NPPs have robust and updated accident management programs. CNSC staff reviews of the SAMGs for other multi-unit stations are ongoing and expected to be completed by 2018.

In response to the CNSC Integrated Action Plan [5], NPP licensees have developed improved methods for deterministic analysis of multi-unit severe accidents. In 2015, industry completed a project called Severe Accident Software Simulator Solution and submitted a set of reports summarizing a detailed evaluation of the current multi-unit modelling capability. Based on this evaluation, industry concluded that the existing approaches to modelling multi-unit events have been found to be sufficient for PSA of multi-unit stations and will continue to be employed in all future PSA work. On this basis, FAIs 3.2.1 and 3.2.2 have now been closed. Station-specific action items have been raised to track further activities related to severe accident modelling of multi-unit NPP.

Concerns raised by an intervenor in Commission Hearings

An intervenor raised a number of concerns related to CANDU reactors at recent Commission meetings, most recently in the 2015 Bruce and Darlington relicensing hearings. Bruce Power committed to the Commission that it would meet with the intervenor to address the topics. The intervenor met with Bruce Power staff in April 2015 and again with personnel from Canadian NPP licensees in early summer 2015. At these meetings, the 34 topics raised by the intervenor in CMD 15-H2.145A and CMD 15-H2.145B were discussed and the technical details elaborated.

As directed by the Commission, the industry undertook a two-phase approach, coordinated by the CANDU Owners Group (COG), to address the concerns raised. Phase 1 would address the four key areas of the intervenor's concerns and Phase 2 would address the remaining topics as well as the feedback from the intervenor on the Phase 1 report. The four key areas addressed in Phase 1 are:

- bleed condenser relief valves
- hydrogen/deuterium production and PARs effectiveness
- Modular Accident Analysis Program (MAAP-CANDU) modelling
- in-vessel retention

A COG report presenting the industry response to the Phase 1 topics was drafted and sent to the intervenor in late December 2015. CNSC staff were also provided with a copy and invited to comment.

Meanwhile, industry has begun Phase 2 work. CNSC staff now understand that the intervenor will comment on both reports at the same time once Phase 2 is completed. COG is planning to have the draft Phase 2 report available in summer 2016. At this stage, only the intervenor's interventions and the draft Phase 1 report are available to CNSC staff.

CNSC staff have confirmed that, based on their knowledge and as previously presented to the Commission, there are no topics raised or discovered that would question the safety of Canada's NPPs. However, as further noted below, they are following up on a number of topics to ensure full clarity and understanding.

CNSC staff have performed a review of the draft Phase 1 COG report. The staff review includes a brief overview of all the original topics raised by the intervenor in CMD 15-H2.145A and CMD 15-H2.145B to ensure the prioritization of issues was appropriate.

CNSC staff accepts the prioritization of topics agreed between the parties. CNSC staff also performed a screening review of the key topics covered by the draft Phase 1 COG report. These topics had been expanded into 82 sub-topics during the meetings between the intervenor and industry. The results of CNSC staff screening review finds industry's disposition of the sub-topics acceptable in the majority of cases. CNSC staff categorizes the status of sub-topics as follows:

- No further action by industry or CNSC is needed 63
- Additional confirmatory work is in progress 4
- Industry should provide further justification 15
- CNSC action is needed 0

Upon completion of internal review, the report documenting CNSC staff position on the topics covered in Phase 1 will be sent to COG and the intervenor. The intent is that the CNSC comments will help clarify the 15 sub-topics where industry's position is unclear or provides inadequate supporting evidence.

In parallel with the above activities, CNSC staff are arranging for external experts to review the CNSC staff assessment process of the intervenor's concerns. The two main objectives are to ensure that the topics have been dispositioned with appropriate technical rigour and to obtain advice on how to best handle such topics in the future (from a regulatory point of view). The results of the external reviews will be incorporated into the final report to be presented to the Commission at one of its public proceedings later this year.

CNSC staff will provide the Commission with further updates when additional information becomes available.

Management of safety issues (including R&D programs)

In 2007, the CNSC initiated a project to systematically reassess the status of potential design and analysis safety issues for CANDU reactors. This project also incorporated the long-standing technical issues known as generic action items (GAIs); as a result, all of the GAIs were closed.

The CANDU safety issues (CSIs) were first classified and categorized in order of risk importance.

By February 2015, six of the original 21 CSIs in the highest risk category (Category 3) remained to be reassessed. (A Category 3 CSI is one that has measures in place to maintain safety margins, but the adequacy of these measures needs to be confirmed.) Three of the six CSIs to be reassessed were related to LBLOCAs.

For non-LBLOCA issues, the licensees have applied to recategorize most of the issues into lower risk categories based on empirical and analytical evidence and actions taken. The licensees and CNSC staff are monitoring and coordinating the implementation of the plan for recategorization of the few remaining issues.

Licensees are making progress on the CSIs and CNSC staff are monitoring their efforts. (See appendix D for more information on the CSIs, including their status.) There are no safety concerns arising from their continuous reassessment efforts.

An update on the status of the CSIs is being prepared for presentation to the Commission in mid-2016.

CNSC staff continue to undertake systematic evaluations of the industry R&D activities, as identified to CNSC through the annual reporting in accordance with REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [2]. These evaluations confirm that licensees maintain a robust R&D capability to address any emerging issues.

2.1.5 Physical design

This SCA relates to activities that affect the ability of structures, systems and components to meet and maintain their design basis as new information arises over time and changes take place in the external environment. The industry average rating for physical design was “satisfactory”, unchanged from the previous year.

Based on the information assessed, CNSC staff concluded that the physical design SCA at NPPs met all applicable regulatory requirements.

Physical design ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
SA	SA	SA	SA	SA	SA	SA

Physical design encompasses the following specific areas:

- design governance
- site characterization (no significant observations to report)
- facility design (no significant observations to report)
- structure design (no significant observations to report)
- system design
- components design

Design governance

CNSC staff reviewed a number of topics under this specific area to develop an overall assessment of design governance. The two topics with significant observations – environmental qualification and human factors in design – are reported on below.

Environmental qualification

An environmental qualification program ensures all required structures, systems and components are capable of performing their designated safety function in a postulated harsh environment resulting from design-basis accidents.

Overall, the industry continued to perform well in this area, with all stations rated "satisfactory" in 2015. Licensees' environmental qualification programs implemented at all NPPs are compliant with CSA standard N290.13-05, *Environmental qualification of equipment for CANDU nuclear power plant* [13]. Although all licensees have mature environmental qualification programs, maintaining a high standard in this area is becoming a greater challenge due to increased reactor aging.

Human factors in design

In December 2014, CSA standard N290.12-14, *Human factors in design for nuclear power plants* [14], was published as an industry-led initiative. This standard was designed to work in conjunction with N286-05, *Management system requirements for nuclear power plants* [7], and reflects the operating experience of Canadian NPPs.

In September 2015, licensees agreed to prepare and execute implementation plans for N290.12-14 [14]. Following licensees' implementation of this standard, CNSC staff will carry out compliance verification activities to ensure processes are in place and meet the requirements of N290.12. This standard will move from the "guidance" section to the "requirement" section of the NPPs' LCH once compliance verification activities confirm licensees are compliant with the standard.

Human and organizational factors were embedded into several Fukushima actions items (FAIs). All of these FAIs were closed after the submission of plans that satisfied the various closure criteria. To monitor the execution of these plans, compliance activities (including inspections) were completed at all NPPs in May 2016.

CNSC staff found licensees are in compliance with applicable CSA standards. Some areas for improvement were identified with the documentation and the performance of human factors-in-design work. These areas of improvement will be addressed by all licensees in their compliance verification program.

System design

CNSC staff reviewed a number of topics to develop an overall assessment of system design.

Reactor control, process and control, and instrumentation and control, including software

The industry has improved the performance and reliability of instrumentation and control systems through the verification of compliance with code and standards, and the corrective maintenance program. All stations met the performance objectives in this area.

Service water, including emergency service water systems

The service water systems provide water to a large number of components and systems. However, from the perspective of nuclear safety, the most important service water loads are associated with:

- the removal of heat in the reactor core (such as moderator heat exchanger cooling and end-shield cooling)

- cooling functions to ensure proper functioning of structures, systems and components important to safety (such as instrument air compressors and boiler room air cooling units)

During 2015, the performance of the service water systems functioned well at all stations. CNSC staff are satisfied with licensees' performance in this area.

Electrical power systems

Electrical power systems are important for cooling, controlling, containing and monitoring reactor and auxiliary systems. To address the various electrical requirements within a nuclear power plant, electrical power systems are subdivided according to groups (1 and 2), classes (1, 2, 3 and 4) and divisions (odd and even). The systems are designed, operated and maintained to supply power to safety-related loads to meet the nuclear safety requirements of the plant.

During 2015, the overall performance of the electrical power systems was satisfactory across all stations.

Fire protection design

In 2015, all NPPs continued to maintain satisfactory fire protection programs. Licensees require a comprehensive fire protection program (i.e., a set of planned, coordinated, controlled and documented activities) to ensure licensed activities do not result in unreasonable risk to health, safety and the environment due to fire, and to ensure the licensee is able to efficiently and effectively respond to emergency fire situations.

Fire protection provisions are applicable to all work related to the design, construction, operation and maintenance of the nuclear facility, including the structures, systems and components that directly support the plant and the protected area.

Seismic qualification

All NPP licensees have established seismic qualifications for their sites.

With the exception of Hydro-Québec for Gentilly-2, all licensees have performed site-specific probabilistic seismic hazard assessments. CNSC and Natural Resources Canada staff have reviewed the assessments and found that licensees met the requirements of the applicable CSA standard.

CNSC staff carried out an inspection on the preservation of seismic qualification at Darlington in 2015. It was concluded that there is sufficient evidence to demonstrate that the seismic design basis at Darlington has been effectively preserved.

Robustness design

Robustness design and assessment covers the physical design of nuclear facilities for sufficient robustness against anticipated threats, such as protection against a malevolent aircraft crash. The assessment and ratings for this specific area are based on licensee performance in meeting the commitments made to CNSC staff, including the submission of detailed aircraft impact assessments. The focus of the review was on mitigating the potential consequences of these accidents. CNSC staff have opened site-specific action items as a follow-up for the implementation of the CNSC's recommendations.

Component design

Fuel inspection program

All operating NPPs had well-developed reactor fuel inspection programs during 2015.

There were, however, issues at some stations in fuel performance, specifically;

- Pickering black fuel deposit issue
- Bruce A Units 1 and 2 fuel defect rate
- Bruce B endplate cracking issue

Licensees continue to work to resolve these outstanding issues and CNSC staff will continue to monitor their progress. These issues are outlined for each station in section 3 of this report.

Cables

Cables are critical to the safe and reliable operation of NPPs due to their widespread use as the connection medium with many systems important to safety. Canada's operating reactors are aging and cables are affected by the aging process. Therefore, licensees have implemented cable condition monitoring/surveillance programs and cable aging management programs to assess, over time, the degradation of cable insulation. Based on compliance verification activities, the CNSC concluded that the licensees have demonstrated acceptable progress in the development and implementation of their respective programs and that the cables at NPPs are safe. CNSC staff are satisfied with the licensees' overall performance in this area.

Valves

The industry identified a component design issue associated with the Newman Hettersley bellow-sealed valves across all stations. No immediate safety concerns have been identified and the stations' evaluations of this issue's impact on the systems are in progress. (This issue is discussed further in section 2.2.2.)

2.1.6 Fitness for service

This SCA covers activities affecting the physical condition of structures, systems and components to ensure they remain effective over time. This includes programs that ensure all equipment is available to perform its intended design function when called upon to do so. The industry average rating for fitness for service in 2015 was "satisfactory", unchanged from the previous year.

Based on the information assessed, CNSC staff concluded that the fitness for service SCA at NPPs met all applicable regulatory requirements.

Fitness for service ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
SA	SA	SA	SA	SA	SA	SA

Fitness for service encompasses the following specific areas:

- equipment fitness for service/equipment performance (no significant observations to report)

- maintenance
- structural integrity
- aging management
- chemistry control (no significant observations to report)
- periodic inspection and testing

Maintenance

Maintenance inspections carried out in 2015 did not identify any non-compliance issues.

The industry average preventive maintenance completion ratio for the NPPs was around 88 percent in 2015, which is an indication that preventive maintenance was effective in reducing corrective maintenance.

Improvements were made to the backlog of corrective critical maintenance, the backlog of deficient critical maintenance and the number of critical preventive maintenance deferrals throughout the 2015 operating year. Although usually not safety significant in themselves, maintenance backlogs are monitored by CNSC staff because they can be a useful indicator of overall maintenance effectiveness and plant operation.

Structural integrity

All operating NPP licensees continued to inspect and demonstrate the structural integrity of NPP components and structures, including those for pressure boundary systems, containment systems and safety-significant balance-of-plant systems, in accordance with the stations' periodic inspection programs and applicable standards.

Compliance monitoring activities conducted by CNSC staff included the review of licensees' governing program documents and inspection reports, and disposition of inspection findings submitted in accordance with relevant CSA standards and REGDOC-3.1.1, *Reporting Requirements of Nuclear Power Plants* [2]. After reviewing the licensees' inspection program results, quarterly pressure boundary reports, operations reports and specific event reports, CNSC staff found no reported degradation to structures, systems and components that affected nuclear safety in 2015.

To develop the engineering methodologies and analytical tools to assess the fitness for service of pressure tubes operating beyond their originally intended operating life, OPG, Bruce Power and Canadian Nuclear Laboratories conducted a fuel channel life management project (FCLMP), under the administration of the CANDU Owners Group (COG). CNSC staff continue to monitor licensee implementation of the deliverables emerging from the FCLMP, namely the new pressure tube fracture toughness models and new methodologies for probabilistic leak-before-break assessments.

Reliability of systems important to safety

As determined through the reviews of station reports, all licensees were in compliance with the regulatory requirements described in RD/GD-98, *Reliability Programs for Nuclear Power Plants* [15].

In accordance with REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [2], NPP licensees are required to report annually to the CNSC the results of their reliability program. This includes reporting on the reliability of the multiple special safety systems available on all CANDU reactors that provide protection against unlikely (but possible) process system failures. These special safety systems include two shutdown

systems that are independent of each other: the first uses shutoff rods (which drop into the reactor core by gravity, with an initial spring assist); the second uses the injection of a neutron-absorbing solution into the moderator. At no time are the shutdown systems allowed to be ineffective. In some rare circumstances their capability might be reduced, but coverage is always assured by the other redundant system and immediate actions are always taken by the operating crew to restore the capability. At least one shutdown system will operate, if required, following any process system failure. In addition to the special safety systems, the CANDU design provides other safety-related systems and features to solely perform safety functions. No reactor is allowed to operate unless the safety systems are available. If unavailability is detected, immediate actions are taken to ensure safety is maintained at all times.

Overall, the special safety systems performed well in meeting their unavailability targets (apart from the exceptions noted in section 3 of this report). Notwithstanding backup systems in place, licensees took appropriate actions to address the incidents leading to unavailability and corrective actions were put in place.

"Safety system test performance" indicates successful completion of tests within the maximum allowable time interval required by licence condition, including those referenced in documents submitted in support of a licence application. It is a measure of a licensee's ability to successfully complete routine tests on safety-related systems and calculate the predicted availability of systems. Data for the stations and the industry as a whole are shown in table 5 and figure 6.

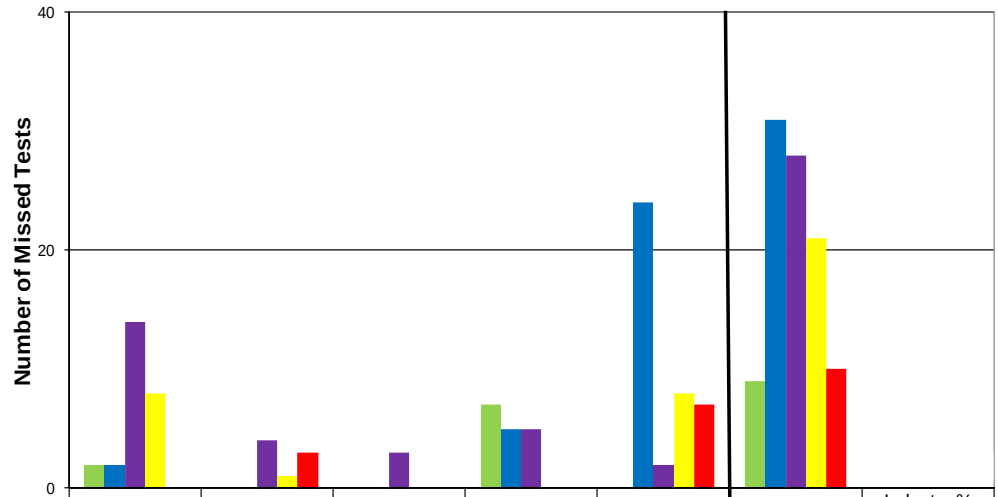
The number of safety system tests that were not completed as planned in 2015 remains very low, decreasing from 21 in 2014 to 10 in 2015. A total number of 63,117 tests were performed over the course of the year, with the overall industry percentage not completed remaining at 0.02 percent. The impact of tests not completed as planned is negligible because the safety systems involved in the tests have sufficiently high redundancy to ensure continuous safety system availability. Tests not completed as planned are tracked and rescheduled by licensees at an appropriate time. Missed tests are tracked by licensees and reported to the CNSC per REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*. Licensees have confirmed that incomplete tests identified in figure 5 were rescheduled and completed.

Table 5: Safety system test performance for 2015

Nuclear power plant	Number of annual planned tests	Safety system tests not completed				Percent not completed
		Special safety systems	Standby safety systems	Safety-related process systems	Total	
Bruce A	20,983	0	0	0	0	0.00%
Bruce B	17,873	1	1	1	3	0.02%
Darlington	12,984	0	0	0	0	0.00%
Pickering	7,303	0	0	0	0	0.00%
Point Lepreau	3,974	4	2	1	7	0.18%
Industry total	63,117	5	3	2	10	0.02%

Note: This safety performance indicator was renamed from "number of missed mandatory safety system tests" for improved clarity and application.

Figure 6: Trend details of safety system test performance for stations and industry, 2011–15



	Bruce A	Bruce B	Darlington	Pickering	Point Lepreau	Industry Total	Industry % Missed Tests
2011	2	0	0	7	n/a	9	0.01%
2012	2	0	0	5	24	31	0.03%
2013	14	4	3	5	2	28	0.04%
2014	8	1	0	0	8	21	0.03%
2015	0	3	0	0	7	10	0.02%

Aging management

All operating NPPs have implemented processes and programs to address aging-related factors that could affect the condition of structures, systems and components important to safety. REGDOC-2.6.3, Aging Management [16], was published in 2014 and sets out the CNSC's requirements for aging management programs during each stage of a plant's life, including operation and safe-storage for decommissioning. All operating NPPs are reviewing and updating their processes and programs in accordance with this regulatory

document. All operating NPPs have component-specific aging management programs, also known as lifecycle management programs (LCMPs), for the major primary heat transport components of their CANDU reactors (i.e., feeders, pressure tubes and steam generators) as well as for concrete-containment structures and balance-of-plant safety-related civil structures. Compliance monitoring activities conducted by CNSC staff included desktop reviews of licensee submissions related to integrated aging management programs and component/structure-specific LCMPs, as well as onsite inspections to assess licensees' implementation of these programs.

Periodic inspection and testing

All operating NPPs have inspection and testing programs in place to provide ongoing monitoring of the fitness for service and structural integrity of safety significant structures, systems and components. After every inspection campaign, the results of these inspections and tests are submitted to CNSC staff in accordance with relevant CSA standards and REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [2]. CNSC staff performed desktop reviews of the submissions and conducted several onsite compliance inspections to verify the licensees' implementation of the inspection and testing programs. During the reporting period, CNSC staff did not identify any program compliance issues affecting NPP safety and concluded that the programs complied with regulatory requirements.

In 2015, inspections and tests were performed for pressure boundary and containment components as well as for concrete containment structures at operating NPPs in accordance with CSA standards N285.4, *Periodic inspection of CANDU nuclear power plant components* [18], N285.5, *Periodic inspection of CANDU nuclear power plant containment components* [19], and N287.7, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants* [20]. CNSC staff reviewed the results of these inspections and tests and confirmed that the programs were implemented in accordance with regulatory requirements outlined in the stations' LCHs and NPP program documents.

2.1.7 Radiation protection

This SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. This program must ensure surface contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (ALARA). The industry average rating for the radiation protection SCA was "satisfactory" unchanged from the previous year.

Based on the information assessed, CNSC staff concluded that the radiation protection programs at NPPs met all applicable regulatory requirements and that doses to workers and members of the public were below regulatory limits.

Radiation protection ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
SA	SA	FS	FS	SA	SA	SA

Radiation protection encompasses the following specific areas:

- application of ALARA

- worker dose control
- radiation protection program performance
- radiological hazard control
- estimated dose to the public

The data presented is based on the radiation exposure records for every individual monitored at a Canadian NPP. This report presents and analyzes these dose records in terms of annual collective dose[1], average measurable effective dose[2], maximum individual effective dose and the distribution of doses among the monitored individuals.

Figures 7, 8,and 9 present the measurable doses (average and maximum) and dose distributions, respectively, based on the dose records provided to the CNSC by each NPP.

Application of ALARA

As required by the *Radiation Protection Regulations*, all NPP licensees continued to implement radiation protection measures to keep the doses to persons ALARA, taking into account social and economic factors.

In 2015, the total collective dose for monitored individuals at all Canadian NPPs was 15.8 person-sieverts (p-Sv), approximately eight percent lower than the industry-wide collective dose reported for the previous year (17.2 p-Sv). The number of persons that received a measurable dose in 2015 (7,500) remained comparable to 2014 values (7,411).

The annual average effective dose in 2015 for all Canadian NPPs was 2.11 millisieverts (mSv), an approximate decrease of nine percent from the 2014 value of 2.32 mSv.

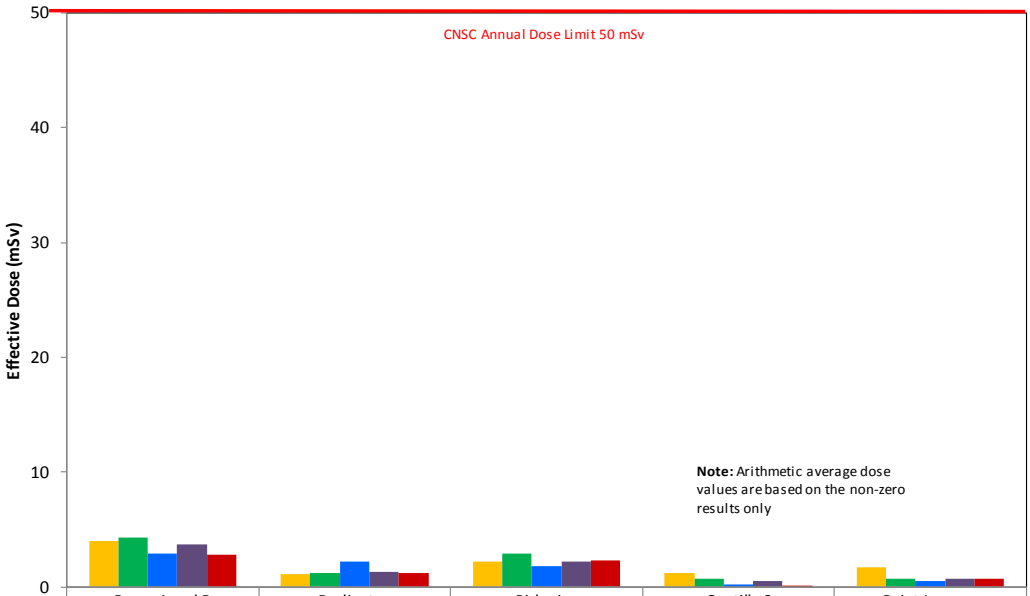
Figure 7 shows the average measurable effective doses to workers at each Canadian NPP for the period 2011 to 2015. This figure shows that for 2015 the average measurable effective dose at each station ranged from 0.12 to 2.78 mSv per year.

In general, the average dose fluctuations from year to year are reflective of the type and scope of work being performed at each facility, and no negative trends were identified in 2015. A minimal industry-wide decrease in worker occupational exposures (e.g., lower industry-wide collective and average dose for workers) was observed in 2015, with the exception of Pickering. The annual collective effective dose for workers at each NPP is presented in appendix E

[1] The “annual collective dose” is the sum of the effective doses received by all the workers at that NPP in a year. It is measured in person-sieverts (p-Sv).

[2] The “average measurable effective dose” or “average effective dose – non-zero results only” is obtained by dividing the total collective dose by the total number of individuals receiving a measurable dose. The minimum reporting level to be considered measurable is 0.01 mSv.

Figure 7: Average effective doses to workers at each Canadian nuclear power plants, 2011–15



	Bruce A and B	Darlington	Pickering	Gentilly-2	Point Lepreau
2011	4.06	1.16	2.26	1.20	1.72
2012	4.30	1.24	2.92	0.71	0.70
2013	2.95	2.25	1.79	0.25	0.54
2014	3.68	1.35	2.21	0.52	0.7
2015	2.78	1.18	2.31	0.12	0.7

Worker dose control

As required by the *Radiation Protection Regulations*, all Canadian NPP licensees implemented radiation protection programs to control the occupational doses received by nuclear energy workers and non-workers (e.g., visitors, members of the public).

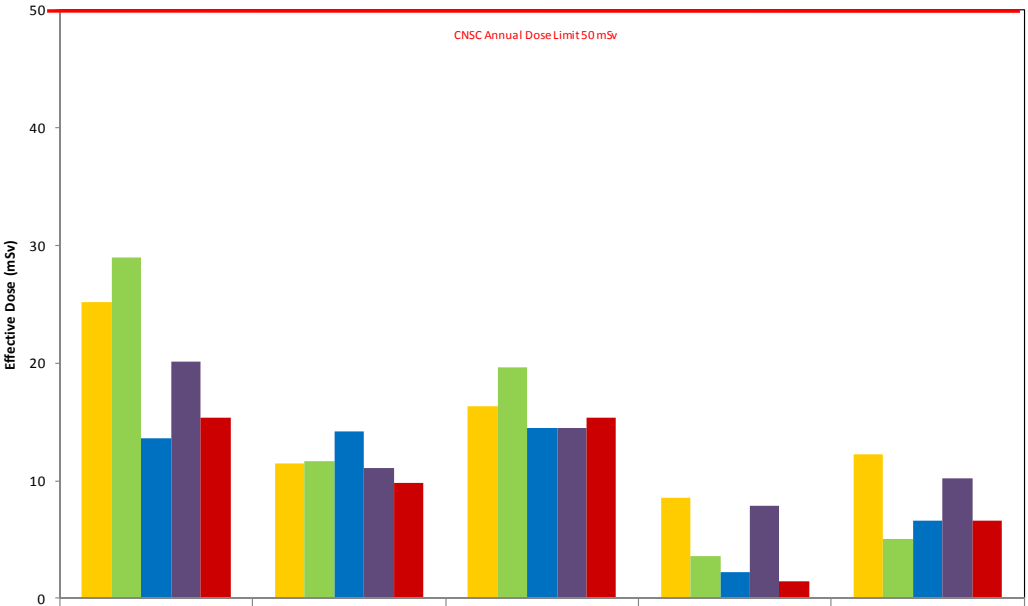
In addition to maintaining doses below regulatory limits[3], all Canadian NPPs have established action levels[4] for worker exposures. During 2015, no worker at any NPP received a radiation dose that exceeded the regulatory action levels or dose limits.

The maximum annual individual effective doses as reported for each NPP for the period 2011 to 2015 are presented in figure 8. In 2015, the maximum individual effective dose received at a single station was 15.4 mSv, received by a worker at the Bruce site.

3 The effective dose limits for nuclear energy workers (NEWs), are 50 millisieverts (mSv) per one-year dosimetry period and 100 mSv over a five-year fixed dosimetry period. The current fixed 5-year dosimetry period is from 2011 through 2015.

4 An action level is defined in the Radiation Protection Regulations as a specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program and triggers a requirement for specific action to be taken.

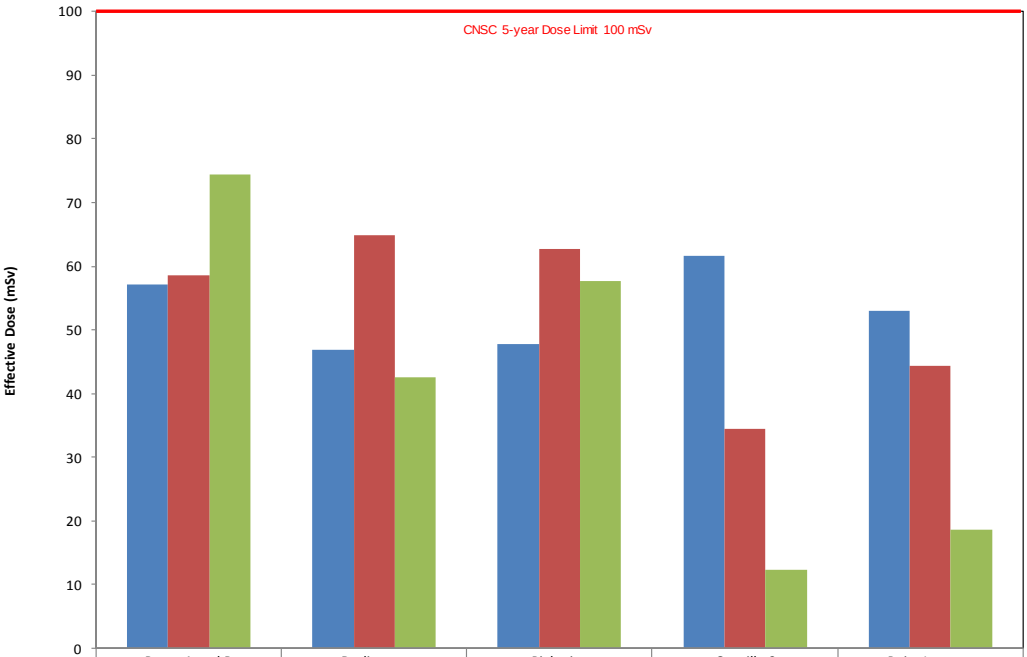
Figure 8: Maximum effective doses to workers at each Canadian nuclear power plants, 2011–15



	Bruce A and B	Darlington	Pickering	Gentilly-2	Point Lepreau
2011	25.16	11.47	16.34	8.51	12.22
2012	29.00	11.70	19.60	3.60	5.10
2013	13.63	14.15	14.50	2.26	6.59
2014	20.17	11.13	14.5	7.85	10.2
2015	15.40	9.78	15.38	1.46	6.6

The maximum individual five-year dose as reported for each NPP for the dosimetry period of 2011 to 2015, along with the previous two five-year periods, is presented in figure 9. This figure shows that since the enforcement of the *Radiation Protection Regulations* in 2001, no worker exceeded the regulatory limit of 100 mSv per five-year dosimetry period at any NPP. This data was obtained from the National Dose Registry.

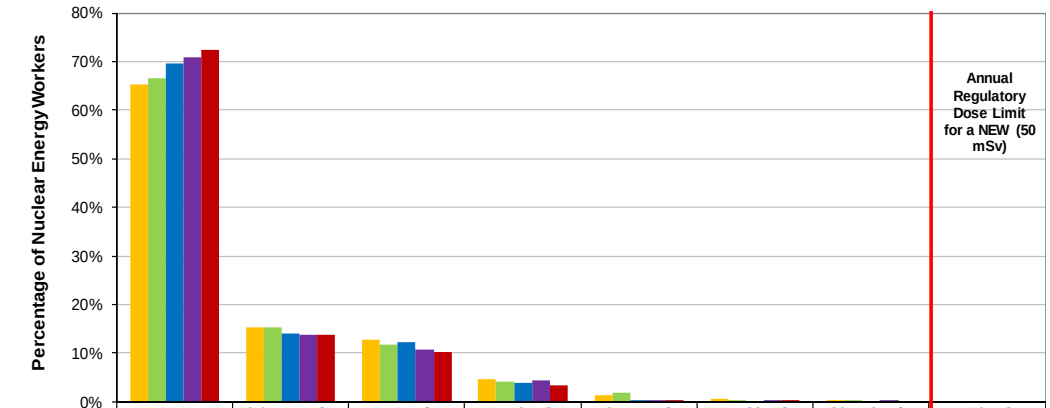
Figure 9: Maximum five-year effective doses to workers at each Canadian nuclear power plants, 2011–15



	Bruce A and B	Darlington	Pickering	Gentilly-2	Point Lepreau
2001-2005	57.14	46.81	47.76	61.71	53.03
2006-2010	58.50	64.95	62.77	34.42	44.32
2011-2015	74.44	42.60	57.75	12.31	18.70

Figure 10 provides the distribution of annual effective doses to workers at all Canadian NPPs from 2011 to 2015 according to dose information provided by each licensee. There were no radiation exposures reported at any Canadian NPP in 2015 that exceeded the annual regulatory dose limit. In addition, approximately 86 percent of workers' doses reported were at or below the annual regulatory dose limit of 1 mSv for non-workers.

Figure 10: Distribution of annual effective doses to workers at Canadian nuclear power plants, 2011–15



Year: Number of Workers Monitored	BRL	0.01 - 1 mSv	1 - 5 mSv	5 - 10 mSv	10 - 15 mSv	15 - 20 mSv	20 - 50 mSv	> 50 mSv
2011: 28,974	65%	15%	13%	5%	1%	0.4%	0.07%	0%
2012: 27,532	67%	15%	12%	4%	2%	0.3%	0.1%	0%
2013: 24,440	70%	14%	12%	4%	0.4%	0%	0%	0%
2014: 25,378	71%	14%	11%	4%	0.4%	0.09%	0.01%	0%
2015: 27,229	72%	14%	10%	3%	0.3%	0.01%	0%	0%

Dose Range (mSv)

Note: The sum of the percentages may not add up to 100%, due to rounding.

Radiation protection program performance

CNSC staff performed regulatory oversight activities at all NPPs during 2015 to verify the effective implementation of licensees' radiation protection programs. This regulatory oversight consisted of desktop reviews of program and performance documentation, complemented by focused inspections of radiation protection-related topics at all NPPs. Routine surveillance of licensees' performance in the area of radiation protection was also conducted by onsite inspectors at each NPP.

Through information gathered from these oversight activities, CNSC staff confirmed that all Canadian NPP licensees have implemented their radiation protection programs to control occupational exposures to workers.

Radiological hazard control

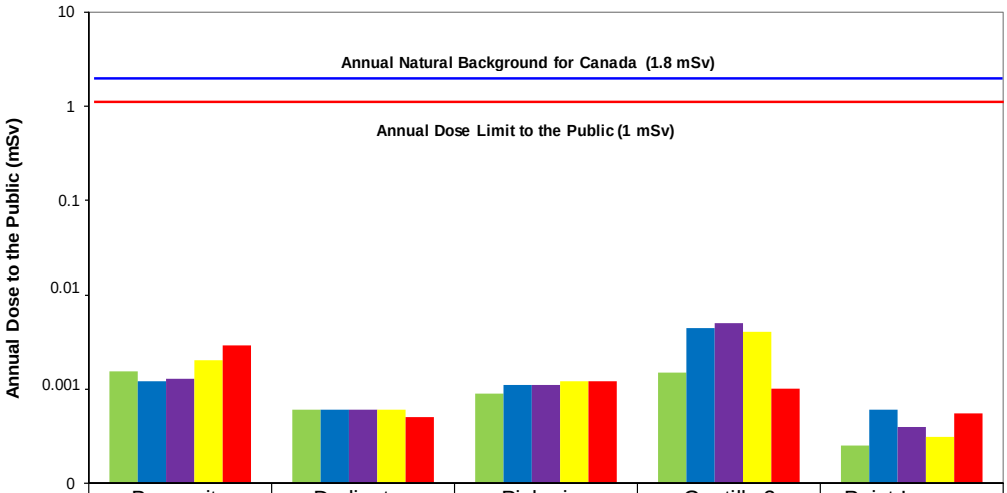
All NPP licensees have implemented measures in their radiation protection programs to monitor and control radiological hazards in their facilities. These measures include, but are not limited to, the use of radiological zoning systems, ventilation systems to control the direction of air flow, and ambient air monitoring and radiation monitoring equipment at zone boundaries. All NPP licensees continue to implement their workplace monitoring programs to protect workers and ensure radioactive contamination is controlled within the site boundary.

Estimated dose to the public

The estimated dose to the public for both airborne emissions and liquid releases from 2011 to 2015 are provided in figure 11. This figure shows that the doses to the public are below the annual regulatory public dose limit of 1 mSv.

The comparison shows that the 2015 doses to the public for Canadian NPPs are within the general range of the 2011 to 2014 values for most stations.

Figure 11: Comparison of estimated dose to the public from Canadian nuclear power plants, 2011–15*



	Bruce site	Darlington	Pickering	Gentilly-2	Point Lepreau
2011	0.0015	0.0006	0.0009	0.0015	0.0003
2012	0.0012	0.0006	0.0011	0.0044	0.0006
2013	0.0013	0.0006	0.0011	0.0050	0.0004
2014	0.0020	0.0006	0.0012	0.0040	0.0003
2015	0.0029	0.0005	0.0012	0.0010	0.0006

Annual Dose (mSv)

* Note that a logarithmic scale is used for the purpose of direct comparison.

2.1.8 Conventional health and safety

This SCA covers the implementation of a program to manage workplace safety hazards and protect personnel and equipment. The industry average rating for conventional health and safety was “fully satisfactory”, unchanged from the previous year.

Based on the information assessed, CNSC staff concluded that the conventional health and safety SCA at NPPs met or exceeded all applicable regulatory requirements.

Conventional health and safety ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
FS	FS	FS	FS	SA	FS	FS

Conventional health and safety encompasses the following specific areas:

- performance
- practices
- awareness

Performance

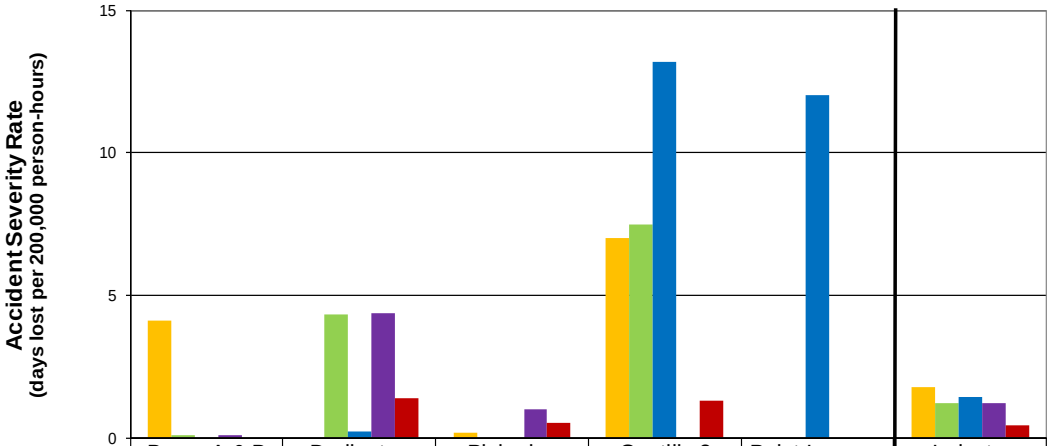
The accident severity rate (ASR), accident frequency (AF) and industrial safety accident rate (ISAR) are parameters reported by NPP licensees that measure the effectiveness of their conventional health and safety program with respect to worker safety. The ASR measures the total number of days lost due to injury for every 200,000 person-hours (approximately 100 person-years) worked at an NPP. The AF is a measure of the number of fatalities and injuries (lost-time and medically treated) due to accidents for every 200,000 person-hours worked at an NPP. The ISAR is a measure of the number of lost-time injuries for every 200,000 hours worked by NPP personnel.

The ASR, AF and ISAR values for the stations and industry average are presented in figures 12, 13 and 14 respectively. These figures show that:

- The ASR value for industry as a whole improved from 1.2 in 2014 to 0.5 in 2015. The lowest ASRs were achieved at Point Lepreau and Bruce A and B, both of which had an ASR of 0 in 2015. The ASR increased for Gentilly-2 while it decreased for both Darlington and Pickering.

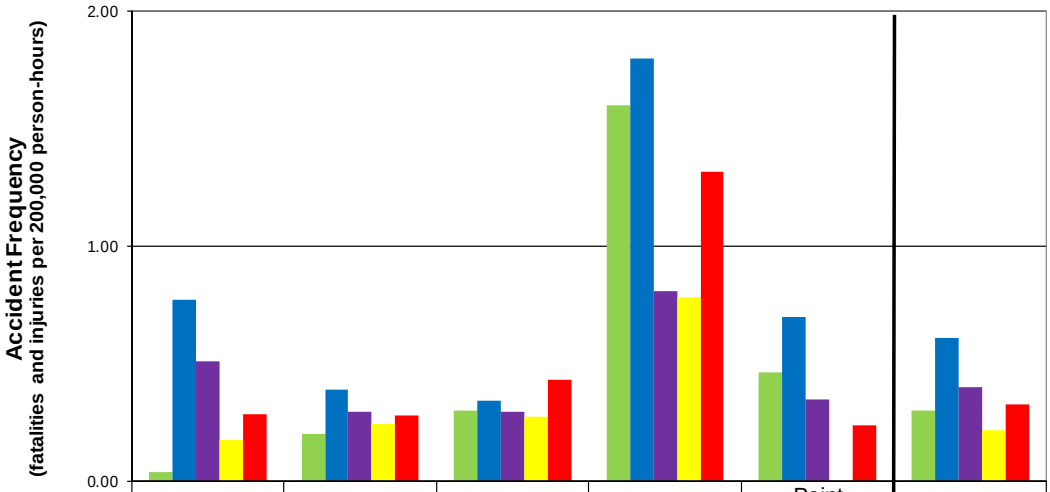
- The AF value for the industry as a whole increased from 0.22 in 2014 to 0.30 in 2015. While the AF increased at all stations, Bruce A and B, Darlington and Point Lepreau remained below the industry average.

Figure 12: Trend details of accident severity rate for stations and industry, 2011–15



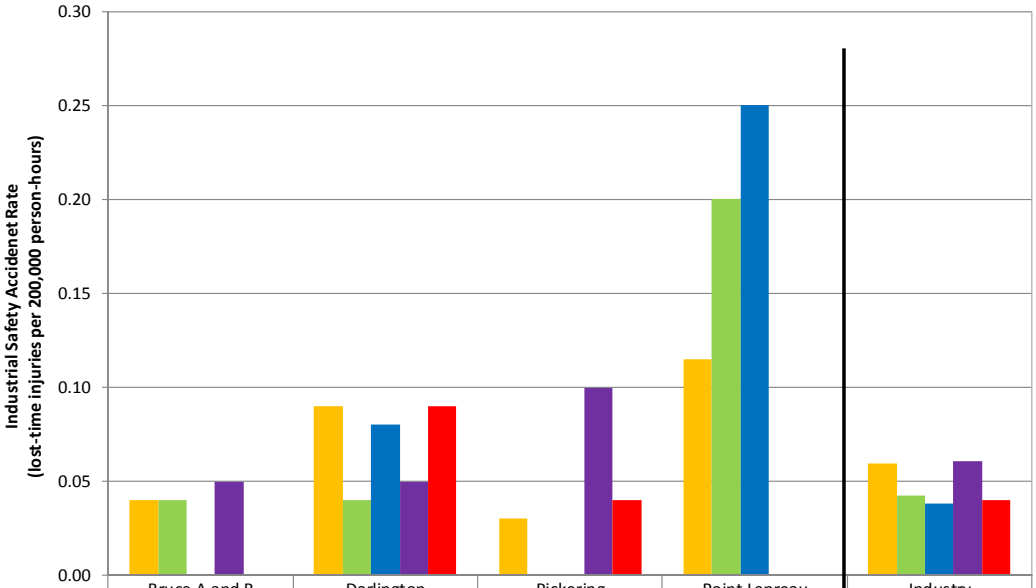
	Bruce A & B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry
2011	4.1	0.0	0.2	7.0	0.0	1.8
2012	0.1	4.4	0.0	7.5	0.0	1.2
2013	0.0	0.2	0.0	13.2	12.0	1.4
2014	0.1	4.4	1.0	0.0	0.0	1.2
2015	0.0	1.4	0.5	1.3	0.0	0.5

Figure 13: Trend details of accident frequency for stations and industry, 2011–15



	Bruce A & B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry
2011	0.04	0.20	0.30	1.60	0.46	0.30
2012	0.77	0.39	0.34	1.80	0.70	0.61
2013	0.51	0.30	0.29	0.81	0.35	0.40
2014	0.17	0.24	0.27	0.78	0.00	0.22
2015	0.28	0.28	0.43	1.32	0.24	0.33

Figure 14: Trend details of industrial safety accident rate for stations and industry, 2011–15



	Bruce A and B	Darlington	Pickering	Point Lepreau	Industry
2011	0.04	0.09	0.03	0.12	0.06
2012	0.04	0.04	0.00	0.20	0.04
2013	0.00	0.08	0.00	0.25	0.04
2014	0.05	0.05	0.10	0.00	0.06
2015	0.00	0.09	0.04	0.00	0.04

Figure 15 shows the ISAR for the Canadian nuclear power industry in comparison to international nuclear power industry values as published by WANO. The Canadian nuclear power industry values are lower than the WANO values, indicating that the Canadian nuclear power industry continues to provide one of the safest industrial work environments in the world.

Figure 15: Trend of international safety accident rate compared to WANO values, 2011–15

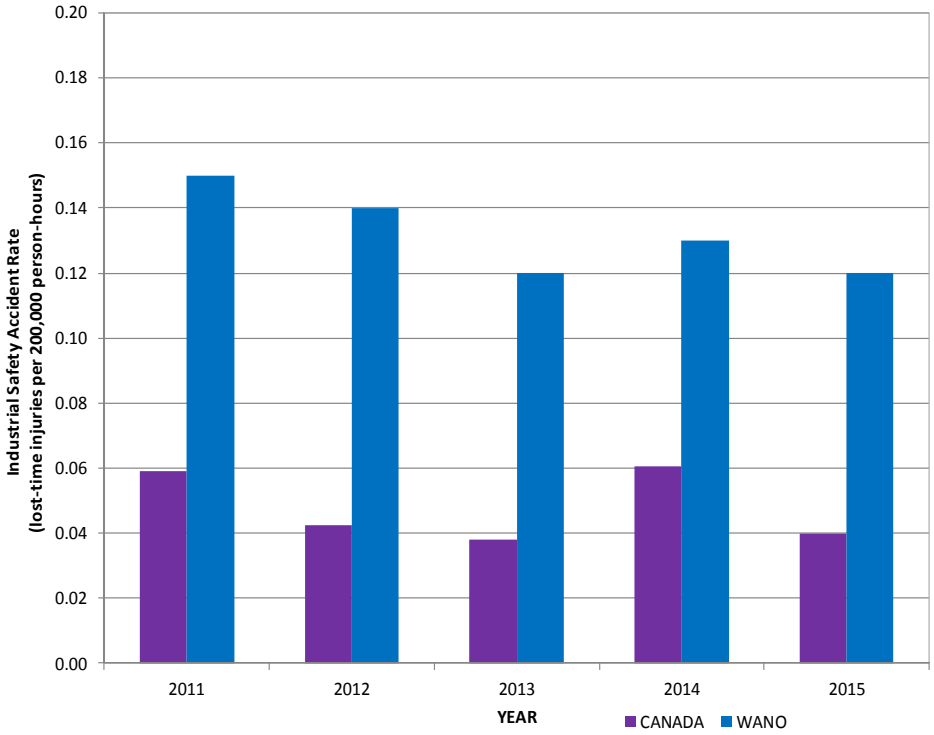
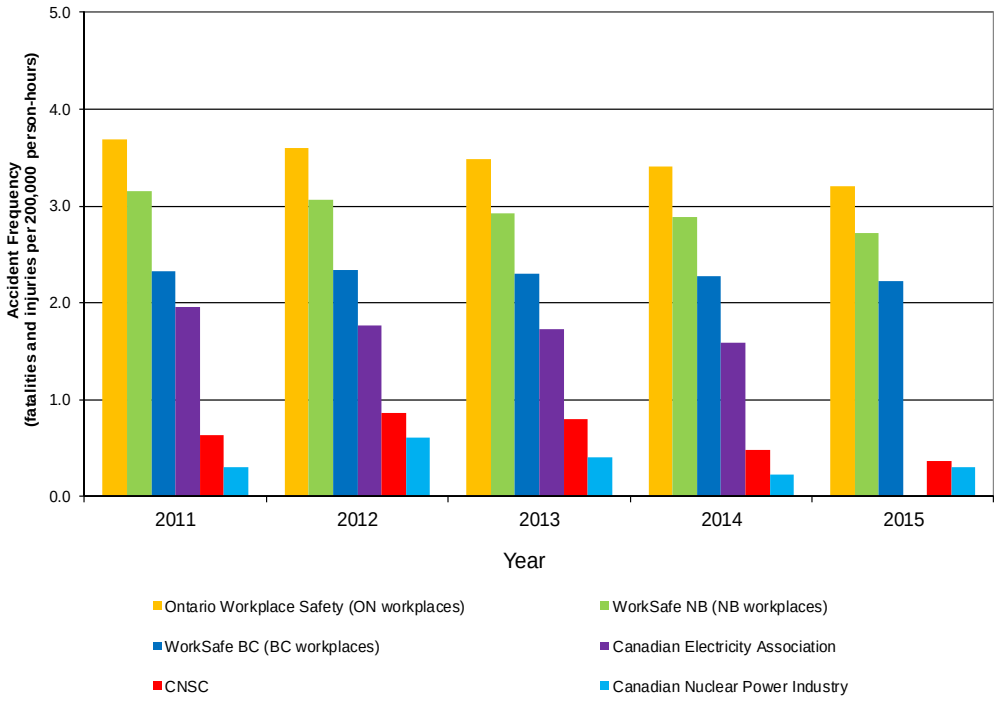


Figure 16 shows the AF values for a wide range of Canadian workplaces, where the AF values are based on fatalities, lost-time injuries and medically treated injuries. There were no work-related fatalities at Canadian NPPs in 2015 and, as shown in figure 16, the Canadian nuclear power industry's AF is lower than that of other Canadian workplaces.

CNSC staff concluded that, for the overall nuclear power industry, the ASR, AF and ISAR remained very low during the year. This is an indication of the strength of the health and safety programs implemented by Canada's nuclear power licensees.

Figure 16: Trend details of accident frequency (based on fatalities, LTIs and MTIs) for Canadian workplaces, 2011– 15



Practices

Each licensee has a conventional health and safety program that was implemented in compliance with the *Canada Labour Code* and/or referenced provincial legislation. CNSC staff determined that all NPP licensees met or exceeded all relevant regulatory requirements in this area.

Awareness

In 2015, NPP licensees met CNSC performance objectives and requirements for this specific area in accordance with their operating licences and LCHs. There were no safety-significant issues from compliance verification activities to report. However, CNSC staff identified minor housekeeping deficiencies and improper storage issues. Licensees are focusing on making improvements in this area, and CNSC staff will follow up and continue to monitor licensee's actions with respect to this area.

2.1.9 Environmental protection

This SCA covers programs that identify, control and monitor all releases of radioactive and hazardous substances and the effects on the environment from facilities or as a result of licensed activities. The industry average rating for environmental protection was "satisfactory", unchanged from the previous year.

Based on the information assessed, CNSC staff concluded that the environmental protection SCA at NPPs met all applicable regulatory requirements.

Environmental protection ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
SA	SA	SA	SA	SA	SA	SA

Environmental protection encompasses the following specific areas:

- effluent and emissions control (releases)
- environmental management system
- assessment and monitoring
- protection of the public
- environmental risk assessment

Environmental risk assessment

As verified by ongoing monitoring, the environmental risk assessments performed at all stations have demonstrated adequate provision for the protection of the environment and public. Work has been completed or is underway at all operating NPPs to document an environmental risk assessment consistent with CSA standard N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [21]. Environmental risk assessments are submitted and reviewed by the CNSC on a five-year cycle.

All licensees have developed and implemented programs to verify that fish are being protected at all stations from the effects of thermal discharge of water as well as intake water withdrawal, and to ensure unreasonable risk to fish populations and the environment do not exist. This work is conducted at the request of CNSC staff with advice from agencies such as Fisheries and Oceans Canada and Environment and Climate Change Canada through a memorandum of understanding (MoU).

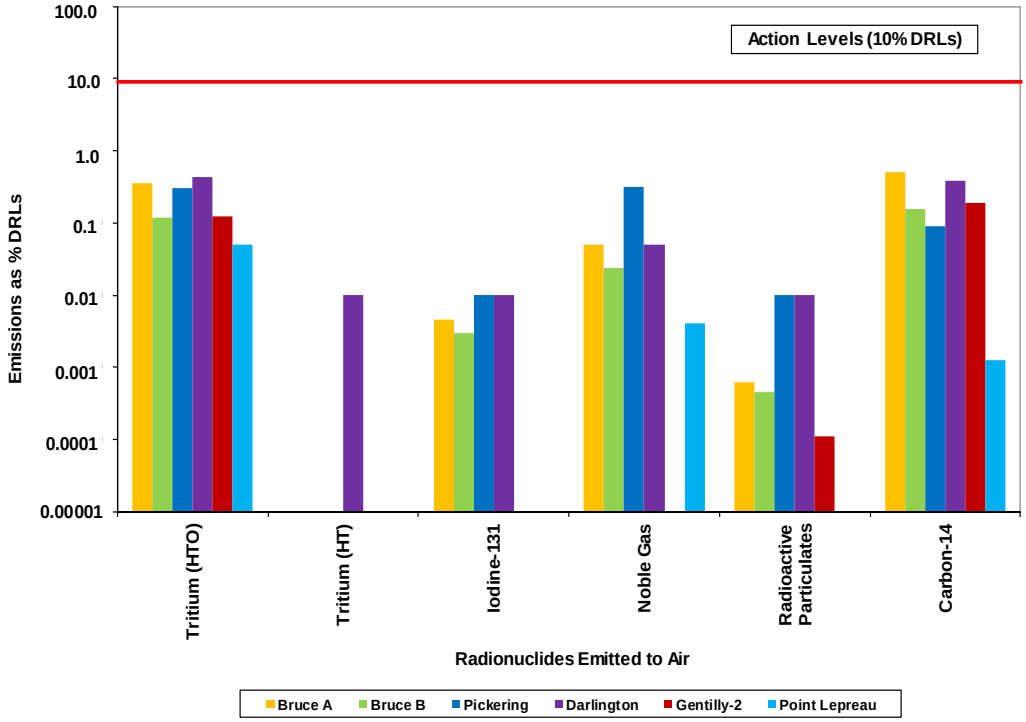
Effluent and emissions control (releases)

Airborne emissions and liquid releases for 2015 are shown in figures 17 and 18. Derived release limits (DRLs) have been developed by licensees to ensure release limits to the environment will not exceed the annual regulatory public dose limit of 1 mSv. The DRLs are stated in each operating licence/LCH and are given in appendix F.

Licensees establish action levels that are set at approximately 10 percent of the DRLs. Action levels, if reached, could indicate a loss of control of part of a licensee's environmental program and the need for specific actions to be taken and reported to the CNSC.

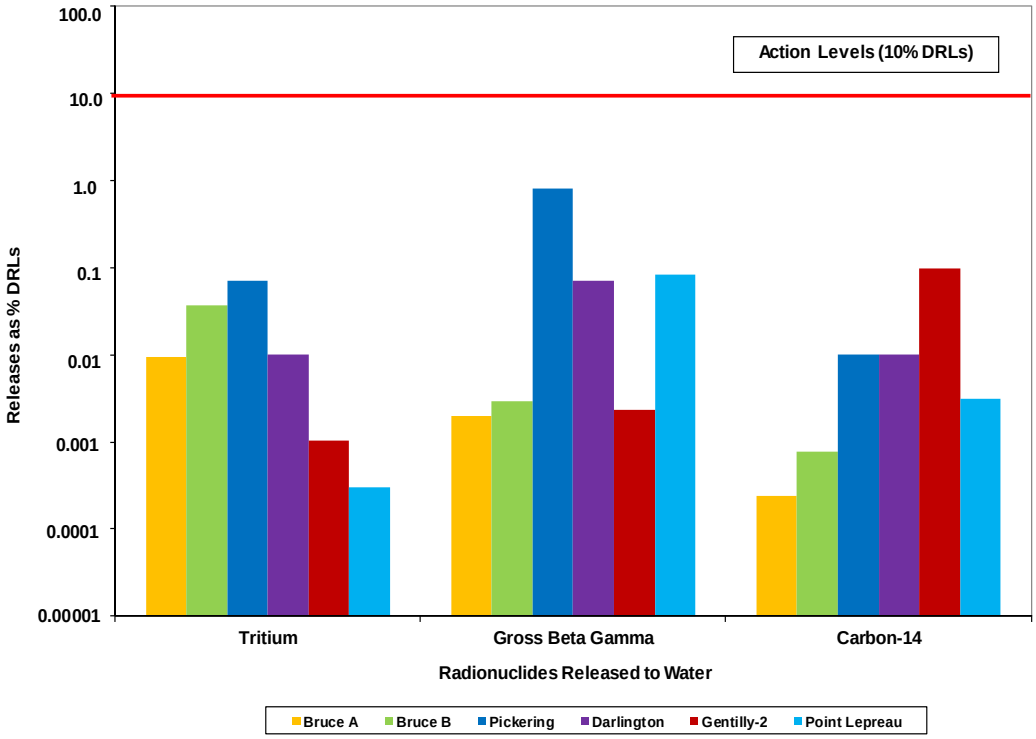
All releases were below action levels and almost negligible compared to the DRLs in 2015.

Figure 17: Radionuclides emitted to air by Canadian nuclear power plants in 2015*



* Note that a logarithmic scale is used for the purpose of direct comparison of the radionuclides.

Figure 18: Radionuclides emitted to water by Canadian nuclear power plants in 2015*



* Note that a logarithmic scale is used for the purpose of direct comparison of the radionuclides.

Environmental research

Although the CNSC is not conducting environmental research, CNSC staff continuously review and verify new information or science on the lowering of emissions and the monitoring of groundwater or waste management. The facts and science provide adequate information for regulatory decisions.

Environmental management system

Canadian NPPs have established and implemented an environmental management program in compliance with CNSC regulatory requirements to assess environmental risks associated with its nuclear activities, and to ensure these activities are conducted in a way that adverse environmental effects are prevented or mitigated.

Assessment and monitoring

Environmental monitoring programs implemented at all stations have demonstrated adequate provision for the protection of the environment. Assessments have been completed or are underway at all operating NPPs to document environmental monitoring programs consistent with CSA standard N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [22].

Groundwater monitoring

Groundwater is monitored regularly around all stations. The results are submitted to the CNSC for review annually. Monitoring results in 2015 indicated no adverse impact on the groundwater environment due to operation of the stations.

Protection of the public

There were no hazardous substances released from NPPs that posed an unacceptable risk to the environment or the public.

2.1.10 Emergency management and fire protection

This SCA covers emergency plans and emergency preparedness programs for dealing with radiological, nuclear and conventional emergencies. It also includes the results of participation in emergency preparedness exercises during the year. For the specific area of fire emergency preparedness and response, only the performance of the fire response organization is addressed in this SCA. Design issues are described under section 2.1.5. Based on the data collected and the observations made during CNSC inspections, the industry average for emergency management and fire protection was rated as "satisfactory", unchanged from the previous year.

Based on the information assessed, CNSC staff concluded that NPP licensees continued to maintain comprehensive and well-documented emergency management programs that met all applicable regulatory requirements.

Emergency management and fire protection ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
SA	SA	SA	SA	SA	SA	SA

Emergency management and fire protection encompasses the following specific areas:

- conventional emergency preparedness and response
- nuclear emergency preparedness and response
- fire emergency preparedness and response

Conventional emergency preparedness and response

All licensees continued to maintain and improve their conventional emergency preparedness and response capabilities at their respective facilities. CNSC staff verified the response programs against the regulatory requirements set out in the operating licences and LCHs. Maintenance of proficiency within this area was achieved through training programs, drills and exercise programs.

Nuclear emergency preparedness and response

All licensees continued to maintain and improve their nuclear emergency preparedness and response capabilities. CNSC staff verified the response programs against the regulatory requirements set out in the operating licences and LCHs. Maintenance of proficiency within this area was achieved through training programs, drills and exercise programs.

Offsite emergency preparedness and response

This area of safety focuses on protecting residences located near the NPPs. Significant changes were introduced in this specific area due to the new regulatory requirement to pre-distribute iodine thyroid blockers, also known as potassium iodide (KI) tablets, in the primary zone and to stockpile KI tablets in the secondary zone. All licensees implemented this regulatory requirement in 2015.

Public information was also disseminated to provide residents with information on the KI tablets, designated evacuation routes and reception centers, and when and how to shelter in place.

Public alerting continues to be a significant item of interest. In addition to existing sirens, licensees are considering additional methods of communication such FM radio, text messages, cell broadcast and phone dial-out systems.

The Ministry of Transportation of Ontario has updated its evacuation plans for the areas around the Pickering and Darlington stations. In preparation for the 2015 Pan American Games held in Toronto, the Ministry conducted extensive traffic and evacuation modelling – some of which was able to be applied to the primary zones around Pickering and Darlington. This modelling extends out to 20 kilometres (well beyond the 10-kilometre primary zone) and is applicable to at least 2021.

As reported during the Darlington relicensing hearing in November 2015, the Ontario Office of the Fire Marshall and Emergency Management is in the process of updating the Provincial Nuclear Emergency Response Plan (PNERP). The revised PNERP will be released for public comment in 2016. CNSC staff reviewed and provided comments on the draft document. The public consultation had not yet started as of the writing of this report.

Ontario will be updating the provincial planning basis for NPPs. The draft planning basis document was reviewed by the Nuclear Emergency Management Coordinating Committee in December 2015, and updates to the emergency planning zones and offsite emergency plans may result from this updated information.

Québec revised its nuclear and radiological risk assessment report to update potential nuclear and radiological risks the province may face, as well as to reflect the Gentilly-2 shutdown and decommissioning phase. CNSC staff contributed to the review of this report; these reviews are carried out on a five-year cycle. In May 2016, the Organisation régionale de la sécurité civile de la Mauricie et du Centre-du-Québec announced its decision to discontinue the external nuclear emergency response plan and associated protection measures at Gentilly-2, including KI tablet distribution. CNSC staff have no concerns regarding this decision given that the Gentilly-2 reactor has been fully defuelled and the facility has reached safe storage state.

CSA standard N1600-2014 R1, *General requirements for nuclear emergency management programs* [23], has undergone a revision and was published on March 17, 2016.

During Commission proceedings, the Commission requested updates and information regarding emergency management. Specifically, the Commission requested:

- that it be provided with the Municipality of Durham emergency planning documents and information about the municipality's lessons learned from Exercise Unified Response (ExUR). The OFMEM committed to providing the Commission with Durham's After Action Report (AAR) and any related updates (Action # M2015-15)
- further updates on the ExUR action plans (Action # M2015-16); and
- an update on ExUR action items from stakeholders; it also indicated that it looked forward to an update on Exercise Intrepid (Action # M2015-17)

The above items are addressed in Supplemental CMD 16-M30.A., while an update on Exercise Intrepid can be found at section 3.5.1.10 of this report.

Fire emergency preparedness and response

All licensees continued to maintain and improve their fire protection and response programs. CNSC staff have closely monitored the effectiveness of any corrective actions as part of their regulatory oversight activities.

2.1.11 Waste management

This SCA covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility. This SCA also covers any planning for eventual decommissioning of the facility. The industry average rating for the waste management SCA was "fully satisfactory", unchanged from the previous year.

Based on the information assessed, CNSC staff concluded that the waste management SCA at NPPs met or exceeded all applicable regulatory requirements.

Waste management ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
FS	FS	FS	FS	SA	SA	FS

Waste management encompasses the following specific areas:

- waste characterization (no significant observations to report)
- waste minimization
- waste management practices
- decommissioning plans

Waste minimization; waste management practices

All licensees have effective programs for managing radioactive and hazardous wastes. According to assessment of the hazard levels, all radioactive waste was disposed of appropriately in compliance with regulatory requirements and licensees' procedures. As was the case in 2014, Bruce A and B and Darlington continue to employ highly effective programs for the minimization, segregation, handling, monitoring and processing of radioactive and hazardous wastes.

Decommissioning plans

Licensees are required to maintain an acceptable plan that sets out how the facility will be decommissioned in the future. This plan must be reviewed and updated by licensees on a regular five-year schedule. The plan also forms the basis for developing a cost estimate for decommissioning. The associated financial guarantee gives the assurance that funds will be available when the facility is ready to be dismantled.

NPP licensees in Canada have a financial guarantee that has been accepted by the Commission. In all cases, the decommissioning strategy proposed by the licensees is to allow for an extended period of storage with surveillance – three or four decades, to allow for radioactive decay – after the end of normal operations and before the onset of active dismantling.

In March 2015, Hydro-Québec submitted a revised decommissioning plan and financial guarantee to address changes resulting from the 2012 shutdown of the Gentilly-2 facility. CNSC staff provided comments on the revised documents to Hydro-Québec in January

2016. The full review and assessment of the revised decommissioning plan and financial guarantee will be completed by CNSC staff in 2016.

2.1.12 Security

This SCA covers the programs licensees are required to implement in support of the security requirements stipulated in the *Nuclear Security Regulations* and associated regulatory documents, in their licences, in orders, or in expectations for their facilities or activities. All licensees continue to maintain and implement adequate security programs in accordance with CNSC requirements. The security rating determined by CNSC staff for industry in 2015 returned to "satisfactory" from "fully satisfactory" rating in 2014".

Based on the information assessed, CNSC staff concluded that the security SCA at NPPs met all applicable regulatory requirements.

Security ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
FS	FS	SA	SA	SA	SA	SA

Security encompasses the following specific areas:

- facilities and equipment
- response arrangements
- security practices
- drills and exercises

Licensees have implemented Security Programs that met regulatory requirements of the *Nuclear Security Regulations* and associated regulatory documents. All licensees continue to maintain and implement adequate security programs in accordance with CNSC requirements. Overall, the industry has attained a "satisfactory" rating within this SCA.

Facilities and equipment

This specific area was adversely affected by deficiencies in the maintenance program at certain facilities where the licensee was either unable to demonstrate an effective preventive maintenance program or did not conduct repairs in a timely manner. Most licensees are sustaining their programs through lifecycle management and modernization of security equipment. CNSC staff concluded that there were no safety significant issues for this specific area.

Security practices

Security practices were affected by reportable events related to procedural non-compliances at certain facilities. Corrective action plans in response to compliance verification activities are being implemented to the satisfaction of CNSC staff. CNSC staff concluded that there were no safety significant issues for this specific area.

Response arrangements

The industry continues to meet its regulatory requirements but is facing challenges with respect to the training of Nuclear Response Force members. Failures to address deficiencies in training techniques could adversely affect security and safety practices. Improvements in management oversight and procedural rigour would significantly

improve this negative trend. Corrective action plans in response to compliance verification activities are being implemented and will be monitored by CNSC staff. CNSC staff concluded that there were no safety significant issues for this specific area.

Drills and exercises

Licensees continue to perform these activities at an acceptable level. Bruce Power exceeded requirements in this area, and Gentilly-2 is trending downwards. CNSC staff concluded that there were no safety significant issues for this specific area.

Cyber security

The cyber security program ensures all essential assets used for safety, security, emergency preparedness and safeguard functions are protected from cyber attacks. CNSC staff concluded that there were no safety significant issues for this area.

Licensees continued to maintain and improve their cyber security programs by performing gap analysis to comply with the new CSA standard N290.7-14 and by working collaboratively through the COG cyber security peer group program to share lessons learned and develop best industry practices. CNSC staff were satisfied with the industry's overall progress in this area.

2.1.13 Safeguards and non-proliferation

This SCA covers the programs and activities required for the successful implementation of Canada's obligations arising from the Canada/International Atomic Energy Agency (IAEA) safeguards agreements as well as other measures arising from the *Treaty on the Non-Proliferation of Nuclear Weapons* [24]. The industry average rating for safeguards and non-proliferation was "satisfactory", unchanged from the previous year.

Based on the information assessed, CNSC staff concluded that the safeguards and non-proliferation SCA at NPPs met all applicable regulatory requirements.

Safeguards and non-proliferation ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
SA	SA	SA	SA	SA	SA	SA

Safeguards and non-proliferation encompasses the following specific areas:

- nuclear material accountancy and control
- access and assistance to the IAEA (no significant observations to report)
- operational and design information (no significant observations to report)
- safeguards equipment, containment and surveillance

The scope of the non-proliferation program for Canada's NPPs is limited to the tracking and reporting of foreign obligations and origins of nuclear material, as specified in RD-336, *Accounting and Reporting of Nuclear Material* [25]. This tracking and reporting assists the CNSC in the implementation of Canada's bilateral nuclear cooperation agreements with other countries.

Nuclear material accountancy and control

All NPPs complied with CNSC's regulatory requirements in accordance with RD-336.

The CNSC launched a new e-business system in November 2013 that allows licensees to upload their nuclear materials accountancy reports through the CNSC's secure website. The NPPs are evaluating the updates required to their internal nuclear material accountancy systems to take advantage of this development.

Safeguards equipment, containment and surveillance

There were no major IAEA equipment installations in 2015. However, licensees were cooperative in supporting the maintenance and repair of IAEA equipment, including the VXI Integrated Fuel Monitor (VIFM) and digital multi-camera optical surveillance air conditioner at Bruce Power and Pickering, as well as repair work to IAEA remote monitoring components at Point Lepreau and Darlington.

2.1.14 Packaging and transport

This SCA pertains to programs that cover the safe packaging and transport of nuclear substances to and from the licensed facility. The industry average rating for this SCA was "satisfactory", unchanged from the previous year.

Based on the information assessed, CNSC staff concluded that the packaging and transport SCA at NPPs met all applicable regulatory requirements.

Packaging and transport ratings

Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
SA	SA	SA	SA	SA	SA	SA

Packaging and transport encompasses the following specific areas:

- package design and maintenance
- packaging and transport
- registration for use

Package design and maintenance

Nuclear substances originating from NPPs are transported using packages that meet CNSC regulatory requirements and, in some cases, the package designs have been certified by the CNSC. Common shipments include substances contaminated with radioactive materials (in both liquid and solid form), samples containing nuclear substances and tritiated heavy water.

Packaging and transport

All NPP licensees are required to have appropriate training for personnel involved in the handling, offering for transport and transport of dangerous goods. Licensees are also required to issue a training certificate to those workers in accordance with the *Transportation of Dangerous Goods Regulations*.

Many NPP licensees maintain a fleet of vehicles used for the transport of certified packages as well as a list of third-party carriers that may be used for shipments of nuclear substances.

Registration for use

All NPP licensees comply with the requirements of both the *Packaging and Transport of Nuclear Substances Regulations, 2015* and the *Transportation of Dangerous Goods Regulations* for all shipments of nuclear substances leaving their sites. They prepare and

maintain documentation demonstrating that the packages used to transport nuclear substances meet the requirements specified in the regulations.

2.2 Regulatory developments

2.2.1 Licensing

Between January 2015 and April 2016, the Commission approved the power reactor operating licences (PROLs) for Bruce A and B and for Darlington.

The Bruce A and B PROL extensions were scheduled to expire on May 31, 2015. The two-part public hearing for the Bruce A and B licence renewal was held in February and April 2015. The Bruce A and Bruce B licences were consolidated into a single licence, similar to what was done for the Pickering site. On May 27, 2015, the Commission renewed the operating licences issued to Bruce Power as a single licence for both Bruce A and B, valid from June 1, 2015 to May 31, 2020.

The 2015 Bruce Power licence renewal hearing resulted in the introduction of updated CNSC regulatory documents and CSA standards into the LCH, as shown in tables 6 and 7, respectively. The documents support the practice of continuous regulatory improvement.

CNSC staff will continue to verify the implementation plan outlined in the CNSC relicensing CMD for Bruce Power and will report to the Commission on any issues that arise from the implementation. The implementation plan is specific to the improvements and existing requirements are still valid until Bruce Power fully implements the requirements set out in the implementation plan.

Table 6: Updated requirements for CNSC regulatory documents for the 2015 Bruce Power PROL

CNSC regulatory document identifier and title	Implementation date
REGDOC-2.3.2, *Severe Accident Management Programs for Nuclear Reactors*	Completed
REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*	Completed
RD-336, *Accounting and Reporting of Nuclear Material*	Completed
REGDOC-2.3.3, *Periodic Safety Reviews*	Completed
REGDOC-2.4.1, *Deterministic Safety Analysis*	Dec. 31, 2017
REGDOC-2.4.2, *Probabilistic Safety Analysis (PSA) for Nuclear Power Plants*	Jun. 30, 2019
RD/GD-210, *Maintenance Programs for Nuclear Power Plants*	Nov. 30, 2017
RD/GD-98, *Reliability Programs for Nuclear Power Plants*	Completed
REGDOC-2.6.3, *Aging Management*	Jun. 30, 2016
REGDOC-2.9.1, *Environmental Protection: Policies, Programs and Procedures*	Dec. 31, 2018
REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*	Aug. 31, 2018
REGDOC-2.12.1, *High-Security Sites: Nuclear Response Force*	Completed
REGDOC-2.12.2, *Site Access Security Clearance*	Completed
RD-321, *Criteria for Physical Protection Systems and Devices at High-Security Sites*	Completed
RD-361, *Criteria for Explosive Substance Detection, X-ray Imaging, and Metal Detection Devices at High-Security Sites*	Completed
RD-327, *Nuclear Criticality Safety*	Completed

Table 7: Updated requirements for CSA standards for the 2015 Bruce Power PROL

CSA standard identifier and title	Implementation date
N286-12, *Management system requirements for nuclear facilities*	Dec. 31, 2018
N290.15-10, *Requirements for the safe operating envelope of nuclear power plants*	Completed
N285.0-12, *General requirements for pressure-retaining systems and components in CANDU nuclear power plants*	Completed
N290.13-10, *Environmental qualification of equipment for CANDU nuclear power plants*	Completed
N285.4-11, *Periodic inspection of CANDU nuclear power plant components*	Dec. 31, 2018
N288.1-08, *Guidelines for calculating derived release limits for radioactive materials in airborne and liquid effluents for normal operation of nuclear facilities*	Completed
N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*	Dec. 31, 2018
N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills*	Dec. 31, 2018
N288.6-12, *Environmental risk assessment at class I nuclear facilities and uranium mines and mills*	Dec. 31, 2018
N293-12, *Fire protection for nuclear power plants*	Completed

The Darlington PROL was scheduled to expire on December 31, 2015. The two-part public hearing for the Darlington licence renewal was held in August and November 2015. On December 23, 2015, the Commission announced the decision to renew the operating licence issued to Ontario Power Generation (OPG) to operate the Darlington Nuclear Generating Station, valid from January 1, 2016 to November 30, 2025.

The 2015 Darlington licence renewal hearing resulted in the introduction of updated CNSC regulatory documents and CSA standards into the LCH, as shown in tables 8 and 9, respectively. The documents support the practice of continuous regulatory improvement and requirements will continue to be valid until OPG becomes compliant with the conditions of the LCH.

CNSC staff will continue to verify the implementation plan outlined in the CNSC relicensing CMD for Darlington and will report to the Commission on any issues that arise from the implementation. The implementation plan is specific to the improvements.

Table 8: Updated requirements for CNSC regulatory documents for the 2016 Darlington PROL

CNSC regulatory document identifier and title	Implementation date
REGDOC-2.2.2, *Personnel Training*	Completed
REGDOC-2.3.2, *Accident Management*	Completed
REGDOC-2.3.3, *Periodic Safety Reviews*	Completed
RD/GD-210, *Maintenance Programs for Nuclear Power Plants*	Completed
REGDOC-2.6.3, *Aging Management*	Jul. 15, 2017
REGDOC-2.9.1, *Environmental Protection: Policies, Programs and Procedures*	Completed
REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*	Dec. 31, 2018
REGDOC-2.12.1, *High-Security Sites: Nuclear Response Force*	Completed
REGDOC-2.12.2, *Site Access Security Clearance*	Completed

Table 9: Updated requirements for CSA standards for the Darlington PROL

CSA standard identifier and title	Implementation date
N286-12, *Management system requirements for nuclear facilities*	Completed
N290.0-11, *General requirements for safety systems*	Completed
N291-08, *Safety-related structures*	Completed
N289.1-08, *Seismic, design and qualification*	Completed
N285.0-12, *General requirements for pressure-retaining systems and components in CANDU nuclear power plants (Annex N only)*	Completed
N285.4-14, *Periodic inspection of components*	Jul. 1, 2019
N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*	Completed
N288.5-11, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills*	Completed
N288.6-12, *Environmental risk assessment*	Dec. 1, 2016
N292.3-08, *Management of low and intermediate level waste*	Completed
N293-12, *Fire protection for nuclear power plants*	Completed

2.2.2 Updates on significant regulatory developments

Neutron overpower protection methodology annual update

Background

CNSC staff have been providing annual updates on the status of the review of a new enhanced neutron overpower protection (E-NOP) extreme value statistics (EVS) methodology since 2009 (CMD 09-M5). The sixth progress report, CMD 15-M30, was presented at the Commission meeting held for the 2014 NPP Report.

The NOP system is composed of a number of fast-response, in-core detectors that provide prompt measurements of neutron flux throughout the core. The design function of the NOP system is to initiate a reactor shutdown whenever the neutron flux reaches a set high level anywhere in the reactor core.

The placement of the in-core detectors provides a robust capability to detect flux distortions in the core. One exception is for Pickering, where Units 1 and 4 each have three out-of-core detectors. To compensate for their location, the setting of these detectors will initiate a reactor shutdown at a lower neutron flux level as compared to those that are in-core.

The shutdown systems will be actuated once the NOP detector signal reaches a pre-established value known as a trip setpoint. The analysis methodology and the method by which the NOP trip setpoints are calculated is referred to as the NOP methodology and the design-basis accident scenario is a postulated slow-loss-of-regulation (SLOR) event.

The onset of intermittent fuel sheath dryout could occur during a SLOR if the power increase is sufficiently large. This condition consists of an unstable dry patch developing on the fuel sheath, leading to a small local increase in temperature at the dry patch. It does not lead to fuel or fuel channel failures. Fuel sheaths can operate under this condition for some duration without damage.

The NOP trip setpoints protect the physical barriers (fuel and fuel channel) against the release of fission products to the environment. Using the NOP methodology, the NOP trip setpoint value is chosen by analysis so that shutdown systems will be activated to prevent the onset of intermittent fuel sheath dryout.

Preventing the onset of dryout provides a large margin to fuel or fuel channel failures if a SLOR event were to occur. The NOP methodology uses a statistical approach to compute trip setpoints that will ensure a NOP-initiated reactor trip occurring before the onset of dryout with high assurance, which also means high probability.

The NOP methodology has always been a risk-based methodology, as it uses a probabilistic criterion to determine the values of the NOP trip setpoints. This also implies that there is a residual probability of exceeding onset of dryout at the time of the NOP-initiated reactor trip. This is acceptable because the consequences would be negligible in that fuel and fuel channels would remain intact if a SLOR were to occur. The design of the NOP system and the robustness of the NOP trip setpoints calculated using the NOP methodology ensures there is a negligible risk associated from this residual probability of exceeding onset of dryout in one or more channels for some reactor configurations at the time of the NOP-initiated reactor trip.

The impact of heat transport system (HTS) aging on the NOP trip setpoints is that they may have to be lowered to maintain shutdown system effectiveness. As such, there is an incentive for the industry to refine the NOP analysis method to gain additional operational margins to NOP trip.

One such proposal is the new E-NOP methodology by OPG and Bruce Power. Point Lepreau does not have the same HTS aging issues as it was recently refurbished and NB Power currently uses the original NOP methodology to set its NOP trip setpoints.

The new E-NOP methodology uses a statistical approach called EVS to statistically compute the NOP trip setpoint. It is a statistical tolerance limit solution to the NOP trip setpoint problem and a correct statistical framework for risk management of situations such as the NOP trip setpoint problem. However, CNSC staff had some residual concerns regarding the formal use of E-NOP for real NOP trip setpoint problem application.

CNSC staff requested licensees provide additional information; Bruce Power and OPG provided their final response to the CNSC’s concerns in March 2015.

CNSC staff have now completed their review of the OPG and Bruce Power proposal and its status is reported below.

Status

In January 2016, CNSC staff completed their review of the OPG and Bruce Power final response submitted in March 2015.

The statistical treatment used to calculate the NOP trip setpoints – called the tolerance limit approach – provides a framework for managing risk and is an accepted international nuclear industry practice. CNSC staff acknowledge that independent experts in nuclear engineering and statistical analysis reviewed the new E-NOP EVS methodology and arrived at the conclusion that it is technically and mathematically sound.

CNSC staff recognize the complexity of the statistical approach specific to EVS and, because of this complexity, residual uncertainties or inaccuracies may be associated with the new methodology. To establish the impact of residual inaccuracies in NOP trip setpoints, CNSC staff performed a detailed evaluation of safety significance.

CNSC staff concluded that residual inaccuracies in NOP trip setpoints calculated with the new methodology have a negligible impact on the ability of the NOP system to trip the reactor and protect the fuel and fuel channel if a SLOR event were to occur.

CNSC staff recognized in their review that the new methodology continues to prevent the onset of dryout with high assurance. This led CNSC staff to acknowledge the following:

- The prevention of onset of dryout was historically adopted to add conservatism and augment the robustness of the NOP trip setpoints in protecting the physical barriers.
- For the remaining risk of some fuel sheaths exceeding the condition of onset of dryout at the NOP-initiated reactor trip, the increase in sheath temperatures would not be high enough to challenge the integrity of the physical barriers.

From these facts, CNSC staff conclude that the new methodology:

- carries sufficient conservatism to maintain the robustness of the NOP system to compensate for any residual uncertainty in the values of the NOP trip setpoints
- continues to ensure that the consequences associated with the residual probability of exceeding onset of dryout in one or more channels for some reactor configurations at the time of the NOP-initiated reactor trip is negligible – meaning the risk of failure of the protective physical barriers in the event of a SLOR is negligible

CNSC staff concluded that OPG and Bruce Power stations are well protected against SLOR events by the NOP trip setpoints calculated using the E-NOP EVS methodology. CNSC staff also appreciate that there are adequate defence-in-depth provisions in place.

CNSC staff acknowledge the potential to introduce non-conservatisms that may lead to non-conservative NOP trip setpoints during the undertaking of an E-NOP analysis. This requires specialized competencies in the personnel performing this type of safety analysis. To address this concern, significant effort has been made to ensure strict controls are in place and adequate engineering judgment developed in the modelling of parameters to ensure the proper application of conservatisms in this methodology. OPG and Bruce Power indicated that they have addressed these concerns and potential non-conservatisms in the undertaking of an E-NOP analysis are adequately guarded against.

As part of their regular compliance verification program, CNSC staff will verify that licensees have put in place administrative and procedural measures to ensure an adequate engineering judgment is developed and documented – allowing that engineering judgment to be utilized effectively in ensuring conservatism in the required NOP trip setpoints and meeting the requirements of licence conditions management systems and safety analysis programs.

There are no outstanding issues regarding the use of the new E-NOP EVS methodology. This is the final annual update on the new methodology.

Suspect materials used to manufacture valves supplied to Canadian NPPs

In March 2015, a valve supplier notified licensees of Canadian NPPs that materials contained in its valve assemblies and components may not conform to accepted standards, specifications or technical requirements. Licensees immediately notified the CNSC about this event, which encompassed valves supplied to Canadian NPPs between 2001 and 2013.

CNSC staff have maintained continuous regulatory oversight of this event and remain satisfied that licensees continue to ensure adequate provisions are made for the protection of their workers, the public and the environment. In response to this event, licensees performed an extent of condition, in accordance with approved engineering evaluation processes in their LCHs, to assess the potential operability of the affected valves and related safety concerns. In accordance with REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, each NPP licensee submitted a preliminary event report in March 2015, followed by a detailed event report in December 2015.

CNSC staff reported this event to the Commission on two occasions: under CMD 15-M9 on March 25, 2015 and under CMD 15-M20 on June 17, 2015 (as part of the status report on power reactors). In addition, CNSC staff presented a third status update on this event at the April 7, 2016 Commission meeting, under CMD 16-M17, highlighting reviews of the detailed event reports as well as the key mitigating measures and initiatives put in place by the licensees to prevent reoccurrences of similar events.

CNSC staff concluded that the engineering assessments and reviews conducted by licensees, suppliers and authorized inspection agencies have been performed thoroughly and in a robust manner. Based on the outcome of these assessments and reviews, there is no safety risk for the continued use of the affected valves under the conditions for which they were designed.

In addition to these reviews and engineering assessments, the defence-in-depth concept, upon which CANDU reactors are built, makes the design less susceptible to the potential effects of non-conforming valves. The concept is supported by means of deterministic and probabilistic safety analyses that evaluate design-basis accidents (specifically for nuclear-class pressure boundary components such as structural failures or malfunctions of valves) to demonstrate that any potential valve failure would not affect nuclear safety.

Update on the CNSC response to independent evaluations of Exercise Unified Response

Consultants performed independent evaluations of Exercise Unified Response held at the Ontario Power Generation Darlington Nuclear Generating Station in May 2014. CNSC staff reviewed and concurred with the conclusions of the independent evaluations. A CNSC Action Plan was prepared to address 35 recommendations relevant to the CNSC. All actions (37) have been completed with the exception of one. Health Canada is the lead for the outstanding action item that deals with organizing a communications

workshop for federal departments and agencies having a role to play in responding to nuclear emergencies involving nuclear power plants. The workshop will consist of a training session in advance of the Huron Resolve 2016 exercise simulated at the Bruce Power Nuclear Generating Station in early October. The CNSC has committed to providing Health Canada with assistance in conducting this workshop.

2.2.3 Updates on major projects and initiatives

Fuel channel life management project

In 2009, Bruce Power, OPG and Atomic Energy of Canada Limited (now Canadian Nuclear Laboratories) jointly initiated a comprehensive R&D project – the fuel channel life management project (FCLMP) – to investigate the feasibility of operating pressure tubes beyond their original assumed design life. In 2011, a protocol was signed that provides governing roles and responsibilities between the licensees and CNSC staff.

Phase I of the FCLMP culminated in CNSC staff's acceptance of two project deliverables:

- predictive models for fracture toughness, whose results can be used in assessments of pressure tube leak-before-break
- sufficient evidence (specifically, Inconel X-750 spacer degradation) to demonstrate that the likelihood of unrecognized pressure tube-to-calandria tube contact would be acceptably low

OPG relied on the first deliverable to support its case for the removal of the 210,000 equivalent full-power hours (EFPH) hold-point on operation of Pickering units. In 2015, Bruce Power applied both deliverables to support the relicensing of the Bruce reactors.

In 2014, the FCLMP partners initiated Phase II of the project. In addition to continuing R&D on outstanding issues from Phase I, the second phase includes:

- development of new probabilistic methodologies for demonstrating leak-before-break and fracture protection
- a test-reactor irradiation program designed to simulate Inconel X-750 spacer degradation out to 210,000 EFPH
- development of fitness-for-service guidelines for the inspection and post-service examination of tight-fitting spacers

CNSC staff continues to monitor the industry's progress on this important project.

2.2.4 Public communication

Reports and presentations related to power reactor regulation

During 2015, the Commission was kept informed of events and activities at NPPs through a total of six status reports on power reactors presented by CNSC staff at public meetings. These reports summarize the status of the power reactors in such areas as operations, licensing, areas of regulatory interest and significant events.
In addition, CNSC staff made 9 presentations to the Commission related to NPP issues and regulation during 2015.

Event initial reports

Throughout the year, licensees are required to notify the CNSC of events that have a public and media interest, or that may pose potential risks to the health and safety of

persons or the environment. CNSC staff use event initial reports (EIRs) to ensure the Commission is aware of any events that may require its decision-making capacity. Three EIRs were presented to the Commission during the period of January 2015 to April 2016. Details of these EIRs are provided in section 3 of this report for each station.

The number of EIRs in a given year is not indicative of the safety of Canada's NPPs. For example, the events reported during 2015 and early 2016 were of low safety significance that did not require immediate regulatory action by the CNSC. The general topics of the submitted reports included environmental protection and radiation protection.

Public information and disclosure programs

In accordance with their power reactor operating licences, all licensees in Canada are required to implement public information and disclosure programs. These programs are supported by disclosure protocols that outline the type of information on the facility and its activities to be shared with the public (e.g., incidents, major changes to operations, periodic environmental performance reports) and how that information will be shared. This ensures timely information about the health, safety and security of persons and the environment and other issues associated with the lifecycle of nuclear facilities are effectively communicated.

In 2015, NPP licensees were in compliance with RD/GD-99.3, *Public Information and Disclosure* [6] by providing information on the status of their facilities through numerous activities. CNSC staff reviewed the communications activities during this period and noted a number of innovative methods and best practices licensees have used to share information with the public:

- OPG launched a new initiative called "Repurposing Pickering" to engage and inform residents on OPG's decommissioning plans and to seek public input on potential future uses of the Pickering site.
- Bruce Power and a coalition of agencies and neighbouring municipalities launched a new website, bepreparedgreybrucehuron.com, to provide residents with information on emergency preparedness.
- NB Power proactively engaged with and informed community members about its full-scale emergency exercise called Exercise Intrepid 2015 to improve public awareness on emergency preparedness.

Public outreach involving CNSC and NPP licensee staff

In support of the CNSC mandate of disseminating objective scientific, technical and regulatory information to the public, CNSC staff regularly visit Canadian communities to help the public understand the CNSC nuclear regulatory role. One of the objectives for CNSC public outreach is to maintain a two-way dialogue with nuclear host communities, including those with NPPs.

In 2015, CNSC staff took part in more than 25 events, including open houses, information sessions and community meetings to discuss a wide variety of nuclear-related topics (including the safety performance of the nuclear facility), demystifying nuclear science and answering questions on CNSC regulatory oversight. In 2015, events attended by CNSC staff included:

- a meeting with Pickering authorized nuclear operators
- a meeting with the Durham Nuclear Health Committee

- a community information session at the Pickering Nuclear Information Centre
- a meeting with the Point Lepreau Generating Station community liaison

Outreach sessions were also held with Aboriginal communities as described below.

Aboriginal consultation activities

The common law duty to consult with Aboriginal groups applies when the Crown contemplates actions that may adversely affect potential or established Aboriginal or treaty rights. The CNSC ensures all of its licensing decisions under the *Nuclear Safety and Control Act* (NSCA) uphold the honour of the Crown and consider potential or established Aboriginal or treaty rights pursuant to section 35 of the *Constitution Act, 1982*. As part of the CNSC's continued commitment to building strong relationships with First Nation and Métis communities with interest in Canada's nuclear generating stations, a copy of the *Regulatory Oversight Report for Canadian Nuclear Power Plants: 2014* was sent to all Aboriginal groups who requested to be kept informed of activities at NPPs. These groups have also been notified of the availability of the CNSC's Participant Funding Program to support participation in the review of this 2015 report.

This section provides a high-level summary of Aboriginal engagement and consultation activities conducted by staff at OPG, Bruce Power, Hydro-Québec and the CNSC in relation to regulatory review processes undertaken for Bruce A and B, Darlington and Gentilly-2 in 2015 and early 2016.

The Commission held a public hearing in April 2015 in Kincardine, ON for Bruce Power's five-year licence renewal. Within their respective CMDs, Bruce Power and CNSC staff described their Aboriginal engagement activities conducted prior to the hearing. The three identified Aboriginal communities – the Saugeen Ojibway Nation (SON), the Historic Saugeen Métis (HSM) and the Métis Nation of Ontario (MNO) – all intervened in the hearing. Key messages raised included the importance of building long-term trusting relationships, ensuring the environment is protected so that each community can continue practicing their traditional activities, the importance of their participation in the section 35 *Fisheries Act* authorization review process, and ongoing engagement related to the operation of the nuclear facility. In June 2015, CNSC staff sent the Commission's decision report to the identified Aboriginal groups, and offered to meet with each one to discuss any concerns or questions.

Since the hearing, CNSC staff have received monthly updates from Bruce Power on the status of its Aboriginal engagement activities. Bruce Power has continued to communicate and meet on a regular basis with the SON, HSM and MNO to discuss topics of interest related to the nuclear generating stations, including the *Fisheries Act* section 35 authorization. In November 2015, Bruce Power provided each community with a five-year regulatory "look ahead" through a letter and slide presentation.

CNSC staff have also continued regular communication with each community to discuss their respective interests. Since the licence renewal hearing, CNSC staff have held multiple teleconferences with the SON about Bruce Power's environmental assessment follow-up program to continue to work on addressing the SON's concerns. The CNSC also met with the SON in March 2016 to present its Independent Environmental Monitoring Program (IEMP) and discuss possible opportunities for future participation in the program.

Communication continued with the HSM throughout 2015, and a meeting took place in March 2016 where CNSC staff presented information on its IEMP to community members and discussed possible opportunities for future participation in the program.

CNSC staff also maintained regular communication with the MNO, hosted an information booth at the MNO's Annual General Assembly in Midland, ON in August 2015 and participated in a meeting with the MNO's Georgian Bay Regional Council in October 2015, where CNSC staff presented information on the IEMP to community members and discussed possible opportunities for future participation in the program. This meeting was part of a day-long meeting hosted by OPG that included a tour of OPG's Western Waste Management Facility as well as Bruce Power's water intake channel. Bruce Power led this part of the tour, which helped MNO members gain a better understanding of the operations of the facility and discussions related to Bruce Power's section 35 *Fisheries Act* authorization review process.

In November 2015, the Commission held public hearings in Clarington, ON for OPG's licence renewal application to continue operations and start refurbishment activities at the Darlington Nuclear Generating Station. Within their respective CMDs, OPG and CNSC staff described their Aboriginal engagement and consultation activities conducted prior to the hearings. While 11 First Nations and the MNO were actively engaged prior to the hearing, only the Mississaugas of the New Credit First Nation and the Mohawks of the Bay of Quinte First Nation chose to intervene at the public hearing. Key messages raised by these two communities included the need for continued engagement, the desire to have more information about nuclear substances transported through their respective traditional territories, emergency management planning and the need for more time to participate effectively in the regulatory review process. In March 2016, CNSC staff sent the Commission's decision report to the identified Aboriginal groups, and offered to meet with each one to discuss any concerns or questions.

Since the hearing, OPG staff have continued engagement activities with the interested First Nation and Métis communities. CNSC staff have also maintained communications with the interested First Nation and Métis communities, offered to meet to discuss topics of interest or concern and, in February 2016, met with Hiawatha First Nation to present information on the CNSC's IEMP and discuss possible opportunities for the community's future participation in the program. This meeting also included an update on the Pickering and Darlington stations.

Upon receipt of Hydro-Québec's licence application to continue decommissioning activities at the Gentilly-2 station, CNSC staff identified a number of First Nation and Métis groups who may be interested in participating the CNSC's regulatory review process. CNSC staff sent letters of information to five identified Aboriginal groups describing the project and the regulatory review process, and notified them that participant funding was available to help them participate in the review process. The Grand Conseil de la Nation Waban-Aki (representing the Abenakis of Odanak and Abenakis of Wolinak First Nations), the Huron Wendat First Nation and the Quebec Métis Nation were awarded participant funding for their participation in the Gentilly-2 decommissioning licence application hearing process. A meeting with CNSC staff was held with the Grand Conseil de la Nation Waban-Aki in March 2016 to discuss Hydro-Québec's decommissioning licence application and the CNSC's IEMP. A full description of the engagement activities conducted by Hydro-Québec and CNSC staff was described in their respective CMDs for the hearing held in May 2016.

While no public hearings took place in 2015 related to the Point Lepreau Generating Station, staff from NB Power have kept CNSC staff apprised of their Aboriginal engagement activities with the Union of New Brunswick Indians and the Passamaquoddy First Nation.

The CNSC is committed to building long-term, meaningful relationships with Aboriginal communities who have an interest in Canada's nuclear generating stations. Engagement and collaboration between licensees, Aboriginal communities and the CNSC are ongoing. CNSC staff will continue to keep the Commission updated on these issues.

2.2.5 Fukushima Daiichi response

Following the Fukushima Daiichi accident in 2011, the CNSC issued a regulatory request under subsection 12(2) of the *General Nuclear Safety and Control Regulations*. Licensees were requested to review the lessons learned from the event, re-examine their safety cases and report on implementation plans to address significant gaps. The initial effort has been completed by licensees.

Subsequently, the CNSC convened a task force to evaluate the operational, technical and regulatory implications of the Fukushima Daiichi accident for the Canadian nuclear industry. The CNSC Task Force was created with the objective of reviewing the capability of NPPs in Canada to withstand conditions similar to those that triggered the Fukushima Daiichi accident.

Specifically, the CNSC Task Force examined the response of NPPs to external events of higher magnitude than had previously been considered in the approved design bases. It also examined the licensees' capacity to respond to such events. The focus was on the need to anticipate the unexpected, including events such as earthquakes, tornadoes or hurricanes that may cause a prolonged loss of electrical power, resulting in operators being unable to continue cooling the reactors.

The *CNSC Fukushima Task Force Report* [26] was published on October 28, 2011. CNSC staff subsequently embarked on a series of consultations with stakeholders and the public to seek their input and increase their understanding of what happened at Fukushima Daiichi. The consultations also allowed CNSC staff to share the measures being planned by the CNSC and the nuclear power industry to address lessons learned from the Fukushima Daiichi accident. Following these consultations, the *CNSC Integrated Action Plan on the Lessons Learned from the Fukushima Daiichi Nuclear Accident* [5] was published and is now largely implemented.

The CNSC Integrated Action Plan consolidated all public and stakeholder comments and recommendations received during public consultations on the *CNSC Fukushima Task Force Report*. As well, it incorporated recommendations from two independent reviews related to lessons learned in light of the Fukushima accident: one by an external advisory committee titled *Examining the Response of the Canadian Nuclear Safety Commission to the 2011 Japanese Nuclear Event* [27] and the other by the IAEA Integrated Regulatory Review Service (IRRS) follow-up mission titled *2011 IRRS Follow-up Mission Report* [28]. The CNSC Integrated Action Plan is applied across all major nuclear facilities by using a risk-informed approach. Its implementation was prioritized into short-, medium- and long-term actions, with implementation dates of 2012, 2013 and 2015 respectively.

Since the last status update included in the 2014 NPP Report, Canadian NPP licensees have submitted additional update reports during the summer of 2015 on the progress made in implementing the lessons learned from the Fukushima accident. These reports

provided details on activities completed to date by NPP licensees, together with the status on the implementation of the Fukushima follow-up activities. Specifically, the update reports presented progress achieved by the NPP licensees in implementing the CNSC Integrated Action Plan to address safety improvements aimed at strengthening defence in depth and enhancing onsite emergency response. From the CNSC Integrated Action Plan, 36 Fukushima action items (FAIs) applicable to Canadian NPPs were derived.

Appendix H presents the status of the FAIs as of March 1, 2016. Updates on the activities leading up to the closure of FAIs since the last update to the Commission in the 2014 NPP Report are available in section 3 under the "Updates on significant regulatory issues" heading for each station.

As reported in the 2014 NPP Report, all short-term FAIs for Canadian NPPs were closed per the deadlines established in the CNSC Integrated Action Plan and to the satisfaction of CNSC staff. Following the receipt and CNSC staff review of *Fukushima Update Report No. 7*, submitted by licensees in 2015, all medium- and long-term FAIs are now closed for all stations.

To follow through on the closure of the FAIs, station-specific action items were raised, where necessary. CNSC staff will continue to monitor the implementation of the station-specific action items as part of their compliance verification activities. These station-specific actions will form part of the day-to-day operation and will be tracked through closure under established compliance verification criteria.

In the long term, implementation of safety improvements to the design, additional mitigating equipment or its availability for service will be integrated into the licensees' systems and programs, and will continue to be monitored through the CNSC's baseline compliance verification program (such as desktop reviews or inspections). In addition, CNSC staff will continue to conduct additional verifications focusing on licensees' implementation of any physical plant modifications and equipment required per the FAI closure criteria. The approach of how these verification activities are conducted is outlined in the section below.

Compliance oversight of Fukushima-related plant modifications and emergency mitigating equipment implementation

As part of the overall CNSC compliance verification program, CNSC staff are conducting compliance verification of Fukushima-related equipment implementation with the objective of ensuring licensees have procured, installed and implemented all equipment that they have committed in their disposition of the respective FAIs. Specifically, CNSC staff coordinated inspection activities to verify implementation of plant modifications and emergency mitigating equipment at Canadian NPPs using a four-level approach:

- **Level 1:** Field verification of equipment procurement, installation and/or assembly. This level corresponds to onsite verifications that the equipment has been purchased and installed.

- **Level 2:** Confirmation of equipment commissioning, turnover to operations or availability for service.

- **Level 3:** Sampling of follow-up compliance verification via normal compliance based on a risk-informed approach.

- **Level 4:** *In situ* demonstration of equipment performance during training drills and exercises. In some instances, the effectiveness of new equipment, such as backup power supplies or means of adding water to various systems to mitigate or arrest the progression of a severe accident, is not proven merely by the existence of the equipment in the field. For those cases, a demonstration of the capability to deploy these resources within a specified mission time is required. This is demonstrated in the field during training, drills and exercises.

Since the last Fukushima response status update in the 2014 NPP Report, CNSC site staff continued to confirm that all post-Fukushima-related equipment currently installed in the field, pre-staged in the field, or purchased and kept in designated storage facilities has been deployed in accordance with licensees' commitments and is available for service. This four-level approach will also be applied for the compliance verification of equipment still to be delivered to the licensees.

As of May 2016, CNSC staff have completed Level 3 inspections at all Canadian NPP sites. Based on the samples of activities reviewed, CNSC staff verified that licensees are properly taking into account human factors in design for specified processes and artefacts that resulted from the FAIs, and are adequately developing and modifying their procedures that resulted from FAIs. In general, CNSC staff found licensees are in compliance with applicable CSA standard N286-05, *Management system requirements for nuclear facilities*; however, some areas for improvement were identified with regard to the documentation and performance of human factors-in-design work. These areas of improvement will be addressed by all licensees per the compliance verification program.

Additionally, CNSC staff have witnessed and participated in three separate large-scale Level 4 exercises (Bruce Power's Exercise Huron Challenge in 2012, OPG's Exercise Unified Response in 2014 and NB Power's Exercise Intrepid in 2015) designed to test the response to a severe accident, the deployment of emergency mitigating equipment and performance standards. The licensees have made enhancements as a result of these exercises and CNSC staff will continue to monitor implementation.

As stated in the previous section, verification of design upgrades, analysis or procedural changes that are specific to a station are tracked through station-specific action items as part of the CNSC's baseline compliance verification program. There are currently six station-specific open AIs for NB Power, five for Bruce Power and three for OPG. Of note is the fact that, in some instances, the timeline for completion or implementation of a design upgrade specific to a station will coincide with scheduled outages.

2.2.6 Darlington new nuclear project

On August 17, 2012, a Commission panel announced its decision to issue a nuclear power reactor site preparation licence (PRSL) to OPG for the new nuclear project at the Darlington site for a period of 10 years (from August 17, 2012 to August 17, 2022).

According to the *Canadian Environmental Assessment Act*, an environmental assessment of the project is required prior to any licensing decisions for a PRSL. The joint review panel (JRP) carried out this environmental assessment in 2011. The assessment and the PRSL were challenged through an application for judicial review before the Federal Court of Canada.

In May 2014, the Federal Court of Canada allowed the application and ordered the environmental assessment be returned to the JRP for further consideration and

determination of the specific issues set out in its decision. As a result, the PRSL was set aside.

The decision by the Federal Court of Canada was appealed and, on September 10, 2015 the Federal Court of Appeal set aside the judgment of the Federal Court of Canada, thereby dismissing the application for judicial review.

An application for leave to appeal the Federal Court of Appeal's decision was filed with the Supreme Court of Canada in November 2015. In April 2016, the Supreme Court decided to not grant leave to appeal the Federal Court of Appeal's decision.

As outlined in OPG's PRSL, work activities in 2014 and 2015 were related to the JRP recommendations, specifically:

- bank swallow monitoring and mitigation
- support for CNSC activities to engage stakeholders in developing policy for land use around nuclear generating stations

Bank swallow monitoring and mitigation

The construction and operation of a new NPP at the Darlington site will require the removal of natural bluffs along the northern shoreline of Lake Ontario. These natural bluffs are known to provide habitat for the bank swallow – habitat that could potentially be lost by the development of a new NPP. The JRP recommended that artificial bank swallow nest habitat be constructed to maintain the population as close to the original bluff site as possible.

As recommended by the JRP, surveys of the bank swallow burrows at the Darlington site and surrounding area have been conducted since 2008. In March 2015, OPG submitted the monitoring results for the earthen embankment artificial nest habitat structure that was constructed in 2012 as part of an investigation into suitable artificial nest habitat for this species. This report indicated there were no burrow excavations noted within the structure and no bank swallow use of the artificial habitat was recorded during the 2014 season. CNSC staff indicated that OPG needs to continue monitoring the structure during the 2015 season. In March 2016, CNSC staff received and are currently reviewing the OPG 2015 bank swallow program results.

Land use planning

Taking into consideration the lessons learned from the Fukushima Daiichi accident, the JRP was of the opinion that a situation where residential areas are located within three kilometres of a nuclear site must be avoided and that appropriate steps must be taken to evaluate and define buffer zones around nuclear facilities in Canada. Given this, the JRP directed recommendations to the CNSC, the Government of Ontario and the Municipality of Clarington regarding land use planning.

Specifically, the JRP's recommendations were in relation to:

- development of policy for land use around nuclear generating stations
- provincial prevention of sensitive land uses within three kilometres of the site boundary
- municipal prevention of sensitive land uses within three kilometres of the site boundary

- management of development in the vicinity of the project site to ensure capacity for evacuation

Significant efforts have been undertaken by various levels of government following the JRP recommendations around land use planning. In 2013, as part of its activities to address the JRP recommendations, the CNSC hosted a land use planning workshop for OPG staff as well as municipal, regional and provincial stakeholders. The CNSC continues to monitor recommendations stemming from this workshop.

Key activities and progress to date are as follows:

- The Government of Ontario released the revised Provincial Policy Statement (PPS) 2014 (which came into effect April 30, 2014). It includes new policy on land use compatibility, which is further supported by definitions for "sensitive land uses" and "major facilities" that include energy generating facilities such as NPPs.

- The Region of Durham has committed to updating its Regional Official Plan to align with the PPS 2014. (The next revision is scheduled for 2018).

- The Proposed Official Plan for the Municipality of Clarington was released in March 2015 and included policies to address the PPS 2014 around land use planning. The draft plan is following municipal and subsequent regional processes for consultation, review and approval. The Municipality of Clarington is targeting full implementation of the revised plan by 2018.

- In February 2016, the CNSC published in REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response* [29]. This regulatory document is based on international best practices for establishing exclusion zones as required for land use planning near nuclear generating stations.

Work activities anticipated by OPG for 2016 and into 2017

As part of the JRP recommendations, OPG is planning for the following work activities in 2016 and into 2017 related to a deep water aquatic methodology study:

- Prepare a draft sampling methodology report for a field collection program to assist in siting the proposed new NPP's intake and diffuser. The CNSC expects this report to be submitted for review and comments by summer 2016.

- Implement aquatic field studies in 2016–17.

The CNSC will continue to monitor all work activities related to the JRP recommendations until their completion.

3 Nuclear power plant safety performance and regulatory developments

This section provides performance ratings for the 14 safety and control area (SCA) described earlier in this report for each nuclear power plant (NPP) in Canada. The ratings reflect CNSC staff evaluations of how well the licensees' programs met regulatory requirements and expectations to protect the overall health, safety and security of persons and the environment, and to meet Canada's international commitments on the peaceful use of nuclear energy.

The safety performance ratings were determined by using a risk-informed approach of integrating findings from surveillance, inspections and desktop reviews of events, as well as progress on enforcement actions by CNSC staff.

This section also provides detailed information on various regulatory developments and issues for each NPP, including licensing, major projects and descriptions of event initial reports. The information provided is as current as allowed by the annual reporting deadlines.

3.1 Bruce A and B

Bruce A Nuclear Generating Station and Bruce B Nuclear Generating Station are located on the shores of Lake Huron, in the Municipality of Kincardine, ON. The facility is operated by Bruce Power under a lease agreement with the owner of the facility, Ontario Power Generation (OPG).

The Bruce A station has four CANDU reactors with a gross power of 805 MWe (megawatts electrical) at Units 1-4, all of which were fully operational throughout 2015. The Bruce B station has four CANDU reactors with a gross power of 872 MWe at Units 5-8, and all of which were fully operational throughout 2015.

This report groups the two stations together because Bruce Power uses common programs at both stations. However, the performance of each station is assessed separately due to the differences in implementation of some programs at Bruce A and Bruce B.

3.1.1 Safety assessment

The safety assessment of Bruce A and B for 2015 resulted in the performance ratings as shown in table 10. Based on CNSC compliance oversight of the SCAs, CNSC staff concluded that Bruce A and B operated safely. The integrated plant ratings were "fully satisfactory (FS)" for Bruce A, an improvement over the "satisfactory" rating of the previous year, and "fully satisfactory" for Bruce B, unchanged from the previous year.

Table 10: Performance ratings for Bruce A and B

Safety and control area	Bruce A	Bruce B	Industry average*
Management system	SA	SA	SA
Human performance management	SA	SA	SA
Operating performance	FS	FS	FS
Safety analysis	SA	SA	SA
Physical design	SA	SA	SA
Fitness for service	SA	SA	SA
Radiation protection	SA	SA	SA
Conventional health and safety	FS	FS	FS
Environmental protection	SA	SA	SA
Emergency management and fire protection	SA	SA	SA
Waste management	FS	FS	FS
Security	FS	FS	SA
Safeguards and non-proliferation	SA	SA	SA
Packaging and transport	SA	SA	SA
Integrated plant rating	FS	FS	SA

* The industry average of all operating NPPs in Canada

Notes:

- For specific areas within the SCAs where there were no significant observations from CNSC staff compliance verification activities, no information is given in this subsection of the report.
- The information presented below is station specific; refer to section 2 for general trends and industry-wide observations.

3.1.1.1 Management system

Based on the information assessed, CNSC staff concluded that the management system SCA at Bruce A and B met performance objectives and all applicable regulatory requirements. As a result, each station received a "satisfactory" rating, unchanged from the previous year.

Management system

Bruce Power's management system complied with the requirements of CSA standard N286-05, *Management system requirements for nuclear power plants* [7]. CNSC staff performed compliance activities of elements of Bruce Power's management system and identified opportunities for improvement.

Organization

CNSC staff observed that Bruce Power has an adequately defined organizational structure and roles and responsibilities.

Safety culture

CNSC staff assessed Bruce Power's nuclear safety culture monitoring process procedure in January 2015. This assessment initiated a series of outreach meetings and discussions with Bruce Power regarding its site-wide initiatives to continually monitor and improve safety culture. Bruce Power continues to follow the established processes for self-assessments of safety culture at planned intervals. CNSC staff are satisfied with Bruce Power's activities in this area and will continue to monitor these assessments and resulting initiatives.

Configuration Management

CNSC staff did not identify any new issues in this area in 2015. An existing corrective action plan related to configuration management is being implemented. CNSC staff will continue to monitor progress through 2016.

Management of contractors

CNSC staff identified minor deficiencies of an administrative nature and failing to adhere to procedures regarding the management of contractors for goods and services. Bruce Power is in the process of taking corrective actions to resolve these issues and expect to complete the required work by the end of 2017. CNSC staff will continue to monitor Bruce Power's corrective actions in this area.

3.1.1.2 Human performance management

Based on the information assessed, CNSC staff concluded that the human performance management SCA at Bruce A and B met performance objectives and all applicable regulatory requirements. As a result, each station received a "satisfactory" rating, unchanged from the previous year.

Human performance program

CNSC staff assessed Bruce Power's human performance program and concluded that Bruce A and B are in compliance with the regulatory requirements of CSA standard N286-05, *Management system requirements for nuclear power plants* [7]. CNSC staff are currently reviewing the latest revision of Bruce Power's human performance program procedure to assess the changes from the previous revision.

Personnel training

Bruce Power has a well-documented and robust systematic approach to training-based training system. The implementation of this system for the training programs at Bruce A and B met regulatory requirements.

Personnel certification

In accordance with regulatory requirements, Bruce Power has a sufficient number of personnel at both Bruce A and B for all certified positions. CNSC staff are satisfied that Bruce Power's program assures the competency of personnel at Bruce A and B to receive certification and perform their duties safely.

Initial certification examinations and requalification tests

The initial certification examination and requalification test programs for certified staff at Bruce A and B met all regulatory requirements.

Work organization and job design

Minimum shift complement

Bruce Power has a sufficient number of personnel for all certified positions. CNSC staff concluded that both Bruce A and B stations are in compliance with the requirements for the minimum shift complement.

Fitness for duty

Bruce Power exceeded the hours-of-work limits at Bruce A and B for certified staff on several occasions to maintain a minimum shift complement. Bruce Power has in place measures to manage the safety-related risks of worker fatigue when an hours-of-work exceedance occurs. CNSC staff continues to monitor the hours of work of certified staff on a quarterly basis.

3.1.1.3 Operating performance

Based on the information assessed, CNSC staff concluded that the operating performance SCA at Bruce A and B met performance objectives and all applicable regulatory requirements. As a result, each station received a rating of "fully satisfactory" which is unchanged for Bruce B and an improvement for Bruce A from the previous year.

Conduct of licensed activities

Bruce Power continued to operate Bruce A and B within the bounds of the operating policies and principles. All reactor units operated within the power limits prescribed by Bruce Power's operating licence for Bruce A and B.

Bruce A experienced no unplanned reactor trips, one stepback and five setbacks. Bruce B experienced one unplanned reactor trip, no stepbacks and seven setbacks. Bruce Power had only one unplanned reactor trip in 2015 for the both stations, exceeding CNSC expectations as well as the industry's performance targets.

Stepbacks and setbacks were controlled properly and power reduction was adequately initiated by the reactor control systems. CNSC staff verified that for all events, Bruce Power staff followed approved procedures, investigated or evaluated the root cause of the event, and took appropriate corrective actions. CNSC staff found that Bruce Power's operating performance met or exceeded regulatory requirements and expectations in 2015.

The power history graphs for the Bruce A and B nuclear reactor units for 2015 are shown in appendix G. These graphs show the occurrences (and causes) of outages and the associated power reductions during the year.

Procedures

CNSC staff found that Bruce Power has well-defined processes for procedure preparation, review, validation, issuance and revision. Bruce Power set out to improve its procedures in 2015 by reducing the number of document change requests and improving its documentation. CNSC staff are satisfied with the quality of Bruce Power's procedures and found that they comply with regulatory requirements.

Reporting and trending

Bruce Power is required to submit quarterly reports on operations and performance indicators as described in REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [2]. It is also required to follow up on all events with corrective actions and apparent cause or root cause analysis, when appropriate. CNSC staff found that Bruce

Power's reporting and trending improved in 2015 while meeting or exceeding regulatory requirements and expectations.

Outage management performance

Bruce Power scheduled six planned outages for Bruce A and B as well as a vacuum building outage for Bruce B in 2015. Bruce Power completed all outages successfully and met the requirements for verification of reactor shutdown guarantees. Minor issues in this specific area were adequately addressed throughout the year. CNSC staff verified and concluded that the reactor shutdown guarantees were applied correctly and the application met the requirements for reactor safety.

In 2015, Bruce A experienced six forced outages among four reactors (mostly at Unit 3). Bruce B experienced six forced outages. All forced outages were caused mainly by events related to service equipment (e.g., generator hydrogen cooler and air cooler repairs). The outage implementation, safety and work management met or exceeded CNSC requirements and expectations.

Safe operating envelope

Bruce Power has completed the implementation of the safe operating envelope based on the requirements of CSA standard N290.15, *Requirements for the safe operating envelope of nuclear power plants* [46]. The safe operating envelope met applicable regulatory requirements and Bruce Power will be implementing ongoing improvements on a permanent basis.

3.1.1.4 Safety analysis

Based on the information assessed, CNSC staff concluded that the safety analysis SCA at Bruce A and B met performance objectives and all applicable regulatory requirements. As a result, each station received a "satisfactory" rating, unchanged from the previous year.

Deterministic safety analysis

Bruce Power has an effective, well-managed program for performing deterministic safety analysis. It continues to implement REGDOC-2.4.1, *Deterministic Safety Analysis* [9]. It is also developing a common-mode events appendix that will be added to the safety reports for both Bruce A and B.

Both Bruce A and B have adequate safety margins and met the CNSC acceptance criteria for safe operation of the NPPs.

Probabilistic safety analysis

Bruce Power is in compliance with S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [30] and is transitioning toward implementation of the recently issued REGDOC-2.4.2, *Probabilistic Safety Analysis (PSA) for Nuclear Power Plants* [12].

Criticality safety

Bruce Power is required to have a criticality safety program. CNSC staff noted that there were no criticality events at Bruce A and B during 2015. Bruce Power's criticality safety program is satisfactory, and it has committed to updating its program to comply with the new licensing requirements of RD-327, Nuclear Criticality Safety [31], in 2016.

3.1.1.5 Physical design

Based on the information assessed, CNSC staff concluded that the physical design SCA at Bruce A and B met performance objectives and all applicable regulatory requirements. As a result, each station received a "satisfactory" rating, unchanged from the previous year.

Design governance

Environmental qualification

The environmental qualification program is fully implemented in all Bruce A and B operating units. Bruce A and B demonstrated compliance with its governing document by maintaining program sustainability.

System design

Electrical systems

There were no significant reportable events during the year that had an effect on the electrical power systems at Bruce A and B. The longstanding issue related to the completion of the Bruce A qualified power supply commercial-grade dedication (CGD) process was successfully addressed in 2015. Specifically, this issue was addressed by Bruce Power's project to qualify standby diesel generator 2 through the CGD process using EPRI NP-5652, *Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Applications*. Some ongoing fieldwork on this project is being executed in 2016.

CNSC staff continued to follow up with Bruce Power on the emergency mitigating equipment portable generator testing duration and battery capacity testing. This issue was resolved in early 2016.

Fire protection design

CNSC staff conducted ongoing regulatory oversight activities at Bruce A and B in 2015, including a fire protection inspection against the requirements of CSA standard N293-07, *Fire protection for CANDU nuclear power plants* [32]. CNSC staff concluded that the fire protection programs at Bruce A and B are comprehensive and in compliance with regulatory requirements.

Component design

Fuel design

Bruce Power has a well-developed reactor fuel inspection program. The fuel defect rate for Units 1 and 2 is higher than the industry average due to damage caused by debris introduced by the recent refurbishment of the units. However, it should be noted that the rate of defects is trending downwards and is expected to return to the industry average within the next few years. The fuel defect rate for Units 3 to 8 is within the industry average of about one bundle per year. Bruce Power has been effective at locating and defuelling defective bundles. No regulatory limits were exceeded during the year.

Bruce Power continues to work on resolving an endplate cracking issue in the acoustic channels for Units 5 to 8, which has caused damage to a small number of fuel bundles. CNSC staff have accepted Bruce Power's corrective action plan and concluded that Bruce Power's fuel program is capable of ensuring safe operations. Additional defence-in-depth analyses for this safety case are expected to be submitted by Bruce Power in

2016. CNSC staff will continue to monitor this issue through REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [2].

Cables

CNSC staff verified and confirmed that the issue regarding the component performance monitoring plan for cables at Bruce A has been fully resolved.

3.1.1.6 Fitness for service

Based on the information assessed, CNSC staff concluded that the fitness for service SCA at Bruce A and B met performance objectives and all applicable regulatory requirements. As a result, each station received a "satisfactory" rating, unchanged from the previous year.

Equipment fitness for service /equipment performance

On the basis of onsite inspections and compliance verification activities, CNSC staff concluded that overall equipment performance at Bruce A and B stations was satisfactory and met regulatory requirements.

Maintenance

In 2015, the overall maintenance program at Bruce A and B met the requirements of CNSC regulatory document RD/GD-210, *Maintenance Programs for Nuclear Power Plants* [33]. Maintenance program performance at both Bruce A and B remained satisfactory with improvements observed on maintenance backlog reduction. The preventive maintenance completion ratios were around 84 percent for Bruce A and 82 percent for Bruce B.

The maintenance backlog results for Bruce A and B are provided in tables 11 and 12, respectively.

Bruce Power reduced its corrective critical maintenance backlog at Bruce A and reached the range of industry best practice. The deficient critical maintenance backlog was also reduced but remained above the industry average. For Bruce B, the licensee maintained its low corrective critical maintenance backlog. While the deficient critical maintenance backlog was significantly reduced, it remained above the industry average.

CNSC staff will continue to monitor the trends in these indicators.

Table 11: Maintenance Backlogs and Deferrals for Critical Components for Bruce A, in 2015

Parameter	Average work orders per unit for the year	Trend during the year	Industry average
Corrective maintenance backlog	4	down	11
Deficient maintenance backlog	123	down	117
Deferrals of preventive maintenance	18	down	49

Table 12: Maintenance Backlogs and Deferrals for Critical Components for Bruce B, 2015

Parameter	Average work orders per unit for the year	Trend during the year	Industry average
Corrective maintenance backlog	6	down	11
Deficient maintenance backlog	180	down	117
Deferrals of preventive maintenance	28	stable	49

Structural integrity

In 2015, Bruce Power inspected selected pressure boundary components, containment components and containment structures for Units 1, 3 and 4 at Bruce A and Units 5–8 at Bruce B. Pressure boundary inspections included elements of the primary heat transport and auxiliary systems, steam generators, feeders and pressure tubes. Bruce Power also conducted positive pressure tests on the containment boundary, including the vacuum building test for all Bruce B units.

Based on compliance monitoring activities, CNSC staff concluded that the structures, systems and components important for safe operation at Bruce A and B met applicable regulatory requirements and acceptable safety margins were maintained.

Bruce Power continued with the implementation of the Fuel Channel Life Management Project to further the development of the analytical tools necessary to demonstrate pressure tube fitness for service for continued operation.

Reliability of systems important to safety

The reliability program at Bruce A and B met the regulatory requirements described in RD/GD-98, Reliability Programs for Nuclear Power Plants [15]. Bruce Power transitioned to RD/GD-98 in 2015 and is in the process of updating its list of systems important to safety in accordance with its most recent probabilistic safety assessment reports.

For Bruce A, all special safety systems met their unavailability targets in 2015, with the exceptions of the shutdown systems for Units 1 and 2 and the negative-pressure containment system (NPCS).

The SDS1 and SDS2 systems for Unit 2 did not meet their unavailability targets due to a control valve that was left slightly open, causing the heat slow transport pressure to drop below the limit and therefore making this trip parameter unavailable. The immediate corrective actions were adequately determined. There was no significant impact on nuclear safety as a result of this issue.

The SDS2 systems for Units 1 and 2 did not meet their unavailability targets due to setting a slightly lower comparator’s threshold voltage during the bench calibration of the SDS2. The loop calibration procedure was revised and the correction factor applied on the amplifiers has been determined to mitigate this issue. There was no significant impact on nuclear safety as a result of this issue.

The NPCS did not meet its unavailability target because of an airlock leakage detected during a safety system leak test. In the unlikely situation of a secondary side line break, this airlock leakage would have rendered the NPCS system slightly less effective.

Bruce Power took appropriate actions to address the temporary impairments and corrective actions to prevent recurrence have been completed.

CNSC staff verified Bruce Power's corrective actions and concluded that there was no significant impact on nuclear safety as a result of these issues.

All special safety systems for Bruce B met their unavailability targets in 2015.

Aging management

Bruce Power has implemented an integrated aging management program at Bruce A and B to ensure the condition of structures, systems and components important to safety is well understood, and that the required activities are in place to assure their health as the plants age. CNSC staff concluded that Bruce Power's aging management program met regulatory requirements.

Bruce Power is in the process of updating its aging management governance processes to comply with REGDOC-2.6.3, *Fitness for Service: Aging Management* [16], with full compliance expected in 2016.

Chemistry control

Bruce Power's chemistry control program performance at Bruce A and B was satisfactory.

A compliance inspection at Bruce B Unit 6 outage concluded that Bruce Power met all applicable requirements for monitoring critical chemistry parameters during the guaranteed shutdown state. CNSC staff did not identify any chemistry control issues at Bruce A or Bruce B.

Periodic inspection and testing

Bruce Power has adequate periodic inspection programs (PIPs) in place at Bruce A and B for the pressure boundary and containment components important to safety.

CNSC staff monitored compliance with the established regulatory requirements for PIPs and concluded that their implementation met these requirements.

Bruce Power is in the process of updating its PIP for pressure boundary components to comply with the 2014 edition of CSA standard N285.4, *Periodic inspection of CANDU nuclear power plant components* [18]. Full implementation of the updated program requirements is expected by 2018.

3.1.1.7 Radiation protection

Based on the information assessed, CNSC staff concluded that the radiation protection SCA at Bruce A and B met performance objectives and all applicable regulatory requirements. As a result, each station received a "satisfactory" rating, unchanged from the previous year.

Application of ALARA

Bruce Power continued to implement a highly effective, well-documented and mature program, based on industry best practices, to keep doses as low as reasonably achievable (ALARA) at Bruce A and B. CNSC staff did not identify any regulatory non-compliances of the ALARA program. The collective radiation exposure values, as provided by Bruce Power, align with the Bruce A and B dose targets. CNSC staff concluded that the application of ALARA by Bruce Power met regulatory requirements and achieved planned goals, with a noticeable improving trend.

Worker dose control

Bruce Power continued to comply with the regulatory requirements to measure and record doses received by workers. Routine compliance verification activities indicate that performance in the area of worker dose control at Bruce Power is effective and met regulatory requirements. No worker at Bruce A and B received a radiation dose resulting from an unplanned exposure in 2015 above action levels. The dose information for Bruce A and B can be found in section 2.1.7 and appendix E.1.

Safety performance indicators related to worker dose control include tracking of occurrences involving doses received from unplanned exposures or uptakes. Bruce Power reported two unplanned exposures, both of which were well below their action level of 2 mSv. As these indicators are meant to drive improvement, CNSC staff did not determine these to be safety significant.

Radiation protection program performance

The Bruce Power radiation protection program performance meets the requirements of the *Radiation Protection Regulations*. The oversight applied by Bruce Power in implementing and improving its program was effective in protecting workers at Bruce A and B stations. Bruce Power continually measures the performance of its radiation protection program against industry established objectives, goals and targets.

Radiological hazard control

No action levels were exceeded for surface contamination at Bruce A or Bruce B in 2015.

In July 2015, CNSC staff conducted a focused inspection of radiological hazards control at Bruce A and Bruce B. While a number of positive findings were noted, CNSC staff also identified areas for improvement. Bruce Power addressed these deficiencies of low safety significance in May 2016. CNSC staff are satisfied that the Bruce Power performance in this area has met applicable regulatory requirements.

Estimated dose to the public

Bruce Power continued to ensure the protection of the public in accordance with the *Radiation Protection Regulations*. In 2015, the reported dose to the public from the Bruce site (which includes Bruce A and B, the Central Maintenance and Laundry Facility, the Western Waste Management Facility and the decommissioned Douglas Point reactor) was 0.00289 mSv, well below the annual public dose regulatory limit of 1 mSv.

3.1.1.8 Conventional health and safety

Based on the information assessed, CNSC staff concluded that the conventional health and safety SCA at Bruce A and B met or exceeded performance objectives and all applicable regulatory requirements. As a result, each station received a "fully satisfactory" rating, unchanged from the previous year.

Performance

As reported by Bruce Power, the accident severity rate (ASR) for Bruce A and B decreased from 0.1 in 2014 to 0.0 in 2015, an indication of outstanding performance. The accident frequency (AF) for Bruce A and B increased slightly from 0.17 in 2014 to 0.28 in 2015 due to increasing medically treated injuries during the reporting period.

The AF and ASR performance indicators were found to be acceptable at both Bruce A and B in 2015. Descriptions of the AF and ASR data for Bruce A and B are also provided in section 2.1.8.

Practices

Bruce Power was compliant with the relevant provisions of the *Occupational Health and Safety Act* of Ontario and the *Labour Relations Act*.

Awareness

Bruce A and B met requirements in this area in 2015. All issues from onsite inspections were adequately addressed throughout the year.

Despite some minor housekeeping deficiencies noticed during onsite inspections, there was a positive trend of improvement of housekeeping in 2015 compared with 2014. All identified issues were addressed by Bruce Power during the year.

3.1.1.9 Environmental protection

Based on the information assessed, CNSC staff concluded that the environmental protection SCA at Bruce A and B met performance objectives and all applicable regulatory requirements. As a result, each station received a "satisfactory" rating, unchanged from the previous year.

Effluent and emissions control

All radiological releases from Bruce A and B were well below regulatory limits.

Only positive findings were observed during the onsite inspections of Bruce A and B in 2015. The derived release limits are provided in appendix E.1.

Environmental management system (EMS)

Bruce Power has established and implemented an environmental management program to assess the environmental risks associated with its nuclear activities, and to ensure these activities are conducted in a way that prevents or mitigates adverse environmental effects.

Assessment and monitoring

CNSC staff reviewed and assessed the Bruce Power environmental monitoring data and did not identify unreasonable risk to the public or the environment.

Protection of the public

There were no hazardous substance releases from Bruce A and B that posed unacceptable risk to the environment or the public.

The reported annual radiation dose from the Bruce site to the public remained very low at 0.29 percent of the public dose limit.

Environmental risk assessment

Bruce Power continued to maintain and implement an effective environmental risk assessment and management program at Bruce A and B in accordance with regulatory requirements.

The risk assessment for fish continued to be updated through the results of the Bruce A environmental assessment follow-up program and ongoing industry/academic whitefish research programs. CNSC staff continue to work closely with Environment and Climate Change Canada on a thermal effects assessment to ensure sensitive fish spawning habitat is protected from thermal discharge.

3.1.1.10 Emergency management and fire protection

Based on the information assessed, CNSC staff concluded that the emergency management and fire protection SCA at Bruce A and B met performance objectives

and all applicable regulatory requirements. As a result, each station received a "satisfactory" rating, unchanged from the previous year.

Conventional emergency preparedness and response
Regulatory oversight activities conducted by CNSC staff at Bruce A and B in 2015 included documentation reviews, onsite observations and participation in drills. Bruce Power maintained its conventional emergency preparedness and response commitments, including enhancements to its emergency (non-nuclear) drill program.

Nuclear emergency preparedness and response
Bruce Power effectively demonstrated its preparedness to respond to a nuclear emergency.

Bruce Power met its licence conditions handbook (LCH) requirement on the distribution of potassium iodide (KI) tablets in 2015. In partnership with the Municipality of Kincardine and the Grey Bruce Health Unit, Bruce Power greatly enhanced the availability of KI tablets to households, schools and businesses in the primary (10 kilometre) and secondary (50 kilometre) zones. A back-up contingency supply of KI tablets is maintained at municipal emergency response centres. The dissemination of emergency preparedness pamphlets to residents around the plant was completed, enhancing public awareness of nuclear emergency preparedness and response.

Fire emergency preparedness and response
Bruce Power opened an indoor fire training facility in April 2015. This facility allows the industrial fire brigade to continually conduct live fire drills onsite. CNSC staff performed a fire drill inspection at Bruce A and B in 2015 to evaluate the response capabilities of the industrial fire brigade. CNSC staff concluded that Bruce Power continues to implement a comprehensive fire response capability that includes effective procedures, training and maintenance of proficiency.

3.1.1.11 Waste management

Based on the information assessed, CNSC staff concluded that the waste management SCA at Bruce A and B met or exceeded performance objectives and applicable regulatory requirements. As a result, each station received a "fully satisfactory" rating, unchanged from the previous year.

Bruce Power's waste management programs at Bruce A and B exceeded expectations in all specific areas for managing radioactive waste.

The OPG decommissioning plan for Bruce A and B was updated in 2012 and remains valid and current.

3.1.1.12 Security

Based on the information assessed, CNSC staff concluded that the security SCA at Bruce A and B met or exceeded performance objectives and all applicable regulatory requirements. As a result, each station received a "fully satisfactory" rating, unchanged from the previous year.

Response arrangements
CNSC staff noted that Bruce Power faced challenges with this specific area, especially as it relates to response force training. This can be directly tied to the need for effective management oversight and rigour of procedures in training practices. Corrective action

plans in response to compliance verification activities are being implemented to the satisfaction of CNSC staff.

Security practices
Bruce Power met or exceeded the regulatory requirements for security practices. It participated in the International Physical Protection Advisory Service (IPPAS) mission to Canada, which included contributing to a workshop in May 2015, responding to interviews and submitting to an international review of its practices in October 2015. It also hosted an incident command course and a World Institute for Nuclear Security (WINS) workshop for industry. Bruce Power is also moving forward on digital fingerprinting to improve its site access security clearance program.

Drills and exercises
Drills and exercises are an integral part of the Bruce Power security program. As part of its participation in the IPPAS mission to Canada, it conducted a security demonstration of its drills. Bruce Power also conducted an important emergency exercise involving significant security components and a large contingent of offsite response resources.

Cyber security
Bruce Power has implemented and continues to maintain an effective cyber security program. CNSC staff concluded that the program complied with applicable regulatory requirements.

3.1.1.13 Safeguards and non-proliferation

Based on the information assessed, CNSC staff concluded that the safeguards and non-proliferation SCA at Bruce A and B met performance objectives and all applicable regulatory requirements. As a result, each station received a “satisfactory” rating, unchanged from the previous year.

Nuclear material accountancy and control
Bruce Power complied with regulatory requirements of RD-336, *Accounting and Reporting of Nuclear Material* [57], at Bruce A and B.

Access and assistance to the IAEA
The International Atomic Energy Agency (IAEA) performed two short-notice random inspections at Bruce A and B to confirm the non-diversion of safeguarded nuclear materials and the absence of undeclared activities. Bruce Power provided support for these inspections, and CNSC staff were informed by the IAEA that the results of these inspections were satisfactory.

The IAEA did not select Bruce A and B for a physical inventory verification (PIV) in 2015. As a result, CNSC staff performed evaluations of Bruce A and B preparedness for a PIV in July 2015. From these evaluations, CNSC staff was satisfied that Bruce A and B would have been adequately prepared for an IAEA PIV had they been selected.

Operational and design information
Bruce Power submitted its annual operational program for Bruce A and B to the CNSC on time, with quarterly updates and an annual update to the information provided pursuant to the *IAEA Additional Protocol* [24].

Safeguards equipment, containment and surveillance
Bruce Power supported IAEA equipment operation and maintenance activities, including maintenance work on the IAEA VXI integrated fuel monitor and digital

multi-camera optical surveillance air conditioners, to ensure the effective implementation of safeguards measures at the site.

3.1.1.14 Packaging and transport

Based on the information assessed, CNSC staff concluded that the packaging and transport SCA at Bruce A and B met performance objectives and all applicable regulatory requirements. As a result, each station received a "satisfactory" rating, unchanged from the previous year.

Bruce Power has a packaging and transport program at Bruce A and B that ensures compliance with the *Packaging and Transport of Nuclear Substances Regulations*, 2015 and the *Transportation of Dangerous Goods Regulations*. The program is effectively implemented at both stations and the transport of nuclear substances to and from the facility is done in a safe manner.

3.1.2 Regulatory developments

3.1.2.1 Licensing

In February and April 2015, the Commission held a two-part public hearing on the application by Bruce Power to renew, for a period of five years, its power reactor operating licences for Bruce A and B. The Commission renewed the operating licences issued to Bruce Power as a single licence for both Bruce A and B, valid from June 1, 2015 to May 31, 2020.

Licence amendments

No amendments were made to the Bruce A and Bruce B power reactor operating licence. Table I.1 of appendix I reflects data about the issuance of a licence for both stations.

Revisions to the licence conditions handbook

No revisions were made to the Bruce A and B Licence Conditions Handbook (LCH) from June 2015 to April 2016. Table I.2 in appendix I shows no changes were made to the LCH during the reporting period.

3.1.2.2 Updates on major projects and initiatives

Bruce A EA environmental assessment follow-up monitoring program

Bruce Power continued to implement the Bruce A environmental assessment follow-up monitoring program related to its refurbishment project and to confirm there have been no significant adverse environmental effects as a result of this project. In 2015, Bruce Power's 2014 annual report verified the predictions of the environmental assessment and demonstrated that adequate progress is being made with the ongoing studies. The follow-up monitoring program is expected to conclude in 2016. CNSC staff continue to work with Environment and Climate Change Canada and Aboriginal groups on environmental issues that have arisen through the program, such as any potential effects on smallmouth bass and lake and round whitefish.

37M fuel project

The 37M fuel project was successfully implemented by Bruce Power. In 2015, CNSC staff reviewed all safety aspects for the modified 37M fuel bundles and approved Bruce Power's implementation of 37M fuel bundles at Bruce B without restriction.

End-of-life project activities and periodic safety review

REGDOC-2.3.3, *Periodic Safety Reviews* [34], issued in April 2015, sets out the regulatory requirements on how to conduct a periodic safety review (PSR). A PSR is a comprehensive evaluation of the design, condition and operation of an NPP.

The Bruce A PSR safety factor reports (SFRs) were submitted to the CNSC in August 2015. CNSC staff completed their review of the Bruce A PSR SFRs and concluded that Bruce Power has properly identified the strengths and gaps presented in the SFRs. However, CNSC staff also identified several additional strengths and gaps that need to be considered in Bruce Power's Global Assessment Report and Integrated Implementation Plan.

In January 2016, Bruce Power submitted a notification of intent to proceed with major component replacement at Bruce A and B. At that time, it also submitted to the CNSC the Bruce B PSR basis document in support of the continued operation of Bruce B. This PSR basis document is the first step in conducting the PSR for Bruce B and has been conditionally accepted by CNSC staff.

Operational Safety Review

In December 2015, Bruce Power participated in an operational safety review led by the IAEA Operational Safety Review Team (OSART) and focused on Bruce B. The OSART program has been in place since 1982 and provides a forum for countries to share best practices and support continuous improvement. OSART is independent from both Bruce Power and the CNSC.

The operational safety review report noted a number of good practices as well as some areas for improvement based on IAEA standards. As Bruce Power is meeting all current regulatory requirements, the recommendations and suggestions are considered to be improvements to existing safe practices. Some of the recommendations are being addressed through the development and implementation of new regulatory requirements, such as those found in the PSR and fitness for duty regulatory documents. The good practices identified will be carried forward and shared with other countries through future OSART reviews. The full OSART report is published on the Bruce Power website at brucepower.com/bruce-power-osart-report/.

3.1.2.3 Updates on significant regulatory issues

Fisheries Act authorization

Bruce Power, Fisheries and Oceans Canada (DFO) and CNSC staff have been meeting regularly to discuss the requirements under the *Fisheries Act* for Bruce A and B stations. Under the memorandum of understanding (MoU) between the CNSC and DFO, CNSC staff are reviewing this information and providing feedback to DFO. CNSC staff meet regularly with Bruce Power to discuss *Fisheries Act* requirements. The authority to issue an authorization remains within the mandate of the Minister of DFO.

In 2015, Bruce Power submitted to CNSC staff the "Draft Assessment on the need for a Department of Fisheries and Oceans (DFO) authorization" for the impingement and entrainment of fish. As the first project being reviewed under the MoU, this information was requested to support on-going discussions regarding the technical information of the application. After CNSC staff review, Bruce Power updated the self-assessment, clarified the technical data, and committed to completing the authorization application process, including Aboriginal engagement and information specific to the

quantification of fish loss. CNSC staff have reviewed this draft assessment and concluded that Bruce Power has correctly understood CNSC staff expectations.

In January 2016, Bruce Power presented to CNSC and DFO staff updated calculations of annual fish loss, production foregone and potential offsetting plans. Currently, this information is under review by CNSC and DFO staff.

Response to the Fukushima Daiichi accident

Following the development of the *CNSC Action Plan on the Lessons Learned from the Fukushima Daiichi Nuclear Accident*, CNSC staff established a project to oversee the implementation of the 36 Fukushima action items (FAIs) applicable to Canadian NPPs. These FAIs were based on the CNSC Task Force recommendations for strengthening reactor defence in depth and enhancing onsite emergency response. All FAIs needed to be adequately addressed by December 2015.

Two progress reports on the CNSC Action Plan were submitted by Bruce Power during the reporting period. Since the last reporting period, Bruce Power had requested closure of FAI 1.3.2 regarding the evaluation of means to prevent unfiltered releases. CNSC staff completed a review of the information provided and confirmed that the closure criteria of the FAI had been met.

CNSC staff confirmed that Bruce Power is prepared for potential emergencies and closed all FAIs in 2015. Follow-up implementation issues are being monitored by CNSC staff under site-specific action items.

Large loss-of-coolant accident margin restoration

The Bruce A and B units remain derated from full power (Bruce A at 92.5 percent and Bruce B at 93 percent) to ensure adequate safety margins are being maintained.

With the relicensing application, Bruce Power submitted analyses on the impact of aging on safety margins for large loss-of-coolant accidents (LOCAs), small LOCAs and loss of flow, covering the period up to 2019. CNSC staff completed the review of the large LOCA analysis and found it to be acceptable. The issues that require follow up will be addressed through normal compliance activities.

CNSC staff completed their assessment of the composite analytical approach that involves systematic reclassification of large LOCA events to the “beyond-design-basis accident” category based on extreme low frequency. During the continued development of the composite analytical approach, the licensing basis of the existing reactors for the large LOCA scenario will continue to be based on traditional conservative safety analysis.

Neutron overpower protection (NOP)

Neutron overpower protection (NOP) is composed of a number of fast-response, in-core detectors that provide measurements of neutron flux throughout the core. Bruce Power has affirmed that the current NOP trip setpoints are adequate for safe operation of Bruce A and B. CNSC staff agree with this statement due to a negligible risk to the stations’ protective physical barriers if a slow loss of regulation event were to occur.

3.1.2.4 Public communication

Event initial reports

One event initial report was submitted for Bruce A and B from January 2015 to April 2016.

This event is still under investigation and, therefore, its safety significance will be assessed and rated in the 2016 NPP Report.

Table 13: Event initial reports for Bruce A and B, 2015

Subject	Brief description
Bruce B, Unit 8. Worker injured while working on Unit 8 generator B-2016-28541536	On February 1, 2016, a worker was performing maintenance on the Unit 8 generator rotor, which had been removed from the generator. The worker was in the process of drilling a hole in a component of the rotor using normal procedures when a flash occurred, likely due to a hydrogen interaction. The worker suffered some burns to his arms, chest and face, and was promptly transported offsite to hospital. Work on the generator was stopped and the work area was quarantined. The Joint Health and Safety Committee and the Ontario Ministry of Labour were notified. All work at Bruce B stopped until each crew had a face-to-face safety discussion with their department manager. The Ministry's investigation is ongoing. This event was reported to Commission in April 2016. Bruce Power's corrective actions to resolve this issue were adequate.

Aboriginal consultation and engagement activities

CNSC staff and Bruce Power continued to work together and cooperate with the Aboriginal peoples in the Bruce Peninsula region with respect to nuclear projects and to ensure personnel safety and environmental protection. Bruce Power values its relationships with Aboriginal peoples and their communities, and strives to keep the three Aboriginal groups identified (Saugeen Ojibway Nation, Historic Saugeen Métis and Métis Nation of Ontario) up to date on its operations and informed on regulatory matters.

In 2015, Bruce Power distributed the aforementioned draft assessment on the need for a DFO authorization to these three Aboriginal groups. Bruce Power will continue to engage these groups with respect to activities related to its operations.

3.2 Darlington

Darlington Nuclear Generating Station is located on the north shore of Lake Ontario, in the Municipality of Clarington, ON. The facility is located five kilometres outside the town of Bowmanville and about 10 kilometres southeast of Oshawa. The facility is owned by Ontario Power Generation (OPG).

Construction of the facility started in 1981 and the first criticality of a reactor unit was in 1989. The nuclear facility consists of four CANDU reactors, with each reactor rated at 881 MWe (megawatts electrical), as well as a tritium removal facility.

3.2.1 Safety assessment

The CNSC staff safety assessment of Darlington for 2015 resulted in the performance ratings as shown in table 14. Based on the observations and assessments of the SCAs, CNSC staff concluded that Darlington operated safely. The integrated plant rating was "fully satisfactory", unchanged from the previous year.

Table 14: Performance ratings for Darlington, 2015

Safety and control area	Rating	Industry average*
Management system	SA	SA
Human performance management	SA	SA
Operating performance	FS	FS
Safety analysis	FS	SA
Physical design	SA	SA
Fitness for service	SA	SA
Radiation protection	FS	SA
Conventional health and safety	FS	FS
Environmental protection	SA	SA
Emergency management and fire protection	SA	SA
Waste management	FS	FS
Security	SA	SA
Safeguards and non-proliferation	SA	SA
Packaging and transport	SA	SA
Integrated plant rating	FS	SA

* Industry average of all operating NPPs in Canada

Notes:

- For specific areas within the SCAs where there were no significant observations from CNSC staff compliance verification activities, no information is given in this subsection of the report.

- The information presented below is station specific; refer to section 2 for general trends and industry-wide observations).

3.2.1.1 Management system

Based on the information assessed, CNSC staff concluded that the management system SCA at Darlington met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Management system
CNSC staff determined that the OPG management system at Darlington complied with the requirements of CSA standard N286-05, *Management system requirements for nuclear power plants* [7].

Organization
OPG completed the transition to a centre-led matrix organizational structure through its business transformation initiatives. OPG has committed to revise several top-tier governing documents pertaining to management system and organization. CNSC staff will review these revised documents upon submission.

Safety Culture
OPG follows an established process for self-assessments of safety culture at planned intervals. OPG completed its most recent safety culture self-assessment at Darlington in 2015. While this assessment was not formally evaluated by CNSC staff, OPG did provide the CNSC with the methodology used as well as a summary of the results and follow-up activities. CNSC staff will continue to monitor these assessments and the resulting initiatives.

Configuration management
CNSC staff identified deficiencies of low safety significance in the area of configuration management at Darlington during planned inspection activities. OPG is preparing a corrective action plan that will be reviewed by CNSC staff once it is received in November 2016.

Records management
CNSC staff identified deficiencies of low safety significance in the area of records management at Darlington during planned inspection activities. OPG is preparing a corrective action plan that will be reviewed by CNSC staff once it is received in November 2016.

Management of contractors
Compliance activities performed at Darlington in 2015 confirmed that the interfaces between OPG and its contractors are planned, defined, controlled and understood in accordance with regulatory requirements.

3.2.1.2 Human performance management

Based on the information assessed, CNSC staff concluded that the human performance management SCA at Darlington met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Human performance program

CNSC staff assessed OPG's human performance program and concluded Darlington is in compliance with the regulatory requirements of CSA standard N286-05, *Management system requirements for nuclear power plants* [7].

Personnel training

OPG has a well-documented and robust fleet-wide training system based on the systematic approach to training. Implementation of this system for the training programs at Darlington met regulatory requirements.

Personnel certification

In accordance with regulatory requirements, OPG has a sufficient number of personnel at Darlington for all certified positions. CNSC staff are satisfied that OPG's program assures the competency of personnel at Darlington to receive certification and perform their duties safely.

Initial certification examinations and requalification tests

The initial certification examinations and requalification tests program for the certified staff at Darlington met all regulatory requirements.

In 2015, CNSC staff conducted an inspection of the design, verification, conduct and grading of a simulator-based certification examination. CNSC staff concluded that OPG met its program and regulatory requirements.

Work organization and job design

Minimum shift complement

To ensure safe operation and adequate emergency response capability, OPG has implemented an effective process at Darlington to ensure a sufficient number of qualified workers are available at the facility at all times. OPG uses the minimum complement coordination program to track the availability of minimum complement and ensure that even short-duration minimum shift complement violations are avoided.

Fitness for duty

OPG has procedures in place to manage the impact of fatigue on worker performance and has measures in place to ensure fitness for duty. Information submitted by OPG indicated that it met applicable hours-of-work requirements at Darlington.

3.2.1.3 Operating performance

Based on the information assessed, CNSC staff concluded that the operating performance SCA at Darlington met or exceeded performance objectives and all applicable regulatory requirements. As a result, the station received a "fully satisfactory" rating, unchanged from the previous year.

Conduct of licensed activities

OPG continued to operate Darlington with a high level of performance. OPG operated within the limits of the Darlington licence, the operating policies and principles and the operational safety requirements.

Darlington experienced one unplanned reactor trip, no stepbacks and two setbacks.

It should be noted that the power transients were controlled properly by OPG and that stepbacks and setbacks address issues at domains far below those of regulatory concern. Consequently, there was no impact on nuclear safety.

The power history graphs for the Darlington nuclear reactor units for 2015 can be seen in appendix G. These graphs show the occurrences (and causes) of outages and the associated power reductions during the year.

Inspections conducted by CNSC staff (including field and control room inspections) identified no significant operations-related compliance issues. OPG was found to be compliant with its governing procedures, documents and regulatory requirements.

Procedures
OPG has governance in place that ensures procedures are written in a consistent and usable manner. Darlington has clearly documented expectations for procedural use and adherence, and a process is in place to manage procedural change.

Based on compliance verification activities carried out by CNSC staff in 2015, it was noted that OPG's procedures at Darlington comply with the regulatory requirements.

Reporting and trending
OPG is required to submit quarterly reports on operations and performance indicators as described in REGDOC 3.1.1, *Reporting Requirements for Nuclear Power Plants* [62]. It is also required to follow up on all events with corrective actions and root cause analysis, when appropriate. CNSC staff did not identify any significant regulatory issues from these reports.

Outage management performance
Darlington scheduled three planned outages and experienced six forced outages. Details of these outages are provided in appendix G. Darlington continues to demonstrate high levels of performance and achievement of objectives during outages. OPG followed up appropriately on all planned and forced outages. All outage-related undertakings, including heat sink strategy management at Darlington, were performed safely by OPG staff.

Safe operating envelope
OPG has completed the implementation of the safe operating envelope based on the requirements of CSA standard N290.15, *Requirements for the safe operating envelope of nuclear power plants* [63]. The safe operating envelope is now in its maintenance phase and meets applicable regulatory requirements.

Tritium removal facility
Darlington is the only NPP in Canada that operates a tritium removal facility. Tritium builds up gradually in some plant systems as a result of day-to-day operations. Removing the tritium minimizes the amount released into the environment and reduces the potential radiation exposure of workers. The tritium is extracted from the reactor's heavy water and stored safely in stainless steel containers within a concrete vault. The operation of the tritium removal facility did not exceed any environmental limits.

3.2.1.4 Safety analysis

Based on the information assessed, CNSC staff concluded that the safety analysis SCA at Darlington met or exceeded performance objectives and all applicable regulatory requirements. As a result, the station received a "fully satisfactory" rating, an improvement over the "satisfactory" rating of the previous year.

Deterministic safety analysis
The CNSC performed an assessment of the implementation of the OPG safety analysis program in December 2015. This covered the programmatic elements of the management of deterministic and probabilistic safety analysis as required by the

Pickering and Darlington licence condition handbooks (LCHs). The assessment concluded that OPG is showing a strong commitment to safety through its safety analysis program. Minor areas for improvement were noted, however, primarily in the area of formal verification of access to safety analysis expertise in the long term. The results of the assessment were documented and communicated to OPG.

The assessment concluded that OPG shows a strong commitment to safety throughout the safety analysis program.

Probabilistic safety analysis

OPG is in compliance with S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [30], and is transitioning toward implementation at Darlington of the recently published REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [12].

3.2.1.5 Physical design

Based on the information assessed, CNSC staff concluded that the physical design SCA at Darlington met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Design governance

Environmental qualification

The environmental qualification program is fully implemented in all Darlington operating units. Darlington demonstrated compliance with its governing document by maintaining the sustainability of its environmental qualification program.

System design

Electrical power systems

There were no significant reportable events during the year that had an effect on the electrical power systems at Darlington. An inspection performed by CNSC staff confirmed that all classes of power systems are being maintained and tested to ensure they will be able to perform their design functions. Areas for improvement have been identified related to battery testing, Class 2 bus maintenance, documentation revision and Class 3 standby generator mission-time testing. However, these issues are of low safety significance. OPG is addressing these issues. To date, two action notices have been closed with updates on the remaining three expected from OPG by the end of August 2016. CNSC staff will continue to monitor OPG's performance in this area as part of the compliance verification program.

Fire protection design

CNSC staff conducted ongoing oversight activities at Darlington in 2015, including specialist document reviews and inspections. CNSC staff concluded that Darlington's fire protection program is both comprehensive and in compliance with the requirements of CSA standard N293-07, *Fire protection for CANDU nuclear power plants* [32].

Components design

Fuel design

OPG has a well-developed reactor fuel inspection program. Fuel performance at Darlington was acceptable in 2015. OPG's corrective action program for the defect excursion noted in 2014 has been implemented and is effective. CNSC staff considers

the OPG fuel program to be robust and that OPG is able to adequately manage issues while maintaining safe operations.

Cables

OPG has a fully implemented cable surveillance program, supplemented with a cable aging program, to focus on safety-related issues for operationally important cables.

In November 2015, OPG addressed and resolved the remaining area for improvement with respect to qualification of the last EQ cables types.

3.2.1.6 Fitness for service

Based on the information assessed, CNSC staff concluded that the fitness for service SCA at Darlington met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Equipment fitness for service /equipment performance

On the basis of inspections and compliance verifications, CNSC staff concluded that the overall equipment fitness for service and performance at Darlington was satisfactory and met regulatory requirements.

Maintenance

The maintenance program met regulatory requirements and performance objectives. The average preventive maintenance completion ratio (PMCR) for the four units at Darlington was 90 percent.

The 2015 maintenance backlog results for Darlington are given in table 15. The corrective critical maintenance backlog, deficient critical maintenance backlog and number of deferrals of critical component preventive maintenance were all less than the industry average. Maintenance programs and program backlogs are monitored by CNSC staff through desktop reviews and compliance monitoring inspections.

CNSC staff will continue to monitor the trends in these indicators.

Table 15: Maintenance backlogs and deferrals for critical components for Darlington

Parameter	Average work orders per unit for the year	Trend during the year	Industry average
Corrective maintenance backlog	5	down	11
Deficient maintenance backlog	75	down	117
Deferrals of preventive maintenance	9	stable	49

Structural integrity

OPG inspected selected Darlington Unit 3 pressure boundary and containment components in 2015. The pressure boundary inspections covered elements of the primary heat transport and auxiliary systems, feeders and pressure tubes. As part of their compliance monitoring activities, CNSC staff performed desktop reviews of inspection reports as well as a compliance monitoring inspection of the vacuum building test. CNSC staff concluded that the structures, systems and components important for safe operation at Darlington met structural integrity requirements.

OPG continued with the implementation of the Fuel Channel Life Management Project to further the development of the analytical tools necessary to demonstrate pressure tube fitness for service for continued operation.

Reliability of systems important to safety
All special safety systems for Darlington Units 1– 4 met their unavailability targets in 2015.

Aging management
OPG has implemented an integrated aging management program to ensure the condition of the structures, systems and components important to safety is well understood and that the required activities are in place to assure their health as the plant ages. CNSC staff concluded that OPG's program met regulatory requirements.

In addition to the integrated aging management program, OPG has implemented lifecycle management plans for the major pressure boundary components, including fuel channels, feeders and steam generator tubes, and containment components and structures. CNSC staff compliance monitoring activities in 2015 were primarily in the form of desktop reviews of OPG submissions related to program governance and implementation.

OPG is in the process of updating its aging management governance and processes to meet the requirements of REGDOC-2.6.3, *Aging Management* [16], with full implementation expected in 2017.

Periodic inspections and testing
OPG has adequate periodic inspection programs (PIPs) in place at Darlington for the pressure boundary and containment components important to safety.

CNSC staff monitored compliance with the established regulatory requirements for PIPs during the year and concluded that their implementation met regulatory requirements.

OPG is in the process of updating its PIP for pressure boundary components to comply with the 2014 edition of CSA standard N285.4, *Periodic inspection of CANDU nuclear power plant components* [18]. Full implementation of the updated program requirements is expected by 2019.

3.2.1.7 Radiation protection

Based on the information assessed, CNSC staff concluded that the radiation protection SCA at Darlington met or exceeded performance objectives and all applicable regulatory requirements. As a result, the station received a "fully satisfactory" rating, unchanged from the previous year.

Application of ALARA
OPG continued to implement a highly effective, well-documented and mature program, based on industry best practices, to keep doses as low as reasonably achievable (ALARA) at Darlington. Compliance activities conducted by CNSC staff verified that, through numerous ALARA initiatives, work planning, and dose monitoring and control, Darlington continued to meet the challenging ALARA targets established by OPG.

Safety performance indicators related to the application of ALARA include tracking of collective radiation exposure values for the station. The values provided by OPG align with the Darlington dose targets.

Worker dose control

OPG continued to comply with the regulatory requirements to measure and record doses received by workers at Darlington. Routine compliance verification activities indicate that performance in the area of worker dose control at Darlington is effective. No worker or member of the public received a radiation dose in excess of the regulatory dose limits or action levels established in the Darlington radiation protection program. The data for doses received at Darlington can be found in section 2.1.7 and appendix E.2.

Safety performance indicators related to worker dose control include tracking of occurrences involving doses received from unplanned exposures or uptakes. No worker received a dose resulting from an unplanned exposure or tritium uptake at Darlington in 2015.

Radiation protection program performance

Darlington has implemented OPG's corporate radiation protection program, which satisfies the requirements of the *Radiation Protection Regulations* and includes performance indicators to monitor program performance. Program documents and supporting procedures are kept current, taking into consideration operating experience and industry best practices.

Challenging goals and targets have been established and initiatives have been implemented to ensure the continuous improvement of OPG's highly effective radiation protection program. The program documents and the oversight applied by OPG in their implementation have ensured the protection of workers at Darlington.

Routine compliance verification activities indicate that Darlington is highly effective in the area of radiation protection program performance.

Radiological hazard control

No action levels were exceeded for surface contamination at Darlington in 2015.

CNSC staff conducted a compliance inspection of radiological hazard control in 2015. CNSC staff identified opportunities for improvement in the areas of station radiological source term characterization and the installation of air monitoring equipment. CNSC staff are reviewing the OPG responses to the action notices and further compliance activities have been scheduled, to verify compliance.

CNSC staff are satisfied that no safety significant incidents or adverse trends were identified through reporting of safety performance indicators.

Estimated dose to the public

OPG continued to ensure the protection of members of the public in accordance with the *Radiation Protection Regulations*. The reported estimated dose to a member of the public from Darlington was 0.0005 mSv, well below the annual public dose limit of 1 mSv.

3.2.1.8 Conventional health and safety

Based on the information assessed, CNSC staff concluded that the conventional health and safety SCA at Darlington met or exceeded performance objectives and all applicable regulatory requirements. As a result, the station received a "fully satisfactory" rating, an improvement over the "satisfactory" rating of the previous year.

Performance
As reported by OPG, the accident severity rate (ASR) for Darlington decreased from 4.4 in 2014 to 0.2 in 2015, while the accident frequency (AF) decreased slightly from 0.24 in 2014 to 0.23 in 2015. The ASR is equal to the industry average while the AF for Darlington is the lowest for Canadian NPPs.

Practices
OPG was compliant at Darlington with the relevant provisions of the *Occupational Health and Safety Act* of *Ontario and the Labour Relations Act*.

Awareness
OPG continued to maintain a safe and efficient working environment at Darlington. The station was clean and tidy, although various instances of improperly stored transient material, including combustibles and hazardous materials, were noted. OPG's performance in this area in 2015 met the CNSC expectations and OPG has completed corrective actions with respect to scaffolding and storage of ladders.

3.2.1.9 Environmental protection

Based on the information assessed, CNSC staff concluded that the environmental protection SCA at Darlington met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Effluent and emissions control
All radiological releases from Darlington remained well below regulatory limits.

OPG completed the implementation of CSA standard N288.5, *Effluent monitoring programs at Class 1 Nuclear Facilities and Uranium Mines and Mills* [35] in December 2015.

The derived release limits for Darlington are provided in appendix E.2.

Environmental management system (EMS)
OPG has established and implemented an environmental management program to assess environmental risks associated with its nuclear activities and to ensure these activities are conducted in a way that prevents or mitigates adverse environmental effects.

Assessment and monitoring
CNSC staff reviewed and assessed the Darlington environmental monitoring data and did not identify any unreasonable risk to the public or the environment.

Protection of the public
There were no hazardous substances released from Darlington that posed an unacceptable risk to the environment or the public.

The reported annual radiation dose to the public from Darlington remained very low at 0.05 percent of the public dose limit.

Environmental risk assessment
OPG continued to maintain and implement an effective environmental risk assessment and management program at Darlington in accordance with regulatory requirements.

OPG is in the process of documenting an environmental risk assessment at Darlington consistent with CSA standard N288.6-12, *Environmental risk assessments at Class I*

nuclear facilities and uranium mines and mills [21]. This risk assessment continued to be informed by baseline monitoring results and reports from the Darlington refurbishment environmental assessment.

A round whitefish population survey was conducted by the Ontario Ministry of Natural Resources and Forestry in partnership with OPG along the north-central shoreline of Lake Ontario near Darlington and Pickering. Results of this population study, which is expected to be completed by 2016, will help inform ongoing management of the round whitefish.

3.2.1.10 Emergency management and fire protection

Based on the information assessed, CNSC staff concluded that the emergency management and fire protection SCA at Darlington met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Conventional emergency preparedness and response

Regulatory oversight activities conducted by CNSC staff at Darlington in 2015 included documentation reviews, onsite observations and participation in drills. OPG maintained its conventional emergency preparedness and response commitments, including enhancements to its emergency (non-nuclear) drill program.

Nuclear emergency preparedness and response

OPG continues to demonstrate its preparedness to respond to a nuclear emergency at the Darlington site. It has successfully pre-distributed potassium iodide (KI) tablets within the primary zone, stockpiled KI tablets for the secondary zone and disseminated pamphlets to local residents around the plant, enhancing public awareness of nuclear emergency preparedness and response around the plant.

Fire emergency preparedness and response

Regulatory oversight activities conducted by CNSC staff at Darlington in 2015 included documentation reviews, onsite observations and participation in drills. CNSC staff concluded that Darlington continues to implement a comprehensive fire response capability that includes effective procedures, training and maintenance of proficiency.

3.2.1.11 Waste management

Based on the information assessed, CNSC staff concluded that the waste management SCA at Darlington met or exceeded performance objectives and all applicable regulatory requirements. As a result, the station received a "fully satisfactory" rating, unchanged from the previous year.

OPG's waste management programs at Darlington exceeded expectations for managing radioactive waste.

OPG's decommissioning plan for Darlington was updated in 2012 and remains valid and current.

3.2.1.12 Security

Based on the information assessed, CNSC staff concluded that the security SCA at Darlington met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, which is lower than the "fully satisfactory" obtained in 2014.

Facilities and equipment/Drills and Exercises
OPG met its regulatory requirements for these two areas. Adequate corrective action plans are being implemented in response to reportable events and inspection findings.

Response arrangements
CNSC staff noted that OPG faced challenges in this area related to elements of training.

Through their compliance verification activities, CNSC staff observed that some elements of the response force need improvement. These issues are being addressed by OPG to the satisfaction of CNSC staff.

Cyber security
OPG has implemented and continues to maintain an effective cyber security program at Darlington. CNSC concluded that the program complied with applicable regulatory requirements.

3.2.1.13 Safeguards and non-proliferation

Based on the information assessed, CNSC staff concluded that the safeguards and non-proliferation SCA at Darlington met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Nuclear material accountancy and control
OPG complied with regulatory requirements at Darlington in accordance with RD-336, *Accounting and Reporting of Nuclear Material* [25].

Access and assistance to the IAEA
The International Atomic Energy Agency (IAEA) performed a physical inventory verification and a design information verification at Darlington in 2015 to confirm the non-diversion of safeguarded nuclear materials and the absence of undeclared activities. The facility provided support for these inspections and CNSC staff were informed by the IAEA that the results of these inspections were satisfactory.

Operational and design information
OPG submitted its annual operational program for Darlington to the CNSC on time, along with quarterly updates and the annual update to the information pursuant to the IAEA Additional Protocol [24].

Safeguards equipment, containment and surveillance
OPG supported IAEA equipment operation and maintenance activities at Darlington, including maintenance and repair work on remote monitoring components, to ensure the effective implementation of safeguards measures at the station.

3.2.1.14 Packaging and transport

Based on the information assessed, CNSC staff concluded that the packaging and transport SCA at Darlington met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

OPG has a packaging and transport program at Darlington that ensures compliance with the *Packaging and Transport of Nuclear Substances Regulations, 2015* and the *Transportation of Dangerous Goods Regulations*. This program is effectively implemented at the Darlington site and the transport of nuclear substances to and from the facility is done in a safe manner.

3.2.2 Regulatory developments

3.2.2.1 Licensing

OPG's licence for Darlington was renewed in December 2015 for a 10-year period (effective until November 30, 2025). The Darlington licence has been issued with an accompanying LCH.

In December 2013, OPG submitted an application to the Commission for the renewal of the power reactor operating licence for Darlington. This was followed by a request in June 2014 to amend the operating licence by one year to allow OPG sufficient time to provide additional material to support the December 2013 licence renewal application and to allow the public adequate time to review this additional material. In July 2014, the Commission approved an amendment of the operating licence until December 31, 2015. In December 2014, OPG submitted an updated application for the renewal of the operating licence for Darlington. The two-part public hearing took place in Ottawa, ON in August 2015 and in Courtice, ON in November 2015.

Licence amendments

No amendments were made to the Darlington licence in 2015. Table I.3 in appendix I provides details on the issuance of the licence for Darlington.

Revisions to the licence conditions handbook

Darlington's previous LCH was issued on March 1, 2013. Two revisions were made to it between January 2015 and December 2015 (when it was replaced by the current LCH that was issued with the new licence). These revisions were issued primarily to refer to newly published CNSC regulatory documents and updated OPG documents. The changes were mostly technical in nature; details of the significant changes are provided in appendix I.

CNSC staff issued Darlington's current LCH on January 1, 2016. No revisions have been made since its issuance.

The revisions to the LCH were approved by the Director General of the CNSC's Directorate of Power Reactor Regulation. The changes have not resulted in an unauthorized change of scope and remain within the licensing envelope.

Environmental assessment screening regarding the proposal to refurbish and continue to operate Darlington

In December 2012, a Commission hearing was held on the environmental assessment screening report. The Commission accepted the screening report and issued the record of decision in March 2013. That decision was subsequently challenged through an application for judicial review in the Federal Court of Canada.

On April 13, 2016, the Federal Court of Appeal dismissed the appeal on the Federal Court decision to dismiss the application for judicial review for the environmental assessment (EA) decision on the refurbishment and continued operation of the Darlington Nuclear Generating Station.

The appeal was brought in November 2014 by Greenpeace Canada, the Canadian Environmental Law Association, Lake Ontario Waterkeeper and Northwatch. They claimed that the Federal Court erred in rejecting their application for judicial review because the Responsible Authorities who conducted the assessment unreasonably excluded severe low probability nuclear accidents from the scope of the assessment and

unreasonably failed to give adequate consideration to the long term management of nuclear fuel waste that the Darlington Facility will generate.

The Federal Court of Appeal did not agree. In its decision, among other points, the court stated that "…the CNSC is much better placed than a reviewing court to factually assess and determine what types of possible accidents are likely to occur at a nuclear power plant and how to conduct the assessment of the environmental impacts of potential accidents. It is therefore inappropriate for a reviewing court to second-guess these determinations through a detailed re-examination of the evidence as the appellants would have us do in the instant case."

Study of consequences of a hypothetical severe nuclear accident and effectiveness of mitigation measures

In the Commission's *Record of Proceedings, Including Reasons for Decision* [36] for the environmental assessment screening regarding the proposal to refurbish and continue to operate Darlington, the Commission requested CNSC staff to assess the health and environmental consequences of severe accident scenarios to address the concerns raised during the December 2012 public hearing. CNSC staff (with contributions from OPG, Pacific Northwest National Laboratories and Dr. L. Zablotska) completed the assessment, which is titled *Study of Consequences of a Hypothetical Severe Nuclear Accident and Effectiveness of Mitigation Measures* [37]. Details of the assessment were presented to the Commission at the June 19, 2014 public meeting.

A number of conservative assumptions were made in the study, which contributed to an overestimation of risk. There were assumptions about the progression of the accident (i.e., it was assumed releases happen) and about the human health risk assessment (i.e., overestimation of dose due to modelling as opposed to direct measurements).

Based on the results of this theoretical study, regardless of the scenario examined, dose would decrease rapidly with distance. The highest doses would occur at one kilometre from the plant, an area that is within OPG's property boundary. Furthermore, for all scenarios examined in this study, the emergency planning zones established under the Ontario Provincial Nuclear Emergency Response Plan, using the established evacuation criteria, would generally be sufficient in size to accommodate the evacuation needed. The radiological impact as a result of this theoretical study is equivalent to the Fukushima Daiichi accident, categorized at International Nuclear and Radiological Event Scale Level 7. The study did not take into account enhancements in the plant's design, operating provisions, accident management and emergency preparedness resulting from the CNSC Integrated Action Plan [5]. These ongoing enhancements would ensure that the likelihood of a severe accident is further reduced and, if it were to occur, emergency response measures would be effective in mitigating offsite releases.

The study was made available for public comments from June 4 to August 29, 2014, with 505 comments received. CNSC staff reviewed and dispositioned the comments and presented the updated report to the Commission on March 26, 2015. The updated report was published on the CNSC website in September 2015.

3.2.2.2 Updates on major projects and initiatives

Refurbishment/life extension

CNSC staff completed the assessment and have accepted OPG's global assessment report and integrated implementation plan (IIP) on condition that OPG make specific changes to the IIP. OPG submitted a revised IIP that incorporated the feedback from

CNSC staff. The revised IIP was presented to the Commission as part of the Darlington licence renewal hearing in August 2015.

End-of-life project activities and periodic safety review

On December 23, 2015, the Commission renewed Darlington's licence as the first 10-year licence issued to a Canadian NPP. This licensing period is based on work completed under the integrated safety review and the recently implemented requirements pertaining to periodic safety reviews (PSR) as defined in REGDOC-2.3.3, *Periodic Safety Reviews* [34]. The primary goal of REGDOC-2.3.3 is to perform a comprehensive evaluation of the design, conditions and operation of an NPP to effectively obtain an overall view of actual plant safety and the quality of safety documentation, and to determine reasonable and practical improvements to ensure safety until the next PSR is undertaken or until the end of commercial operation. PSRs have been effective in achieving improvements in safety and in support of licence renewal to ensure the continued improvement of plant safety. Application of a PSR is seen as an evolution of current practice based on past experiences with life-extension projects.

Darlington refurbishment environmental assessment follow-up program

As directed by the record of decision on the Darlington refurbishment environmental assessment, OPG developed a more detailed follow-up program in consultation with the CNSC, Fisheries and Oceans Canada (DFO) and other stakeholders. It issued this program in October 2013. OPG continues to work with the CNSC, DFO and Environment and Climate Change Canada (ECCC) on detailed sampling plans for the pre-refurbishment and refurbishment phases regarding aquatic matters. Several of these studies will be completed before the first unit refurbishment outage execution, which is planned to begin in 2016.

As part of the environmental assessment follow-up, OPG is developing a thermal monitoring program to be implemented during refurbishment and continued operations. This program considers the results of research on thermal effects on round whitefish eggs. The study was published by the CANDU Owners Group (COG) in 2014 and submitted to CNSC, ECCC and DFO staff. CNSC staff are currently reviewing the study report in collaboration with ECCC.

OPG also continued to participate in the round whitefish action plan with the CNSC, DFO, ECCC and the Ontario Ministry of Natural Resources and Forestry.

3.2.2.3 Updates on significant regulatory issues

***Fisheries Act* authorization**

Darlington impinges and entrains fish of many species despite the use of an offshore, submerged, porous-veneer velocity-cap intake. In response to a commitment made during the Darlington refurbishment EA, OPG submitted to DFO an application for authorization pursuant to the *Fisheries Act*. A DFO *Fisheries Act* authorization was issued to OPG on June 24, 2015. Under the CNSC-DFO Memorandum of Understanding, CNSC staff are responsible for and continue to ensure compliance with the *Fisheries Act* authorization. The *Fisheries Act* authorization contains a reporting condition on the offset plan to both DFO and CNSC staff.

Response to the Fukushima Daiichi accident

OPG has made considerable progress in addressing Fukushima action items (FAIs) at Darlington and Pickering. As of January 2015, all FAIs applicable to OPG stations have been closed (see appendix H).

CNSC staff concluded that OPG has strengthened reactor defence in depth and enhanced its emergency response at Darlington and Pickering stations in response to lessons learned from the Fukushima nuclear accident.

OPG has committed to additional future safety improvements under the refurbishment project for Darlington, many of which are targeted for completion prior to the first unit refurbishment begins in 2016. These include the provision of a containment filtered venting system for a severe accident and the installation of a third emergency power generator.

As part of its continuous improvement efforts, OPG had committed to assessing the feasibility or potential benefits of accelerating the transfer of spent fuel from the irradiated fuel bays (IFBs) to dry storage containers at its nuclear facilities, moving from the current 10-year retention period in the IFBs to a six-year retention period. Currently, there appear to be no safety drivers that mandate the accelerated transfer of spent fuel from wet to dry storage. However, OPG is committed to updating the Commission on this issue by the end of 2016.

CNSC staff will continue to monitor FAI implementation at Darlington through the established compliance verification program.

3.2.2.4 Public communication

Event initial reports

One event initial report was submitted for Darlington from January 2015 to April 2016. The event had low safety significance.

Table 16: Event initial reports for Darlington

Subject	Brief description
Heavy water leak during maintenance at Darlington NGS	On April 14, 2015, a leak of heavy water from the Unit 2 D2O transfer system occurred from a disassembled valve during planned maintenance. Control room operators were able to quickly diagnose the event and isolate the leak per procedures. Unit 2 was shut down normally without any operational or safety issues. Approximately 7,000 litres of heavy water spilled from piping and was contained in two rooms within drain tanks located in confinement. There was no contamination of the maintainers at the site of the leak because they were wearing appropriate protective equipment and followed applicable procedures on initiation of the leak. This event was reported to the Commission through CMD 15-M21 on June 17, 2015.

3.3 Pickering

Pickering Nuclear Generating Station is located on the north shore of Lake Ontario in Pickering, ON. The facility lies 32 kilometres northeast of Toronto and 21 kilometres southwest of Oshawa. The facility is owned by Ontario Power Generation (OPG).

The nuclear facility consists of eight CANDU reactors. Units 2 and 3 are not operating. These two units were defuelled in 2008 and will be maintained in safe storage until the eventual decommissioning of the Pickering station.

Each operating reactor for Units 1 and 4 has a gross electrical output of 542 MWe (megawatts electrical). Each operating reactor for Units 5–8 has a gross electrical output of 540 MWe.

Construction of the facility started in 1966 and the first criticality of a reactor unit was in 1971. The in-service dates ranged from 1971 to 1973 for Units 1–4, and from 1983 to 1986 for Units 5 to 8.

3.3.1 Safety assessment

The CNSC staff safety assessment of Pickering for 2015 resulted in the performance ratings as shown in table 17. Based on the observations and assessments of the SCAs, CNSC staff concluded that Pickering operated safely. The integrated plant rating was "fully satisfactory", an improvement over the "satisfactory" rating of the previous year.

Table 17: Performance ratings for Pickering, 2015

Safety and control area	Rating	Industry average*
Management system	SA	SA
Human performance management	SA	SA
Operating performance	FS	FS
Safety analysis	FS	SA
Physical design	SA	SA
Fitness for service	SA	SA
Radiation protection	FS	SA
Conventional health and safety	FS	FS
Environmental protection	SA	SA
Emergency management and fire protection	SA	SA
Waste management	FS	FS
Security	SA	SA
Safeguards and non-proliferation	SA	SA
Packaging and transport	SA	SA
Integrated plant rating	FS	SA

* The industry average of all operating NPPs in Canada

Notes:

- For specific areas within the SCAs where there were no significant observations from CNSC staff compliance verification activities, no information is given in this subsection of the report.
- The information presented below is station specific; refer to section 2 for general trends and industry-wide observations.

3.3.1.1 Management system

Based on the information assessed, CNSC staff concluded that the management system SCA at Pickering met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Management system

CNSC staff determined that the OPG management system complied with the requirements of CSA standard N286-05, *Management System requirements of nuclear power plants* [7].

Organization

OPG completed the transition to a centre-led matrix organizational structure through its business transformation initiatives. OPG has committed to revising several top-tier governing documents pertaining to its management system and organization. CNSC staff will review these revised documents upon submission.

Safety culture

OPG follows an established process for self-assessments of safety culture at planned intervals. OPG completed its most recent safety culture self-assessment at Pickering in 2015. While this assessment was not formally evaluated by CNSC staff, OPG did provide the CNSC with the methodology used as well as a summary of the results and follow-up activities. CNSC staff will continue to monitor these assessments and the resulting initiatives.

Configuration management

Through compliance activities, CNSC staff identified minor deficiencies with position assured component control and work protection barriers. OPG provided a corrective action plan and many of the corrective actions have been completed. The CNSC will continue to monitor OPG progress on this issue in 2016.

Management of contractors

CNSC staff identified some deficiencies as a result of minor non-compliances associated with supplier evaluation and qualification as well as handling and storage practices. OPG responded with a corrective action plan and has since completed implementation of all corrective actions.

3.3.1.2 Human performance management

Based on the information assessed, CNSC staff concluded that the human performance management SCA at Pickering met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Human performance program

CNSC staff assessed OPG's human performance program and concluded that Pickering is in compliance with the regulatory requirements of CSA standard N286-05, *Management system requirements for nuclear power plants* [7].

Personnel training

OPG has a well-documented and robust fleet-wide training system based on the systematic approach to training. Implementation of this system for the training programs at Pickering met regulatory requirements.

Personnel certification

In accordance with regulatory requirements, OPG has sufficient certified personnel at Pickering for all certified positions. CNSC staff are satisfied that OPG's program assures the competency of personnel at Pickering to receive certification and perform their duties safely.

Initial certification examinations and requalification tests

The initial certification examination and requalification test program for certified staff at Pickering met all regulatory requirements.

Work organization and job design

Minimum shift complement

To ensure safe operation and adequate emergency response capability, OPG has implemented an effective process at Pickering to ensure a sufficient number of qualified workers are available at the facility at all times. OPG uses the minimum complement coordination program to track the availability of minimum complement and ensure that even short-duration minimum shift complement violations are avoided.

Fitness for duty

OPG has procedures in place to manage the impact of fatigue on worker performance and has measures in place to ensure fitness for duty. Information submitted by OPG indicated that it met applicable hours-of-work requirements at Pickering.

3.3.1.3 Operating performance

Based on the information assessed, CNSC staff concluded that the operating performance SCA at Pickering met or exceeded performance objectives and all applicable regulatory requirements. As a result, the station received a "fully satisfactory" rating, an improvement over the "satisfactory" rating of the previous year.

Conduct of licensed activities

OPG continued to operate Pickering with a high level of performance. OPG operated within the limits of the Pickering licence, the operating policies and principles and the operational safety requirements.

Pickering Units 1 and 4 experienced no unplanned reactor trips and two setbacks. (These two reactors do not have stepbacks.) Pickering Units 5–8 experienced one unplanned reactor trip, one stepback and no setbacks.

It should be noted that the power transients were controlled properly by OPG and that stepbacks and setbacks address issues at domains far below those of regulatory concern. Consequently, there was no impact on nuclear safety.

The power history graphs for the Pickering nuclear reactor units for 2015 can be seen in appendix G. These graphs show the occurrences (and causes) of outages and the associated power reductions during the year.

Because OPG implemented a comprehensive reliability plan, the forced loss rate due to fuelling machine breakdowns has significantly improved.

Inspections conducted by CNSC staff (including field and control room inspections) identified no significant operations-related compliance issues. OPG was found to be compliant with its governing procedures, documents and regulatory requirements.

Procedures

OPG has governance in place that ensures procedures are written in a consistent and usable manner. Pickering has clearly documented expectations for procedural use and adherence, and a process is in place to manage procedural change.

Based on compliance verification activities carried out by CNSC staff in 2015, it was noted that OPG's procedures at Pickering comply with the regulatory requirements.

Reporting and trending

OPG is required to submit quarterly reports on operations and performance indicators as described in REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [2]. It is also required to follow up on all events with corrective actions and root cause analysis, when appropriate. CNSC staff did not identify any significant regulatory issues from these reports.

Outage management performance

Pickering Units 1 and 4 scheduled one planned outage and experienced five forced outages. Pickering Units 5–8 scheduled two planned outages and experienced four forced outages. Details of these outages are provided in appendix G. Pickering continues to demonstrate high levels of performance and achievement of objectives during outages. OPG followed up appropriately on all planned and forced outages. All outage-related undertakings, including heat sink strategy management at Pickering, were performed safely by OPG staff.

OPG has implemented a corrective action plan for the iron oxide (black) fuel deposit issue. The percentage of overall black deposits sheath coverage continues to decline, an indication that the corrective action plan is improving the situation.

Safe operating envelope

OPG has completed the implementation of the safe operating envelope based on the requirements of CSA standard N290.15, *Requirements for the safe operating envelope of nuclear power plants* [38]. The safe operating envelope is now in its maintenance phase and meets applicable regulatory requirements.

Severe accident management and recovery

Pickering has a robust severe accident management program. Its severe accident management guideline (SAMG) program has been fully implemented, with an organizational structure that clearly establishes the roles and responsibilities of all program participants, including operating staff and emergency response/support groups. There appears to be a strong commitment to the continued training of the personnel responsible for the SAMG program. The leadership of the Pickering SAMG program is strong and demonstrates a willingness for continuous improvement.

The Pickering SAMG, including the emergency mitigation equipment guideline, has been verified and validated through tabletop exercises and drills. Lessons learned from those activities are fed back to improve or update the documentation.

3.3.1.4 Safety analysis

Based on the information assessed, CNSC staff concluded that the safety analysis SCA at Pickering met or exceeded performance objectives and all applicable regulatory requirements. As a result, the station received a "fully satisfactory" rating, an improvement over the "satisfactory" rating of the previous year.

Deterministic safety analysis

CNSC performed an assessment of the implementation of the OPG safety analysis program in December 2015. This covered the programmatic elements of the management of deterministic and probabilistic safety analysis as required by the Pickering and Darlington licence condition handbooks (LCHs). The assessment concluded that OPG is showing a strong commitment to safety through its safety analysis program. Minor areas for improvement were noted, however, primarily in the area of formal verification of access to safety analysis expertise in the long term. The results of the assessment were documented and communicated to OPG.

Probabilistic safety analysis

In 2015, OPG requested a licence amendment to replace S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [30] with REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [12], and provided a plan for PSA updates to meet the requirements established by REGDOC-2.4.2 at a frequency of every five years.

OPG will complete the PSA update for Pickering Units 5–8 by the end 2017 (in time to support the Pickering relicensing) and for Pickering Units 1 and 4 by the end of 2018 (per the requirement of a five-year cycle outlined in REGDOC 2.4.2).

3.3.1.5 Physical design

Based on the information assessed, CNSC staff concluded that the physical design SCA at Pickering met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Design governance

Environmental qualification

The environmental qualification program is fully implemented in all Pickering operating units. Pickering demonstrated compliance with its governing document by maintaining the sustainability of its environmental qualification program. However, there is opportunity for improvement in the operations staff's awareness of the program's sustainability requirements.

System design

Electrical power systems

An inspection performed by CNSC staff confirmed that all classes of power systems are being maintained and tested to ensure they will be able to perform their design functions. Areas for improvement have been identified related to procedural documentation, configuration management and surveillance testing frequency for

cables and cable trays. However, these issues are of low safety significance. CNSC staff will continue to follow up with OPG on these minor outstanding items.

Fire protection design

CNSC staff conducted ongoing oversight activities at Pickering in 2015, including specialist document reviews and inspections. CNSC staff concluded that Pickering's fire protection program is both comprehensive and in compliance with the requirements of CSA standard N293-07, *Fire protection for CANDU nuclear power plants* [32].

Components design

Fuel design

OPG has a well-developed reactor fuel inspection program. CNSC staff confirmed that OPG has implemented its corrective action plan to address the issue of black deposits on the fuel. Inspection results are showing an improving trend and that fuel defect rates have not been affected by the deposits. CNSC considers the OPG fuel program to be robust and that OPG is able to adequately manage this issue while maintaining safe operations.

Cables

In September 2015, CNSC staff performed an electrical power systems inspection at Pickering Units 5–8, identifying an area for improvement associated with the deficiency of periodic testing of cable insulation and visual inspections of cables and cable trays. OPG has completed some of the corrective actions and the remainder will be monitored through regular compliance activities.

3.3.1.6 Fitness for service

Based on the information assessed, CNSC staff concluded that the fitness for service SCA at Pickering met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Equipment fitness for service /equipment performance

On the basis of inspections and compliance verifications, CNSC staff concluded that the overall equipment fitness for service and performance at Pickering was satisfactory and met regulatory requirements.

Maintenance

The maintenance program performance at Pickering remained satisfactory in 2015. The preventive maintenance completion ratio was around 92 percent, indicating an overall effective maintenance program.

The 2015 maintenance backlog results for Pickering are provided in table 18. The corrective critical maintenance backlog and the number of deferrals of critical preventive maintenance were higher than the industry average. The deficient critical maintenance backlog also increased but was within the average range of the industry. Measures to reduce the maintenance backlogs are monitored by CNSC staff through routine maintenance-related desktop reviews and compliance inspections.

CNSC staff will continue to monitor the trends in these indicators.

Table 18: Maintenance backlogs and deferrals for critical components for Pickering, 2015

Parameter	Average work orders per unit for the year	Trend during the year	Industry average
Corrective maintenance backlog	26	down	11
Deficient maintenance backlog	96	down	117
Deferrals of preventive maintenance	120	stable	49

Structural integrity

OPG inspected selected pressure boundary and containment components for Pickering Units 1, 5 and 6. CNSC staff concluded that the structures, systems and components important for safe operation at Pickering met structural integrity requirements.

OPG continued with the implementation of the Fuel Channel Life Management Project to further the development of the analytical tools necessary to demonstrate pressure tube fitness for service for continued operation.

Reliability of systems important to safety

All special safety systems for Pickering Units 1,4 and 5–8 met their unavailability targets in 2015.

Aging management

OPG has implemented an integrated aging management program to ensure the condition of the structures, systems and components important to safety is well understood and that the required activities are in place to assure their health as the plant ages. CNSC staff concluded that OPG's program met regulatory requirements.

In addition to the integrated aging management program, OPG has implemented lifecycle management plans for the major pressure boundary components, including fuel channels, feeders and steam generator tubes, and containment components and structures. CNSC staff compliance monitoring activities in 2015 were primarily in the form of desktop reviews of OPG submissions related to program governance and implementation.

OPG is in the process of updating its aging management governance and processes to meet the requirements of REGDOC-2.6.3, *Aging Management* [16], with full implementation expected in 2017.

Chemistry control

Compliance verification activities conducted during the year confirmed that the chemistry control program remained compliant with regulatory requirements.

As demonstrated through periodic updates submitted by OPG, the chemistry optimization efforts to control fuel bundle black deposits in Pickering Unit 1 have been effective. There was no observed increase in the deposits and, following the long maintenance outage, deposit sizes decreased.

Periodic inspections and testing

OPG has adequate periodic inspection programs (PIPs) in place at Pickering for the pressure boundary and containment components important to safety.

CNSC staff monitored compliance with the established regulatory requirements for PIPs during the year and concluded that their implementation met regulatory requirements.

CNSC staff conducted an inspection of Pickering's implementation of CSA standard N285.4-05, *Periodic inspection of CANDU nuclear power plant components* [18], focusing on OPG's compliance with the inspection procedure requirements for pressure tube-to-calandria tube contact and scrape sampling for hydrogen measurement. This compliance inspection is part of a series planned for the fuel channel PIP at Pickering in 2015 and 2016. There were no findings of unsafe operation or immediate risk to the health and safety of persons or the environment. Findings related to future programmatic improvements are being addressed by OPG.

3.3.1.7 Radiation protection

Based on the information assessed, CNSC staff concluded that the radiation protection SCA at Pickering met or exceeded performance objectives and all applicable regulatory requirements. As a result, the station received a "fully satisfactory" rating, unchanged from the previous year.

Application of ALARA

OPG continued to implement a highly effective, well documented and mature program, based on industry best practices, to keep doses as low as reasonably achievable (ALARA) at Pickering. CNSC staff verified that Pickering's five-year ALARA plan includes dose-reduction initiatives based on a review of operational experience, including an initiative to reduce overall collective radiation exposure. Compliance activities conducted by CNSC staff verified that ALARA is implemented into work planning and dose monitoring and control processes.

Safety performance indicators related to the application of ALARA include tracking of collective radiation exposure values for the station. The values provided by OPG align with the Pickering dose targets.

Routine compliance activities indicate that Pickering is exceeding expectations in the application of ALARA. There were no changing performance trends to report in this specific area.

Worker dose control

OPG continued to comply with the regulatory requirements to measure and record doses received by workers at Pickering. Routine compliance verification activities indicate that performance in the area of worker dose control at Pickering is highly effective. No worker or member of the public received a radiation dose in excess of the regulatory dose limits or action levels established in the Pickering radiation protection program. The data for doses received at Pickering can be found in section 2.1.7 and in appendix E.3.

Safety performance indicators related to worker dose control include tracking of occurrences involving doses received from unplanned exposures or uptakes. No worker received a dose resulting from an unplanned internal tritium exposure at Pickering in 2015. One worker was reported as receiving an unplanned external whole body exposure greater than 0.10 mSv of the planned dose. The 0.36 mSv received did not exceed an OPG action level. Since the dose was less than 1% of the regulatory limit for nuclear energy workers (50 mSv per year), CNSC staff did not determine this event to be safety significant.

Radiation protection program performance
Pickering has implemented OPG's corporate radiation protection program, which satisfies the requirements of the *Radiation Protection Regulations* and includes performance indicators to monitor program performance. Program documents and supporting procedures are kept current, taking into consideration operating experience and industry best practices.

Challenging goals and targets have been established and initiatives have been implemented to ensure the continuous improvement of OPG's highly effective radiation protection program. The program documents and the oversight applied by OPG in their implementation have ensured the protection of workers at Pickering.

Routine compliance activities indicate that the implementation of the radiation protection program at Pickering is meeting expectations.

Radiological hazard control
No action levels were exceeded for surface contamination at Pickering in 2015.

CNSC staff conducted a compliance inspection of radiological hazard control at Pickering and confirmed that processes governed by OPG's radiation protection program were effective in monitoring and controlling radiological hazards. CNSC staff are satisfied that no safety significant incidents or adverse trends were identified through reporting of safety performance indicators.

Estimated dose to the public
OPG continued to ensure the protection of members of the public in accordance with the Radiation Protection Regulations. The reported estimated dose to a member of the public from Pickering was 0.0012 mSv, well below the annual public dose limit of 1 mSv.

3.3.1.8 Conventional health and safety

Based on the information assessed, CNSC staff concluded that the conventional health and safety SCA at Pickering met or exceeded performance objectives and all applicable regulatory requirements. As a result, the station received a "fully satisfactory" rating, an improvement over the "satisfactory" rating of the previous year.

Performance
As reported by OPG, the accident severity rate (ASR) for Pickering decreased from 1.0 in 2014 to 0.5 in 2015. This decrease in ASR is attributed to a single reported loss-time injury in 2015 (specifically, a knee injury caused by a pothole). Accident frequency increased from 0.27 in 2014 to 0.43 in 2015.

Practices
OPG was fully compliant at Pickering with the relevant provisions of the *Occupational Health and Safety Act* of *Ontario and the Labour Relations Act*.

Awareness
OPG continued to maintain a safe and efficient working environment at Pickering. The targets for the conventional health and safety program were met during the outages and OPG was very proactive in remediating the adverse conditions and minor housekeeping deficiencies in the field.

3.3.1.9 Environmental protection

Based on the information assessed, CNSC staff concluded that the environmental protection SCA at Pickering met performance objectives and all applicable regulatory

requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Effluent and emissions control
All radiological releases from Pickering remained well below regulatory limits.

A compliance inspection of the Pickering effluent monitoring program found that the control, monitoring and reporting of emissions was compliant with regulatory requirements.

OPG completed the implementation of CSA standard N288.5, *Effluent monitoring programs at Class 1 nuclear facilities and uranium mines and mills* [35], in December 2015.

The derived release limits are provided in appendix E.3.

Environmental management system
OPG has established and implemented an environmental management program to assess environmental risks associated with its nuclear activities and to ensure these activities are conducted in a way that prevents or mitigates adverse environmental effects.

Assessment and monitoring
CNSC staff reviewed and assessed the Pickering environmental monitoring data and did not identify any unreasonable risk to the public or the environment.

Protection of the public
There were no hazardous substances released from Pickering that posed an unacceptable risk to the environment or the public.

The reported annual radiation dose to the public from Pickering remained very low at 0.12 percent of the public dose limit.

Environmental risk assessment
OPG continued to maintain and implement an effective environmental risk assessment and management program at Pickering in accordance with regulatory requirements.

OPG completed work toward documenting an environmental risk assessment at Pickering consistent with CSA standard N288.6-12, Environmental risk assessments at Class I nuclear facilities and uranium mines and mills [21].

3.3.1.10 Emergency management and fire protection

Based on the information assessed, CNSC staff concluded that the emergency management and fire protection SCA at Pickering met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Conventional emergency preparedness and response
Regulatory oversight activities conducted by CNSC staff at Pickering in 2015 included documentation reviews, onsite observations and participation in drills. OPG maintained its conventional emergency preparedness and response commitments, including enhancements to its emergency (non-nuclear) drill program.

Nuclear emergency preparedness and response
OPG continues to demonstrate its preparedness to respond to a nuclear emergency at the Pickering site. It has successfully pre-distributed potassium iodide (KI) tablets within the primary zone, stockpiled KI tablets for the secondary zone and disseminated

pamphlets to local residents around the plant, enhancing public awareness of nuclear emergency preparedness and response around the plant.

Fire emergency preparedness and response
Regulatory oversight activities conducted by CNSC staff at Pickering in 2015 included documentation reviews, onsite observations and participation in drills. CNSC staff concluded that Pickering continues to implement a comprehensive fire response capability that includes effective procedures, training and maintenance of proficiency.

3.3.1.11 Waste management

Based on the information assessed, CNSC staff concluded that the waste management SCA at Pickering met or exceeded performance objectives and all applicable regulatory requirements. As a result, the station received a "fully satisfactory" rating, an improvement over the "satisfactory" rating of the previous year.

OPG's waste management programs at Pickering exceeded expectations for managing radioactive waste.

OPG's decommissioning plan for Pickering was updated in 2012 and remains valid and current.

3.3.1.12 Security

Based on the information assessed, CNSC staff concluded that the security SCA at Pickering met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, which is lower than the "fully satisfactory" rating achieved in the previous year.

Facilities and equipment
Facilities and equipment were adversely affected by deficiencies in the maintenance program where OPG failed to effectively correct security equipment issues in a timely manner. OPG has responded with corrective actions to address this issue and CNSC staff will continue to monitor their implementation through regular compliance activities in 2016.

On January 12, 2016, the CNSC issued an administrative monetary penalty to OPG for two separate violations for failure to comply with conditions of the Pickering power reactor operating licence (PROL). Despite prior interactions and communications with the CNSC, OPG took unilateral decisions to cease the corrective actions necessary for compliance. The penalty was issued to promote OPG's compliance with conditions of the Pickering PROL and to deter reoccurrence of behaviour that prevents the CNSC from fulfilling its mandate of verifying the sufficiency of safety and security measures.

Security practices
Security practices were affected by reportable events related to procedural non-compliances. OPG has implemented compensatory measures until corrective measures can be put in place. CNSC staff will continue to monitor this issue.

Cyber security
OPG has implemented and continues to maintain an effective cyber security program at Pickering. CNSC staff concluded that the program complied with applicable regulatory requirements.

3.3.1.13 Safeguards and non-proliferation

Based on the information assessed, CNSC staff concluded that the safeguards and non-proliferation SCA at Pickering met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Nuclear material accountancy and control
OPG complied with regulatory requirements at Pickering in accordance with RD-336, *Accounting and Reporting of Nuclear Material* [25].

Access and assistance to the IAEA
The International Atomic Energy Agency (IAEA) performed two short-notice random inspections, a physical inventory verification and a design information verification at Pickering in 2015 to confirm the non-diversion of safeguarded nuclear materials and the absence of undeclared activities. The facility provided support for these inspections and CNSC staff were informed by the IAEA that the results of these inspections were satisfactory.

Operational and design information
OPG submitted its annual operational program for Pickering to the CNSC on time, along with quarterly updates and the annual update to the information pursuant to the IAEA Additional Protocol [24].

Safeguards equipment, containment and surveillance
OPG supported IAEA equipment operation and maintenance activities at Pickering, including maintenance work on the IAEA VXI integrated fuel monitor air conditioner, to ensure the effective implementation of safeguards measures at the station.

3.3.1.14 Packaging and transport

Based on the information assessed, CNSC staff concluded that the packaging and transport SCA at Pickering met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

OPG has a packaging and transport program at Pickering that ensures compliance with the *Packaging and Transport of Nuclear Substances Regulations, 2015* and the *Transportation of Dangerous Goods Regulations*. This program is effectively implemented at the Pickering site and the transport of nuclear substances to and from the facility is done in a safe manner.

3.3.2 Regulatory developments

3.3.2.1 Licensing

OPG's licences for Pickering Units 1 and 4 and Pickering Units 5–8 were combined into a single site licence in August 2013 and renewed for a five-year period (effective until August 31, 2018).

Licence amendments
The Pickering licence was amended once between May 1, 2015 and April 30, 2016. Details of the amendment are given in appendix I.

Revisions to the licence conditions handbook

The Pickering LCH was revised once between May 2015 and April 2016. The changes were administrative in nature; details of the significant changes are provided in appendix I.

The revisions to the LCH were approved by the Director General of the CNSC's Directorate of Power Reactor Regulation. The changes have not resulted in an unauthorized change of scope and remain within the licensing envelope.

3.3.2.2 Updates on major projects and initiatives

End-of-commercial operation project activities and periodic safety review

OPG continues to plan and implement measures that will ensure the continued safe and reliable operation of Pickering.

In January 2016, the Government of Ontario announced the approval of OPG's plans to pursue continued operation of Pickering beyond 2020 up to 2024. To support this plan, OPG will conduct a periodic safety review in accordance with REGDOC-2.3.3, *Periodic Safety Reviews* [34], as requested by CNSC staff.

In accordance with a licence condition, OPG must confirm in writing by June 30, 2017, the end date of commercial operations for all Pickering units. If the decision is made to operate until 2024, remaining open actions from the continued operations plan (COP), sustainable operations plan (SOP) and stabilization activity plan (SAP) will be dispositioned in a manner commensurate with the matters subject of this decision.

In December 2015, OPG submitted the annual updates of the COP, SOP and SAP. It has made good progress in dispositioning the actions related to the COP, with only one action remaining open. OPG requested closure of four actions. CNSC staff are assessing OPG's request and will update the Commission. Given the current uncertainty of the start of the stabilization activities, the 2015 SAP provides a high-level overview of the planned arrangements and activities, with flexibility applied to the direction, timing, execution and specification of deliverables.

CNSC staff are satisfied with the safety and control measures that are in place or planned, and will continue to assess and evaluate the implementation of the activities and commitments made in the COP, SOP, and SAP to ensure the continued safe and reliable operation of Pickering as it approaches its end of commercial operation.

3.3.2.3 Updates on significant regulatory issues

Annual updates following the Commission request from 2014 Pickering hold point hearing

Following the CNSC's approval in 2014 of OPG's request to remove the hold point from the Pickering operating licence, CNSC staff and OPG made a commitment to provide annual updates on the fitness for service of major components, the risk-improvement plan, the whole-site based safety goals and the probabilistic safety assessment methodology. The details for each of these issues are given below.

Fitness for service of major components update

On February 26, 2016, OPG submitted its annual summary report on the fitness for service of the major components at Pickering. OPG inspects each of the operating units approximately every two years during planned outages. Part of the inspection scope focuses on selected samples from all major components (i.e., fuel channels, feeders and steam generators). Units 4, 7 and 8 were inspected in 2014. Units 1, 5 and 6 were inspected in 2015.

CNSC staff are satisfied with the current status of the fitness for service of the major components at Pickering, and confirm the findings meet CNSC regulatory requirements.

Fuel channels
Diametral expansion of pressure tubes due to service-induced creep can affect design margins and neutron overpower setpoints and is therefore monitored. At the present creep rates, it is estimated that diametral expansion limits will not be reached until 288,000 equivalent full power hours. Hydrogen ingress into the pressure tube material affects the material fracture toughness, which in turn affects the material's resistance to failure from crack-like flaws should they develop. At present estimated rates of hydrogen pick-up, the limit of 80 ppm (based on the effect on material fracture toughness) will not be exceeded within the expected operating life of the units.

Feeders
When looking at wall loss due to flow-accelerated corrosion, the three lead feeders have remaining wall thicknesses that are sufficient to maintain structural integrity for the next operating cycle. OPG concluded that there is high confidence that the Pickering feeders will remain fit for service for the planned period of operation.

Steam generators
OPG assessed and confirmed that there are no steam generators in Pickering exceeding the limits of tube plugging and sufficient margins exist for future operation of these steam generators. While excessive tube plugging can cause operability issues (such as derating of reactor power), there are no safety concerns. There have been no in-service steam generator tube leaks detected in the Pickering units since 2001.

Pickering risk improvement plan update

On February 26, 2016, OPG submitted its annual report on the implementation of the risk-improvement plan for Pickering as well as the status of the development of whole-site safety goals and PSA methodology.

One of the activities of the risk-improvement plan is the implementation of additional emergency mitigating equipment (EME), which is in progress. (CNSC staff are monitoring the implementation of the remaining EME improvement initiatives at Pickering under a separate action item). All other identified risk-improvement activities were completed by December 31, 2015. Beyond the Pickering risk-improvement plan items, OPG is exploring additional risk-improvement items and plans to provide the CNSC with another update by February 2017.

Some detailed risk modelling and requantification will be provided in the 2017 PSA for Pickering Units 5–8, as part of the PSA updates, in time for the CNSC's high-level review to support the Pickering relicensing. The detailed risk modelling and requantification for Pickering Units 1 and 4 will be provided by the end of 2018 in the PSA update, well in advance of the five-year cycle required by REGDOC 2.4.2.

In addition, OPG has identified some potential items to further reduce the internal events large release frequency and the fire severe core damage frequency. These items will be considered in the 2018 PSA update for Units 1 and 4.

Table 19 below provides the details of Pickering's physical and analytical risk-improvement actions. OPG has implemented the risk-improvement items to the satisfaction of CNSC staff that will result in the further reduction of plant risk.

Table 19: Details of the February 2016 Pickering risk-improvement update

Description of the improvement	Physical/Analytical Improvement	Timeline and status
Committed improvement		
Emergency mitigating equipment modifications.	Physical	Implementation per the plan and schedule provided for FAI 1.7.1 closure.
Extension of auxiliary power supply mission time to 72 hours	Physical	**Complete**
Analysis to remove conservatism from Level 2 outage assumptions.	Analytical	**Complete**
Trace cables for select systems that are currently not credited in the fire probabilistic safety analysis.	Physical and analytical	**Complete**
Crediting of some severe accident management guideline (SAMG) operator actions where possible (e.g., filtered air discharged system activation)	Physical and analytical	**Complete**
Improvements being considered		
Update risk-reduction calculation for all committed improvements	Analytical	**Complete** Detailed risk requantification will be provided in the 2017 Units 5–8 and 2018 Units 1 and 4 PSA updates.
Cost/benefit analysis for various additional physical and analytical possible improvements	Analytical	**Complete**
Implementation of selected additional improvements	Physical and analytical	**Complete**

Whole-site Based Safety Goals and PSA Methodology Update

OPG's plan to develop whole-site safety goals and PSA methodology for Pickering remains unchanged. The work will be performed in three phases:

- **Phase A:** Safety goals framework (to be completed Q2 2016)
- **Phase B:** Risk-aggregation studies (to be completed 2016)
- **Phase C:** Pilot whole-site PSA (to be completed 2017)

Work has progressed in collaboration with the industry. CNSC staff will be informed on the results and status in the next annual update of this risk-improvement action plan.

In addition, CNSC staff have conducted the following activities that complement OPG's whole-site safety goals and PSA methodology:

CNSC Working Group on Safety Goals

The CNSC Working Group on Safety Goals is making good progress in developing whole-site safety goals using a hierarchical structure.

CNSC workshop on whole-site PSA

In May 2016, CNSC staff organized an information-exchange meeting with industry on whole-site safety goals, risk-aggregation approaches and PSA development. This workshop allowed CNSC staff to be updated on the plan and milestones for the development of the Pickering whole-site PSA pilot project.

International cooperation

In 2015, CNSC staff initiated a proposal for the Nuclear Energy Agency Working Group on Risk for the development of an activity on multi-unit PSA. The results of the first round of this project showed a common interest by all Nuclear Energy Agency member countries to further investigate the following topics:

- risk aggregation from full spectrum of internal and external hazards
- whole-site safety goals development
- accident progression and multi-unit interactions

Bilateral cooperation

As part of its cooperation with the United States Nuclear Regulatory Commission, CNSC staff organized a teleconference in 2015 to exchange and share experiences on multi-unit PSA development and the challenges in developing site-based safety goals.

CNSC staff also follow up with the IAEA regarding new developments on whole-site safety goals and multi-unit PSA methodology.

Fisheries Act authorization

CNSC staff have discussed with OPG the key amendments to the *Fisheries Act*, highlights of the CNSC-Department of Fisheries and Oceans (DFO) Memorandum of Understanding, and key DFO policy documents related to the interpretation of the amended *Fisheries Act*, specifically, the Habitat Protection Prohibition clauses of the *Fisheries Act*. Discussions included OPG's ongoing fish impingement and entrainment studies and initial discussions of OPG's self-assessment to determine the requirement for a *Fisheries Act* application. OPG has informed DFO of their intention to submit an application for the permit to obtain authorization under the *Fisheries Act* for Pickering in January 2017, with a target date for receiving a permit by the middle of the 2017.

Intake fish impingement

OPG has implemented a seasonally deployed barrier net as mitigation to reduce fish mortality due to impingement. OPG continued in 2015 to monitor year-round screen house fish counts and seasonal net performance to confirm the performance of the barrier net. Preliminary results show a large increase in fish impingement in 2015; this increase was mainly driven by a single impingement event in on May 29, 2015. Without this single event, the impingement rate in 2015 would have been consistent with previous years, which met the CNSC reduction target of 80 percent.

This impingement event was also presented to the Commission in CMD 15-M20. OPG had an episodic fish impingement event at Pickering that impinged an estimated of biomass between 5,410 to 6,428 kg in the fish net. The main fish species impinged was alewife. Fisheries and Oceans Canada conducted an investigation and issued a warning letter to OPG. CNSC staff will continue to work with OPG to ensure that adequate corrective actions are being implemented to protect fish.

For the impingement of northern pike that occurs in the winter months when the barrier net is not installed, OPG committed to offsetting residual fish loss with a 3 hectare wetland improvement project. OPG has entered into a contract with the Toronto and Region Conservation Authority to upgrade a 4.6 hectare portion of Duffins Creek to meet the CNSC's request. The project construction phase was initiated in 2015 and the estimated completion date is the fourth quarter of 2016. CNSC staff will continue to follow up with the implementation of this impingement offset project.

In addition, OPG plans to apply for a *Fisheries Act* authorization for causing ongoing serious harm to fish as defined under the *Fisheries Act.*

Response to the Fukushima Daiichi accident

OPG has made considerable progress in addressing Fukushima action items (FAIs) at Darlington and Pickering. As of January 2015, all FAIs applicable to OPG stations have been closed (see appendix H).

CNSC staff concluded that OPG has strengthened reactor defence in depth and enhanced its emergency response at Darlington and Pickering stations in response to lessons learned from the Fukushima nuclear accident.

As part of its continuous improvement efforts, OPG had committed to assessing the feasibility or potential benefits of accelerating the transfer of spent fuel from the irradiated fuel bays (IFBs) to dry storage containers at its nuclear facilities, moving from the current 10-year retention period in the IFBs to a six-year retention period. Currently, there appear to be no safety drivers that mandate the accelerated transfer of spent fuel from wet to dry storage. However OPG is committed to updating the Commission on this issue by the end of 2016.

CNSC staff will continue to monitor the implementation of site-specific FAIs at Pickering through the established compliance verification program. Updates on FAI implementation will be provided to the Commission as part of the annual NPP Report.

3.3.2.4 Public communication

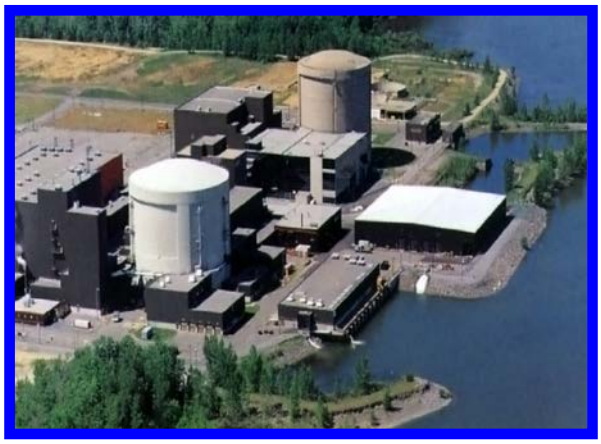
Event initial reports

One event initial report was submitted for Pickering from May 1, 2015 to April 30, 2016, as shown in table 20. The event had low safety significance.

Table 20: Event initial reports for Pickering, 2015

Subject	Brief description
Minor injury incident of security staff	Confidential information (per CMD 15-M34).

3.4 Gentilly-2



Gentilly-2 facility, operated by Hydro-Québec, is located on the south shore of the Saint Lawrence River in Bécancour, QC, about 15 kilometres east of Trois-Rivières.

The CANDU reactor has a nominal capacity of 675 MWe (megawatts electrical). It went into commercial operation in 1983.

Based on a recommendation from Hydro-Québec, the Government of Québec decided in 2012 to close Gentilly-2. The reactor was shutdown on December 28, 2012 and completely defuelled by September 3, 2013. Gentilly-2 was in a safe storage state during 2015, its fuel stored in the irradiated fuel bay and dry storage.

A Commission hearing as well as operational and performance discussions took place in April 2016 regarding the Hydro-Québec application to obtain a decommissioning and waste management licence. On June 22nd,2016, the Commission announced its decision to issue a power reactor decommissioning licence to Hydro-Québec for the Gentilly-2 facility. The licence is valid from July 1, 2016 to June 30, 2026.

This will be the final station write-up for Gentilly-2 in the annual NPP Report. Future regulatory oversight reporting for Gentilly-2 will be found in the *Regulatory Oversight Report for Waste Management, Storage and Processing Facilities in Canada*.

3.4.1 Safety assessment

The CNSC staff safety assessment of Gentilly-2 for 2015 resulted in the performance ratings as shown in table 21. Based on the observations and assessments of the SCAs, CNSC staff concluded that Gentilly-2 was maintained in a safe state. The integrated plant rating was “satisfactory”, unchanged from the previous year.

Table 21: Performance ratings for Gentilly-2

Safety and control area	Rating	Industry average*
Management system	SA	SA
Human performance management	SA	SA
Operating performance	SA	FS
Safety analysis	SA	SA
Physical design	SA	SA
Fitness for service	SA	SA
Radiation protection	SA	SA
Conventional health and safety	SA	FS
Environmental protection	SA	SA
Emergency management and fire protection	SA	SA
Waste management	SA	FS
Security	SA	SA
Safeguards and non-proliferation	SA	SA
Packaging and transport	SA	SA
Integrated plant rating	**SA**	**SA**

* The industry average of all operating NPPs in Canada

Notes:

- For specific areas within the SCAs where there were no significant observations from CNSC staff compliance verification activities, no information is given in this subsection of the report.
- The information presented below is station specific; refer to section 2 for general trends and industry-wide observations.

3.4.1.1 Management system

Based on the information assessed, CNSC staff concluded that the management system SCA at Gentilly-2 met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Management system; organization

Hydro-Québec implemented a new management system in 2015. It is a simplified version of the system previously used at Gentilly-2 and takes into account the current staffing levels and organizational structure.

CNSC staff assessed the changes made to the management system and found that Hydro-Québec still met the requirements of CSA standard N286-05, *Management system requirements for nuclear power plants* [7].

3.4.1.2 Human performance management

Based on the information assessed, CNSC staff concluded that the human performance management SCA at Gentilly-2 met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Human performance program

The organization of Gentilly-2 continued to evolve in 2015 after the safe storage state was achieved. Hydro-Québec modified and reduced staffing at Gentilly-2 (on the basis

of reduced risk and work volume) by retooling equipment, procedures and staff capability based on a plan submitted to the CNSC.

Hydro-Québec issued a new human performance management procedure in May 2015 to reinforce the staff behaviour expected to maintain a good safety culture and continually reduce the frequency and severity of events.

CNSC staff are satisfied with the plans proposed by Hydro-Québec and the action taken to ensure that human performance remains adequate.

Personnel training

The implementation of Hydro-Québec's new training program, developed in 2014, continued throughout 2015. This program is adapted to Gentilly-2's new organizational structure and the site's safe storage state activities.

Hydro-Québec implemented a training matrix and qualifications log to ensure employees are qualified to safely execute the tasks they have to perform.

Hydro-Québec prepared and distributed specific training prior to carrying out the work on systems decommissioning. CNSC staff reviewed a sample of the prepared training material and found it to be satisfactory.

As part of the transition to the new organizational structure, Hydro-Québec did a systematic task analysis to determine the training needs for all the groups affected by the restructuring. Further to this analysis, Hydro-Québec assigned the operation of each of the systems remaining in operation at Gentilly-2 to one of the teams in the new permanent structure. For each of these systems, Hydro-Québec has provided or will provide training to the teams concerned. A detailed training schedule for the permanent organization has been prepared for this purpose. The training began in late 2014 and will be completed in 2016. CNSC staff inspected the implementation of the training and no major problems were identified.

Personnel certification: initial certification exams and requalification tests

The certification programs for operating personnel have been abandoned because Gentilly-2 is no longer in production. The senior health physicist position is the only one at Gentilly-2 that requires CNSC certification. In 2015, a certification examination was administered and certification was granted for a new senior health physicist at Gentilly-2.

Work organization and job design

Meetings between Hydro-Québec and CNSC staff were held in 2015 to clarify the regulatory requirements with respect to the changes being made to equipment and staff numbers and responsibilities at Gentilly-2.

CNSC staff also completed document reviews of technical reports describing the basis of the approach as well as certain planned and implemented actions (such as the proposed training programs) in support of this approach. Onsite observation was also done for some of the new processes proposed by Hydro-Québec to confirm that required personnel are available to use and operate the necessary equipment in the event of a malfunction or incident.

CNSC staff are satisfied that a sufficient number of qualified personnel are available to ensure safety is maintained at Gentilly-2.

3.4.1.3 Operating performance

Based on the information assessed, CNSC staff concluded that the Operating Performance SCA at Gentilly-2 met performance objectives and all regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Conduct of licensed activity

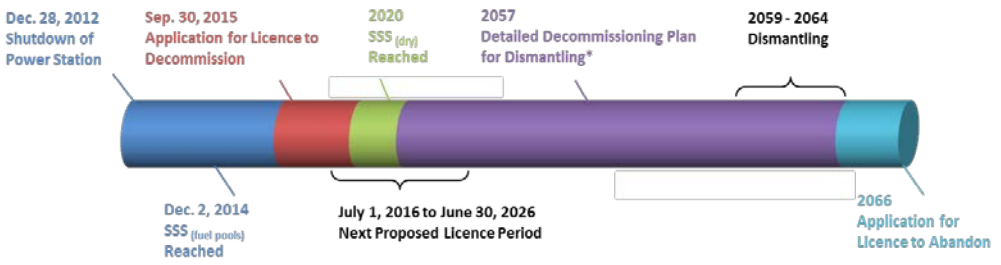
Although Gentilly-2 ceased power production in late 2012, regulatory oversight by CNSC staff continued during the stabilization period until the safe storage state was reached and throughout 2015.

As no CNSC staff have been onsite at Gentilly-2 since March 31, 2015, the schedule of regulatory activities and inspections is now managed from the CNSC's head office in Ottawa. The results of these activities confirmed that Hydro-Québec was conducting its licensed activities in accordance with regulatory requirements and that the existing programs enabled effective performance.

Hydro-Québec has to operate the Gentilly-2 facility in compliance with its operating policies and principles, which set out specific requirements to meet the design basis of the facility for safe operation. During the licence period, no major non-compliances with the operating policies and principles were observed by CNSC staff or reported by Hydro-Québec. Some minor deviations for maintenance or repair purposes were submitted to CNSC staff for approval.

CNSC staff are satisfied that Hydro-Québec is implementing the required programs to meet the CNSC's regulatory requirements and expectations for this safety area.

Figure 19: Major milestones for Gentilly-2 decommissioning



Major Milestones	Dates
Shutdown of Gentilly-2 power station	December 28, 2012
Complete Reactor Defueling (CDS)	September 3, 2013
Amendment to licence CDS phase	July 22, 2014
SSS (fuel pools) reached	December 2, 2014
Administrative amendment to licence for SSS (fuel pools) phase	June 5, 2015
Application by Hydro-Québec for licence to decommission	September 30, 2015
Scheduled date for CNSC hearing	May 5, 2016
Expiry date of current Gentilly-2 licence	June 30, 2016
Detailed decommissioning plan* for SSS(dry) phase	2019
SSS(dry) reached	2020
Expiry date of next proposed licence for Genilly-2	June 30, 2026
Detailed decommissioning plan* for dismantling	2057
Start of dismantling activities	2058
Dismantling	2059-2064
Site restoration	2065-2066
Application for licence to abandon	2066

*Includes environmental assessment that may be required

3.4.1.4 Safety analysis

Based on the information assessed, CNSC staff concluded that the safety analysis SCA at Gentilly-2 met performance objectives and all regulatory requirements. As a result, the facility received a “satisfactory” rating, unchanged from the previous year.

During 2015, Hydro-Québec prepared a reliability study of the coolant system of the irradiated fuel storage pool. As the reactor has been fully defuelled, reliability requirements have been reduced; Hydro-Québec provided assurance that the irradiated fuel pool would always be adequately cooled until the facility reached the safe storage state with irradiated fuel in dry storage in CANDU storage (CANSTOR) modules.

Hydro-Québec successfully performed the tasks required to meet the regulatory requirements with regard to reliability and probabilistic risk assessment. The probabilistic risk assessments and reports submitted were in compliance with regulations.

Hydro-Québec submitted the revised Gentilly-2 safety report in December 2014. The review by CNSC staff found that the technical content was acceptable and met the requirements of REGDOC-2.4.1, *Deterministic Safety Analysis* [9].

3.4.1.5 Physical design

Based on the information assessed, CNSC staff concluded that the physical design SCA at Gentilly-2 met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Design governance

Environmental qualification

The environmental qualification program requirements were removed from the Gentilly-2 operating licence and licence conditions handbook (LCH) in 2014 to align regulatory requirements with the state of the facility's systems, which are no longer in service.

Pressure boundary design

On the basis of compliance verification activities, CNSC staff were satisfied with the implementation of the pressure boundary program at Gentilly-2.

System design

Hydro-Québec has maintained the electrical power, instrumentation and control systems at Gentilly-2 required for a safe storage state with fuel storage in spent fuel pools. Modifications were implemented to ensure the reliability of these systems in the facility's current context.

Hydro-Québec does not plan to make other modifications to the electrical systems prior to reaching a safe storage state with dry fuel storage in CANSTOR modules.

Regarding the instrumentation and control system, Hydro-Québec submitted a project summary for the installation of a new parameter monitoring system for Gentilly-2, which will result in the replacement of two control computers. Their replacement will be conducted during 2016. CNSC staff will conduct a regulatory follow up of these activities and the above-mentioned project.

3.4.1.6 Fitness for service

Based on the information assessed, CNSC staff concluded that the fitness for service SCA at Gentilly-2 met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Maintenance

Hydro-Québec updated its maintenance program in 2015 to take into account the current context at Gentilly-2. This program is supported by several documents and ensures appropriate management of maintenance work and procedures.

Based on compliance verifications, CNSC staff concluded that the Gentilly-2 maintenance program performance is satisfactory and complies with regulatory requirements.

Structural integrity; aging management; periodic inspection and testing

Hydro-Québec continued to develop and update its periodic inspection and aging management programs in 2015 to comply with the applicable regulations. These programs now take into account the systems that have been removed and those that will be removed once a safe storage state with dry fuel storage in CANSTOR modules has been reached in 2020. Hydro-Québec submitted the latest version of the program

documents in September 2015. CNSC staff reviewed these documents and determined that the additional information and details were necessary.

CNSC staff subsequently conducted an inspection in late January 2016 to verify that the appropriate programs had been implemented at Gentilly-2. No major non-compliance was identified during this inspection. Hydro-Québec has implemented programs that are identified, monitored and approved by management. The people assigned to these programs are qualified, have a good understanding of the tasks to be done and perform them in accordance with procedures.

CNSC staff concluded that Hydro-Québec's periodic inspection and aging management programs had been revised to reflect the current context at Gentilly-2 and that the changes to these programs were in effect. CNSC staff will continue its regulatory follow up of these programs in 2016.

Reliability of systems important to safety
The Gentilly-2 reliability program meets regulatory requirements, which have been adjusted to reflect the facility's status as a safe storage state.

Chemistry control
Hydro-Québec has a chemistry control program that takes into account the current context at Gentilly-2. CNSC staff inspected the chemistry control on the irradiated fuel storage pool in March 2015. The findings of this inspection show that Hydro-Québec has implemented an appropriate chemistry control program and that the staff assigned to the program are qualified and follow appropriate work procedures.

3.4.1.7 Radiation protection

Based on the information assessed, CNSC staff concluded that the radiation protection SCA at Gentilly-2 met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Application of ALARA
Hydro-Québec continued to implement a program at Gentilly-2 that integrates the "as low as reasonably achievable" (ALARA) principle into planning, scheduling and work control. To ensure occupational dose control measures are optimized, ALARA plans were developed for work and activities that present a higher risk. CNSC staff reviewed the ALARA plans and confirmed that the radiation protection measures implemented by Hydro-Québec were satisfactory.

Routine compliance activities indicate that Gentilly-2 is meeting expectations in the application of ALARA.

Worker dose control
Hydro-Québec continued to comply with the regulatory requirements to measure and record radiation doses received by workers. Compliance activities indicated that Gentilly-2 meets the expectations with regard to dose limits for workers. No worker or member of the public received a radiation dose in excess of regulatory limits, and there were no incidents that resulted in a dose that exceeded Hydro-Québec action levels. The data for doses received at Gentilly-2 can be found in section 2.1.7 and appendix E.4.

Radiation protection program performance

The Gentilly-2 radiation protection program satisfies the requirements of the *Radiation Protection Regulations*. This program consists of a series of standards and procedures for the conduct of radiological activities at Gentilly-2.

In late 2015, Hydro-Québec revised the radiation protection program, which was developed while the station was in operation, to align it with the revised management system and support future radiological activities to be completed at the site. CNSC staff will maintain its regulatory oversight activities to verify the implementation of the revised radiation protection program at Gentilly-2.

Radiological hazard control

No action levels were exceeded for surface contamination at Gentilly-2 in 2015.

CNSC staff performed two follow-up visits in May and October 2015 to verify the status of all open radiation protection action notices and the effectiveness of the corrective measures implemented by Hydro-Québec further to previous inspections.

CNSC staff concluded that, despite the fact that Hydro-Québec had developed a radiation protection program that satisfies the requirements of the *Radiation Protection Regulations*, the radiological hazard control was not fully effective in 2015, with minor deficiencies noted in the following areas:

- reassessment of radiological hazards that could be present in various rooms or locations
- inefficiency of certain surveillance and atmospheric contamination measurement systems
- timelines for the implementation of one of the compensatory measures relating to heavy water storage reservoirs
- non-compliance of some of the temporary radiation shelters under construction
- labelling of tritiated heavy water barrels

CNSC staff expect the application of the radiation protection program to be rigorously maintained in this particular area to ensure an optimal maintenance of radiation protection at Gentilly-2. A follow-up visit by CNSC staff is planned for 2016 to check the status of action notices that are still open and verify the effectiveness of the corrective measures implemented by Hydro-Québec.

Estimated dose to public

Hydro-Québec continued to ensure the protection of members of the public in accordance with the Radiation Protection Regulations. The reported dose to the public from the Gentilly-2 nuclear facility is 0.001 mSv, well below the regulatory annual public dose limit of 1 mSv.

3.4.1.8 Conventional health and safety

Based on the information assessed, CNSC staff concluded that the conventional health and safety SCA at Gentilly-2 met performance objectives and all applicable regulatory requirements. As a result, the station received a “satisfactory” rating, unchanged from the previous year.

Performance
According to the reports submitted by Hydro-Québec, the accident severity rate rose from 0 to 1.3, while the accident frequency rate increased from 0.78 to 1.32. Both indicators were above the average for operating NPPs in Canada.

Practices
At Gentilly-2, Hydro-Québec complied with the relevant provisions of provincial legislation (specifically, the act pertaining to occupational health and safety) and its associated regulations.

3.4.1.9 Environmental protection

Based on the information assessed, CNSC staff concluded that the environmental protection SCA at Gentilly-2 met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Effluent and emissions control
Further to a review of the environmental monitoring report submitted by Hydro-Québec, CNSC staff concluded that radiological releases to the environment from the Gentilly-2 station remained below regulatory limits.

The derived release limits are provided in appendix E.4.

Environmental management system
Hydro-Québec has established and implemented an environmental management program to assess environmental risks associated with its nuclear activities and to ensure these activities are conducted in a way that prevents or mitigates adverse environmental effects.

Assessment and monitoring
CNSC staff continued to closely monitor Hydro-Québec's environmental program activities at Gentilly-2 further to the achievement of a safe storage state with spent fuel being stored in fuel bays.

Protection of the public
There were no hazardous substances released from Gentilly-2 that posed an unacceptable risk to the environment or the public.

The reported annual radiation dose to the public from Gentilly-2 remained very low at 0.1 percent of the public dose limit.

3.4.1.10 Emergency management and fire protection

Based on the information assessed, CNSC staff concluded that the emergency management and fire protection SCA at Gentilly-2 met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Conventional emergency preparedness and response; nuclear emergency preparedness and response
Given the station's current state, the level of radiological risk at Gentilly-2 has diminished considerably. As a result, Hydro-Québec has reviewed its emergency preparedness plan to bring it in line with the residual risks and ensure it reflects the changes made to its organizational structure.

The current Gentilly-2 emergency procedures, as reviewed and approved by CNSC staff, cover various emergency situations that do not currently apply to the Gentilly-2 site. These procedures have been temporarily adjusted to take the facility's current state into account until such a time as they are replaced by new procedures drafted in accordance with REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response* [29]. Hydro-Québec also plans to conduct an exercise in fall 2016 to confirm the effectiveness of the adjusted procedures. CNSC staff will maintain the regulatory oversight activities required to verify compliance with respect to the implementation of the new procedures.

Fire emergency preparedness and response

Gentilly-2 has a fire protection and prevention program that meets regulatory requirements. The facility also has a permanent, onsite industrial fire brigade that includes not only operational staff but also professional firefighters certified in the areas of fire response, rescue, first aid and hazardous material.

Joint drills and ongoing training involving both the Gentilly-2 industrial fire brigade and the Bécancour fire department have ensured the compatibility and coordination of these two entities should the need for mutual assistance be required at the facility.

CNSC staff will maintain regulatory follow up in area.

3.4.1.11 Waste management

Based on the information assessed, CNSC staff concluded that the waste management SCA at Gentilly-2 met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Waste management practices

Although the volume of waste produced at Gentilly-2 has decreased significantly since the shutdown of the reactor in December 2012, the manner in which waste is managed remains unchanged. Depending on the nature of the waste, all low- and intermediate-level radioactive waste is prepared and then transferred to either solid radioactive waste management facilities or the radioactive waste storage area.

Spent fuel bundles extracted from the reactor are placed in racks and stored in the fuel bay designed for this purpose for a period of approximately seven years, after which the bundles are transferred in stainless steel baskets (see figure 20). Once full, the baskets are removed, cleaned, sealed by means of welding and then transferred to CANSTOR modules for dry storage. To provide adequate radiological shielding, CANSTOR modules are made of leak-tight steel liners inserted in a reinforced concrete matrix that is 96.5 cm thick. Each CANSTOR module measures 8.1 x 7.5 x 21.6 metres and has 20 cylinders, each of which can hold 600 spent fuel bundles, for a total of 12,000 bundles per CANSTOR module (see figures 21 and 22).

Figure 20: Fuel basket (for spend fuel bundles)

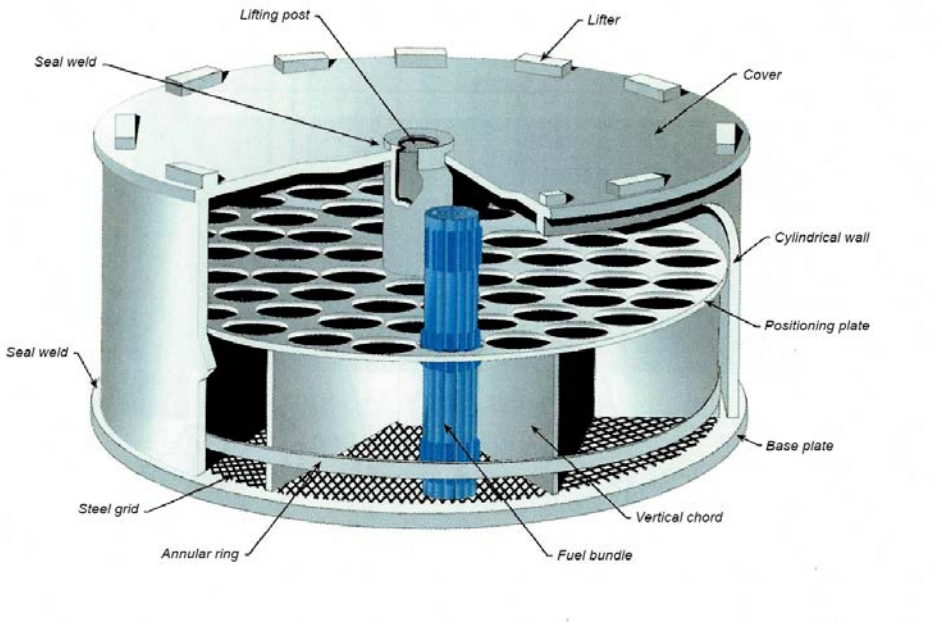


Figure 21: CANSTOR module

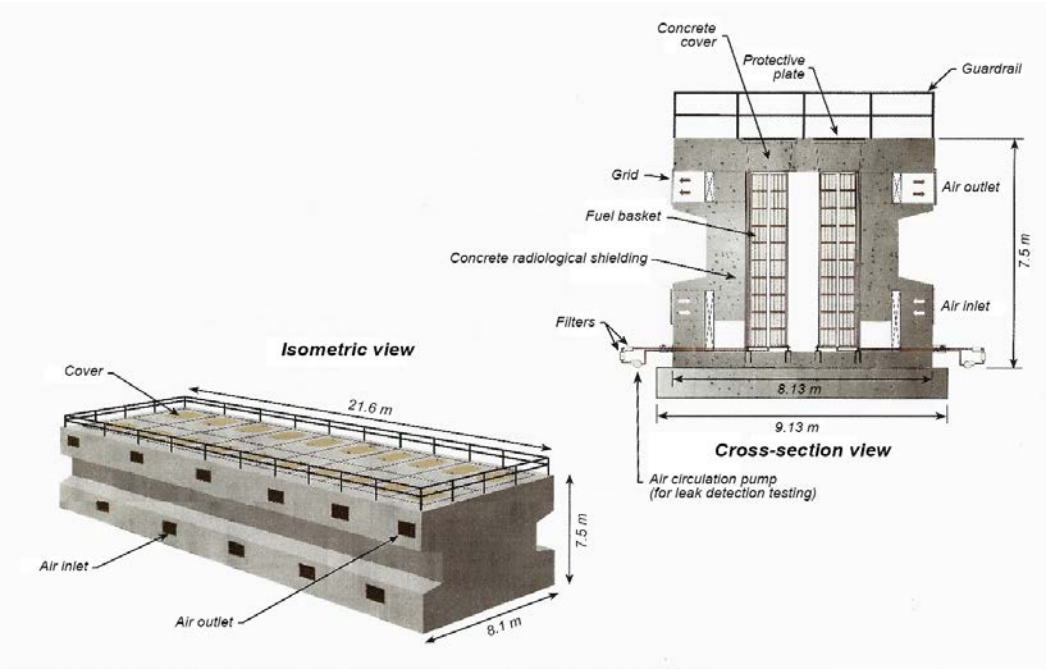
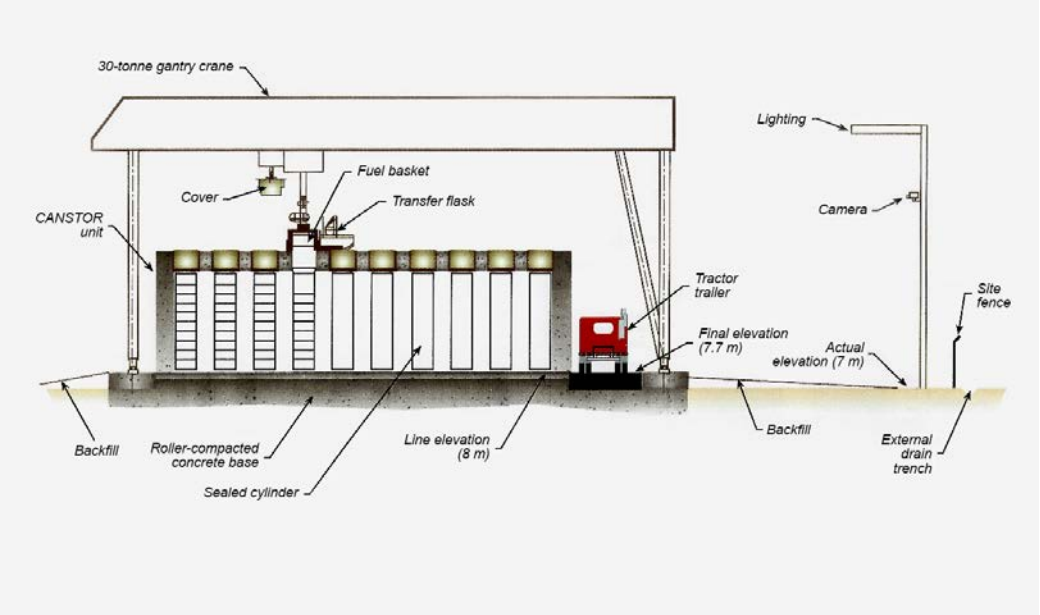


Figure 22: Fuel basket (bundle) transfer



There are currently nine CANSTOR modules at the used fuel dry storage facility. Hydro-Québec has been authorized to build two additional CANSTOR modules to store all the bundles currently held in the fuel bay. It plans to carry out the final transfer campaign to the CANSTOR modules in 2020, after which all the irradiated fuel bundles will be in dry storage.

CNSC staff inspected the Gentilly-2 waste management area in September 2015 and found that Hydro-Québec's performance was in compliance with the applicable codes and regulations. CNSC staff noted two administrative findings, which were subsequently corrected by Hydro-Québec.

Decommissioning plans

The Québec government announced the permanent closure of Gentilly-2 in September 2012. The existing decommissioning plan and related financial guarantees were based upon the completion of the refurbishment of the station and the resulting extended operational life. Hydro-Québec updated the decommissioning plan and financial guarantee to reflect the permanent closure of Gentilly-2. Hydro-Québec submitted a preliminary decommissioning plan and a confirmation of the financial guarantees, which takes into account the current situation involving the shutdown of the site rather than its repair. CNSC staff have completed the review of these documents and has determined that they meet regulatory requirements.

3.4.1.12 Security

Based on the information assessed, CNSC staff concluded that the security SCA at Gentilly-2 met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Response Arrangements

Hydro-Québec's nuclear safety officers are trained and equipped to provide an armed response, exceeding the requirements for a facility in transition to a decommissioned

site. Nevertheless, there is a deficiency in the area of maintenance of training records. These issues are being addressed by Hydro-Québec to the satisfaction of CNSC staff.

Exercises and drills
It was determined during compliance verification activities that drills and exercises at Gentilly-2 were trending toward non-compliance. CNSC staff will continue to monitor this issue.

Cyber security
CNSC staff concluded that Hydro-Québec needs to maintain a cyber security program at Gentilly-2 that takes into consideration the current state of the facility. There were no significant cyber security issues in 2015.

3.4.1.13 Safeguards and non-proliferation

Based on the information assessed, CNSC staff concluded that the safeguards and non-proliferation SCA at Gentilly-2 met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Nuclear material accounting and control
CNSC staff concluded that Hydro-Québec complied with the regulatory requirements set forth in RD-336, *Accounting and Reporting of Nuclear Material* [25].

Access and assistance to the IAEA
The IAEA performed a physical inventory verification and a design information verification at the Gentilly-2 facility in 2015 to confirm the non-diversion of safeguarded nuclear materials, and the absence of undeclared activities. The facility provided support to these inspections and the CNSC was informed by the IAEA that the results of these inspections were satisfactory.

Operational and design information
In addition to its annual operational program for Gentilly-2, Hydro-Québec also submitted to the CNSC, in a timely manner, quarterly updates and an annual update of the information provided pursuant to the IAEA Additional Protocol [24].

Safeguards equipment, containment and surveillance
Hydro-Québec supported IAEA equipment operation and maintenance to ensure the effective implementation of safeguards measures at Gentilly-2.

3.4.1.14 Packaging and transport

Based on the information assessed, CNSC staff concluded that the packaging and transport SCA at Gentilly-2 met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

CNSC staff reached this conclusion based on onsite monitoring activities and a review of the reports submitted in accordance with S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1], and REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [2]. No significant events were reported regarding consignments transported to and from the Gentilly-2 site. Hydro-Québec continued to implement and maintain an effective packaging and transport program at Gentilly-2.

3.4.2 Regulatory developments

3.4.2.1 Licensing

The Gentilly-2 licence was renewed in June 2011 for a five-year period (effective until June 30, 2016); however, Gentilly-2 ended commercial operation on December 28, 2012. CNSC and Hydro-Québec staff have begun the preparatory work and activities required for the renewal of the Gentilly-2 licence. The Commission hearing was scheduled for May 5, 2016.

Licence amendments

The Gentilly-2 licence was amended once between January 2015 and April 2016. Details of the amendments are given in appendix I. The purpose of this administrative amendment, which took effect on June 5, 2015, was to include the requirements of REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [2] as they relate to stabilization activities taking place at Gentilly-2 and the state of the station's systems and equipment. The requirements of REGDOC 3.1.1 replaced those set forth in S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1].

Revisions to the licence conditions handbook

The Gentilly-2 (LCH) was revised once between January 2015 and April 2016. Details of the revision are given in appendix I.

The revisions to the LCH were approved by the Director General of the CNSC's Directorate of Power Reactor Regulation. The changes have not resulted in an unauthorized change of scope and remain within the licensing envelope.

3.4.2.2 Updates on major projects and initiatives

Hydro-Québec plans to complete the activities and projects required for the transition from a safe storage state with the fuel stored in irradiated fuel bays to a safe storage state with the fuel placed in dry storage in CANSTOR modules, which is scheduled for 2020. It is also planning some preparatory projects required for the dormancy phase.

The key activities to be completed by the end of 2020 to achieve the safe storage state with the fuel placed in dry storage include:

- transferring irradiated fuel from the fuel bay to CANSTOR modules; these transfers will involve a series of annual and seasonal campaigns that will be completed by 2020
- transferring the content of the auxiliary bays to the solid radioactive waste management facility (SRWMF); this transfer is expected to be completed by 2020
- draining the irradiated fuel bay and the auxiliary bays; this is scheduled to take place in late 2020
- transferring spent resins to the SRWMF; the initial phases of this operation took place in 2013 and 2014, and Hydro-Québec plans to carry out the final phase in 2017
- draining the reactor's shield cooling system; this is planned for late 2020
- rinsing and draining the heavy water purification towers; this will be carried out by 2020

- reconfiguring buildings or rooms where residual radioactive material can be found; this will be completed gradually between now and 2020
- developing a detailed decommissioning plan covering the entire dormancy phase; this plan will be created in 2019

The key projects required to prepare the dormancy phase include:

- building two additional CANSTOR modules; this scheduled for 2016
- rehabilitating radioactive and non-radioactive drainage pumps; this is scheduled to take place by 2020
- reconfiguring the pump house; this is scheduled to take place by 2020
- placing in a dormant state the buildings on the Gentilly-2 site, except for the reactor building and buildings containing residual radioactive material (e.g., administrative buildings, warehouses, workshops); this will be completed gradually between now and the end of 2020

CNSC staff intend to pursue regulatory follow up of Hydro-Québec's activities and projects. To this end, targeted technical meetings with Hydro-Québec personnel will continue to take place, along with literature reviews and inspections.

3.4.2.3 Updates on significant regulatory issues

Transition to safe storage and future decommissioning

An administrative protocol between the CNSC and Hydro-Québec was signed on January 15, 2013. It was then updated on April 29, 2013; March 3, 2014; and April 1, 2015. The most recent version of the protocol covered the operational phase leading up to the next licence renewal, which is scheduled for June 2016.

The Hydro-Québec/CNSC liaison committee, set up immediately after the protocol was signed in 2013, continued to meet on a bi-weekly basis in 2015 to address technical operational issues as well as issues related to the implementation of the current licence and regulations.

***Fisheries Act* authorizations**

CNSC and Hydro-Québec staff discussed the key amendments to the *Fisheries Act* and the implementation of the Memorandum of Understanding (MoU) between CNSC and Fisheries and Oceans Canada (DFO).

The complete shutdown of the reactor in 2012 led to a substantial reduction in the heating of water discharged in the outlet channel, and also resulted in a significant decrease in the amount of water pumped from the St. Lawrence River (down from approximately 700 million cubic meters (m^3) in 2012 to 58 million m^3 in 2015).

Most of this water is used to maintain the raw water cooling system pumps, which ensure the effective operation of facility equipment that remain in service, as well as air-conditioning in rooms still in use.

These significant reductions in water heating and pumping eliminate or further reduce the potential risks and effects on fish populations and the structure of benthic communities.

Nevertheless, CNSC staff have asked Hydro-Québec to conduct a self-assessment of the impact of its current water intake on biomass and fish entrainment and impingement. This request, made in accordance with the *Fisheries Act*, was deemed necessary to confirm that water pumping activities at Gentilly-2 are still not causing any serious harm.

Hydro-Québec provided the results of the self-assessment to CNSC staff in February 2016. The results of the Hydro-Québec self-assessment were reviewed and accepted by CNSC staff and concluded that authorization under subsection 35(2) of the *Fisheries Act* is not required.

CNSC staff will continue to follow up on this matter.

Response to the Fukushima Daiichi accident

After ending commercial operations at the Gentilly-2 site in December 2012, Hydro-Québec began placing the reactor in a safe storage state in preparation for the upcoming decommissioning. As a result, most of the Fukushima action items (FAIs) were suspended for Gentilly-2, with the exception of those involving improvements to emergency response and irradiated fuel bay mitigation measures.

Hydro-Québec has provided assurance that irradiated fuel bay cooling will remain adequate until the safe dry storage state is achieved.

Hydro-Québec also implemented, to the satisfaction of CNSC staff, the improvements required by the CNSC in response to lessons learned from the Fukushima Daiichi incident. The water-supply and electricity-generation equipment introduced by Hydro-Québec at the CNSC's request is still in place at the Gentilly-2 site.

CNSC staff have completed the review of the FAIs that were still open and are of the opinion that, in the case of Hydro-Québec, all of the FAIs are now closed.

CNSC staff will continue to monitor the implementation of FAIs at Gentilly-2 through its existing compliance verification program.

3.4.2.4 Public communication

Event initial reports

No event initial reports were submitted for Gentilly-2 from January 2015 to April 2016.

Aboriginal consultation and engagement activities

In November 2014, Hydro-Québec presented an outline of the process being considered to consult and engage Aboriginal communities during the Gentilly-2 licence renewal process planned for 2015 and 2016. CNSC staff confirmed the acceptability of the proposed process, which included three main elements:

- notice of the Gentilly-2 licence renewal application
- communication of information pertaining to the licence renewal application
- description of the procedure for obtaining additional information about the licence renewal application, if necessary

CNSC staff reviewed the Hydro-Québec's proposed Aboriginal consultation and engagement process and confirmed its acceptability.

Hydro-Québec's licence application involves activities occurring within an existing restricted access nuclear facility, and there are no proposed changes to the facility's

current footprint. The purpose of the proposed activities is to prepare the site for dormancy.

Based on the information received and reviewed, CNSC staff are of the opinion that the licence application to allow Hydro-Québec to continue its activities related to the decommissioning of the Gentilly-2 nuclear facility is not expected to result in any adverse impacts to any potential or established Aboriginal or treaty rights. As such, the licence application does not raise the duty to consult. However, all of the identified First Nations and Métis groups have been encouraged to participate in the review process (including the public hearing associated with the licence application) and raise any concerns they may have with CNSC staff.

3.5 Point Lepreau

Point Lepreau Generating Station is located on the Lepreau Peninsula, 40 kilometres southwest of Saint John, NB. The station is owned and operated by NB Power and consists of a single CANDU reactor with a rated capacity of 705 MWe (megawatts electrical).

3.5.1 Safety assessment

The CNSC staff safety assessment of Point Lepreau for 2015 resulted in the performance ratings as shown in table 22. Based on the observations and assessments of the SCAs, CNSC staff concluded that Point Lepreau operated safely. The integrated plant rating was "satisfactory", unchanged from the previous year.

Table 22: Performance ratings for Point Lepreau, 2015

Safety and control area	Rating	Industry average*
Management system	SA	SA
Human performance management	SA	SA
Operating performance	SA	FS
Safety analysis	SA	SA
Physical design	SA	SA
Fitness for service	SA	SA
Radiation protection	SA	SA
Conventional health and safety	FS	FS
Environmental protection	SA	SA
Emergency management and fire protection	SA	SA
Waste management	SA	FS
Security	SA	SA
Safeguards and non-proliferation	SA	SA
Packaging and transport	SA	SA
Integrated plant rating	SA	SA

* The industry average of all operating NPPs in Canada

Notes:

- For specific areas within the SCAs where there were no significant observations from CNSC staff compliance verification activities, no information is given in this subsection of the report.
- The information presented below is station specific; refer to section 2 for general trends and industry-wide observations.

3.5.1.1 Management system

Based on the information assessed, CNSC staff concluded that the management system SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Management system

Regulatory oversight of NB Power's management system revealed weaknesses in complying with the requirements of CSA standard N286-05, *Management system requirements of nuclear power plants* [7]. Improvements are needed to maintain an effective management system. Weaknesses were also identified in the area of management oversight of procedures, procedure adequacy and procedure adherence by Point Lepreau staff. These weaknesses need to be corrected to ensure an acceptable level of safety performance is maintained.

NB Power recognizes that managerial oversight of procedures is important and has developed a corrective action plan. CNSC staff increased their regulatory oversight activities during 2015 and will continue monitor the implementation of the NB Power corrective action plan in 2016.

Organization

CNSC staff identified minor deficiencies with the definitions in the NB Power organizational structure. Roles, responsibilities and accountability for performing oversight of contractors were not adequately defined and documented in the most recent version of the nuclear management manual. CNSC staff have requested that NB Power address these issues in the next revision of the manual. CNSC staff will continue to monitor this issue through regular compliance activities in 2016.

Management of contractors

As noted above, CNSC staff identified minor deficiencies in defining the roles and responsibilities related to contractor oversight. NB Power has completed most of the corrective actions and the remainder will be completed in 2016. CNSC staff will continue to monitor progress on this issue through regular compliance activities.

3.5.1.2 Human performance management

Based on the information assessed, CNSC staff concluded that the human performance management SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Human performance program

NB Power continued to improve its human performance program. In 2015, NB Power indicated a three-year frequency for the self-assessment of its program and updated its related program documents accordingly.

Personnel training

NB Power has a training system based on the systematic approach to training. Implementation of this system for the training programs at Point Lepreau met regulatory requirements.

Personnel certification

In accordance with regulatory requirements, NB Power has a sufficient number of personnel at Point Lepreau for all certified positions. CNSC staff are satisfied that NB Power's program assures the competency of personnel at Point Lepreau to receive certification and perform their duties safely.

Initial certification examinations and requalification tests

The initial certification examination and requalification test programs for certified personnel at Point Lepreau met all regulatory requirements.

Work organization and job design

Minimum shift complement

NB Power updated its assessment of the Point Lepreau minimum shift complement. CNSC staff are currently reviewing the assessment through normal verification activities.

Fitness for duty

CNSC staff raised concerns in 2014 regarding NB Power's hours-of-work reporting process. (Specifically, there were concerns about the method used to detect hours-of-work non-compliances reportable to the CNSC.) In 2015, NB Power improved its process for monitoring compliance with its hours-of-work procedures. There were no identified hours-of-work non-compliances reported for certified staff in 2015. CNSC staff will continue to monitor the hours-of-work limits of certified staff.

3.5.1.3 Operating performance

Based on information assessed, CNSC staff concluded that the operating performance SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Conduct of licensed activities

NB Power continued to operate Point Lepreau at a satisfactory level. NB Power operated within the limits of the Point Lepreau licence, the operating policies and principles and the operational safety requirements.

Point Lepreau experienced no unplanned reactor trips, no stepbacks and one setback.

The power history graphs for the Point Lepreau nuclear reactor units for 2015 can be seen in appendix G. These graphs show the occurrences (and causes) of outages and the associated power reductions during the year.

Inspections conducted by CNSC staff (including field and control room inspections) identified no significant operations-related compliance issues.

Procedures

The implementation of NB Power procedures, as required by its licence, continued to be a challenge in 2015. Weaknesses remain in the areas of procedural adequacy and adherence. These weaknesses need to be corrected to ensure an acceptable level of safety performance is maintained.

NBP has several programs in place to improve procedures and procedure adherence. CNSC staff have increased regulatory oversight activities during 2015 and will continue monitor the implementation of the NB Power corrective action plan in 2016. CNSC staff expectations are for NB Power to meet all regulatory requirements prior to the next licence renewal.

Reporting and trending

NB Power is required to submit quarterly reports on operations and performance indicators as described in REGDOC-3.1.1 *Reporting Requirements for Nuclear Power Plants* [2]. It is also required to follow up on all events with corrective actions and root cause analysis, when appropriate. CNSC staff did not identify any significant regulatory issues from these reports.

Outage management performance

Point Lepreau did not schedule any planned outages in 2015. However, it experienced four unplanned outages and one production outage. In addition, Point Lepreau experienced some unexpected additional maintenance during the first unplanned outage. In all instances, the unit was returned to service while maintaining proper oversight of outage-related undertakings.

Safe operating envelope

CNSC staff conducted a safe operating envelope (SOE) inspection at Point Lepreau in May 2015. This inspection confirmed that NB Power has implemented and maintained an SOE program based on the requirements of CSA standard N290.15, Requirements for the safe operating envelop of nuclear power plants [38]. CNSC staff identified a few minor maintenance issues regarding SOE documentation. These issues are being addressed in a manner that is acceptable to CNSC staff. CNSC staff will continue to monitor this issue as part of their ongoing compliance monitoring activities.

3.5.1.4 Safety analysis

Based on the information assessed, CNSC staff concluded that the safety analysis SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. As a result, the station received a “satisfactory” rating, unchanged from the previous year.

Deterministic safety analysis

NB Power has an effective, well-managed program for performing deterministic safety analysis. NB Power continues to implement REGDOC-2.4.1, *Deterministic Safety Analysis* [9]. Point Lepreau has adequate safety margins and these met the CNSC’s acceptance criteria for safe operation of the NPP.

Probabilistic safety analysis

NB Power is in compliance with S-294, Probabilistic Safety Assessment (PSA) for Nuclear Power Plants [30], and is transitioning toward implementation at Point Lepreau of the recently issued REGDOC-2.4.2, Probabilistic Safety Assessment (PSA) for Nuclear Power Plants [12]. NB Power submitted a detailed and acceptable transition plan for the implementation of REGDOC-2.4.2. To maintain compliance with S-294, NB Power is required to submit an updated PSA in 2016.

3.5.1.5 Physical design

Based on the information assessed, CNSC staff concluded that the physical design SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. As a result, the station received a “satisfactory” rating, unchanged from the previous year.

Site characterization

CNSC staff conducted ongoing oversight activities at Point Lepreau in 2015 and concluded that the site characterization at Point Lepreau met regulatory requirements.

As a part of renewal of the Point Lepreau licence in 2012, the Commission required that NB Power complete a site-specific seismic hazard assessment and to post a summary of the assessment on the NB Power website. The final assessment – which included a probabilistic seismic hazard assessment as well as a paleoseismology investigation – was completed and submitted by NB Power to the CNSC in May 2015. A summary of the assessment has been posted on the NB Power website.

To address a number of Fukushima action items (FAIs), in June 2015 NB Power submitted two additional external hazard assessments: a high wind assessment and a site-specific probabilistic tsunami hazard assessment. These were accompanied by plans to address any follow-up activities. Staff from the CNSC, Natural Resources Canada, and Environment and Climate Change Canada have completed their respective reviews of these assessments. Based on the result of these reviews, CNSC staff are satisfied with these assessments and their related follow-up plans.

System design

Electrical power system

There were no significant reportable events during the year that had an effect on the electrical power systems at Point Lepreau. NB Power is addressing some ongoing issues regarding the duration of battery tests and related documentation. NB Power has committed to proposing mitigation measures to CNSC staff for review in June 2016. These issues are all of low safety significance and CNSC staff will continue to monitor NB Power's progress in this area in 2016.

Fire protection

CNSC staff conducted ongoing oversight activities at Point Lepreau in 2015, including a fire protection inspection against the requirements of CSA standard N293-07, *Fire protection for CANDU nuclear power plants* [32]. CNSC staff concluded that Point Lepreau's fire protection program is both comprehensive and in compliance with regulatory requirements.

Components design

Fuel design

NB Power has a well-developed reactor fuel inspection program. Fuel performance at Point Lepreau was acceptable in 2015.

Cables

The NB Power aging management program does not include cable condition monitoring to assure adequate assessments of the aging and degradation of non-environmentally qualified cables (including underground cables). However, the overall impact of this issue is of low safety significance. NB Power is developing a cable aging management program and its implementation has been postponed to 2016. CNSC staff continues to monitor NB Power's progress in this area.

3.5.1.6 Fitness for service

Based on the information assessed, CNSC staff concluded that the fitness for service SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Equipment fitness for service /equipment performance

On the basis of inspections and compliance verifications, CNSC staff concluded that the overall equipment fitness for service and performance at Point Lepreau was satisfactory and met regulatory requirements.

Maintenance

CNSC staff conducted an inspection on the NB Power system health monitoring process in 2015. The inspection determined that although the safety functions of systems important to safety have been continuously maintained, NB Power's

governance for the process was not compliant with regulatory requirements and its implementation was not fully effective. CNSC staff requested that NB Power develop a corrective action plan to integrate system health monitoring with its other related processes. NB Power is currently implementing its corrective action plan, with ongoing reviews and monitoring by CNSC staff.

The NB Power preventive maintenance completion ratio at Point Lepreau was 86 percent in 2015.

The 2015 maintenance backlog results for Point Lepreau are given in table 23. The corrective critical maintenance backlog and the number of deferrals of critical preventive maintenance were both below the industry average, indicating continuous improvement. The deficient maintenance backlog, however, continues to be higher than the industry average. CNSC staff determined that the deficient maintenance backlog at Point Lepreau is not safety-significant. NB Power's measures to reduce the deficient maintenance backlog will continue to be monitored by CNSC staff through routine compliance activities.

CNSC staff will continue to monitor the trends in these indicators.

Table 23: Maintenance backlogs and deferrals for critical components for Point Lepreau, 2015

Parameter	Average work orders per unit for the year	Trend during the year	Industry average
Corrective maintenance backlog	1	stable	11
Deficient maintenance backlog	142	down	117
Deferrals of preventive maintenance	1	stable	49

Structural integrity

CNSC staff compliance monitoring activities in 2015 indicated that the structures, systems and components important to safety met structural integrity requirements.

Reliability of systems important to safety

All special safety systems for Point Lepreau met their unavailability targets in 2015.

Aging management

NB Power has implemented station processes at Point Lepreau to ensure the condition of the structures, systems and components important to safety is well understood and the required activities are in place to assure their health as the plant ages. NB Power's aging management process documents were developed prior to the issuance of REGDOC-2.6.3, *Aging Management* [16]. In 2015, NB Power completed a gap assessment of its existing station processes with the requirements of REGDOC-2.6.3 and is now updating its processes accordingly, with full compliance expected in 2017.

CNSC staff concluded that NB Power's aging management program met regulatory requirements.

Chemistry control

Based on information provided in NB Power's quarterly reports on safety performance indicators, CNSC staff concluded that the chemistry control program performance at Point Lepreau was satisfactory.

Periodic inspections and testing

NB Power has adequate periodic inspection and testing programs (PIPs) in place at Point Lepreau for the pressure boundary and containment components important to safety.

CNSC staff monitored compliance with the established regulatory requirements for the PIPs during the year and concluded that their implementation met regulatory requirements.

3.5.1.7 Radiation protection

Based on the information assessed, CNSC staff concluded that the radiation protection SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Application of ALARA

NB Power continued to implement a program to keep doses as low as reasonably achievable (ALARA). The five-year ALARA plan for Point Lepreau was updated in 2015 following benchmarking with industry accepted practices and includes initiatives to further reduce collective radiation exposure.

Safety performance indicators related to the application of ALARA include tracking of collective radiation exposure values for the station. The values provided by NB Power align with the Point Lepreau dose targets. An improving trend in this specific area was noted for this reporting period.

Worker dose control

NB Power continued to comply with the regulatory requirements to measure and record doses received by workers. No worker received a radiation dose in excess of the regulatory dose limits or action levels established in the Point Lepreau radiation protection Program. The data for doses received at Point Lepreau can be found in section 2.1.7 and appendix E.5.

NB Power addressed all regulatory findings resulting from a 2014 CNSC inspection focusing on worker dose control. These findings were all determined to be of low safety significance. NB Power initiated improvements to its radiation protection program to provide assurance that every uptake of nuclear substances would be detected and doses resulting from these unlikely events would be accurately determined. NB Power also established and implemented a confirmatory alpha bioassay program to confirm that workers in the most-at-risk areas are being adequately protected against alpha hazards.

Safety performance indicators related to worker dose control include tracking of occurrences involving doses received from unplanned exposures or uptakes. There were no adverse trends or safety significant unplanned exposures due to the licensed activities at Point Lepreau in 2015.

An improved trend was observed in this area during 2015.

Radiation protection program performance

The NB Power radiation protection program met the requirements of the *Radiation Protection Regulations* and includes performance indicators to monitor program performance. In 2015, improvements were made to the program documents and supporting procedures, taking into consideration operating experience and industry best practices.

NB Power has also established a "Radiation Protection Improvement Charter" to support the implementation of standard industry practices in radiation protection.

CNSC staff noted that program improvements were made in a number of areas, including but not limited to ALARA and radiation work planning.

Challenging goals and targets for assessing overall program performance continue to be updated and monitored on an ongoing basis to improve performance.

An improving trend in this specific area was noted for this reporting period.

Radiological hazard control

No action levels were exceeded for surface contamination at Point Lepreau in 2015.

NB Power continued to ensure measures remained in place to monitor and control radiological hazards. CNSC staff noted an improving trend in this area.

NB Power addressed all remaining regulatory findings in the area of alpha monitoring and control in 2015. NB Power also completed baseline characterization of radiation source terms that present occupational hazards to workers and updated affected procedures accordingly.

Estimated dose to the public

NB Power continued to ensure the protection of members of the public in accordance with the *Radiation Protection Regulations*. The reported estimated dose to a member of the public from Point Lepreau was 0.00056 mSv, well below the annual public dose limit of 1 mSv.

3.5.1.8 Conventional health and safety

Based on the information assessed, CNSC staff concluded that the conventional health and safety SCA at Point Lepreau met or exceeded performance objectives and all applicable regulatory requirements. As a result, the station received a "fully satisfactory" rating, unchanged from the previous year.

Performance

As reported by NB Power, the accident severity rate for Point Lepreau remained at zero in 2015, unchanged from 2014. Accident frequency was below the industry average at 0.24 in 2015; however, this is an increase from 2014.

Practices; awareness

NB Power's performance in the practice specific area exceeded CNSC requirements at Point Lepreau in 2015.

NB Power was compliant at Point Lepreau with the relevant portions of New Brunswick's *Occupational Health and Safety Act*, the *Worker's Compensation Act* and the *Workplace Health, Safety and Compensation Commission Act*.

3.5.1.9 Environmental protection

Based on the information assessed, CNSC staff concluded that the environmental protection SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous year.

Effluent and emissions control

All radiological releases from Point Lepreau remained well below regulatory limits.

NB Power provided a gap analysis regarding CSA standard N288.5, *Effluent monitoring programs at Class 1 nuclear facilities and uranium mines and mills* [35], and will be providing an updated action plan for its implementation.

The derived release limits are provided in appendix E.5.

Environmental management system
NB Power has established and implemented an environmental management program to assess environmental risks associated with its nuclear activities and to ensure these activities are conducted in a way that prevents or mitigates adverse environmental effects.

Assessment and monitoring
CNSC staff reviewed and assessed the NB Power environmental monitoring data and did not identify any unreasonable risk to the public or the environment.

Protection of the public
There were no hazardous substances released from Point Lepreau that posed an unacceptable risk to the environment or the public.

The reported annual radiation dose to the public from Point Lepreau remained very low at 0.056 percent of the public dose limit.

Environmental risk assessment
NB Power continued to maintain and implement an effective environmental risk assessment and management program at Point Lepreau in accordance with regulatory requirements.

NB Power submitted an environmental risk assessment in 2015 according to CSA standard N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [21], and continued to work on addressing identified gaps in its environmental protection programs. Fish mortality (impingement and entrainment) monitoring due to cooling water intake also continued throughout 2015. CNSC staff will review the final NB Power reports expected in 2016.

3.5.1.10 Emergency management and fire protection

Based on the information assessed, CNSC staff concluded that the emergency management and fire protection SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. As a result, the station received a “satisfactory” rating, unchanged from the previous year.

Conventional emergency preparedness and response
Regulatory oversight activities conducted by CNSC staff at Point Lepreau in 2015 included documentation reviews, onsite observations and participation in drills. NB Power maintained its conventional emergency preparedness and response commitments, including enhancements to its emergency (non-nuclear) drill program.

Nuclear emergency preparedness and response
NB Power maintained its commitment to nuclear emergency preparedness and response and implemented enhancements to its emergency drill program.

NB Power continued to distribute and stockpile potassium iodide (KI) tablets in the primary and secondary zones around Point Lepreau. NB Power also distributed emergency preparedness pamphlets to local residents around the plant to enhance public awareness of nuclear emergencies.

Exercise Intrepid 2015

In November 2015, NB Power held a large-scale nuclear exercise called Exercise Intrepid. The purpose of this two-day exercise was to validate the preparedness of Point Lepreau, NB Power, various levels of governments, and non-government organizations and agencies to respond to a large-scale nuclear event. It provided all players involved with opportunities to test emergency response plans and measures and to identify areas for improvement.

CNSC staff evaluated Exercise Intrepid and concluded that there were no significant issues that would have affected the operating unit or the completion of offsite actions. The validation of emergency plans and lessons learned provided valuable information and experience for the participating organizations. CNSC staff concluded that NB Power and other agencies continue to successfully demonstrate readiness to respond to a nuclear emergency.

Fire emergency preparedness and response

CNSC staff continued to conduct regulatory oversight activities at Point Lepreau in 2015, including inspections that verified the effectiveness of equipment and performance enhancements to the industrial fire brigade. CNSC staff concluded that Point Lepreau continues to implement a comprehensive fire response capability that includes effective procedures, training and maintenance of proficiency.

3.5.1.11 Waste management

Based on the information assessed, CNSC staff concluded that the waste management SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. As a result, the station received a “satisfactory” rating, unchanged from the previous year.

Waste characterization; waste minimization;

All findings from CNSC staff compliance verification activities in 2015 for the waste characterization and waste minimization specific areas confirmed that Point Lepreau met regulatory requirements.

Waste management plan

CNSC staff conducted an inspection of the conventional hazardous waste management program at Point Lepreau. The inspection identified non-conformances related to procedures and procedural adherence (see section 3.5.1.3 – Procedures). These non-conformances related to the identification of hazardous waste that had the potential to affect the effectiveness of the program’s implementation. CNSC staff issued a directive and action notices requiring NB Power to take actions to correct the non-conformance. CNSC staff will monitor the implementation of NB Power’s corrective actions through regular compliance activities in 2016. CNSC staff expectations are for NB Power to meet all regulatory requirements prior to the next licence renewal.

The Point Lepreau site includes a solid radioactive waste management facility. As the facility is located a short distance from the station on the Point Lepreau site, waste must be transported from the station to the facility. CNSC staff provide regulatory oversight for these waste transfers. CNSC staff concluded that NB Power demonstrated consistent and compliant management and control of waste handling and storage.

Decommissioning plans

NB Power submitted its preliminary decommissioning plan and associated cost estimate for CNSC review in 2015. Based on their assessment of the revised

documentation, CNSC staff concluded that NB Power's decommissioning plan, cost estimate and financial guarantee remain current and meet regulatory requirements.

3.5.1.12 Security

Based on the information assessed, CNSC staff concluded that the security SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. As a result, the station received a rating of "satisfactory" rating, unchanged from the previous year.

Facilities and equipment
Facilities and equipment were affected by a lack of an effective maintenance program that includes preventative measures. This is a repeat issue and, despite assurances from NB Power, has not yet been addressed. Investments in screening area equipment and layout have been realized.

Response arrangements
Deficiencies in training and qualification documentation activities, including maintenance of these records, were identified as challenges for NB Power. The integration with offsite response was also observed as needing improvement. CNSC staff are tracking these issues closely and will review them in 2016.

Despite these findings, Point Lepreau showed strengths in other areas of response arrangements, such as offsite nuclear response force training.

Drills and exercises
It was determined during compliance verification activities that drills and exercises were trending toward non-compliance. NB Power has provided a corrective action plan to address the findings. Corrections were made in the second half of the year and NB Power is now performing adequately in this area.

Cyber security
NB Power has implemented and continues to maintain an effective cyber security program at Point Lepreau. CNSC staff concluded that the program complied with applicable regulatory requirements.

3.5.1.13 Safeguards and non-proliferation

Based on the information assessed, CNSC staff concluded that the safeguards and non-proliferation SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. The station received a "satisfactory" rating, unchanged from the previous year.

Nuclear material accountancy and control
NP Power complied with regulatory requirements at Point Lepreau in accordance with RD-336, *Accounting and Reporting of Nuclear Material* [25].

Access and assistance to the IAEA
The International Atomic Energy Association (IAEA) performed one short-notice random inspection at Point Lepreau in 2015 to confirm the non-diversion of safeguarded nuclear materials and the absence of undeclared activities. The facility provided support for this inspection and CNSC staff were informed by the IAEA that the result of this inspection was satisfactory.

The IAEA did not select Point Lepreau for a physical inventory verification (PIV) in 2015. As a result, CNSC staff performed an evaluation of Point Lepreau's preparedness

for a PIV in September 2015. From this evaluation, CNSC staff was satisfied that Point Lepreau was adequately prepared for an IAEA PIV in 2015 had it been selected.

Operational and design information

NB Power submitted its annual operational program for Point Lepreau to the CNSC on time, along with quarterly updates and the annual update to the information pursuant to the IAEA Additional Protocol [24].

Safeguards equipment, containment and surveillance

NB Power supported IAEA equipment operation and maintenance activities, including maintenance and repair work on IAEA remote monitoring equipment components to ensure the effective implementation of safeguards measures at the station.

3.5.1.14 Packaging and transport

Based on the information assessed, CNSC staff concluded that the packaging and transport SCA at Point Lepreau met performance objectives and all applicable regulatory requirements. As a result, the station received a "satisfactory" rating, unchanged from the previous years.

NB Power has a packaging and transport program that ensures compliance with the *Packaging and Transport of Nuclear Substances Regulations*, 2015 and the *Transportation of Dangerous Goods Regulations*.

The programs are effectively implemented at Point Lepreau and the transport of nuclear substances to and from the facility is done in a safe manner. There were some instances where the process for document control and record keeping was not followed. NB Power is addressing these issues. CNSC staff will monitor the implementation of NB Power's corrective actions through regular compliance activities in 2016.

3.5.2 Regulatory developments

3.5.2.1 Licensing

The Point Lepreau nuclear power reactor operating licence will expire on June 30, 2017. On November 4, 2015, CNSC staff sent a letter to NB Power outlining the licence renewal application requirements and followed up on February 8, 2016 with a letter detailing the CNSC regulatory documents and CSA standards that will be included in the licensing basis. CNSC staff have requested that NB Power submit its licence renewal application to the CNSC on or before June 30, 2016. NB Power has stated that it intends to apply for a five-year licence.

CNSC staff anticipate that the licensing hearings will be scheduled as follows: a first public hearing in late January or early February 2017 in Ottawa, followed by a second public hearing in late April or early May 2017 in New Brunswick.

Licence amendments

The Point Lepreau licence was amended once between January 2015 and April 2016. Details of these amendments are given in appendix I.

Revisions to the licence conditions handbook

Point Lepreau's licence conditions handbook (LCH) was issued on February 20, 2012. Between January 2015 and April 2016, three revisions were made to the Point Lepreau LCH. The changes were mostly administrative in nature; details of the significant changes are provided in appendix I.

The revisions to the LCH were approved by the Director General of the CNSC's Directorate of Power Reactor Regulation. The changes have not resulted in an unauthorized change of scope and remain within the licensing envelope.

3.5.2.2 Updates on major projects and initiatives

Environmental monitoring

In accordance with CNSC requirements, NB Power continued to maintain and implement an effective environmental risk assessment and management program for the protection of the environment and human health at Point Lepreau. NB Power submitted an environmental risk assessment in 2015 according to CSA standard N288.6-12, Environmental risk assessments at Class I nuclear facilities and uranium mines and mills [21], and continues to work on addressing identified gaps in its environmental protection programs. Fish mortality (impingement and entrainment) monitoring due to cooling water intake continued throughout 2015.

3.5.2.3 Updates on significant regulatory issues

***Fisheries Act* authorization**

CNSC staff have discussed the key amendments to the *Fisheries Act*, highlights of the CNSC-Department of Fisheries and Oceans (DFO) Memorandum of Understanding (MoU), and key DFO policy documents related to the interpretation of the amended Fisheries Act, specifically, the Habitat Protection Prohibitions clauses of the *Fisheries Act* with NB Power. Discussions included NB Power's ongoing fish impingement and entrainment studies and initial discussions of NB Power's self-assessment to determine the requirement for a *Fisheries Act* application. NB Power has been requested to complete a self-assessment for Point Lepreau on the need for a *Fisheries Act* authorization.

Response to the Fukushima Daiichi accident

As a part of renewal of the Point Lepreau licence in 2012, the Commission required that NB Power complete a site-specific seismic hazard assessment for Point Lepreau. The final assessment (Probabilistic Seismic Hazard Assessment (PSHA) and a Paleoseismology Investigation) was completed by the NB Power contractor (AMEC) and submitted by NB Power to the CNSC on May 11, 2015. These studies were tracked via Fukushima action items (FAIs) 2.1.1 and 2.1.2 (see appendix H for details).

On June 30, 2015, NB Power submitted its other External Hazard Assessments [High Wind Assessment, site-specific Probabilistic Tsunami Hazard Assessment (PTHA)] as required by FAIs 2.1.1 and 2.1.2, including plans for any follow-up activities based on these assessments. This submission also requested the closure of these two FAIs.

Staff from the CNSC, Natural Resources Canada, and Environment and Climate Change Canada have reviewed the submissions made by NB Power in 2015 requesting the closure of FAIs 2.1.1 and 2.1.2. (See appendix H for details on these FAIs.) These submissions included:

- a probabilistic seismic hazard assessment and paleoseismology investigation
- a high wind hazard assessment
- a site-specific probabilistic tsunami hazard assessment
- plans and schedules for follow-up activities related to the above-noted assessments

In December 2015, NB Power submitted supplemental information requesting the closure of FAI 2.1.2. This supplemental information consisted of:

- an assessment of other external hazards for the Point Lepreau site
- emergency procedures to prepare for severe weather conditions

CNSC staff concluded that the NB Power submissions related to FAI 2.1.1 and FAI 2.1.2 met the established closure criteria. As a result, FAI 2.1.1 and FAI 2.1.2 have been closed for Point Lepreau.

NB Power has posted the Point Lepreau seismic hazards summary report to its website. It provides further details on the evolution of seismic evaluation methodologies as well as an update on seismic-related work.

CNSC staff will continue to monitor FAI implementation at Point Lepreau through the established compliance verification program. Updates on FAI implementation will be provided to the Commission as part of the annual NPP Report.

3.5.2.4 Public communication

Event initial reports

No event initial reports were submitted for Point Lepreau from January 2015 to April 2016.

4 Summary and conclusions

This report summarizes the Canadian Nuclear Safety Commission (CNSC) staff's assessment of the safety performance of nuclear power plant (NPP) licensees and the Canadian nuclear power industry as a whole in 2015. It also provides information on the CNSC staff evaluation of how well licensees met regulatory requirements and CNSC expectations for the 14 safety and control areas (SCAs) of the regulatory framework. The assessment reviews generic issues, identifies industry trends, and compares Canadian NPP industry safety performance indicators with those of international NPP operators and other industries. The assessments in this report were based on the consideration of findings from inspections, desktop reviews, site surveillance activities, field rounds and other compliance verification activities against relevant requirements, expectations and performance objectives.

CNSC staff concluded that NPPs in Canada were operated safely during 2015, and that licensees made adequate provisions to protect the health, safety and security of persons and the environment, as well as to ensure that Canada continued to meet its international obligations on the peaceful use of nuclear energy. Licensees complied with the requirements to report events requiring regulatory oversight, and they followed up on these events as necessary.

These conclusions are based on the following observations:

- There were no serious process failures at the NPPs.
- No member of the public received a radiation dose that exceeded the regulatory limits.
- No worker at any NPP received a radiation dose that exceeded the regulatory limits.
- The frequency and severity of non-radiological injuries to workers were minimal.
- No radiological releases to the environment from the stations exceeded the regulatory limits.
- Licensees complied with licence conditions concerning Canada's international obligations.
- No NPP events above Level 0 on the International Nuclear and Radiological Event Scale (INES) were reported to the International Atomic Energy Agency.

Table 24 summarizes the 2011–15 ratings for Canada's NPPs. For each station, the SCAs are presented along with the industry averages and the integrated plant ratings that reflect a plant's overall safety performance. Overall, the trend is one of maintaining or improving performance with respect to SCA and integrated plant ratings. Specifically, in 2015:

- A total of 19 SCAs across the NPPs were rated as "fully satisfactory" (FS). This is the highest number of "full satisfactory" ratings since the SCA framework was introduced in 2010 – and an increase of five from the previous high recorded in 2014.
- The Canadian nuclear power industry achieved an average rating of "fully satisfactory" in the operating performance, conventional health and safety, and waste management SCAs. For conventional health and safety, five of the six stations

received “fully satisfactory” ratings while four of the six stations received “fully satisfactory” ratings for operating performance and waste management. The average rating for the operating performance SCA improved from “satisfactory” (SA) in 2014 to “fully satisfactory” in 2015. Conversely, the industry average rating for the security SCA fell from “fully satisfactory” in 2014 to “satisfactory” in 2015.

- Bruce A, Bruce B, Darlington and Pickering all achieved an integrated plant rating of “fully satisfactory” in 2015. Gentilly-2 and Point Lepreau received an “satisfactory” integrated plant rating. The integrated plant rating for Bruce B, Darlington, Gentilly-2 and Point Lepreau was unchanged from 2014, while the rating for Bruce A and Pickering improved to “fully satisfactory” in 2015 from “satisfactory” in 2014.

None of the NPPs received a rating of below expectations (BE) or unacceptable (UA) in 2015. This is unchanged from the final results for 2011 to 2014.

Table 24: Trends of ratings from 2011 to 2015

Safety and control area	Year	Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average*
Management system	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	SA	SA	SA	SA	SA	SA	SA
	2014	SA	SA	SA	SA	SA	SA	SA
	2015	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Human performance management	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	SA	SA	SA	SA	SA	SA	SA
	2014	SA	SA	SA	SA	SA	SA	SA
	2015	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Operating performance	2011	SA	SA	FS	SA	SA	SA	SA
	2012	SA	SA	FS	SA	SA	SA	SA
	2013	SA	SA	FS	SA	SA	SA	SA
	2014	SA	FS	FS	SA	SA	SA	SA
	2015	***FS***	***FS***	***FS***	***FS***	***SA***	***SA***	***FS***
Safety analysis	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	SA	SA	SA	SA	SA	SA	SA
	2014	SA	SA	SA	SA	SA	SA	SA
	2015	***SA***	***SA***	***FS***	***FS***	***SA***	***SA***	***SA***
Physical design	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	SA	SA	SA	SA	SA	SA	SA
	2014	SA	SA	SA	SA	SA	SA	SA
	2015	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Fitness for service	2011	SA	SA	FS	SA	SA	SA	SA
	2012	SA	SA	FS	SA	SA	SA	SA
	2013	SA	SA	SA	SA	SA	SA	SA
	2014	SA	SA	SA	SA	SA	SA	SA
	2015	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Radiation protection	2011	SA	SA	FS	SA	SA	SA	SA
	2012	SA	SA	FS	SA	SA	SA	SA
	2013	SA	SA	FS	FS	SA	SA	SA
	2014	SA	SA	FS	FS	SA	SA	SA
	2015	***SA***	***SA***	***FS***	***FS***	***SA***	***SA***	***SA***
Conventional health and safety	2011	FS	FS	FS	SA	SA	SA	SA
	2012	FS	FS	FS	SA	SA	FS	FS
	2013	FS	FS	FS	SA	SA	FS	FS
	2014	FS	FS	SA	SA	SA	FS	FS
	2015	***FS***	***FS***	***FS***	***FS***	***SA***	***FS***	***FS***
Environmental protection	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	SA	SA	SA	SA	SA	SA	SA
	2014	SA	SA	SA	SA	SA	SA	SA
	2015	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Emergency management and fire protection	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	SA	SA	SA	SA	SA	SA	SA
	2014	SA	SA	SA	SA	SA	SA	SA

Safety and control area	Year	Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average*
	2015	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Waste management	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	SA	SA	SA	SA	SA	SA	SA
	2014	FS	FS	FS	SA	SA	SA	FS
	2015	***FS***	***FS***	***FS***	***FS***	***SA***	***SA***	***FS***
Security	2011	FS	FS	SA	SA	SA	SA	SA
	2012	FS	FS	SA	SA	SA	SA	SA
	2013	FS	FS	FS	FS	SA	SA	FS
	2014	FS	FS	FS	FS	SA	SA	FS
	2015	***FS***	***FS***	***SA***	***SA***	***SA***	***SA***	***SA***
Safeguards and non-proliferation	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	SA	SA	SA	SA	SA	SA	SA
	2014	SA	SA	SA	SA	SA	SA	SA
	2015	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Packaging and transport	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	SA	SA	SA	SA	SA	SA	SA
	2014	SA	SA	SA	SA	SA	SA	SA
	2015	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Integrated plant rating	2011	SA	SA	FS	SA	SA	SA	SA
	2012	SA	SA	FS	SA	SA	SA	SA
	2013	SA	SA	FS	SA	SA	SA	SA
	2014	SA	FS	FS	SA	SA	SA	SA
	2015	***FS***	***FS***	***FS***	***FS***	***SA***	***SA***	***SA***

* The industry average of all operating NPPs in Canada.

Furthermore, as shown in table 24, in 2015, within the Canadian nuclear power industry:

- Bruce A received four “fully satisfactory” safety performance ratings (in operating performance, conventional health and safety, waste management and security), an increase of one from 2014. The rating for operating performance improved from “satisfactory” in 2014 to “fully satisfactory” in 2015.

- Bruce B received four “fully satisfactory” safety performance ratings (in operating performance, conventional health and safety, waste management and security), unchanged from 2014.

- Darlington received five “fully satisfactory” safety performance ratings (in operating performance, safety analysis, radiation protection, conventional health and safety, and waste management), an increase of one from 2014. The ratings for safety analysis and conventional health and safety improved from “satisfactory” in 2014 to “fully satisfactory” in 2015. However, the rating for security returned to “satisfactory” in 2015 from “fully satisfactory” in 2014.

- Pickering received five “fully satisfactory” safety performance ratings (in operating performance, safety analysis, radiation protection, conventional health and safety and waste management), an increase of three from 2014. The ratings for operating performance, safety analysis, conventional health and safety, and waste management improved from “satisfactory” in 2014 to “fully satisfactory” in 2015. However, the

rating for security returned to “satisfactory” in 2015 from “fully satisfactory” in 2013 and 2014.

- Point Lepreau received one “fully satisfactory” safety performance rating (in conventional health and safety), unchanged from 2014.

During 2015, CNSC staff verified that licensees continued to implement safety enhancements in response to the Fukushima Daiichi accident. The Fukushima action items (FAIs) as specified in the *CNSC Integrated Action Plan on the Lessons Learned from the Fukushima Daiichi Nuclear Accident* [5] and implemented by NPP licensees are aimed at strengthening defence in depth and enhancing onsite emergency response. All Canadian NPP licensees have made considerable progress in addressing and implementing the 36 FAIs at their stations.

As of May 2016, CNSC staff had completed Level 3 inspections of emergency mitigation equipment, which was implemented as a result of the Fukushima lessons learned at all Canadian NPP sites.

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Acronyms and abbreviations

AECL	Atomic Energy of Canada Limited
AF	accident frequency
AI	action item
ALARA	as low as reasonably achievable
ASR	accident severity rate
CAA	composite analytical approach
CANDU	Canada Deuterium Uranium
CANSTOR	CANDU storage (for used fuel)
CGD	commercial-grade dedication
CMD	Commission member document
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group
COP	continued operations plan
CSA	Canadian Standards Association (now known as CSA Group)
CSI	CANDU safety issue
CVC	compliance verification criteria
CVP	compliance verification program
DAC	derived acceptance criteria
DFO	Fisheries and Oceans Canada
DRL	derived release limit
E-NOP	enhanced neutron overpower protection
EA	environmental assessment
ECCC	Environment and Climate Change Canada
ECIS	emergency coolant injection system
EFPH	equivalent full-power hour(s)
EIR	event initial report
EMS	environmental management system
E-NOP	enhanced neutron overpower protection

EPRI	Electric Power Research Institute
EVS	extreme value statistics
FAI	Fukushima action item
FCLMP	fuel channel life management project
FLR	forced loss rate
HSM	Historic Saugeen Métis
HT	elemental tritium
HTO	tritium oxide
HTS	heat transport system
IAEA	International Atomic Energy Agency
IEMP	Independent Environment Monitoring Program
IIP	integrated implementation plan
INES	International Nuclear and Radiological Event Scale
IPPAS	International Physical Protection Advisory Service
IST	Industry Standard Toolset
JRP	joint review panel
KI	potassium iodide
LBLOCA	large-break loss-of-coolant accident
LCH	licence conditions handbook
LLOCA	large loss-of-coolant accident
LOCA	loss-of-coolant accident
MAAP–CANDU	Modular Accident Analysis Program
MNO	Métis Nation of Ontario
MoU	memorandum of understanding
MWe	megawatts electrical (i.e., megawatts of electrical power)
NEA	Nuclear Energy Agency
NOP	neutron overpower protection
NPCS	negative-pressure containment system
NPP	nuclear power plant
NSCA	*Nuclear Safety and Control Act*
OPG	Ontario Power Generation

PIP	periodic inspection program
PIV	physical inventory verification
PNERP	Provincial Nuclear Emergency Response Plan
PPS	Provincial Policy Statement
PROL	power reactor operating licence
PRSL	power reactor site preparation licence
PSA	probabilistic safety assessment
PSR	periodic safety review
R&D	research and development
RD	regulatory document
RD/GD	regulatory document/guidance document
REGDOC	regulatory document
SAMG	severe accident management guideline
SAP	stabilization activity plan
SCA	safety and control area
SDS1	shutdown system number 1
SLOR	slow loss of regulation
SMART	simple model for activity removal and transport
SOE	safe operating envelope
SON	Saugeen Ojibway Nation
SOP	sustainable operations plan
U0O	Unit 0 operator
VXI	VME bus eXtensions for Instrumentation
WANO	World Association of Nuclear Operators

Glossary

accident frequency

A measure of the number of fatalities and injuries (lost-time and medically treated) due to accidents for every 200,000 person-hours (approximately 100 person-years) worked.

accident severity rate

A measure of the total number of days lost due to a work-related injury for every 200,000 person-hours worked.

becquerel

The unit of measure for the quantity of radioactive material. One becquerel (Bq) is equal to the decay of one atom per second.

beyond-design-basis accident

Accident conditions less frequent and more severe than a design-basis accident. A beyond-design-basis accident may or may not involve core degradation.

calandria tubes

Tubes that span the calandria and separate the pressure tubes from the moderator. Each calandria tube contains one pressure tube.

Commission

The Canadian Nuclear Safety Commission was established by section 8 of the *Nuclear Safety and Control Act* (NSCA). It is a corporate body of not more than seven members, appointed by the Governor in Council. The objects of the Commission are:

a) to regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information in order to:
   - prevent unreasonable risk, to the environment and to the health and safety of persons, associated with that development, production, possession or use
   - prevent unreasonable risk to national security associated with that development, production, possession or use
   - achieve conformity with measures of control and international obligations to which Canada has agreed

b) to disseminate objective scientific, technical and regulatory information to the public concerning the activities of the CNSC and the effects, on the environment and on the health and safety of persons, of the development, production, possession and use referred to in paragraph a)

Commission member document

A document prepared for Commission hearings and meetings by CNSC staff, proponents and intervenors.

derived release limit

A limit imposed by the CNSC on the release of a radioactive substance from a licensed nuclear facility such that compliance with the derived release limit gives reasonable assurance that the regulatory dose limit is not exceeded.

design basis

The range of conditions and events taken explicitly into account in the design of a facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits by the planned operation of safety systems.

design-basis accident

Accident conditions against which a nuclear power plant is designed according to established design criteria and for which the damage to the fuel and the release of radioactive material are kept within authorized limits.

design life

The period specified for the safe operation of the facility, systems, structures and components.

equivalent full-power hour

The period over which a component sees service that equals the amount of full service the component would have experienced if it had been operated continuously over a full hour.

feeder

One of several hundred channels in a CANDU reactor that contains fuel. The feeders are pipes attached to each end of the channels and are used to circulate heavy water coolant from the fuel channels to the steam generators.

forced outage

A reactor shutdown that results in an outage that had not been identified in the licensee's long-term plan or that is not due to a surplus baseload generation request.

guaranteed shutdown state

The reactor shall be considered to be in a guaranteed shutdown state if the following is in place:

- There is sufficient negative reactivity to ensure sub-criticality in the event of any process failure.
- Approved administrative safeguards (i.e., reactor shutdown guarantees) – approved by the senior operations authority and concurred with by the CNSC – are in place to prevent net removal of negative reactivity.

industrial safety accident rate

A measure of the number of lost-time injuries for every 200,000 hours worked by nuclear power plant personnel.

International Atomic Energy Agency

An independent international organization related to the United Nations system. Located in Vienna, the International Atomic Energy Agency (IAEA) works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies. The IAEA reports annually to the United Nations General Assembly and, when appropriate, to the United Nations Security Council regarding non-compliance by Member States with respect to their safeguards obligations, as well as on matters related to international peace and security.

licensing basis

A set of requirements and documents for a regulated facility or activity comprising the:

- regulatory requirements set out in applicable laws and regulations
- conditions and safety and control measures described in the facility's or activity's licence and documents directly referenced in that licence
- safety and control measures described in the licence application and documents needed to support that licence application

minimum shift complement

The minimum number of qualified workers who must be present at all times to ensure the safe operation of a nuclear facility and adequate emergency response capability. Also referred to as "minimum staff complement."

Millisievert

A millisievert (mSv) is equal to one-thousandth of a sievert.

pressure tubes

Tubes that pass through the calandria and contain 12 or 13 fuel bundles. Pressurized heavy water flows through the tubes, cooling the fuel.

probabilistic safety assessment

For a nuclear power plant or fission reactor, a probabilistic safety assessment (PSA) is a comprehensive and integrated assessment of the plant or reactor's safety. It considers the probability, progression and consequences of equipment failures or transient conditions to derive numerical estimates that provide a consistent measure of safety, as follows:

- A Level 1 PSA identifies and quantifies the sequences of events that may lead to the loss of core structural integrity and massive fuel failures.
- A Level 2 PSA starts from the Level 1 results. It analyzes the containment behaviour, evaluates the radionuclides released from the failed fuel and quantifies releases to the environment.

- A Level 3 PSA starts from the Level 2 results. It analyzes the distribution of radionuclides in the environment and evaluates the resulting effect on public health.

A PSA may also be referred to as a "probabilistic risk assessment".

risk

The chance of injury or loss, defined as a measure of the probability and severity of an adverse effect (consequence) to health, property, the environment or other things of value. Mathematically, it is the probability of occurrence (likelihood) of an event multiplied by its magnitude (severity).

risk-informed approach

An approach to decision making that includes risk insight as one of the factors in determining a course of action.

root cause analysis

An objective, structured, systematic and comprehensive analysis designed to determine the underlying reason(s) for a situation or event. Such an analysis is conducted with a level of effort consistent with the safety significance of the event.

safety-related system

As defined in CSA standard N285.0-08, *General requirements for pressure-retaining systems and components in CANDU nuclear power plants*, and referenced in the nuclear power plant licence, safety-related systems are those systems and their related components and supports that, by failing to perform in accordance with the design intent, have the potential to affect the radiological safety of the public or nuclear power plant personnel. Those systems and their components involve:

- the regulation (including controlled start-up and shutdown) and cooling of the reactor core under normal conditions (including all normal operating and shutdown conditions)
- the regulation, shutdown and cooling of the reactor core under anticipated transient conditions and accident conditions, and the maintenance of the reactor core in a safe shutdown state for an extended period following such conditions
- limiting the release of radioactive material and the exposure of plant personnel and/or the public to meet the criteria established by the licensing authority with respect to radiation exposure during and following normal, anticipated transient conditions and accident conditions

Notes:

1) The term "safety-related system" covers a broad range of systems, from those having very important safety functions to those with a less direct effect on safety. The larger the potential radiological safety effect due to system failure, the stronger the "safety-related" connotation.
2) "Safety-related" also applies to certain activities associated with the design, manufacture, construction, commissioning, and operation of safety-related systems and to other activities that can similarly affect the radiological safety of the public or plant personnel, such as environmental and effluent monitoring, radiation protection and dosimetry, and radioactive

material handling (including waste management). The larger the potential radiological safety effect associated with the performance of the activity, the stronger the "safety-related" connotation.

3) Certain failures of other systems can adversely affect a safety-related system (e.g., through flooding or mechanical damage).

safety report

A report, as described in REGDOC-S-99, *Reporting Requirements for Operating Nuclear Power Plants*, which provides descriptions of the structures, systems and components of a facility, including their design and operating conditions. This includes a final safety analysis report demonstrating the adequacy of the design of the nuclear facility.

safety system

A system provided to ensure the safe shutdown of a reactor or the residual heat removal from the core, or to limit the consequences of anticipated operational occurrences and design-basis accidents.

serious process failure

With respect to reporting requirements for CANDU nuclear power plants, a failure of a process structure, system or component that leads to a systematic fuel failure or a significant release from the plant or that could lead, in the absence of action by any special safety system, to a systematic fuel failure or a significant release from the plant.

setback

A system designed to automatically reduce reactor power at a slow rate if a problem occurs. The setback system is part of the reactor-regulating system. See also "stepback".

sievert

A unit of dose corresponding to the rem, which is another unit of dose (1 Sv = 100 rem). One sievert (Sv) is defined as one joule of energy absorbed per kilogram of tissue (i.e., 1 Sv = 1 J/kg) multiplied by an appropriate, dimensionless weighting factor.

special safety system

One of the following systems of a nuclear power plant: shutdown system number one, shutdown system number two, the containment system or the emergency core cooling system.

steam generator

A heat exchanger that transfers heat from the heavy water coolant to ordinary water. The ordinary water boils, producing steam to drive the turbine. The steam generator tubes separate the reactor coolant from the rest of the power-generating system.

stepback

A system designed to automatically reduce reactor power at a fast rate if a problem occurs. The stepback system is part of the reactor-regulating system. See also "setback."

structures, systems and components

A general term encompassing all of the elements (items) of a facility or activity that contribute to protection and safety. Structures are the passive elements (e.g., buildings, vessels, shielding). A system comprises several components assembled to perform a specific (active) function. A component is a discrete element of a system. Examples are wires, transistors, integrated circuits, motors, relays, solenoids, pipes, fittings, pumps, tanks and valves.

systematic approach to training

A logical approach to training that consists of several phases, including the:

- analysis phase, during which the competencies with respect to knowledge and skills required to work in a position are identified
- design phase, during which the competency requirements for a position are converted into training objectives and a training plan is produced
- development phase, during which the training material needed to meet training objectives is prepared
- implementation phase, during which the training is conducted using the material developed
- evaluation phase, during which data regarding each of the above phases are collected and reviewed to determine the effectiveness of training and appropriate actions are taken to improve training effectiveness

systems important to safety

Structures, systems and components of the nuclear power plant associated with the initiation, prevention, detection or mitigation of any failure sequence that have the most significant impact in reducing the possibility of damage to fuel, associated release of radionuclides, or both.

Terabecquerel

A terabecquerel (TBq) is equal to a trillion becquerels. See “becquerel.”

unavailability target

Unavailability targets are compared against actual plant performance to identify deviations from expected performance. Availability is the fraction of time for which the system can be demonstrated to meet all of the minimum allowable performance standards. Licensees are expected to not exceed unavailability targets.

World Association of Nuclear Operators

A non-profit organization whose stated mission is to maximize the safety and reliability of nuclear power plants worldwide by working together to assess, benchmark and improve performance through mutual support, exchange of information and emulation of best practices.

Appendix A: Five-year trend in compliance activities

A.1 Bruce A and B

Table A.1: Five-year trend in compliance activities for Bruce A and B, 2011–15

Compliance activities effort (person-days)	2011	2012	2013	2014	2015
Inspections	2,200	2,600	1,540	1,520	1,030
Event reviews	236	212	234	250	198
Other compliance activities *	1,993	1,435	3,297	3,597	3,899
Total effort (person-days)	4,429	4,247	5,071	5,367	5,127

* Includes verification activities such as station walkdowns and reviews of licensee-submitted documents and reports.

A.2 Darlington

Table A.2: Five-year trend in compliance activities for Darlington, 2011–15

Compliance activities effort (person-days)	2011	2012	2013	2014	2015
Inspections	1,128	1,030	1,275	1,226	1,079
Event reviews	134	96	180	214	128
Other compliance activities *	2,231	1912	2,338	2,290	2,141
Total effort (person-days)	3,493	3,038	3,793	3,730	3,348

* Includes verification activities such as station walkdowns and reviews of licensee-submitted documents and reports.

A.3 Pickering

Table A.3: Five-year trend in compliance activities for Pickering, 2011–15

Compliance activities effort (person-days)	2011	2012	2013	2014	2015
Inspections	1,582	2,251	1,643	1,460	1,460
Event reviews	252	270	286	228	132
Other compliance activities *	2,671	2,041	2,702	3,245	3,453
Total effort (person-days)	4,505	4,562	4,630	4,933	5,045

* Includes verification activities such as station walkdowns and reviews of licensee-submitted documents and reports.

A.4 Gentilly-2

Table A.4: Five-year trend in compliance activities for Gentilly-2, 2011–15

Compliance activities effort (person-days)	2011	2012	2013	2014	2015
Inspections	1,176	784	882	490	147
Event reviews	48	20	18	28	4
Other compliance activities *	890	1,353	706	303	416
Total effort (person-days)	2,114	2,157	1,606	821	567

* Includes verification activities such as station walkdowns and reviews of licensee-submitted documents and reports.

A.5 Point Lepreau

Table A.5: Five-year trend in compliance activities for Point Lepreau, 2011–15

Compliance activities effort (person-days)	2011	2012	2013	2014	2015
Inspections	1,569	1,324	1,520	1,079	1,030
Event reviews	90	128	82	80	58
Other compliance activities *	472	428	1,435	1,402	1,874
Total effort (person-days)	2,132	1,880	3,037	2,561	2,962

* Includes verification activities such as station walkdowns and reviews of licensee-submitted documents and reports.

A.6 Canadian NPPs

Table A.6: Five-year trend in compliance activities for Canadian NPPs, 2011–15

Compliance activities effort (person-days)	2011	2012	2013	2014	2015
Inspections	7,655	7,989	6,860	5,775	4,746
Event reviews	764	732	814	802	520
Other compliance activities *	8,253	7,163	10,463	10,833	11,783
Total effort (person-days)	16,672	15,884	18,137	17,410	17,049

* Includes verification activities such as station walkdowns and reviews of licensee-submitted documents and reports.

Appendix B: Definitions of safety and control areas

The CNSC evaluates how well licensees meet regulatory requirements and CNSC expectations for the performance of programs in 14 safety and control areas (SCAs).

These SCAs are further divided into 69 specific areas that define the key components of the SCA. The SCAs and specific areas used in the CNSC's safety performance evaluation for 2015 are given in table B.1.

Table B.1: Safety control areas and specific areas for assessing licensee safety performance

Safety control areas	Specific area
Management system	• management system • organization • change management • safety culture • configuration management • records management • management of contractors • business continuity
Human performance management	• human performance program • personnel training • personnel certification • initial certification examinations and requalification tests • work organization and job design • fitness for duty
Operating performance	• conduct of licensed activity • procedures • reporting and trending • outage management performance • safe operating envelope • severe accident management and recovery • accident management and recovery
Safety analysis	• deterministic safety analysis • probabilistic safety analysis • criticality safety • severe accident analysis • management of safety issues (including R&D programs)
Physical design	• design governance • site characterizations • facility design • structure design • system design • component design

Safety control areas	Specific area
Fitness for service	• equipment fitness for service/equipment performance • maintenance • structural integrity • aging management • chemistry control • periodic inspections and testing
Radiation protection	• application of as low as reasonably achievable (ALARA) • worker dose control • radiation protection program performance • radiological hazard control • estimated dose to public
Conventional health and safety	• performance • practices • awareness
Environmental protection	• effluent and emissions control (releases) • environmental management system • assessment and monitoring • protection of the public • environmental risk assessment
Emergency management and fire protection	• conventional emergency preparedness and response • nuclear emergency preparedness and response • fire emergency preparedness and response
Waste management	• waste characterization • waste minimization • waste management practices • decommissioning plans
Security	• facilities and equipment • response arrangements • security practices • drills and exercises
Safeguards and non-proliferation	• nuclear material accountancy and control • access and assistance to the International atomic Energy Agency • operational and design information • safeguards equipment, containment and surveillance
Packaging and transport	• package design and maintenance • packaging and transport • registration for use

1. Management system

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

Performance objectives

An effective management system – which addresses all requirements and related objectives, enables the licensee to continuously monitor and manage performance against those objectives, and maintains a healthy safety culture – is in place.

2. Human performance management

This SCA covers activities that enable effective human performance through the development and implementation of processes that ensure licensees have sufficient personnel in all relevant job areas (i.e., people with the necessary knowledge, skills, procedures and tools to carry out their duties safely).

Performance objectives

Workers are sufficient in number. Human performance is managed so that all workers are capable, competent, qualified and supported to carry out their work tasks safely.

3. Operating performance

This SCA includes an overall review of licensed activities as well as the activities that enable effective performance.

Performance objectives

Plant operation is safe and secure, with adequate regard for health, safety, security, radiation and environmental protection, and international obligations.

4. Safety analysis

This SCA involves maintaining the safety analyses that support the overall safety case for a facility. Safety analysis involves the systematic evaluation of potential hazards associated with the conduct of a proposed activity or facility. It considers the effectiveness of preventive measures as well as strategies for reducing the effects of such hazards. For nuclear power plants, safety analysis is primarily deterministic in demonstrating the effectiveness of implementing the fundamental safety functions of "control, cool and contain" through a defence-in-depth strategy. To identify challenges to physical barriers, risk contributors are considered using probabilistic safety analysis. However, appropriate safety margins should be applied to address the uncertainties and limitations of probabilistic safety analysis.

Performance objectives

Updates to safety analysis incorporate feedback from various sources, continually demonstrating a facility's ability to adequately control power, cool fuel, and contain or limit any plant releases.

5. Physical design

This SCA relates to activities affecting the ability of structures, systems and components to meet and maintain their design basis, taking into account new information as it arises, as well as changes in the external environment.

Performance objectives

Structures, systems and components that are important to safety and security continue to meet their design basis.

6. Fitness for service

This SCA covers activities that affect the physical condition of structures, systems and components over time, including programs that ensure all equipment is available to perform its intended design function.

Performance objectives

Structures, systems and components – the performance of which may affect safety or security – remain available, reliable, effective and consistent with design, analysis and quality control measures.

7. Radiation protection

This SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. This program must ensure surface contamination levels and radiation doses received by individuals are monitored, controlled and maintained as low as reasonably achievable (ALARA).

Performance objectives

The health and safety of persons are protected through the implementation of a radiation protection program that ensures that radiation doses are kept below regulatory dose limits and are optimized and maintained ALARA.

8. Conventional health and safety

This SCA covers the implementation of a program to manage workplace safety hazards and protect personnel and equipment.

Performance objectives

Conventional health and safety work practices and conditions achieve a high degree of personnel safety.

9. Environmental protection

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

Performance objectives

The licensee takes all reasonable precautions to protect the environment and the health and safety of persons. This includes identifying, controlling and monitoring the release of nuclear and hazardous substances to the environment.

10. Emergency management and fire protection

This SCA covers emergency plans and preparedness programs for emergencies and non-routine conditions (including any results of participation in exercises).

Performance objectives

Emergency preparedness measures and fire protection response capabilities are in place to prevent and mitigate effects of nuclear and hazardous substances releases (both onsite and offsite) and fire hazards, to protect workers, the public and the environment.

11. Waste management

This SCA covers a facility's internal waste-related programs up to the point where the waste is removed and transferred to a separate waste management facility. This SCA also covers planning for decommissioning.

Performance objectives
A facility- and waste stream-specific waste management program is fully developed, implemented and audited to control and minimize the volume of nuclear waste generated by the licensed activity. Waste management is included as a key component of the licensee's corporate and safety culture. A decommissioning plan is maintained.

12. Security
This SCA covers programs required to implement and support security requirements stipulated in the regulations, in the licence, in orders, or in expectations for the facility or activity.

Performance objectives
Loss, theft or sabotage of nuclear material or sabotage of the licensed facility is prevented.

13. Safeguards and non-proliferation
This SCA covers the programs and activities required of a licensee to successfully implement the obligations arising from the Canada / International Atomic Energy Agency (IAEA) safeguards agreements and the *Treaty on the Non-Proliferation of Nuclear Weapons*.

Performance objectives
The licensee conforms with measures required to meet Canada's international safeguards obligations through:

- timely provision of accurate reports and information
- provision of access and assistance to IAEA inspectors for verification activities
- submission of annual operational information and accurate design information on plant structures, processes and procedures
- development and satisfactory implementation of appropriate facility safeguards procedures
- demonstration of capability, as confirmed through CNSC onsite evaluations, to meet all requirements in support of physical inventory verifications of nuclear material by the IAEA

14. Packaging and transport
This SCA covers the programs for the safe packaging and transport of nuclear substances to and from the licensed facility.

Performance objectives
Nuclear substances are packaged and transported safely.

Appendix C: Rating definitions and methodology

C.1 Definitions

Performance ratings used in this report are defined as follows:

Fully satisfactory (FS)
Safety and control measures implemented by the licensee are highly effective. In addition, compliance with regulatory requirements is fully satisfactory, and compliance within the safety and control area (SCA) or specific area exceeds requirements and CNSC expectations. Overall, compliance is stable or improving, and any problems or issues that arise are promptly addressed.

Satisfactory (SA)
Safety and control measures implemented by the licensee are sufficiently effective. In addition, compliance with regulatory requirements is satisfactory. Compliance within the SCA meets requirements and CNSC expectations. Any deviation is minor and any issues are considered to pose a low risk to the achievement of regulatory objectives and CNSC expectations. Appropriate improvements are planned.

Below expectations (BE)
Safety and control measures implemented by the licensee are marginally ineffective. In addition, compliance with regulatory requirements falls below expectations. Compliance within the SCA deviates from requirements or CNSC expectations to the extent that there is a moderate risk of ultimate failure to comply. Improvements are required to address identified weaknesses. The licensee is taking appropriate corrective action.

Unacceptable (UA)
Safety and control measures implemented by the licensee are significantly ineffective. In addition, compliance with regulatory requirements is unacceptable and is seriously compromised. Compliance within the SCA is significantly below requirements or CNSC expectations, or there is evidence of overall non-compliance. Without corrective action, there is a high probability that the deficiencies will lead to unreasonable risk. Issues are not being addressed effectively, no appropriate corrective measures have been taken and no altern ative plan of action has been provided. Immediate action is required.

C.2 Rating methodology

Methodology for rating licensees is detailed, relying on multiple sources of input derived primarily from CNSC staff findings. These findings are based on regulatory activities such as inspections, desktop reviews, field rounds, and follow-ups on licensee progress on enforcement actions. This methodology is not based entirely on a computational system; it also requires engineering judgment and input from regulatory program managers.

The methodology is based on ratings made at three distinct levels:

- specific areas
- SCAs
- overall plant (also called the integrated plant rating (IPR))

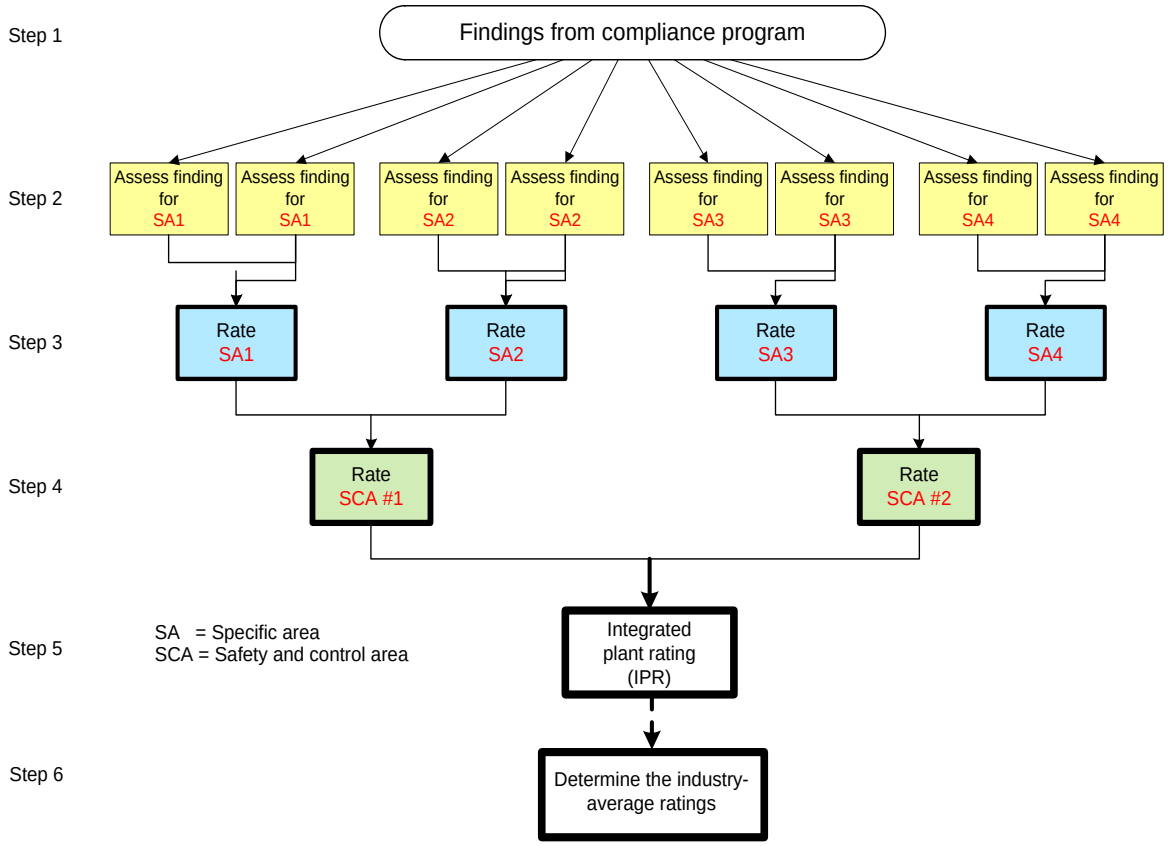
The significance of findings within a specific area is used to determine the performance rating within that area. This rating process results in performance ratings for each SCA, as given in appendix C.

An algorithm is applied to determine the individual SCA performance ratings for each station. The algorithm converts each SCA's specific area ratings to numeric values using a conversion table. It then computes the average value and converts that value (based on a rating grid) into an SCA performance rating. This results in 14 SCA performance ratings for each of the six Canadian nuclear power plants (NPPs).

Each NPP's integrated plant rating is calculated by averaging the 14 SCA performance ratings for that NPP. The 14 ratings are mathematically combined using weighting factors to give a single, overall value for each NPP. This overall value is converted based on the rating grid to an overall integrated plant rating for the NPP.

Figure C.1 shows the methodology used to determine the integrated plant rating. To simplify the process, only four specific areas are shown.

Figure C.1: Methodology for determining performance ratings



Steps shown, from top to bottom in figure C.1, are as follows:

Step 1: Identifying the findings
Findings are identified for each specific area using information from a variety of sources, including inspections, desktop reviews, field rounds and follow-ups on the licensee's progress on enforcement actions. Findings are evaluated against a set of compliance criteria developed for each area, to measure the degree of conformity with legal requirements.

Step 2: Assessing the findings
CNSC staff evaluate the findings against the compliance criteria and assign an assessment: high, medium, low, negligible or compliant. The assessment depends on the degree to which a specific area's effectiveness is negatively affected:

> **High –** Licensee's measures are absent, completely inadequate or ineffective in meeting expectations or the intent of CNSC requirements and compliance expectations.
>
> **Medium –** Performance significantly deviates from expectations or from the intent or objectives of CNSC requirements and compliance expectations.

Low – Performance deviates from expectations or from the intent or objectives of CNSC requirements and compliance expectations.

Negligible – Performance insignificantly deviates from expectations or objectives of CNSC requirements and compliance expectations.

Compliant – Performance meets applicable CNSC requirements and compliance expectations.

Step 3: Rating the specific area
CNSC staff consider the relevant findings for the specific area and determine effectiveness using a CNSC-developed guideline. The findings are judged in the context of the performance objective for the relevant SCA. The effectiveness categories for all findings in a specific area are converted into a performance rating of FS, SA, BE or UA:

FS – Safety and control measures are highly effective.

SA – Safety and control measures are sufficiently effective.

BE – Safety and control measures are marginally ineffective.

UA – Safety and control measures are significantly ineffective.

Performance rating definitions are applied for the rating of specific areas, SCAs and IPRs.

Step 4: Rating the SCA
Specific area ratings are converted to an integer-based value. Individual specific area values are averaged to determine the overall SCA value, which is then converted to an SCA rating using the rating grid.

Step 5: Determining the integrated plant rating
The integrated plant rating is determined for each station by mathematically combining the values for all 14 SCA ratings for each station using weighting factors. The weighting factor for each SCA is determined by applying a risk-informed regulatory approach. Weighting factors provide a comparison of the relative risk of each SCA to overall plant safety. The calculated integrated value is converted to a performance rating using the rating grid.

Step 6: Determining industry-average ratings
Industry-average ratings are determined by averaging the individual SCA and integrated plant ratings for all stations. The SCA ratings for each NPP are used to determine the overall industry-average rating for each SCA. The integrated plant ratings for each NPP are used to determine the overall industry-average integrated plant rating.

Summary
The annual ratings are based on a methodology that employs a full range of CNSC findings. In addition, CNSC staff use engineering and professional inputs to judge the effectiveness of safety and control measures associated with a specific area.

Once all specific area ratings have been determined, SCA values are calculated using integer-based values obtained by converting their specific area ratings. SCA values are then converted to performance ratings. A similar process is used for the integrated plant ratings (using SCA values).

A rating of full satisfactory is given if the findings demonstrate that the licensee has exceeded regulatory requirements and expectations. A satisfactory rating demonstrates that the licensee has met requirements. Ratings of below expectations and unacceptable indicate that the licensee is either marginally or significantly ineffective and must take corrective action to improve the station's performance.

The performance rating methodology is based on a standardized approach that allows for consistency in ratings across the nuclear power industry and between each annual NPP Report.

The complete results for 2015 are shown in table 1 (in the executive summary), and the five-year trend is shown in table 24 (in section 4).

Appendix D: Research and development efforts in support of NPP regulations

This appendix provides information on research and development (R&D) activities conducted by the industry and the CNSC to enhance the safety of nuclear power plant (NPP) operations.

D.1 Industry research and development activities

The CANDU Owners Group (COG) has an overall R&D program and the Industry Standard Toolset (IST) program, which are sponsored by three Canadian utilities (Bruce Power, Ontario Power Generation and NB Power), the Romanian Societatea Nationala NuclearElectrica, and Atomic Energy of Canada Limited.

In 2012–13 Hydro Québec and the Korea Hydro and Nuclear Power Company sponsored the safety and licensing R&D program. In 2012–13, the Korea Hydro and Nuclear Power Company also sponsored the IST program.

As specified in COG-12-9007, *COG R&D Program Overview: 2012/13*, the COG R&D and IST programs were established to support the safe, reliable and efficient operation of CANDU reactors, and are managed under five technical areas:

- fuel channels
- safety and licensing
- health, safety and the environment
- chemistry, materials and components
- IST

Throughout the year, the CNSC reviewed submissions from the industry on the workplans, analysis methodology and results for these ongoing safety analysis programs.

Bruce Power and Ontario Power Generation are continuing a joint COG R&D initiative: the fuel channel life-management program. This program aims to develop the engineering methodologies and analytical tools necessary to continue demonstrating the fitness for service of pressure tubes beyond their nominal design life of 210,000 equivalent full-power hours.

D.2 CNSC research and development activities

The CNSC has an active research program, which focuses on regulatory issues and is managed by its Regulatory Research and Evaluation Division. Although the program includes all safety and control areas (SCAs), it largely focuses on safety analysis, physical design and fitness for service. The program also contributes to many international programs relevant to NPP safety. Examples of research activities that were active in 2015 and that are relevant to NPPs are given below. In most cases, final reports on regulatory research activities are available at the CNSC's Scientific and technical information Web page.

Safety analysis

The CNSC sponsored a series of six contact boiling water experiments that were completed at the Canadian Nuclear Laboratories (CNL) facility in Chalk River. Similar experiments had been

carried out previously by industry; these new tests aimed to confirm the acceptance criterion for calandria tube strain and to obtain more data supporting the correlation adopted for the calandria tube quench temperature.

The CNSC completed a study titled *Feasibility of Uncertainty Quantification Framework with Application to Steady-state and Transient Reactor Physics Simulations*. The study's objective was to evaluate the feasibility of a comprehensive framework for uncertainty characterization with application to CANDU core steady-state and transient reactor physics simulations. The proposed framework could provide a rigorous basis for independent regulatory verification and enhance confidence in uncertainties reported by industry.

The CNSC completed a review of *Flood Hazard Assessment for Nuclear Facilities in Canada*. Following the Fukushima Daiichi accident in Japan, operators and regulators around the world were encouraged to review design and operational procedures to enhance flood protection at nuclear facilities. This study compares best practices in flood hazard assessment nationally and internationally to identify areas for improvement. The CNSC completed a gap analysis of flood hazard assessment approaches taken by licensees by reviewing publicly available licensee reports.

The *Expert Review of Containment Radionuclide Behaviour*, an independent review of the Simple Model for Activity Removal and Transport (SMART) code was completed. Industry developed the SMART code as an IST component to model aerosol transport and behaviour and to calculate public dose.

Work is currently in progress on the application of the Bayes method in evaluation of regional overpower / neutron overpower protection (ROP/NOP) trip setpoints. This is under a multi-phase project to develop a method and computer code, based on the Bayes method, for use in regulatory independent verification and confirmation activities. The framework and software that will be produced are intended to support CNSC staff's assessment of ROP and NOP trip setpoints under aging conditions, as well as risk-informed decision-making processes.

Physical design

Soil-structure interaction is a key issue in the seismic assessment of nuclear facilities. The CNSC completed a theoretical study of soil-structure interaction with a view to developing a balanced and comprehensive regulatory approach to seismic assessments at nuclear facilities.

Modular, composite structures are part of new-build designs, but currently there is no code provision or regulatory requirement for this type of structure. A three-year research project, *Testing and Development of Regulatory Requirements for Steel Plate Concrete Structures*, is in progress to address this gap. This research will provide valuable assistance to CNSC staff in developing regulatory requirements for composite structures.

The safety analysis of a nuclear power reactor is a complex undertaking. Within this analysis, each safety system must be capable of performing its task in the presence of any single failure – a requirement referred to as the single failure criterion. The CNSC has carried out a review of the single failure criterion and sought recommendations for its revision in design requirements for new reactors. The resulting study, *Assessing Regulatory Requirements for the Single Failure Criterion*, considers best practices for in-service testing, maintenance, repair, inspection and monitoring of systems, structures and components.

Fitness for service

The CNSC has been researching the vulnerability of steam generator tubes, for both design-basis and beyond-design-basis postulated accidents. Under a project titled *Loading of Steam Generator Tubes during Main Steam Line Break*, the CNSC completed a series of experiments using the CANDU-designed steam generator experimental loop at McMaster University. The results are

being analyzed to determine the dynamic tube loading of steam-generator tubes during a main steam pipe rupture. This work will assist in evaluating tube integrity safety margins during this type of rupture.

In considering the life extension of NPPs, there is a need to investigate the degradation mechanisms of existing civil structures. One of the most common concrete degradations is due to alkali aggregate reactions. While the chemistry of the problem is relatively well understood, potential mechanical consequences are unknown. The CNSC will complete a related multi-year program, *Investigation of Consequences of Concrete Alkali Aggregate Reaction on Existing Nuclear Structures*, in 2017.

To address limitations in current leak-before-break assessments, a probabilistic framework consisting of Level 1 and Level 2 methodologies has been proposed for CANDU pressure tubes. An independent third-party assessment of industry-proposed probabilistic Level 1 and Level 2 methodologies (*Evaluation of Probabilistic Leak-Before-Break Methodologies*) is in progress. The project includes the development of a modelling tool using Level 1 methodology.

The CNSC is investigating the parameters governing fracture-toughness properties of Zr-2.5Nb, the material used in CANDU pressure tubes. These studies, which are to account for high hydrogen concentration, will increase confidence in assessing the lifetime and fitness for service of pressure tubes. There are two parts to this work: modelling the fracture process and testing the model experimentally. The analytical part of the investigation is currently underway.

Steam generator tubes represent a major portion of the reactor primary coolant pressure boundary surface area in both CANDU reactors and pressurized water reactors. These tubes have an important safety role because they constitute one of the primary barriers between the radioactive and non-radioactive sides of the plant. The ability to estimate leak rates from wall cracks in a steam-generator tube is important for calculating source terms, assessing the operational management of steam generators and demonstrating leak-before-break deterministic analysis methodology. A research project titled *Regulatory Assessment of Leakage through Cracks in Steam Generator Piping Components* will develop a comprehensive database and model the steam-generator tube degradation process and resulting leak rates. This information will assist the CNSC in independently verifying fitness-for-service assessments for steam-generator tubes as plants age. It will also provide CNSC staff with the technical basis to determine regulatory requirements for steam-generator tubing.

The CNSC completed an independent review titled *Expert Review of Technical Basis For Probabilistic Assessments of Pressure Tube to Calandria Contact and Blister Susceptibility.* This review assessed a newly proposed probabilistic methodology.

The CNSC is also providing support for the International Atomic Energy Agency's International Generic Ageing Lessons Learned program. Through this cooperation, it hopes to benefit from extensive international experience on the aging of NPP components.

Radiation protection

Workers at CANDU facilities may be exposed to aerosols contaminated by alpha-emitting radionuclides during refit and maintenance operations. To gain more information about these risks, the CNSC has been funding a study titled *Characterization of alpha radiation hazards: Bio-solubility of radionuclides within CANDU reactor aerosols and implications for internal dosimetry*. Exposure to tritium is also a potential hazard at CANDU facilities. However, there been debate about tritium's toxicity. Work to establish the toxicity of tritium was started in 2011 and continues at the Canadian Nuclear Laboratories in cooperation with France's Institut de Radioprotection et de Sûreté Nucléaire.

The CNSC also supports the North American Technical Center, which maintains the Information System of Occupational Exposure, a program in which Canadian NPP operators also participate.

Human performance management

The number and qualifications of workers in the minimum staff complement must be adequate to successfully respond to all credible events, including the most resource-intensive conditions for any facility state. The CNSC's regulatory guide, G-323, *Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities – Minimum Staff Complement*, addresses this issue. In preparation for a review of G-323, the CNSC carried out a study titled *Minimum Staff Complement: A Review of Regulatory Requirements through a Literature Review and Synthesis of Experience from Stakeholders*. The study reviewed regulatory requirements, industry practices and scientific literature related to minimum staffing from a range of high-reliability industries. It also gathered feedback from internal and external stakeholders about how to implement G-323.

D.3 CANDU safety issues

Issues identified as CANDU safety issues (CSIs) should not be viewed as questioning the safety of operating reactors, which have attained a very high operational safety record. Rather, these are areas where uncertainty in knowledge exists, the safety assessment has been based on conservative assumptions and regulatory decisions are required or need to be confirmed. Further work, including experimental research, may be required to more accurately determine the overall effect of an issue on a facility's safe operation and to confirm that adequate safety margins exist. Note that some of the safety issues identified for CANDU reactors are common to other reactor types as well.

CSIs are categorized according to their safety significance categories as Category 1, 2 or 3, as shown in table D.1. Six CSIs requiring further experimental and/or analytical studies were pending resolution, as shown in tables D.2 and D.3. Three of these are related to large loss-of-coolant accidents (LLOCAs), while the other three belong to the group of non-LLOCA issues.

A CNSC/industry working group was set up to better define the issues pertaining to LBLOCA and to identify effective risk control measures (RCMs). The composite analytical approach (CAA) was chosen by the working group as the most practical from the stand point of implementation of RCMs. During the continued development of the CAA approach, the licensing basis of existing CANDU reactors for the LBLOCA scenario will continue to be based on traditional conservative safety analysis for which acceptance criteria are clearly established.

The CNSC maintains regulatory control of the resolution of the safety issues by monitoring the path forward, established through mutual agreement between the CNSC and the NPP licensees.

Table D.1: Categories of safety significance for CANDU safety issues

Category	Meaning
1	The issue has been satisfactorily addressed in Canada.
2	The issue is a concern in Canada. However, licensees have appropriate control measures in place to address the issue and maintain safety margins.
3	The issue is a concern in Canada. Measures are in place to maintain safety margins, but further experiments or analyses are required to improve knowledge and understanding of the issue, and to confirm that the measures are adequate.

Table D.2: Details of the Category 3 LLOCA CANDU safety issues

CSI	Title	Brief description	Notes	Target date
AA 9	Analysis for void reactivity coefficient	The LLOCA design-basis event is one of the most difficult accidents to analyze for a CANDU reactor because many aspects of reactor behaviour under accident conditions are subject to uncertainties.	The CNSC has developed an interim regulatory position that is consistent with the risk control measures for CSIs and will remain in effect until the recommendations of the COG LLOCA working group are accepted by the CNSC and are fully implemented by industry.	Continues to be developed by industry and under review by CNSC staff
PF 9	Fuel behaviour in high-temperature transients			
PF 10	Fuel behaviour in power-pulse transients			

Table D.3: Details for the Category 3 non-LLOCA CANDU safety issues

CSI	Title	Brief description	Notes	Target date
GL 3	Aging of equipment and structures	Safety-related functions in NPPs must remain effective throughout the life of the plant. Licensees are expected to have a program in place to prevent, detect and correct significant degradation due to aging.	Licensees have aging management programs as well as fitness-for-service guidelines for life-limiting components (e.g., feeders, pressure tubes, steam generator tubes). However, Point Lepreau programs for managing other systems' aging and components have not been systematically implemented.	June 2016 (remains for Point Lepreau)
IH 6	Systematic assessment of high-energy line-break effects	Dynamic effects at high-energy line breaks (e.g., pipe whip, jet impingement) can cause consequential failure of structures, systems and components and impair defence in depth.	Pickering and Point Lepreau must provide systematic analysis for protecting structures, systems and components from the effects of postulated pipe rupture.	December 2016 (remains for Pickering and Point Lepreau)
PF 18	Fuel bundle and element behaviour under post-dryout conditions	Specific models, such as fuel bundle deformation, require improvements to increase confidence in the prediction of fuel element or fuel channel failure.	Licensees need to present experimental or analytical evidence to clarify conditions for fuel deformation and for sheath failure (e.g., dryout, fuel temperature, timing of failure), and for the consequential failure of fuel channels.	September 2016

Appendix E: Collective effective dose

The following figures show the five-year trend in annual collective effective doses to workers at each station (hereafter referred to as "collective doses"). This information illustrates the reactor's operational state when the dose was received (i.e., during operation or during outages or refurbishment) and the pathways of exposure (i.e., internal or external). The figures show the doses received by the same group of workers.

For each nuclear power plant (NPP):

- The first figure shows collective doses received during routine, day-to-day operations versus doses received during outages or refurbishment. The collective dose shown for routine operations and outages or refurbishment includes both external and internal doses.
- The second figure shows the collective doses received from internal and external exposures for all radiological activities performed during the year.

The annual collective dose is the sum of the effective doses received by all workers at an NPP in a year. It is measured in person-sieverts (p-Sv). There is no regulatory dose limit for the annual collective dose; however, the regulatory limit is used internationally as a benchmark for assessing the reactor dose optimization performance.

For routine operations, variations between years are attributed partly to how long the plant operated during each year as well as to typical dose rates associated with the station's operation.

The outage dose (planned and forced) includes the dose to all personnel, including contractors. Parameters affecting the dose include the number of outages for the year, the scope and duration of the work, the number of workers involved and dose rates associated with the outage work.

The external dose is the portion of the dose received from radiation sources outside the body. The internal dose is the portion received from radioactive material taken into the body.

In 2015, approximately 85 percent of the collective dose was due to outage activities and most of the radiation dose received by workers came from external exposure. Approximately 11 percent of the dose was from internal exposure and tritium was the main contributor to exposed workers' internal doses.

Note: Caution should be used when comparing the collective dose data between NPPs. Such a comparison is not entirely appropriate because of differences between individual stations (e.g., design, age, operation and maintenance).

E.1 Annual collective doses at Bruce A and B

In 2015, Bruce Power was effective in controlling radiological exposures to workers at Bruce A and B.

Bruce A

Figures E.1 and E.2 show the collective doses at Bruce A Units 1–4.

At Bruce A, all four units were operational with a total of approximately 160 outage days. Outage activities at Bruce A accounted for approximately 92 percent of the total collective dose. Planned outage work included fuel channel inspection, boiler work, condenser repair, feeder replacement, Grayloc refurbishment and feeder replacement. Routine operations accounted for approximately 8 percent of the total collective dose.

Internal dose was approximately 5 percent of the total Bruce A collective dose. This is a slight decrease from 2014 (when the internal dose rate was 7 percent), attributed to reducing primary heat transport leak rates and repairing vault vapour recovery driers.

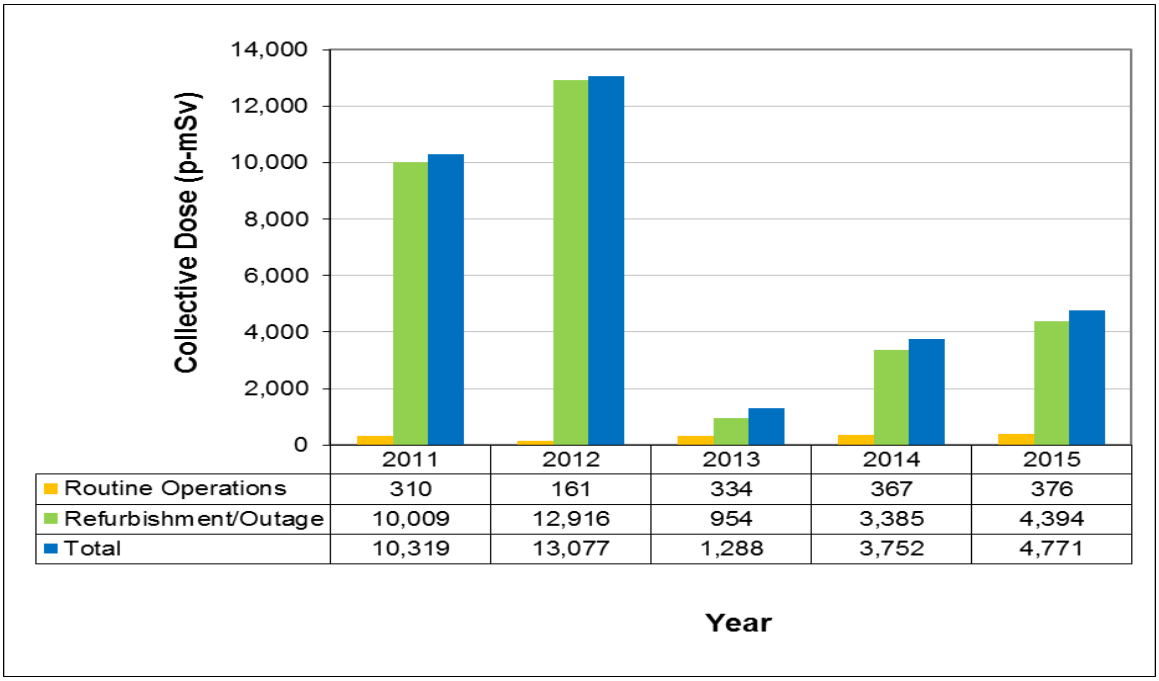
Bruce B

Figures E.3 and E.4 reflect the collective doses at Bruce B Units 5–8.

At Bruce B, all four units were operational with a total of 110 outage days. Outage activities at Bruce B accounted for approximately 81 percent of the total collective dose. Planned outage work included feeder inspections in Unit 6 and a vacuum building inspection. Routine operations accounted for approximately 19 percent of the total station collective dose.

Internal dose was approximately 6 percent of the total collective dose, attributed to reducing primary heat transport leak rates.

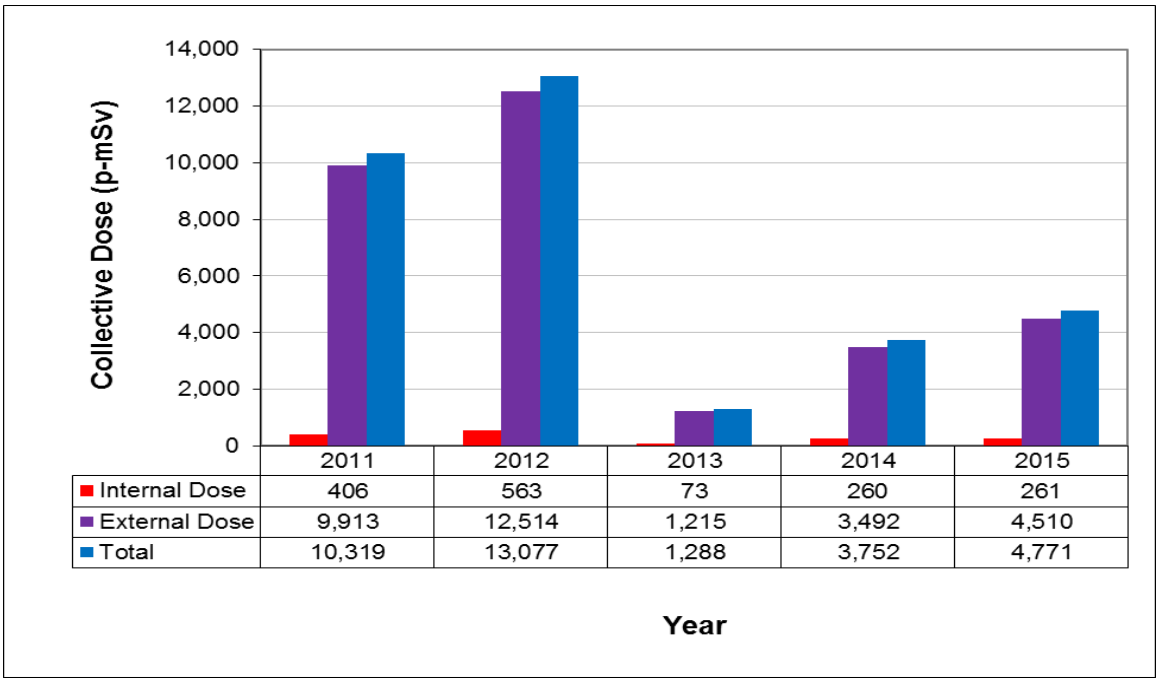
Figure E.1: Collective dose by operational state for Bruce A, 2011–15*



	2011	2012	2013	2014	2015
Routine Operations	310	161	334	367	376
Refurbishment/Outage	10,009	12,916	954	3,385	4,394
Total	10,319	13,077	1,288	3,752	4,771

* Refurbishment was in progress from 2010 to 2012.

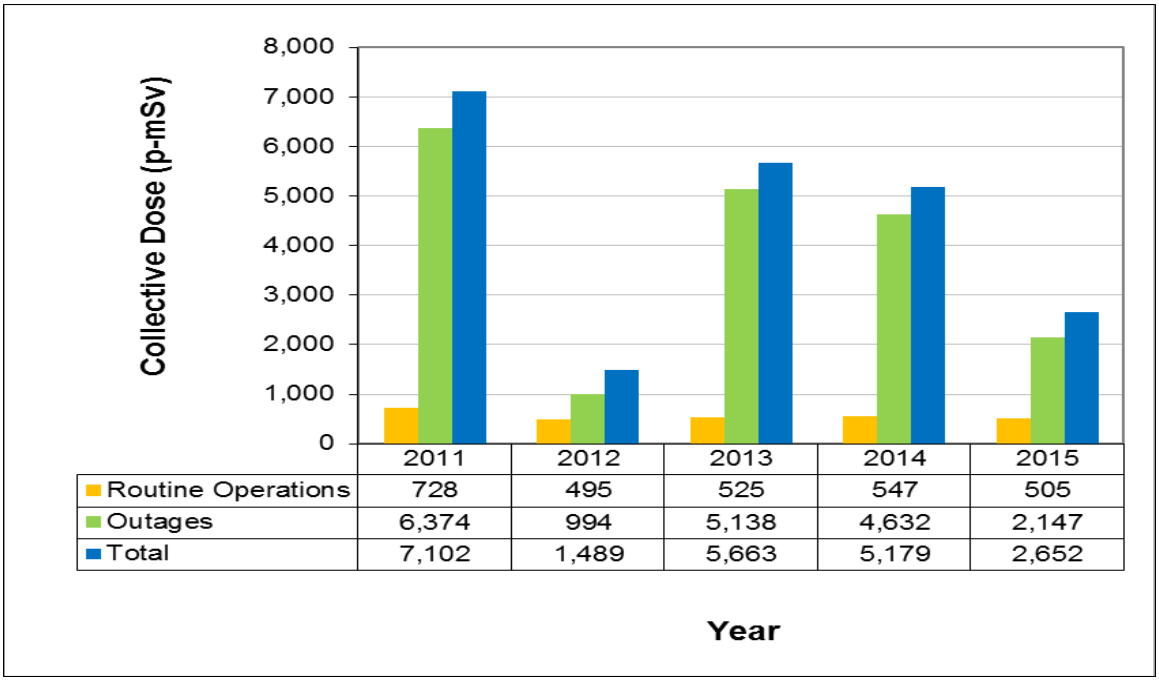
Figure E.2: Collective dose from internal and external exposures for Bruce A, 2011–15*



	2011	2012	2013	2014	2015
Internal Dose	406	563	73	260	261
External Dose	9,913	12,514	1,215	3,492	4,510
Total	10,319	13,077	1,288	3,752	4,771

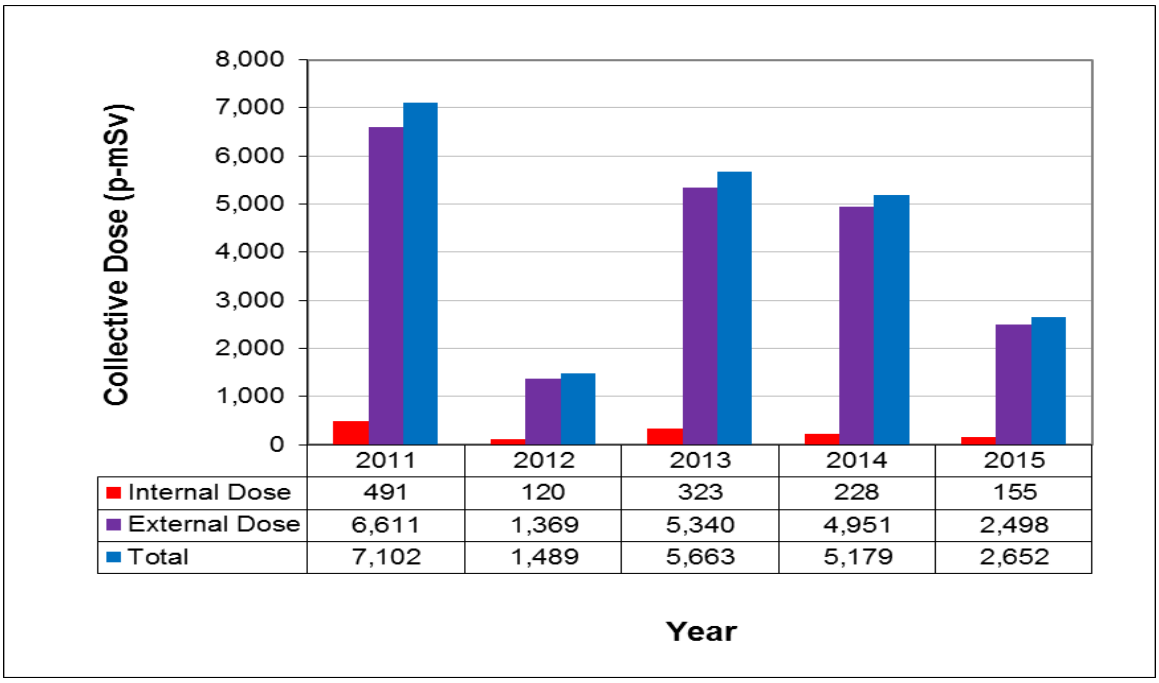
* Refurbishment was in progress from 2010 to 2012.

Figure E.3: Collective dose by operational state for Bruce B, 2011–15



	2011	2012	2013	2014	2015
Routine Operations	728	495	525	547	505
Outages	6,374	994	5,138	4,632	2,147
Total	7,102	1,489	5,663	5,179	2,652

Figure E.4: Collective dose from internal and external exposures for Bruce B, 2011–15



	2011	2012	2013	2014	2015
Internal Dose	491	120	323	228	155
External Dose	6,611	1,369	5,340	4,951	2,498
Total	7,102	1,489	5,663	5,179	2,652

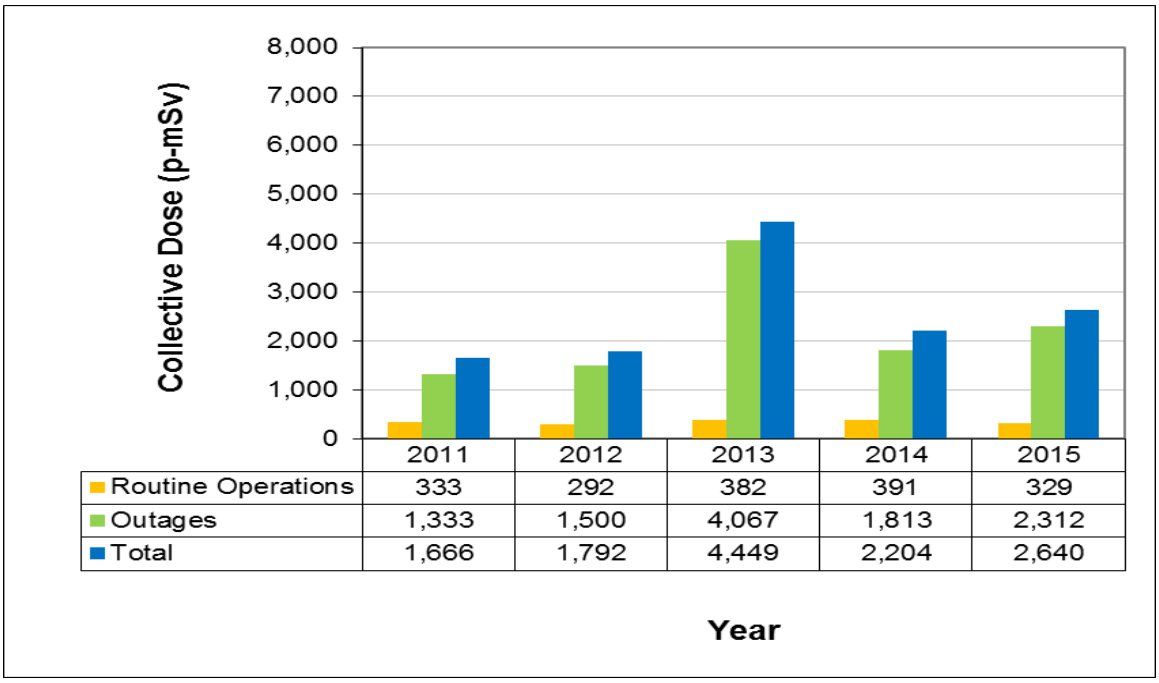
E.2 Annual collective doses at Darlington

In 2015, Ontario Power Generation (OPG) was effective in controlling worker radiological exposures at Darlington. Figures E.5 and E.6 show collective doses at Darlington Units 1–4.

At Darlington, all four units were operational with a total of approximately 101 outage days. Outage activities at Darlington accounted for approximately 88 percent of the total collective dose. This was slightly higher than in 2014 and reflects the scope and type of work. Planned outage work included feeder and boiler inspections in Unit 3 and a vacuum building inspection. Routine operations accounted for approximately 12 percent of the total collective dose.

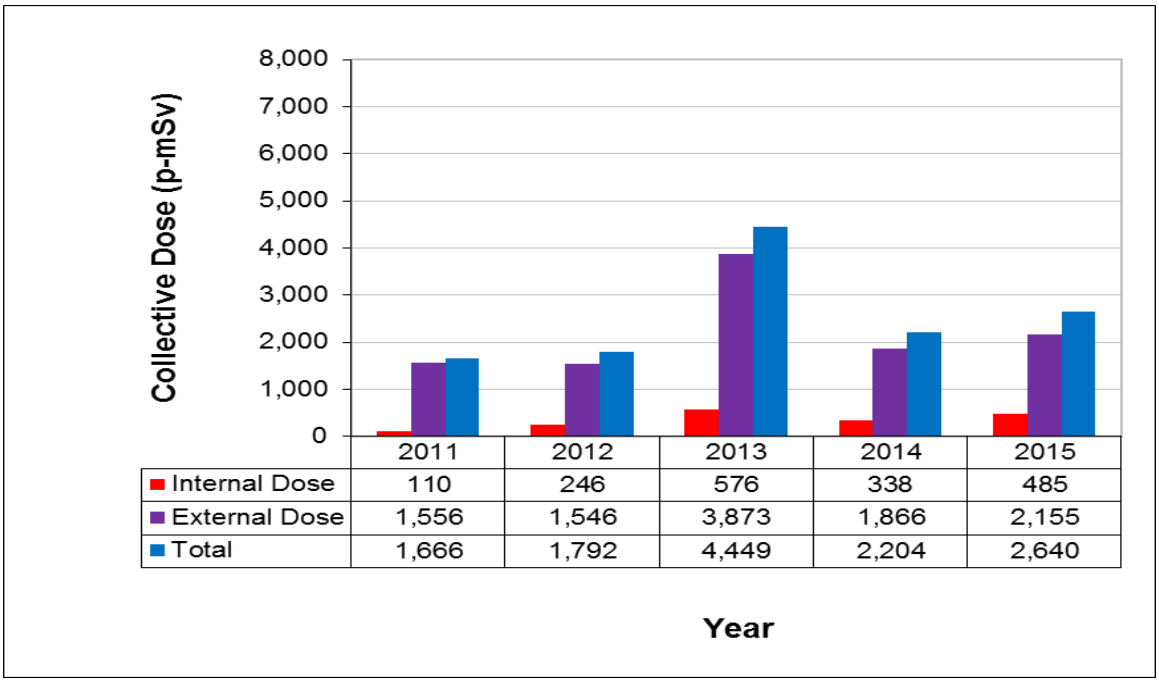
Internal dose was approximately 18 percent of the total collective dose, a slight increase from the internal dose rate of 15 percent reported in 2014. This increase can be attributed partly to increased airborne tritium levels in containment combined with a higher number of personnel making containment entries.

Figure E.5: Collective dose by operational state for Darlington, 2011–15



	2011	2012	2013	2014	2015
Routine Operations	333	292	382	391	329
Outages	1,333	1,500	4,067	1,813	2,312
Total	1,666	1,792	4,449	2,204	2,640

Figure E.6: Collective dose from internal and external exposures for Darlington, 2011–15



	2011	2012	2013	2014	2015
Internal Dose	110	246	576	338	485
External Dose	1,556	1,546	3,873	1,866	2,155
Total	1,666	1,792	4,449	2,204	2,640

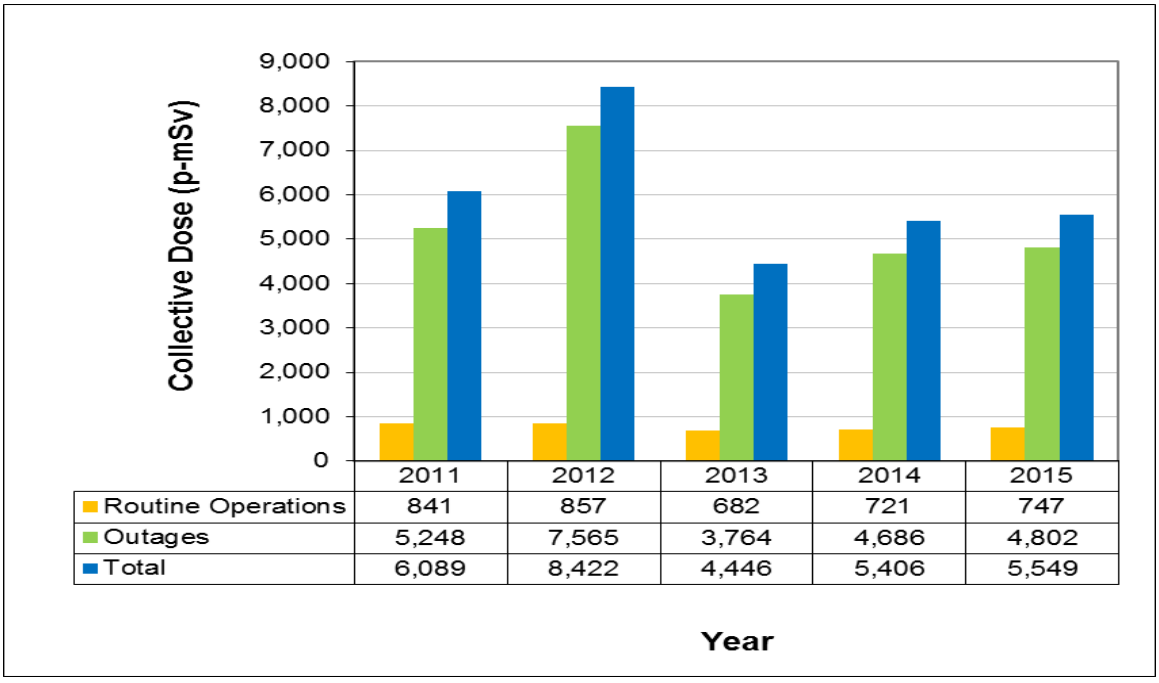
E.3 Annual collective doses at Pickering

In 2015, OPG was effective in controlling worker radiological exposures at Pickering. Figures E.7 and E.8 present the collective doses at Pickering.

Pickering Units 1, 4 and 5– 8 were operational with approximately 416 outage days. Units 2 and 3 continued to remain in a safe storage state. Outage maintenance and inspection activities accounted for approximately 87 percent of the total station collective dose. Routine operations accounted for approximately 13 percent of the total collective dose.

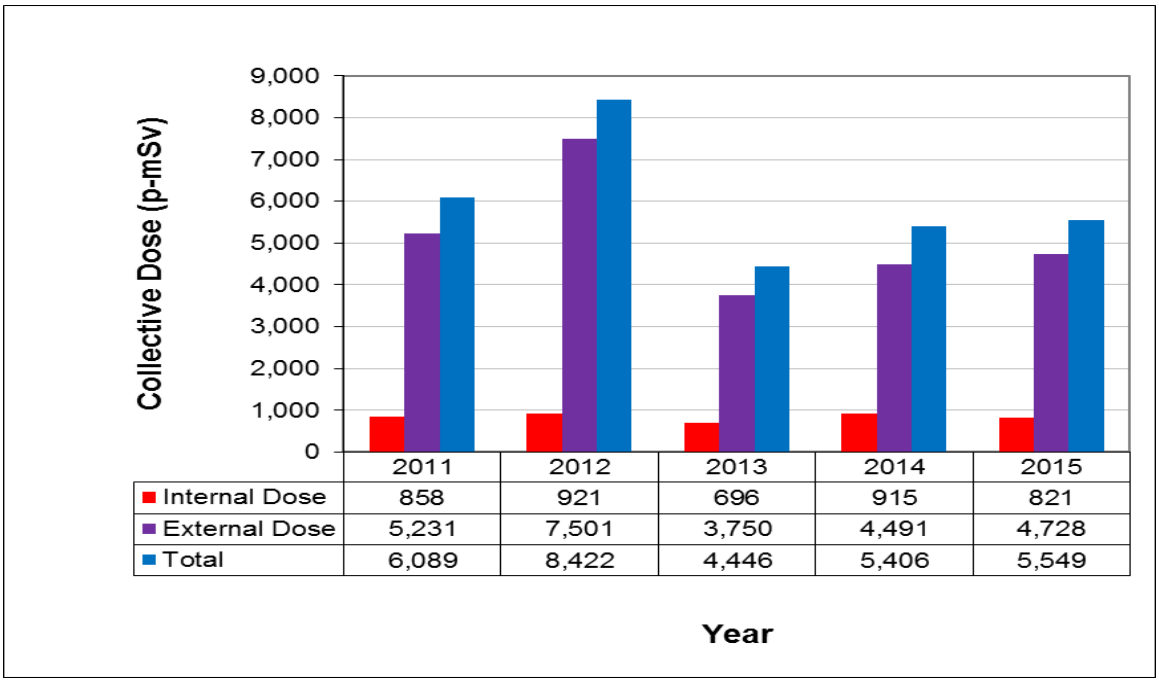
Internal dose was approximately 15 percent of the total collective dose, a slight decrease from the internal dose rate of 17 percent reported in 2014. This decrease can be attributed to the scope and type of work performed.

Figure E.7: Collective dose by operational state for Pickering, 2011–15



	2011	2012	2013	2014	2015
Routine Operations	841	857	682	721	747
Outages	5,248	7,565	3,764	4,686	4,802
Total	6,089	8,422	4,446	5,406	5,549

Figure E.8: Collective dose from internal and external exposures for Pickering, 2011–15



	2011	2012	2013	2014	2015
Internal Dose	858	921	696	915	821
External Dose	5,231	7,501	3,750	4,491	4,728
Total	6,089	8,422	4,446	5,406	5,549

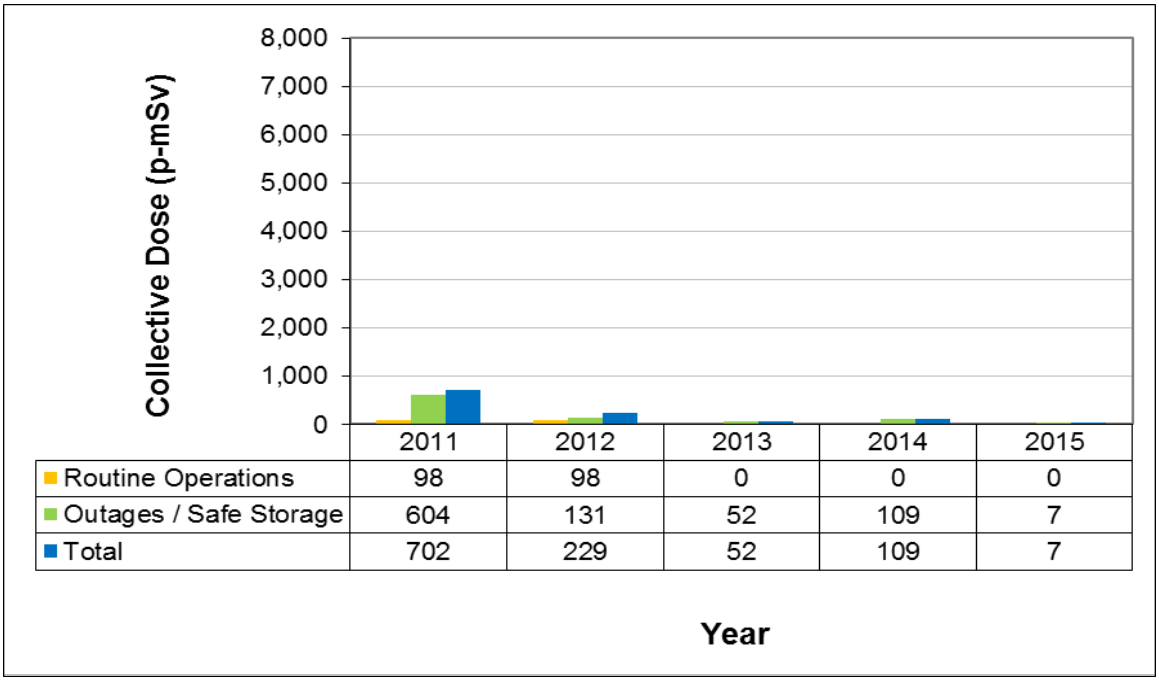
E.4 Annual collective doses at Gentilly-2

In 2015, Hydro-Québec was effective in controlling worker radiological exposures at Gentilly-2. Figures E.9 and E.10 show the collective doses at Gentilly-2.

There was a decrease in the collective doses at Gentilly-2 because the majority of radiological work activities associated with the transition from an operational unit to a safe storage state occurred in 2014.

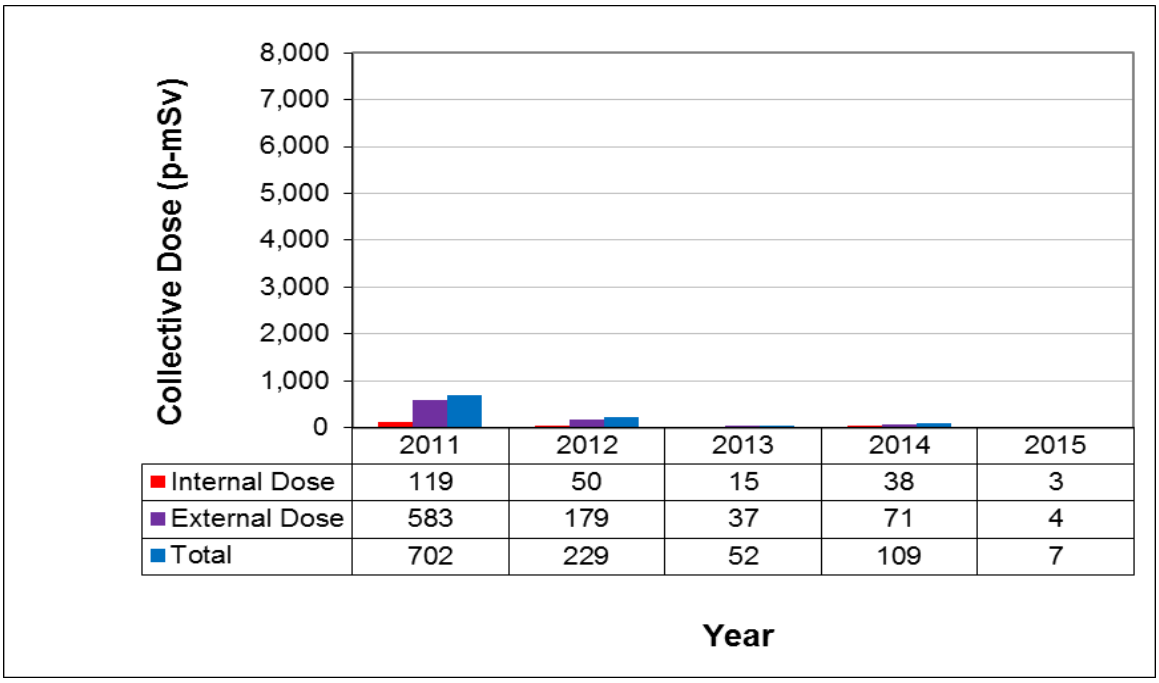
The collective dose total for the station is attributed to safe storage transition activities. Internal dose was approximately 41 percent of the total station collective dose. While this is an increase from 2014 (when the internal dose rate was 35 percent), its magnitude is largely attributable to it being a relative fraction of the very small total collective dose.

Figure E.9: Collective dose by operational state for Gentilly-2, 2011–15



	2011	2012	2013	2014	2015
Routine Operations	98	98	0	0	0
Outages / Safe Storage	604	131	52	109	7
Total	702	229	52	109	7

Figure E.10: Collective dose from internal and external exposures for Gentilly-2, 2011–15



	2011	2012	2013	2014	2015
Internal Dose	119	50	15	38	3
External Dose	583	179	37	71	4
Total	702	229	52	109	7

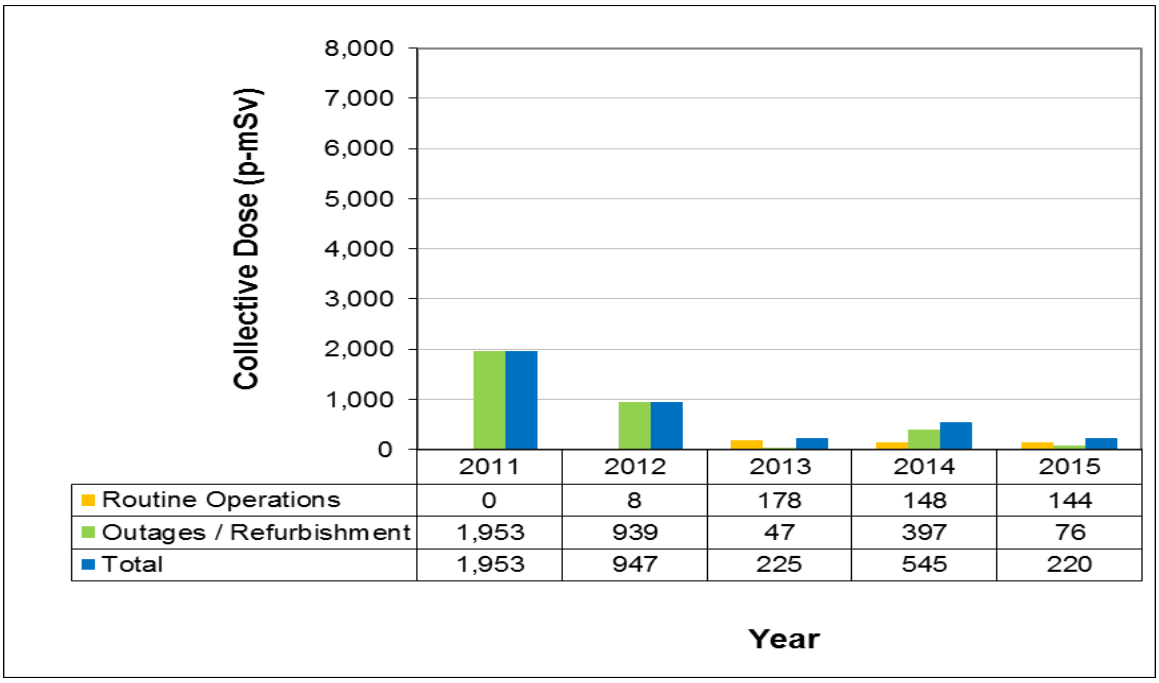
E.5 Annual collective doses at Point Lepreau

In 2015, NB Power was effective in controlling worker radiological exposures at Point Lepreau. Figures D.11 and D.12 show the collective doses at Point Lepreau.

Point Lepreau was operational with approximately 58 outage days. Outage activities at Point Lepreau accounted for approximately 35 percent of the total collective dose. Routine operations accounted for approximately 65 percent of the total station collective dose. The fact that Point Lepreau did not conduct a major planned outage in 2015 explains why the outage dose is relatively low.

Internal dose was approximately 20 percent of the total station collective dose, which is a slight increase over 2014 (when the internal dose rate was 15 percent). The increased dose contribution from tritium was due in part to a leaking fitting on the primary heat transport system. This fitting is scheduled for repair during planned outage in the spring of 2016.

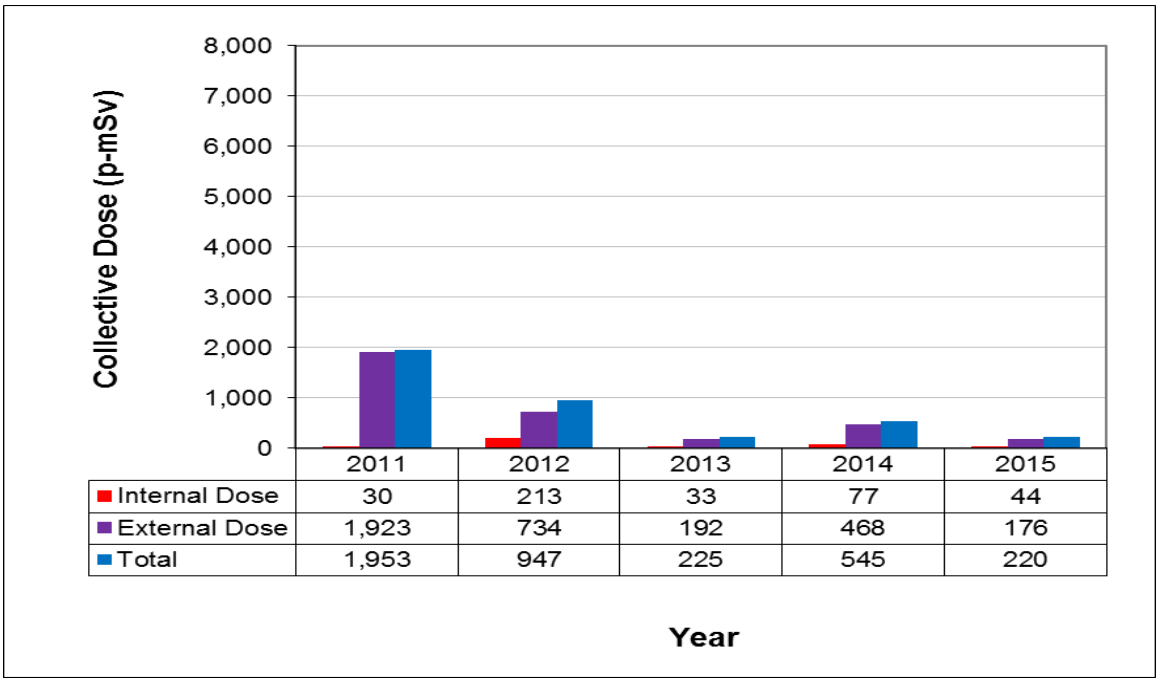
Figure E.11: Collective dose by operational state for Point Lepreau, 2011–15*



	2011	2012	2013	2014	2015
Routine Operations	0	8	178	148	144
Outages / Refurbishment	1,953	939	47	397	76
Total	1,953	947	225	545	220

* Refurbishment was in progress 2010 to 2012.

Figure E.12: Collective dose from internal and external exposures for Point Lepreau, 2011–15*



	2011	2012	2013	2014	2015
Internal Dose	30	213	33	77	44
External Dose	1,923	734	192	468	176
Total	1,953	947	225	545	220

* Refurbishment was in progress 2010 to 2012.

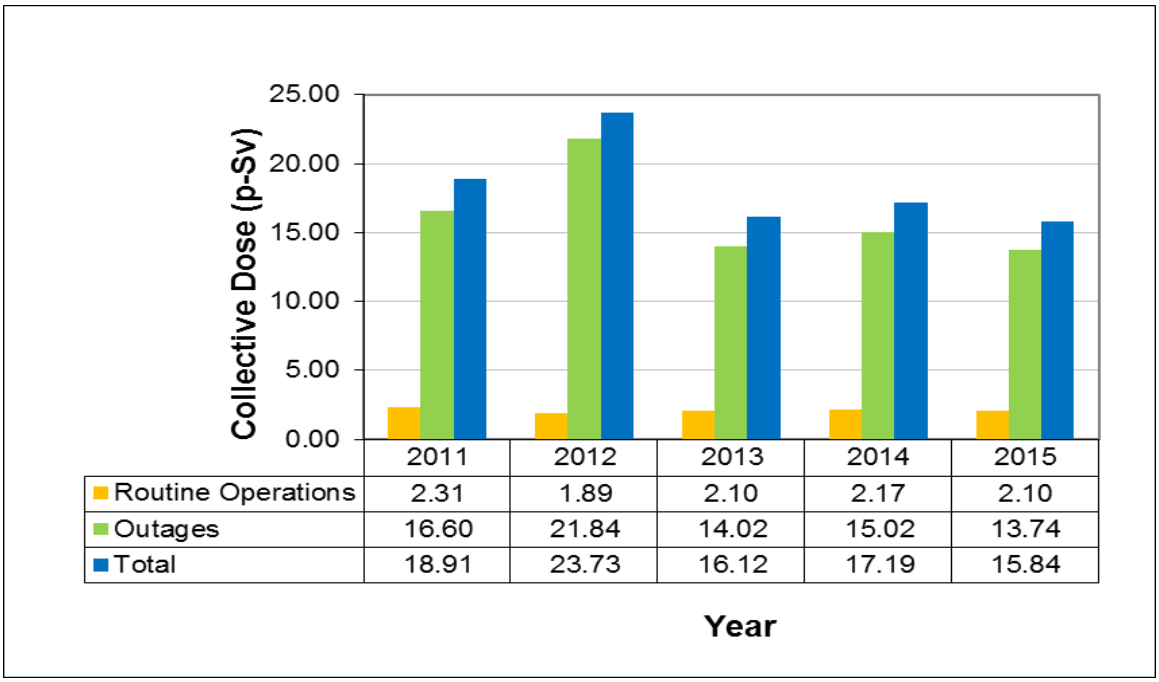
E.6 Average collective doses for all Canadian NPPs in operation

Nineteen reactor units were operational across Canada in 2015.

As shown in figures E.13 and E.14, the total collective doses and average collective dose per unit at operating Canadian NPPs decreased slightly from 2014; however, trends have remained steady since 2013. This decrease reflects the type and scope of work being performed at each facility.

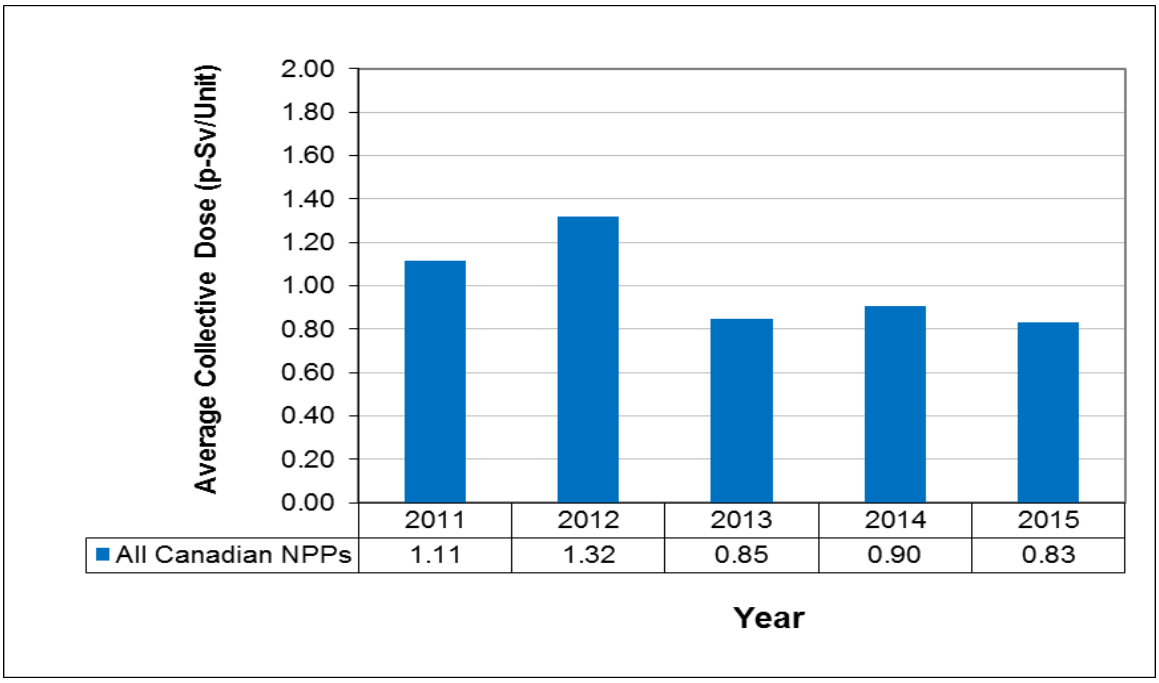
The 2015 annual collective dose per operating unit, 0.83 p-Sv, is below the 1.05 p-Sv per unit average observed for the previous four years (2010–2014). It approaches the 0.8 p-Sv dose target set by the World Association of Nuclear Operators for CANDU reactors. The implementation of initiatives to keep doses as low as reasonably achievable (ALARA) – such as improved shielding, source term reduction activities and improved work planning – continues to reduce the collective dose per unit across the Canadian industry overall. In addition, completion of refurbishment activities in 2012 removed a significant dose contribution resulted in higher Canadian industry averages.

Figure E.13: Collective dose by operational state for operating Canadian nuclear power plants, 2011–15



	2011	2012	2013	2014	2015
Routine Operations	2.31	1.89	2.10	2.17	2.10
Outages	16.60	21.84	14.02	15.02	13.74
Total	18.91	23.73	16.12	17.19	15.84

Figure E.14: Average collective dose for operating Canadian nuclear power plants, 2011–15



Appendix F: Derived release limits (DRLs) for Canadian nuclear power plants

To calculate radiation doses received by members of the public from routine releases at nuclear power plants (NPPs), a quantity known as a derived release limit (DRL) is used. This value is based on the regulatory dose limit of 1 millisievert per year (1 mSv/y).

DRLs are required because nuclear materials released into the environment through gaseous and liquid effluents from NPPs can expose members of the public to low radiation doses via external and internal pathways. External exposure occurs from direct contact with radionuclide-contaminated ground surfaces, or by immersion into contaminated water and air clouds. Internal exposure occurs through the intake of radionuclides by inhalation (breathing) or by eating contaminated foods. Such radiation doses to members of the public are subject to statutory limits set out in sections 13 and 14 of the *Radiation Protection Regulations.*

DRL calculations are based on a method recommended in CSA standard N288.1-08, *Guidelines for calculating derived release limits for radioactive materials in airborne and liquid effluents for normal operation of nuclear facilities.* [39]

The DRLs for gaseous and liquid effluents from Canadian NPPs are shown in tables F.1 and F.2. The units of measurement for noble gases are either terabecquerel (TBq) for individual radionuclides or terabecquerel-million electron volts for mixtures of radionuclides.

Table F.1: Derived release limits for gaseous effluents, 2015

Nuclear power plant	Tritium[a] (TBq)	Iodine-131 (TBq)	Noble gases (TBq)	Particulates (TBq)	Carbon-14 (TBq)
Bruce A[i]	1.98×10^5	1.14	1.12×10^5 [c]	1.73[d]	6.34×10^2
Bruce B[i]	3.16×10^5	1.35	2.17×10^5 [c]	3.61[d]	7.56×10^2
Darlington[ii]	5.9×10^4 (HTO) 8.5×10^5 (HT)[b]	1.4	4.5×10^4 [c]	0.67	3.5×10^2
Pickering 1, 4[iii]	1.2×10^5	9.8	3.2×10^4 [c]	0.49	2.2×10^3
Pickering 5–8[iii]	1.9×10^5	8.9	4.7×10^4 [c]	0.72	2.0×10^3
Gentilly-2[iv]	8.6×10^4	0.3	7.7×10^4 [c]	1.2	2.0×10^2
Point Lepreau[v]	2.8×10^5	6.0×10^1	1.2×10^5	1.8	6.8×10^3

a. Tritium oxide (HTO)
b. For elemental tritium (HT) resulting from operations at the tritium removal facility at Darlington
c. Terabecquerel-million electron volts
d. Particulate (beta/gamma)
i CNSC, *Nuclear Power Reactor Operating Licence Bruce Nuclear Generating Stations A and B* (PROL 18.00/2020), appendix C: Derived Release Limits, May 2014.
ii Ontario Power Generation, *Derived Release Limits for Darlington Nuclear Generating Station*, NK38-REP-03482-10001-R01 (as referenced in LCH-DNGS-R000 for PROL 13.00/2014), September 2011.

iii CNSC, *Licence Conditions Handbook* (LCH-PNGS-R000 for PROL 48.00/2018), September 2013.
iv CNSC, *Licence Conditions Handbook* (MCP-GENTILLY-2-R003 for PERP 10.02/2016), July 2014.
v CNSC, *Nuclear Power Reactor Operating Licence Point Lepreau Nuclear Generating Station* (PROL 17.02/2017), appendix A.3: Derived Release Limits, September 2013.

Table F.2: Derived release limits for liquid effluents, 2015

Nuclear power plant	Tritium [a] (TBq)	Gross beta-gamma activity (TBq)	Carbon-14 (TBq)
Nuclear power plant	Tritium [a] (TBq)	Gross beta-gamma activity (TBq)	Carbon-14 (TBq)
Bruce A[i]	2.3×10^{6}	4.58×10^{1}	1.03×10^{3}
Bruce B[i]	1.84×10^{6}	5.17×10^{1}	1.16×10^{3}
Darlington[ii]	5.3×10^{6}	7.1×10^{1}	9.7×10^{2}
Pickering 1, 4[iii]	3.7×10^{5}	1.7	3.2×10^{1}
Pickering 5–8[iii]	7.0×10^{5}	3.2	6.0×10^{1}
Gentilly-2[iv]	1.44×10^{7}	2.23×10^{1}	3.06×10^{2}

a. Tritium oxide (HTO)

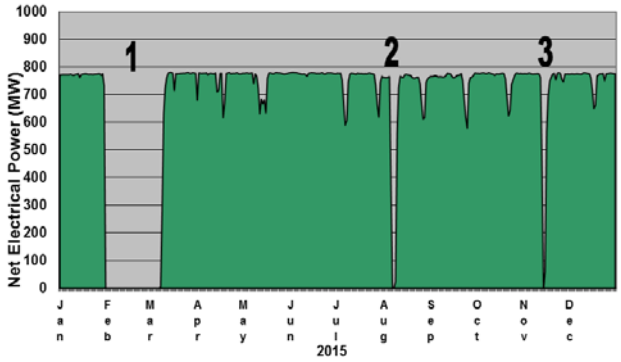
i CNSC, *Nuclear Power Reactor Operating Licence Bruce Nuclear Generating Stations A and B* (PROL 18.00/2020), Appendix C: Derived Release Limits, May 2014.
ii Ontario Power Generation, *Derived Release Limits for Darlington Nuclear Generating Station*, NK38-REP-03482-10001-R01 (as referenced in LCH-DNGS-R000 for PROL 13.00/2014), September 2011.
iii CNSC, *Licence Conditions Handbook* (LCH-PNGS-R000 for PROL 48.00/2018), September 2013.
iv CNSC, *Licence Conditions Handbook* (MCP-GENTILLY-2-R003 for PERP 10.02/2016), July 2014.
v CNSC, *Nuclear Power Reactor Operating Licence Point Lepreau Nuclear Generating Station* (PROL 17.02/2017), Appendix A.3: Derived Release Limits, September 2013.

Appendix G: 2015 power history graphs for Canadian reactor units

Nuclear Power Plant licensees are directly responsible for managing the operation of their plants in a manner that protects health, safety, security and the environment, while respecting Canada's international obligations. The CNSC is responsible to Canadian, through Parliament, for assuring that these responsibilities are properly discharged. The CNSC does not regulate the amount of electricity generated by each NPP but, like an automobile, the amount of time the engine was running provides a general comparison of how well each plant operated.

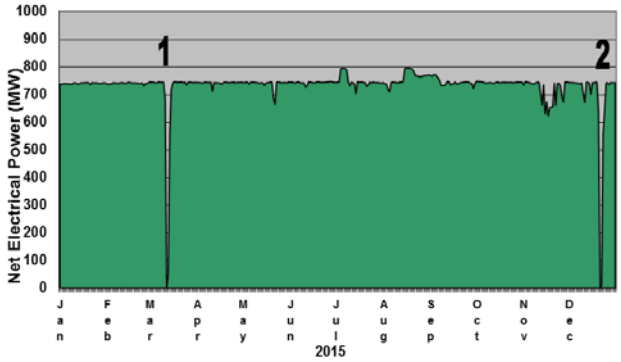
The 2015 power history graphs for licensed Canadian nuclear power reactor units are shown below in figures G.1 to G.20. The graphs show only visible power outages with a brief corresponding explanation for the outage. The number of outages shown include both forced and planned outages which do not match the number of unplanned transients reported under section 2.1.3. In addition, short duration outages are not visible on the scale of these graphs.

Figure G.1: Power history for Bruce A, Unit 1, 2015



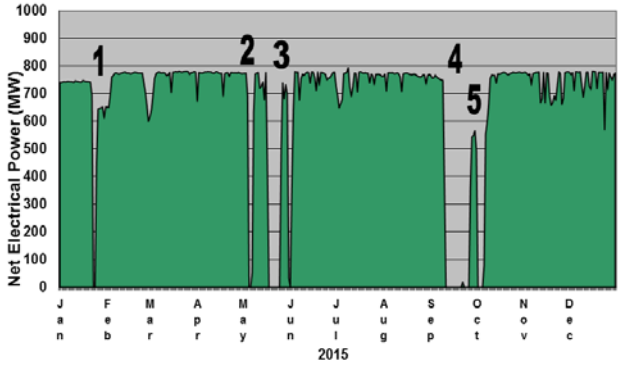
1 Planned outage for routine maintenance and component inspections
2 Forced outage to repair an emergency coolant injection valve
3 Forced outage to repair a failed electrical switchyard component

Figure G.2: Power history for Bruce A, Unit 2, 2015



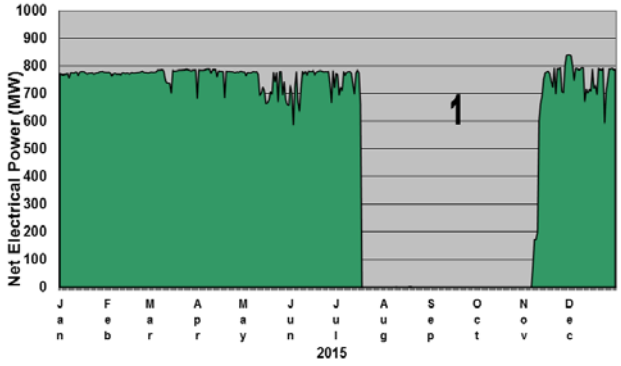
1 Planned outage to replace a switchyard breaker
2 Forced outage to repair a valve in a reactor control system

Figure G.3: Power history for Bruce A, Unit 3, 2015



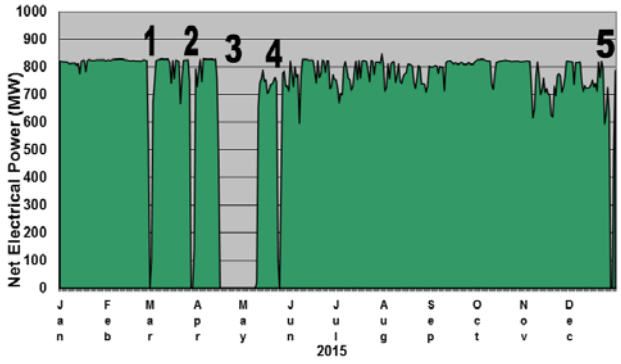
1 Planned outage for excitation system modifications
2 Forced outage due to excitation system fault
3 Forced outage due to excitation system fault
4 Planned outage for selective defueling of fuel channels
5 Forced outage to retrieve stuck fueling machine

Figure G.4: Power history for Bruce A, Unit 4, 2015



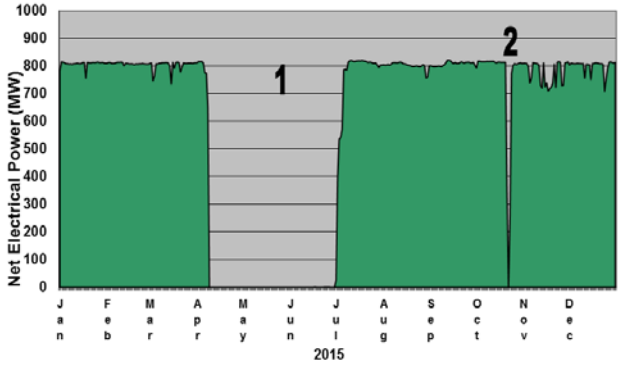
1 Planned outage for routine maintenance and component inspections

Figure G.5: Power history for Bruce B, Unit 5, 2015



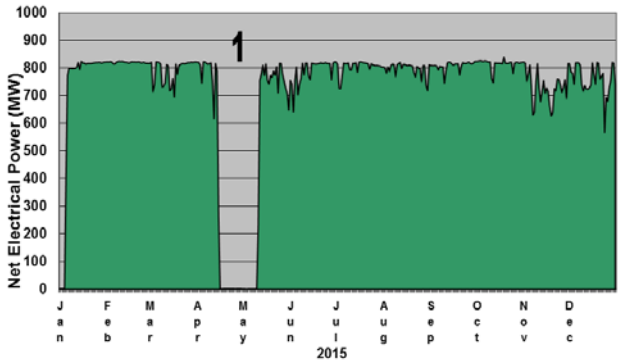
1 Forced outage to repair faulty SDS1 rod
2 Forced outage to repair leaking generator cooler
3 Planned outage for vacuum building maintenance
4 Surplus baseload generation outage
5 Forced outage to repair a maintenance cooling system valve

Figure G.6: Power history for Bruce B, Unit 6, 2015



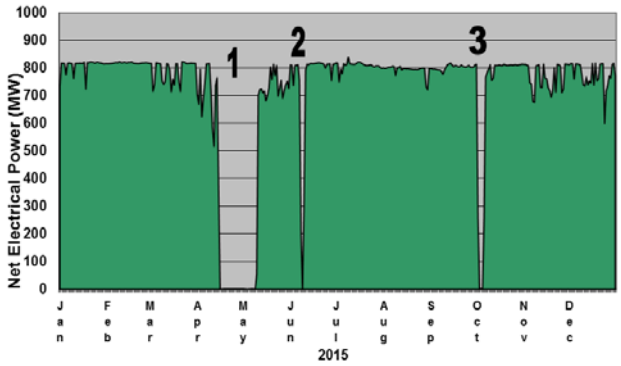
1 Planned outage for routine maintenance, cobalt harvest, component inspections and vacuum building maintenance
2 Forced outage to repair a boiler feedwater line

Figure G.7: Power history for Bruce B, Unit 7, 2015



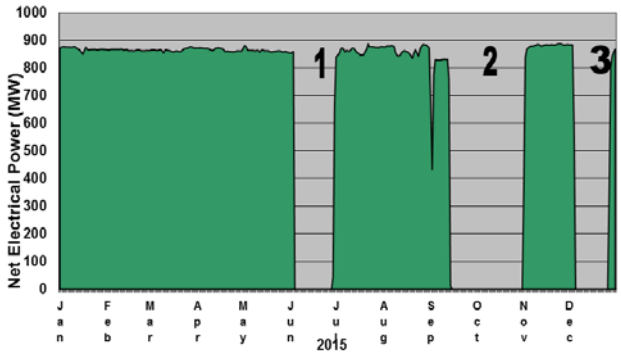
1 Planned outage for vacuum building maintenance

Figure G.8: Power history for Bruce B, Unit 8, 2015



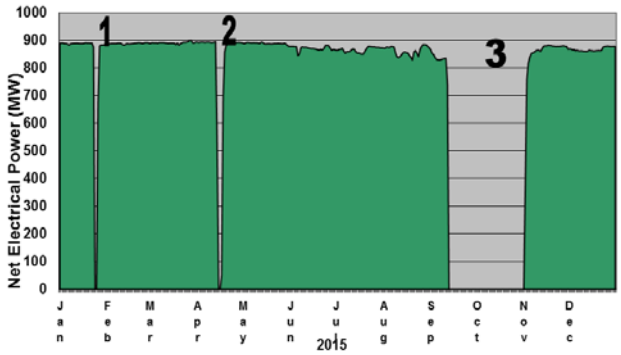
1 Planned outage for vacuum building maintenance
2 Forced outage to repair a heat transport system pump motor
3 Forced outage to repair a liquid zone control valve

Figure G.9: Power history for Darlington, Unit 1, 2015



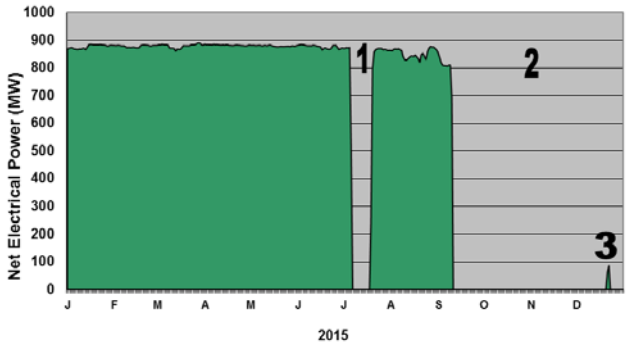
1 Planned outage for replacement of heat transport pump motor #3
2 Planned outage for vacuum building maintenance
3 Planned outage for replacement of heat transport pump motor #1

Figure G.10: Power history for Darlington, Unit 2, 2015



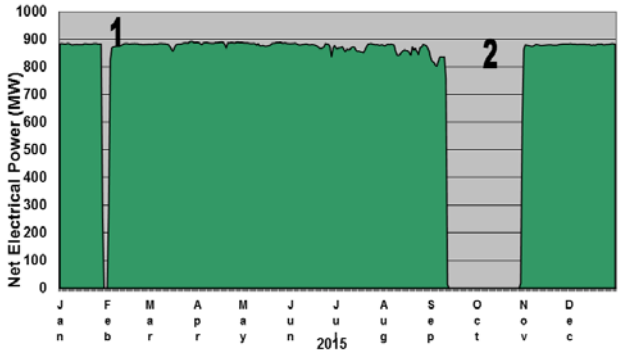
1 Forced outage from a start test of turbine trip standby pump
2 Forced outage to repair a heat transport pipe leak
3 Planned outage for vacuum building maintenance

Figure G.11: Power history for Darlington, Unit 3, 2015



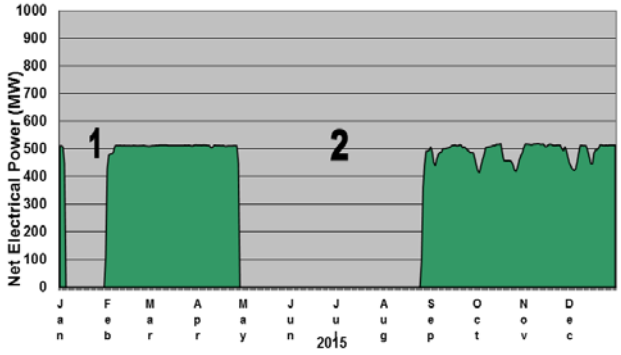
1 Forced outage to repair a generator seal oil leak
2 Planned outage for vacuum building maintenance
3 Forced outage to repair a heat transport pressurizer heater leak

Figure G.12: Power history for Darlington, Unit 4, 2015



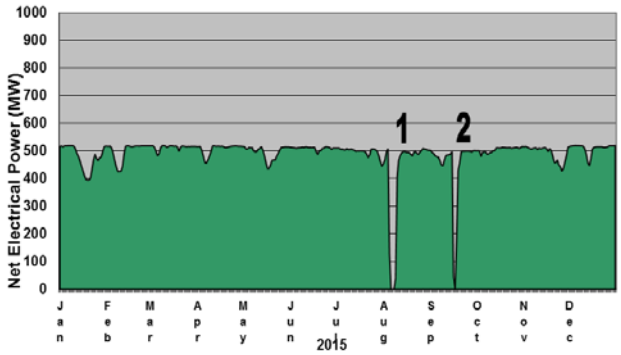
1 Forced outage to repair a recirculation cooling water leak
2 Planned outage for vacuum building maintenance

Figure G.13: Power history for Pickering, Unit 1, 2015



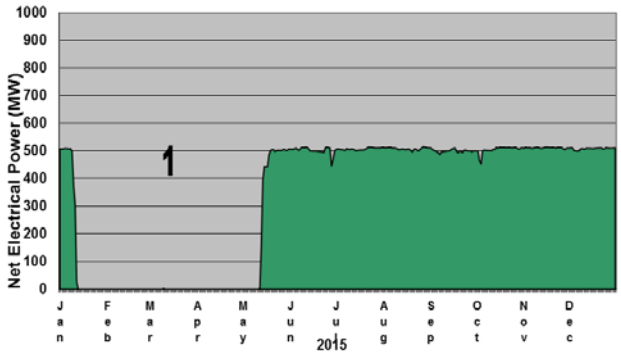
1 Planned outage for moderator calandria inlet valve maintenance
2 Planned outage for Fukushima modifications, heat transport pump and turbine maintenance

Figure G.14: Power history for Pickering, Unit 4, 2015



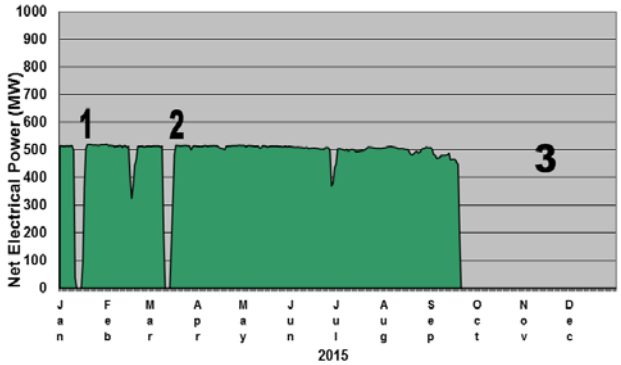
1 Forced outage to repair boiler temperature alarm unit
2 Forced outage due to power loss on boiler temperature alarm unit

Figure G.15: Power history for Pickering, Unit 5, 2015



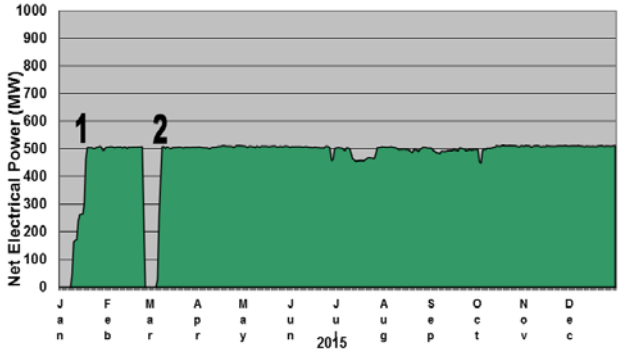
1 Planned outage for routine maintenance

Figure G.16: Power history for Pickering, Unit 6, 2015



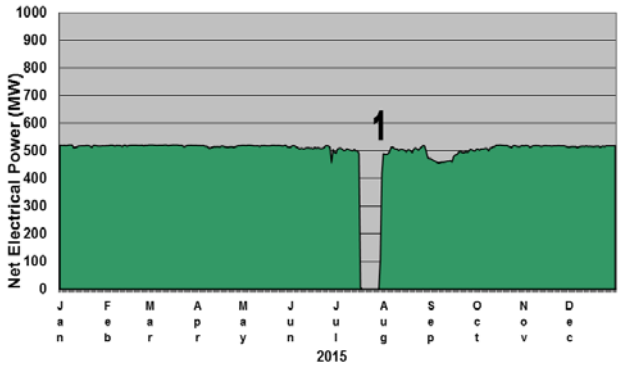
1 Forced outage due to fault in shutdown control system
2 Forced outage due to turbine pressure loss
3 Planned outage for routine maintenance and component inspections

Figure G.17: Power history for Pickering, Unit 7, 2015



1 Continuation of planned outage from 2014
2 Forced outage to repair hydrogen recombination units

Figure G.18: Power history for Pickering, Unit 8, 2015



1 Planned outage for repair of liquid injection shutdown system

Figure G.19: Power history for Gentilly-2, 2015

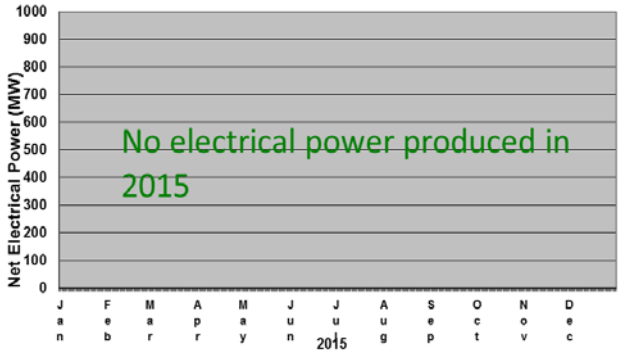
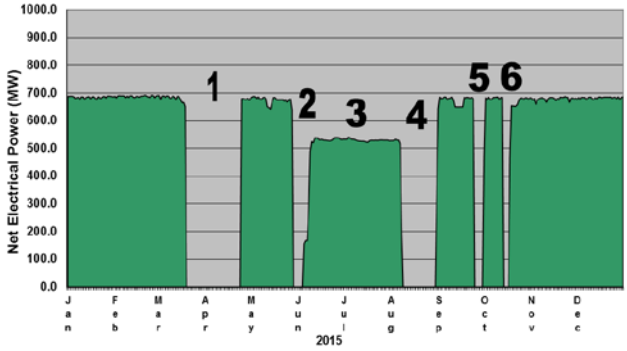


Figure G.20: Power history for Point Lepreau, 2015



1 Forced outage for repair of fueling machine
2 Forced outage for repair of reheater
3 Power reduction due to reheater
4 Planned outage for repair of reheater
5 Forced outage due to containment isolation valve seals
6 Forced outage to repair turbine hydraulic control system leak

Appendix H: Status of Fukushima action items applicable to NPPs

Table H.1 provides the status of the Fukushima action items (FAIs) that apply to each station as of May 24, 2016, followed by a description of each FAI. In some cases, station-specific FAIs were opened to track the performance of further deliverables. The follow-up actions were managed as part of normal compliance verification.

A complete description of these FAIs can be found in the *CNSC Integrated Action Plan on the Lessons Learned from the Fukushima Daiichi Nuclear Accident*. [5] As licensees have produced the required deliverables, all FAIs are now closed.

Table H.1: Status of Fukushima action items (FAIs) as of March 24th, 2016

	Darlington				Pickering Units 1, 4				Pickering Units 5–8				Bruce A				Bruce B				Point Lepreau				Gentilly-2			
FAI*	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15	'12	'13	'14	'15
AI 1.1.1	√				√				√				√				√				√				√			
AI 1.1.2	√				√				√				√				√				√				√			
AI 1.2.1		√				NA				√				√				√				√				√		
AI 1.2.2		√				NA				√				√				√				√				√		
AI 1.2.3		√				NA				√				√				√				√				√		
AI 1.3.1				√				√				√				√				√				√				S
AI 1.3.2				√				√				√				√				√				√				S
AI 1.4.1	√				√				√				√				√				√				√			
AI 1.5.1		√				√				√				√				√				√				√		
AI 1.6.1		√				√				√				√				√				√				√		
AI 1.6.2		NA				√				√				√				√				√				√		
AI 1.7.1		√				√				√				√				√				√				√		
AI 1.8.1		√				√				√				√				√				√				S		
AI 1.9.1			√				√				√				√				√				√				√	
AI 1.10.1	√				√				√				√				√				√				S			
AI 1.10.2	√				√				√				√				√				√				S			
AI 1.11.1	√				√				√				√				√				√				S			
AI 2.1.1		√				√				√				√				√					√			√		
AI 2.1.2		√				√				√				√				√					√			√		
AI 2.2.1		√				√				√				√				√				√				S		
AI 3.1.1		√				√				√				√				√				√				S		
AI 3.1.2		√				√				√				√				√				NA				NA		
AI 3.1.3		√				√				√				√				√				√				√		
AI 3.1.4		√				√				√				√				√				√				S		
AI 3.2.1	√				√				√				√				√				NA				NA			
AI 3.2.2	√				√				√				√				√				NA				NA			
AI 4.1.1	√				√				√				√				√				√				√			
AI 4.1.2	√				√				√				√				√				√				√			
AI 4.2.1	√				√				√				√				√				√				√			
AI 5.1.1	√				√				√				√				√				√				S			
AI 5.1.2	√				√				√				√				√				√				S			
AI 5.2.1	√				√				√				√				√				NA				√			
AI 5.2.2	√				√				√				√				√				NA				S			
AI 5.2.3	√				√				√				√				√				NA				√			
AI 5.3.1	√				√				√				√				√				√				S			
AI 5.4.1	NA				NA				NA				NA				NA				√				S			
Total	18	15	1	2	18	15	1	2	18	15	1	2	18	15	1	2	18	15	1	2	18	13	3	2	18	15	1	2
Closed/NA	18	15	1	2	18	15	1	2	18	15	1	2	18	15	1	2	18	15	1	2	18	13	3	2	18	15	1	2
Active	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* A description of each FAI follows on the next page

S – Suspended for Gentilly-2

NA – Not applicable

Table H.2: Description of Fukushima action items and target completion dates

FAI #	Fukushima action item description
1.1.1	An updated evaluation of the capability of bleed condenser/degasser condenser relief valves providing additional evidence that the valves have sufficient capacity. December 2012.
1.1.2	If required, a plan and schedule either for confirmatory testing of installation or provision for additional relief capacity. December 2012.
1.2.1	An assessment of the capability of shield tank/calandria vault relief. December 2013.
1.2.2	If relief capacity is inadequate, an assessment of the benefit available from adequate relief capacity and the practicability of providing additional relief. December 2013.
1.2.3	If additional relief is beneficial and practicable, a plan and schedule for provision of additional relief. December 2013.
1.3.1	Assessments of the adequacy of existing means to protect containment integrity and prevent uncontrolled releases in beyond-design-basis accidents, including severe accidents. December 2015.
1.3.2	Where the existing means to protect containment integrity and prevent uncontrolled releases of radioactive products in beyond-design-basis accidents, including severe accidents, are found inadequate, a plan and schedule for design enhancements to control long-term radiological releases and, to the extent practicable, unfiltered releases. December 2015.
1.4.1	A plan and schedule for the installation of passive autocatalytic recombiners as quickly as possible. December 2012.
1.5.1	An evaluation of the potential for hydrogen generation in the irradiated fuel bay (IFB) area and the need for hydrogen mitigation. December 2013.
1.6.1	An evaluation of the structural response of the IFB structure to temperatures in excess of the design temperature, including an assessment of the maximum credible leak rate following any predicted structural damage. December 2013.
1.6.2	A plan and schedule for deployment of any additional mitigating measures shown to be necessary by the evaluation of structural integrity. December 2013.
1.7.1	A plan and schedule for optimizing existing provisions (to provide coolant makeup to primary heat transport system, steam generators, moderator, etc.) and putting in place additional coolant makeup provisions, and supporting analyses. December 2013.
1.8.1	A detailed plan and schedule for performing assessments of equipment survivability, and a plan and schedule for equipment upgrades, where appropriate, based on the assessment. December 2013.
1.9.1	An evaluation of the habitability of control facilities under conditions arising from beyond-design-basis and severe accidents. Where applicable, detailed plan and schedule for control facilities upgrades. December 2014.
1.10.1	An evaluation of the requirements and capabilities for electrical power for key instrumentation and control. The evaluation should identify practicable upgrades that would extend the availability of key instrumentation and control, if needed. December 2012.
1.10.2	A plan and schedule for deployment of identified upgrades. A target of eight hours without the need for offsite support should be used. December 2012.
1.11.1	A plan and schedule for procurement (of emergency equipment and other resources that could be stored offsite). December 2012.
2.1.1	Re-evaluation, using modern calculations and state-of-the-art methods, of the site-specific magnitudes of each external event to which the plant may be susceptible. December 2013.

FAI #	Fukushima action item description
2.1.2	Evaluate if the current, site-specific design protection for each external event assessed in 2.1.1, above, is sufficient. If gaps are identified, a corrective plan should be proposed. December 2013.
2.2.1	Site-specific implementation plans for regulatory document RD-310 *Safety Analysis for Nuclear Power Plants*. December 2013.
3.1.1	Where severe accident management guidelines (SAMGs) have not been developed/finalized or fully implemented, provide plans and schedules for completion. December 2013.
3.1.2	For multi-unit stations, provide plans and schedules for the inclusion of multi-unit events in SAMGs. December 2013.
3.1.3	For all stations, plans and schedules for the inclusion of IFB events in station operating documentation where appropriate. December 2013.
3.1.4	Demonstration of effectiveness of SAMGs via table-top exercise and drills. December 2013.
3.2.1	An evaluation of the adequacy of existing modelling of severe accidents in multi-unit stations. The evaluation should provide a functional specification of any necessary improved models. December 2012.
3.2.2	A plan and schedule for the development of improved modelling, including any necessary experimental support. December 2012.
4.1.1	An evaluation of the adequacy of existing emergency plans and programs. December 2012.
4.1.2	A plan and schedule to address any gaps identified in the evaluation. December 2012.
4.2.1	A plan and schedule for the development of an improved exercise program. December 2012.
5.1.1	An evaluation of the adequacy of backup power for emergency facilities and equipment. December 2012.
5.1.2	A plan and schedule to address any gaps identified. December 2012.
5.2.1	Identify the external support and resources that may be required during an emergency. December 2012.
5.2.2	Identify the external support and resource agreements that have been formalized and documented. December 2012.
5.2.3	Confirm if any undocumented arrangements can be formalized. December 2012.
5.3.1	Provide a project plan and installation schedule. December 2012.
5.4.1	Develop source term and dose modelling tools specific to each NPP. December 2012.

Appendix I: Licence amendments and licence conditions handbook revisions

The tables in this appendix outline amendments to the power reactor operating licence (PROL) and revisions to the licence conditions handbook (LCH) for each nuclear power plant (NPP) licensee from January 1, 2015 to April 30, 2016.

I.1 Bruce A and B

Table I.1: Amendments to the Bruce A and Bruce B PROLs, 2015

PROL number and effective date	Amendment applications
PROL 18.00/2020 June 1, 2015	No amendments were made to the Bruce A and B PROL (PROL 18.00/2020) during the reporting period.
15.00/2015, May 28, 2015, Bruce A	PROL 15.00/2015 for Bruce A was renewed as a single PROL 18.00/2020 for both Bruce A and B stations effective June 1, 2015.
16.00/2015, May 28, 2015, Bruce B	PROL 16.00/2015 for Bruce B was renewed as a single PROL 18.00/2020 for both Bruce A and B stations effective June 1, 2015.

Table I.2: Significant changes to the Bruce A and Bruce B LCH, 2015

LCH section	Description of change	Revision type	LCH
NA	No changes were made to the Bruce A and B LCH (LCH-BNGS-R000) during the reporting period.	NA	Bruce A and B

I.2 Darlington

Table I.3: Amendments to the Darlington PROL, 2015

PROL number and effective date	Amendment applications
PROL 13.00/2025 January 1, 2016	Renewal of PROL, valid from January 1, 2016 to November 30, 2025.

Table I.4: Significant changes to the Darlington LCH, 2015

LCH section	Description of change	Revision type
All	The LCH was reissued to refer to the current PROL (PROL 13.00/2025).	Renewal
5.1	The LCH was updated to include REGDOC-2.4.1 and REGDOC-2.4.2.	Technical
11.1	Compliance verification criteria were updated to better align with RD-353 and REGDOC-2.10.1.	Administrative
14.1	The LCH was updated to include RD-336.	Technical
Several	The LCH was updated to replace a reference to S-99 with a reference to REGDOC-3.1.1.	Technical

I.3 Pickering

Table I.5: Amendments to the Pickering PROL, 2015

PROL number and effective date	Amendment applications
48.02/2018 December 18, 2015	The licence was amended to replace references to RD-310, *Safety Analysis for Nuclear Power Plants*, and S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*, with REGDOC-2.4.1, *Deterministic Safety Analysis*, and REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*.

Table I.6: Significant changes to the Pickering LCH, 2015

LCH section	Description of change	Revision type
1.4	A reference to Ontario Power Generation's agreement with City of Pickering for fire response to the exclusion zone was updated.	Administrative
3.3	Compliance verification criteria were updated to clarify RD-204 requirements for certified control room shift supervisor and shift manager co-piloting (paragraphs 25.2.6 and 26.7 of RD-204).	Administrative
4.1	A reference to the CNSC's acceptance of installed neutron overpower protection trip setpoints was updated. A reference to the CNSC's concurrence with using the rod-based guaranteed shutdown state with a drained moderator was added.	Administrative
5.1	References to RD-310 and S-294 were replaced with references to REGDOC-2.4.1 and REGDOC-2.4.2.	Administrative
6.1	CSA standard N290.12-14 was added to the Recommendations and Guidance sections.	Administrative
7.1	References to the periodic inspection program were updated. Information about certification for personnel conducting non-destructive examinations was clarified.	Administrative
5.1, 10.1	Section 5.1 on the status of AI 2012-48-3489 was updated. Section 10.1 on annual reporting requirement for fish impingement and entrainment monitoring was also updated.	Administrative
10.1	Text on the implementation of CSA standard N288.4-10 was updated.	Administrative
11.1	Text on compliance verification criteria related to emergency drills and exercises was updated.	Administrative
12.1	Notification and reporting requirements for waste sent to landfill facilities was removed.	Administrative
13.1	Text reflecting the CNSC's acceptance of the Canadian nuclear security fitness test was added.	Administrative

I.4 Gentilly-2

Table I.7: Amendments to the Gentilly-2 PROL, 2015

PROL number and effective date	Amendment applications
10.03/2016 June 5, 2015	The licence was amended to replace references to S-99, *Rapports à soumettre par les exploitants de centrales nucléaires*, to references with REGDOC-3.1.1, *Rapports à soumettre par les exploitants de centrales nucléaires*.

Table I.8: Significant changes to the Gentilly-2 LCH, 2015

LCH section	Description of change	Revision type
3.3.2	Changes were made to the minimum shift complement.	Administrative
3.5.2	The requirement to submit a probabilistic safety assessment was removed.	Administrative
3.10.2, 3.10.4	I-131 and noble gases were removed from derived release limits and action level tables.	Administrative

I.5 Point Lepreau

Table I.9: Amendments to the Point Lepreau PROL, 2015

Power reactor operating licence # - Effective date	Amendment applications
17.04/2017 – January 1, 2015	On October 24, 2014, NB Power submitted a request to the CNSC for a licence amendment to the Point Lepreau licence. This licence amendment request was to replace references to S-99 with REGDOC-3.1.1 and to include associated changes to two licence conditions. To maintain continuity of reporting requirements, CNSC staff recommended, and the applicant agreed, that the Commission include in the licence a reference to RD-336 under licence condition 14.1. The CNSC approved this licence amendment request on December 23, 2014 and it became effective on January 1, 2015.

Table I.10: Significant changes to the Point Lepreau LCH, 2015

LCH section	Description of change (LCH–PLNGS–R006) October 23, 2015	Revision type
Multiple sections	Text was edited to reflect modifications to the LCH template and other administrative changes, corrections and updates.	Administrative
1.1, 3.1, 4.5, 4.6, 5.1, 6.5, 7.2, 7.5, 10.3, 12.2, Appendix B.2, Appendix C.2	Administrative changes were made due to the Commission's approval of licence amendment #4, which replaced S-99 with REGDOC-3.1.1 for the Point Lepreau Generating Station (PROL 17.04/2017).	Administrative

LCH section	Description of change (LCH–PLNGS–R006) October 23, 2015	Revision type
1.3	Licence condition 1.3 and LCH text were withdrawn (effective January 1, 2015) based on licence amendment #4 (PROL 17.04/2017).	Administrative
11.2	The implementation strategy for CSA N293-07 was removed following the lifting of the hold point.	Administrative
14.1, Appendix C	Licence conditions and LCH text were amended based on PROL amendment #4. RD-336 was added to licence condition 14.1 (PROL 17.04/2017).	Administrative
16.4	Major milestones for the CSA standard N293-07 compliance plan were removed following the lifting of the hold point.	Administrative
LCH section	**Description of change (LCH–PLNGS–R007) March 1, 2016**	**Revision type**
Multiple sections	Text was edited to reflect administrative changes and corrections, and updates to the LCH.	Administrative
5.2	A revised probabilistic safety assessment (PSA) submission schedule was added.	Administrative
5.2	Text was added to reflect NB Power's commitments to submit a gap assessment and implementation plan for REGDOC-2.4.2 by December 31, 2015 and to finalize and submit a PSA program for acceptance by CNSC staff by August 1, 2016.	
7.3, Appendix D	Text was revised to incorporate the acceptance of NB Power's fuel channel pressure tube periodic inspection plan in accordance with CSA standard N285.4-09 and of the compliance plan for CSA standard N285.8.	Administrative
10.1	An update was included to reflect NB Power's submission of a gap analysis and implementation plan for CSA standards N288.4 and N288.5 (which have been reviewed and accepted by CNSC staff).	Administrative

LCH section	Description of change (LCH-PLNGS-R008) March 22, 2016	Revision type
5.2	Multiple revisions referring to the PSA program and submission schedule were done. A statement that NB Power has met the requirements of REGDOC-2.4.2 was added. The environmental risk assessment (ERA) section was moved to section 10.1 per changes effective January 1, 2016.	Administrative
6.5	The Canadian registration number and buried fire protection piping exemption was clarified. Text was clarified regarding personnel conducting non-destructive examinations.	Administrative
7.3, Appendix D	References to CSA standard N285.5-M90 were deleted (NB Power has implemented the 2008 version). Text was added to eliminate the need for an administrative request from licensees to accept a deviation from CSA standards N285.4 and N285.5. A completion date for the 2014 reactor building leak rate test acceptance was added. A reference for the transition to an aging management program that complies with RD-334 was added.	Administrative
10.1	An update on the ERA was added to reflect completion of the revised ERA. Minor edits to the section on CSA N288.4 were made to reflect current progress.	Administrative
16.2	A record of CNSC acceptance of results of the reactor leak rate test was added.	Administrative
Appendix G	A record ofCNSC staff consent for a variance to CSA standard N285.0–08 in accordance with LC 6.5 and 6.6 was added.	Administrative