Canada's Nuclear Regulator

CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2013

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CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2013

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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). The *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2013* ("2013 NPP Report") summarizes the CNSC staff's assessment of the Canadian nuclear power industry's safety performance during 2013 and details the progress of regulatory issues and initiatives up to May 31, 2014.

In 2013:

- six NPPs had operating licences
- 19 reactor units were operational
- Gentilly-2 was transitioning to safe storage throughout the year
- Pickering Units 2 and 3 remained in safe storage, consistent with previous years, after they were defuelled in 2008

Overall performance highlights

Through site inspections, reviews and assessments, CNSC staff concluded that the NPPs operated safely during 2013. The evaluations of all findings for the safety and control areas (SCAs) show that, overall, NPP licensees made adequate provision 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.

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 their licence conditions concerning Canada's international obligations

Table 1 summarizes the 2013 ratings for Canada's NPPs. This table presents the SCAs for each station, the industry averages, and the integrated plant ratings that gauge a plant's overall safety performance. The rating categories are "fully satisfactory" (FS), "satisfactory" (SA), "below expectations" (BE) and "unacceptable" (UA). A rating of "satisfactory" indicates the licensee's safety and control measures are effective, while a "fully satisfactory" indicates they are highly effective. An SCA rating of "below expectations" indicates the safety and control measures are marginally ineffective, while "unacceptable" indicates the safety and control measures are significantly ineffective.

All NPPs received SCA ratings of either "fully satisfactory" or "satisfactory". There were 11 "fully satisfactory" ratings across the stations, a net increase of two in comparison to 2012. Improvements resulted in increases in the safety performance ratings for Pickering in radiation protection and in security to "fully satisfactory" and for Darlington in security to "fully

satisfactory". The fitness for service rating for Darlington for 2013 returned to "satisfactory" from "fully satisfactory".

The industry average was "satisfactory" for 12 SCAs and "fully satisfactory" for two SCAs, an increase of one "fully satisfactory" (in security) in comparison to 2012. The safety performance rating of "fully satisfactory" for conventional health and safety remained unchanged from 2012.

The integrated plant ratings in 2013 were "fully satisfactory" for Darlington and "satisfactory" for all other stations, unchanged in comparison to the previous year. None of the plants received an integrated plant rating of "below expectations" or "unacceptable".

Table 1: Canadian nuclear power plant safety performance ratings for 2013

Safety and control area	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Management system	SA	SA	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA	SA	SA
Operating performance	SA	SA	FS	SA	SA	SA	SA
Safety analysis	SA	SA	SA	SA	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	SA	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	SA	SA	SA	SA	SA	SA	SA
Security	FS	FS	FS	FS	SA	SA	FS
Safeguards and non-proliferation	SA	SA	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA	SA	SA
Integrated plant rating	SA	SA	FS	SA	SA	SA	SA

Performance highlights of each NPP

Bruce A and B

The 2013 integrated plant ratings for Bruce A and B were both "satisfactory", unchanged from 2012.

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

- conventional health and safety
- security

These SCA ratings were unchanged from 2012.

Bruce Power continued to address hours of work issues at Bruce A and CNSC staff are closely monitoring the measures being implemented. The environmental assessment (EA) monitoring program related to the refurbishment project continued to verify the conclusion of the EA that there were no significant adverse environmental effects due to the project.

In 2013, Bruce Power submitted applications for licence renewal as the Bruce A and Bruce B licences will expire in late 2014. CNSC staff are reviewing the applications. In March 2014, Bruce Power applied for, and the Commission approved, an amendment of the licence period until May 31, 2015 in order to facilitate an appropriate level of public participation in the public hearing process.

Darlington

The 2013 integrated plant rating for Darlington was "fully satisfactory", unchanged from 2012.

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

- operating performance
- radiation protection
- conventional health and safety
- security

CNSC staff noted that, regarding the four SCAs above, the security rating had improved from "satisfactory" in 2012 to "fully satisfactory" in 2013 and the remaining three were unchanged from the previous year. As well, the fitness for service rating determined by CNSC staff for Darlington for 2013 returned to "satisfactory" from "fully satisfactory".

Changes to the organization and the management system have been implemented at Ontario Power Generation (OPG) through the introduction of the "Business Transformation Initiatives". These changes have resulted in re-alignments at Darlington. No safety significant deficiencies resulted from these changes and CNSC staff are monitoring the progress of the implementation.

OPG's radiation protection program at Darlington is highly effective and initiatives were implemented throughout the year to reduce worker dose exposures.

In February 2013, the Commission renewed the operating licence for Darlington for the period March 1, 2013 to December 31, 2014. In late 2013, OPG submitted an application for licence renewal for the Darlington facility. The licence renewal process will be based on periodic implementation of integrated safety review.

Pickering

The 2013 integrated plant rating for Pickering was "satisfactory", unchanged from 2012.

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

- radiation protection
- security

This was an improvement in both SCAs from "satisfactory" in 2012.

As stated above in the Darlington summary, changes to the organization and the management system have been implemented at OPG through the introduction of the "Business Transformation Initiatives". The changes have resulted in re-alignments at Pickering. No safety significant deficiencies resulted from these changes and CNSC staff are monitoring the progress of the implementation.

In 2013, OPG demonstrated to the satisfaction of CNSC staff that the average size of iron oxide deposits on Unit 1 fuel bundles at Pickering was decreasing. Unit 1 was authorized by the Commission to return to full power operation as there was no evidence of bowing and no effects on fuel cooling as a result of the deposits.

OPG's radiation protection program at Pickering is highly effective and initiatives were implemented throughout the year to reduce worker dose exposures.

In 2013, the two licences for the two stations at the Pickering site were amalgamated into a single licence. The Pickering operating licence was renewed for the period September 1, 2013 to August 31, 2018. The Commission imposed a regulatory hold point prohibiting operation of Pickering B (now referred to as Pickering 5-8) beyond 210,000 effective full power hours, which is the original assumed design life of the pressure tubes.

The regulatory prerequisites for the release of the hold point are:

- the revised probabilistic safety assessment (PSA) for Pickering A (now referred to as Pickering 1, 4) that meets the requirements of S-294
- an updated PSA for both Pickering A and Pickering B that takes into account the enhancements required under the *CNSC Integrated Action Plan*
- a whole-site PSA or methodology for a whole-site PSA, specific to the Pickering site
- a report on OPG's analysis and way forward for further enhancements to protect containment through its Fukushima action items

OPG made progress on the incorporation of Fukushima Daiichi enhancements into its PSA, along with the development of a PSA for the whole site. OPG submitted the required hold point release reports in early 2014 and requested the removal of the hold point at the May 7, 2014 public hearing. As of the end of May 2014, the Commission was in deliberation on this issue.

Gentilly-2

The 2013 integrated plant rating for Gentilly-2 was "satisfactory", unchanged from 2012.

CNSC staff noted that all SCA ratings were "satisfactory". During 2013, Hydro-Québec continued to progress with transitioning the plant to a safe storage state following the shutdown of the plant at the end of 2012. The plant had reached the core defuelled state by September 2013. Stabilizing operations conducted during the year included emptying and draining several plant systems.

As a result of the reactor shutdown, Hydro-Québec must submit a revision to its decommissioning plan and the related financial guarantee for Gentilly-2. These revisions are expected to be submitted to CNSC staff by the end of March 2015.

Point Lepreau

The 2013 integrated plant rating for Point Lepreau was "satisfactory", unchanged from 2012.

CNSC staff noted that the safety performance rating in conventional health and safety was "fully

satisfactory", unchanged from 2012. All other SCA ratings were "satisfactory".

As a prerequisite for continued operation of the plant, the Commission, in its relicensing decision of 2012, included a regulatory hold point for New Brunswick (NB) Power's compliance with N293-07, *Fire protection at CANDU nuclear power plants*, by December 31, 2014. NB Power is currently implementing N293-07 at Point Lepreau and compensatory measures have been implemented. In addition, the Commission required that NB Power complete a site-specific seismic hazard assessment and disclose the results through its public information program.

NB Power has invested significantly in enhancement of the firefighting capability of the industrial fire brigade through the acquisition of equipment. The industrial fire brigade shows signs of improvements from the additional training and exercising conducted in 2013.

NB Power submitted the preliminary results of its site-specific seismic hazard assessment to the CNSC and posted those results on the NB Power website. The results have been reviewed and comments provided to NB Power. NB Power will submit the final assessment by the end of 2014.

CNSC staff identified areas for improvement in the monitoring of alpha radiation hazards. NB Power is addressing these regulatory findings.

Response to the Fukushima Daiichi accident

CNSC staff observed during 2013 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* and implemented by NPP licensees, address safety improvements aimed at strengthening defence-in-depth, and enhancing onsite emergency response. All Canadian NPP licensees have made considerable progress in addressing and implementing FAIs at their stations. Specifically, for this reporting period, all medium-term FAIs that were to be completed by the end of 2013 are closed with the exception of a few pending completion of review by CNSC staff (related to PSA for external hazard assessment). The Canadian nuclear power industry is on track to complete all enhancements by the December 2015 deadline set forth in the *CNSC Integrated Action Plan*.

Darlington new-build project

The power reactor site licence (PRSL) for the Darlington New Nuclear Project (DNNP) is valid for 10 years – from August 17, 2012 to August 17, 2022.

In December 2013, the government of Ontario released a *Long-Term Energy Plan,* which indicated that the new nuclear project will be deferred because the demand for electricity is lower than previously forecasted. The government of Ontario has also indicated, however, that it will work with OPG to maintain the PRSL. OPG is now focused on collecting information to assist the site-specific design activities to be undertaken after a vendor is selected.

In May 2014, the Federal Court released a decision on the judicial review of the environmental assessment and the PRSL. The environmental assessment is to be returned to the Joint Review Panel for further consideration of its compliance with the *Canadian Environmental Assessment Act* (1992). The power reactor site licence was quashed owing to deficiencies in the environmental assessment.

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CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2013

1. Overview

The Canadian Nuclear Safety Commission (CNSC) is the federal government body that regulates the use of nuclear energy and materials to protect the health, safety and security of persons and the environment, and to implement Canada's international commitments on the peaceful use of nuclear energy. 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 – the industry as a whole and the performance of each nuclear power plant (NPP). This assessment is summarized in the *CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2013* (commonly referred to as the "2013 NPP Report").

This assessment aligns with the regulatory oversight of NPPs based on the legal requirements of the *Nuclear Safety and Control Act* (NSCA), the regulations made under the NSCA, the conditions of operating licences, and applicable standards and regulatory documents. The evaluations are supported by information obtained through inspections, site-surveillance activities, field rounds, document assessments, desktop reviews and performance indicator data. The report makes comparisons and shows trends, where possible, and it also highlights emerging regulatory issues pertaining to the industry at large and to each licensed station.

The 2013 NPP Report consists of the following sections:

- this overview, which provides a summary of the nuclear power industry throughout Canada
- the assessment and ratings of the safety performance for the overall nuclear power industry, covering the 2013 calendar year (January to December)
- the assessment and ratings of the safety performance for each licensed station, covering the 2013 calendar year (January to December)
- detailed information on licensing and other regulatory issues pertaining to the industry, covering an extended period of January 1, 2013 to May 31, 2014 (to permit the most up-to-date view of issues for the industry)
- detailed information on licensing and other regulatory issues pertaining to each licensed station, covering an extended period of January 1, 2013 to May 31, 2014 (to permit the most up-to-date view of issues at each station)

The report also includes seven appendices and concludes with a glossary and a list of references. New to this year's report is the inclusion, as appendix F, of the power history graphs for each reactor unit. These graphs show outages and power reductions that occurred during the year and provide brief explanations for these.

In addition to providing the CNSC staff integrated safety assessment of Canadian NPPs, the 2013 NPP Report includes, in sections 4 and 5, updates on activities conducted by the industry as a whole and by licensees following the Fukushima Daiichi nuclear accident and in response to the *CNSC Integrated Action Plan* [1].

In 2012, the Commission issued a licence to prepare site to Ontario Power Generation (OPG) for the Darlington new-build project. This report contains, in section 4, the annual update on work performed by the licensee and the regulator with respect to the Darlington New Nuclear Project (DNNP).

Canada's nuclear power plants

There are six licensed NPPs 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 it is licensed to the SNC-Lavalin Group Inc. through its wholly owned subsidiary, Candu Energy Inc.

Figure 1 also provides plant data for each of the NPPs, including the generating capacity of the reactors at each NPP, their initial startup dates, the names of the licensees, and the expiry dates of the operating licences.

In 2013:

- six NPPs had operating licences
- 19 reactor units were operational
- Gentilly-2 was transitioning to safe storage throughout the year
- at Pickering, Units 2 and 3 remained in safe storage, consistent with previous years, after they were defuelled in 2008

Regulatory oversight

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

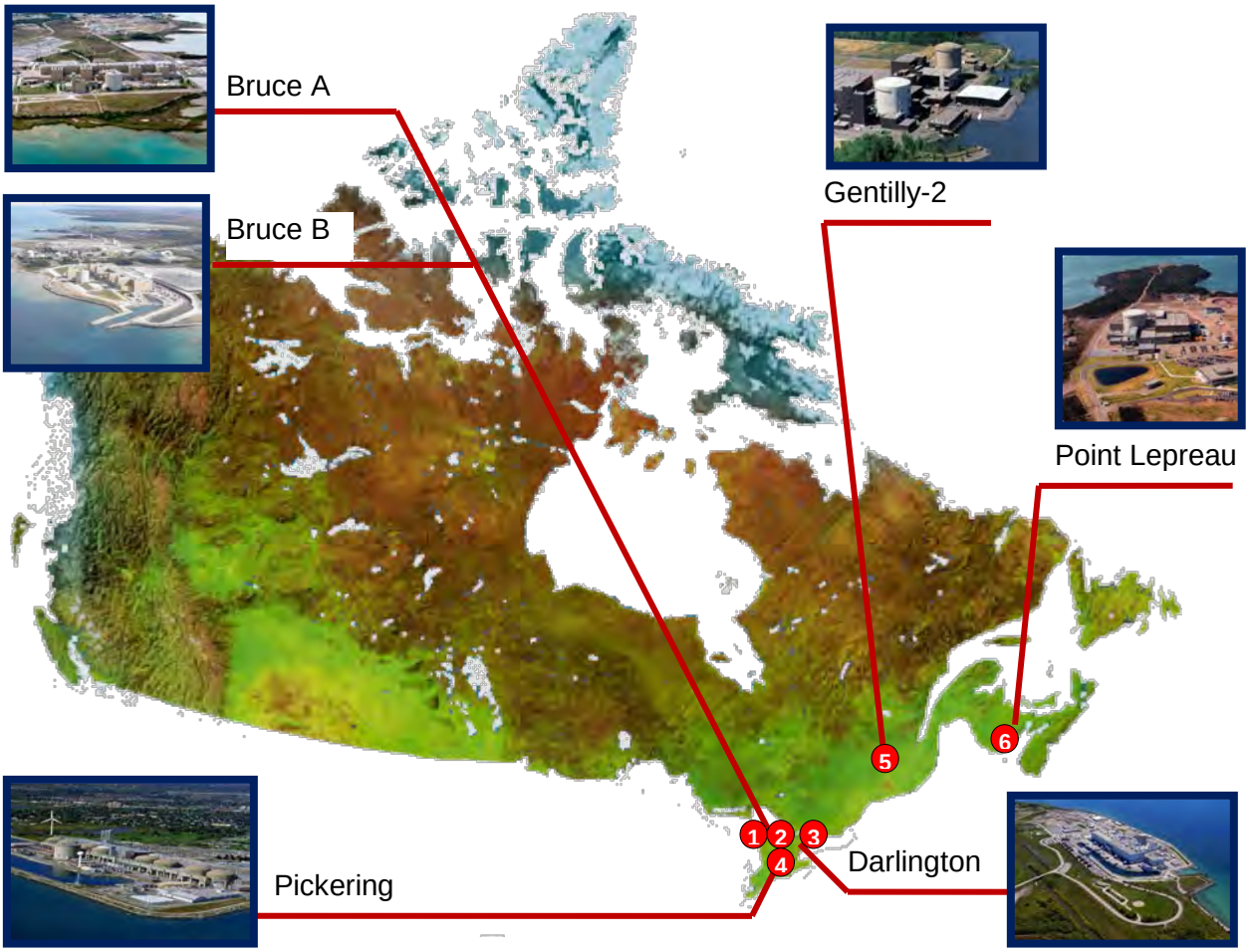
The Power Reactor Regulatory Program involves the direct efforts of 230 CNSC staff, plus support from other members of the organization. This total effort includes 32 CNSC employees who are located onsite at the six NPP facilities and who perform inspections, monitor safety performance and provide regulatory support.

Safety and control area framework

CNSC staff use the safety and control area (SCA) framework in evaluating each licensee's safety performance. The framework includes 14 SCAs. Each SCA is sub-divided into specific areas that define its key components. For a complete list of the SCAs and specific areas used in this report, see appendix A.

In response to RD/GD-99.3, *Public Information and Disclosure* [2], 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 4.2, "Public communication".

Figure 1: Locations and data for Canadian nuclear power plants



NPP	Licensee	Location	State of reactor units	Design capacity per unit (MWe)	Startup[1]	Licence expiry
Bruce A	Bruce Power Inc.	Tiverton, ON	4 operating	904	1977	May 31, 2015[2]
Bruce B	Bruce Power Inc.	Tiverton, ON	4 operating	915	1984	May 31, 2015[2]
Darlington	Ontario Power Generation Inc	Darlington, ON	4 operating	935	1990	Dec. 31, 2014[2]
Pickering	Ontario Power Generation Inc	Pickering, ON	6 operating, 2 defuelled and in safe storage	Units 1, 4: 542 Units 5-8: 540	Units 1, 4: 1971 Units 5-8: 1982	August 31, 2018
Gentilly-2	Hydro-Québec	Bécancour, QC	1 defuelled[3]	675	1983	June 30, 2016
Point Lepreau	New Brunswick Power Corp.	Lepreau, NB	1 operating	705	1982	June 30, 2017

[1] For the multi-unit NPPs, this indicates the startup of the first reactor unit
[2] Relicensing is in progress
[3] Gentilly-2 ended commercial operation in 2012 and is transitioning to safe storage

Licensing

In 2013, the Commission amended the operating licences for Pickering A and Pickering B for a period of two months in order to consolidate the two licences into a single-site licence encompassing Pickering A and Pickering B and expiring on August 31, 2018. Pickering A is now referred to as Pickering 1, 4 (i.e., Units 1 and 4). Pickering B is now referred to as Pickering 5-8 (i.e., Units 5 to 8).

The 2013 Pickering relicensing hearing resulted in the introduction of new CNSC regulatory documents and CSA standards into Pickering's operating licence. These new documents assist with improving the regulation of NPPs.

The operating licence for Darlington was renewed in February 2013 for a 22-month period (effective until December 31, 2014).

Licence renewal applications were received from Bruce Power for Bruce A and B and from OPG for Darlington during 2013.

In March 2014, Bruce Power applied for, and the Commission approved, an amendment of the licence period for Bruce A and Bruce B until May 31, 2015 to facilitate an appropriate level of public participation in the public hearing process.

As Canadian NPPs approach the end of their original assumed design life, initially projected to be 210,000 effective full power hours (EFPH), continued operation must be supported by the demonstration of fitness for service of the pressure tubes. Operation of a reactor unit beyond 210,000 EFPH is not permitted unless approved by the Commission.

The Commission was kept informed of events and activities at NPPs through *Status reports on power reactors*, event initial reports and presentations made at public meetings.

CNSC staff conducted several consultation activities with a number of Aboriginal communities in relation to the 2013 Pickering licence renewal, as well as in preparation for the 2014 Darlington and 2015 Bruce Power NPP operating licence renewals.

Reporting requirements

In April 2014, the Commission approved REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants* [3], to replace S-99, *Reporting Requirements for Operating Nuclear Power Plants* [4]. CNSC staff are developing an implementation plan in consultation with licensees. It is anticipated that implementation of the new regulatory document into the operating licences will be completed in 2015.

Currently, the CNSC's reporting requirements are documented in the regulations, in S-99 [4], and in other specific licence conditions. CNSC staff use these reports to respond to events, verify compliance performance and monitor routine operations of safety and control measures.

During 2013, NPP licensees reported to CNSC staff on 336 events and submitted 137 scheduled reports as a result of the requirements of S-99 [4]. Only one of the events resulted in a medium safety significant finding. This reportable event was caused by a temporary impairment of the emergency coolant injection system, see details in section 3.1.6. There were no findings of high safety significance.

Compliance verification program

The safety performance of NPPs presented in this report was determined by CNSC staff using the results of activities planned through the compliance verification program (CVP). These compliance activities include surveillance and monitoring 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 are performed through an effective combination of document review, workplace observation and worker interview. All compliance activities are fully documented and record the objective evidence that is the basis of the compliance results.

Inspection of new fuel bundles, before they are inserted into the reactor.

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

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

In this way, the CNSC ensures that the CVP for NPPs is always timely, risk-informed, performance-based and tailored to individual stations.

Safety performance assessment

The 2013 NPP 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 over 1,400 findings. Of this total number of findings, over 99% were assessed as being either of positive, negligible or low safety significance – in other words, each of these finding had a positive, insignificant or small negative impact on the assessment of the specific area. The remainder (less than 1%) had a negative effect on the assessment of a specific area. The findings were categorized into appropriate SCAs and assessed against a set of CNSC-developed performance objectives and criteria.

The assessment presented in the 2013 NPP Report includes an integrated plant rating (IPR) for each NPP. The IPR is a general measure of the overall safety performance at each NPP; it is determined by combining the ratings of the 14 individual SCAs.

2. Industry Safety Performance

This section presents the CNSC staff's integrated assessment of the safety performance of the industry in each of the SCAs and highlights generic issues and observations. The overall performance of the industry is determined by calculating an "industry average" rating for each SCA.

CNSC staff evaluated how well licensees' programs met regulatory requirements and expectations and contributed to protect the overall health, safety and security of persons and the environment, in addition to implementing Canada's international commitments on the peaceful use of nuclear energy. The evaluations are based on findings made throughout the year during inspections, desktop reviews, field rounds and follow-ups on licensee progress on enforcement actions and are categorized according to the following 14 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 SCA definitions, performance objectives and specific areas are given in appendix A, "Definitions of Safety and Control Areas". The definitions of the performance ratings and the rating methodology used in this report can be found in appendix B, "Rating Definitions and Methodology".

CNSC and World Association of Nuclear Operators (WANO) performance indicators (PIs) are included in this section to illustrate various trends. CNSC PIs are defined in S-99, *Reporting Requirements for Operating Nuclear Power Plants* [4]. Note that comparing NPP data in any particular year is difficult because many factors – such as the number of operating units, design, unit capacity, or NPP governing documents – contribute to differences in PI data.

2.1 Management system

The management system SCA covers the framework that establishes the processes and programs required to ensure an organization achieves its safety objectives, continuously monitors its

performance against those objectives, and fosters a healthy safety culture. The industry average for management system was “satisfactory”, unchanged from the previous year.

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

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Management system	SA	SA	SA	SA	SA	SA	SA

Management system encompasses the following specific areas:

- management system (no significant observations to report)
- organization
- change management (no significant observations to report)
- safety culture
- configuration management (no significant observations to report)
- records management
- management of contractors (no significant observations to report)
- business continuity (no significant observations to report)

CNSC staff have concluded that the NPP licensees’ management systems continue to meet CNSC requirements. Overall, the implementation of all specific areas of management system is effective.

Organization

There were, and continues to be, organizational changes within Ontario Power Generation (OPG). CNSC staff are monitoring the changes to ensure safe and reliable operation of OPG NPPs.

Safety culture

OPG and Bruce Power have conducted self-assessments of safety culture in 2012 and 2013, respectively. CNSC staff found the OPG self-assessments to be satisfactory. CNSC staff agreed with the preliminary implementation of the results at the Bruce Power stations.

Further improvement initiatives in the area of safety culture have included the implementation by licensees of recent Institute of Nuclear Power Operations (INPO) and Nuclear Energy Institute (NEI) documents on safety culture. The application of additional organizational learning initiatives through leadership and team training based on recent operating experience (OPEX) findings has led to improvements.

Records management

All licensees’ performance in this area was satisfactory. Implementation of records management was effective and continues to be monitored by CNSC staff.

2.2 Human performance management

The human performance management SCA covers activities that enable effective human performance through the development and implementation of processes that ensure that licensees have sufficient staff in all relevant job areas and have the necessary knowledge, skills, procedures

and tools in place to safely carry out their duties. The industry average rating for human performance management was “satisfactory”, unchanged from the previous year.

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

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Human performance management	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

Inspections of human performance were carried out at all sites. These identified that licensees have adequate human performance programs that are moving towards the broader consideration of factors influencing human performance. This includes increased emphasis on eliminating potential deficiencies that can impair defences against human errors. This is a positive trend aligned with industry good practice.

Integrated system validation activities continued to be carried out by licensees to address changes to the plant design, procedures and staffing strategies. Validations provide assurance that the proposed arrangements will meet performance and safety goals, including human factors and human performance considerations. CNSC staff have identified improving trends in the licensees' validation approaches, including a growing maturity of the methodologies and using the findings to make improvements.

Personnel training

All Canadian NPPs employ systematic approach to training (SAT)-based training systems. Implementation of these systems for the many training programs at each facility met the regulatory requirements. Potential deficiencies in the implementation of the training systems are being addressed by the licensees in accordance with their corrective action plan processes and do not represent an increased risk to nuclear safety.

Personnel certification

All licensees are required to have plant shift supervisors (also called shift managers), control room shift supervisors, reactor operators (also called authorized nuclear operators or control room operators), Unit 0 control room operators (Unit 0 handles shared services at certain multi-unit NPPs) and senior health physicists (also called responsible health physicists) certified by the CNSC. In 2013, all licensees maintained sufficient numbers of personnel for their certified positions. CNSC staff are confident that all certified staff at Canadian NPPs are competent to perform the duties of their positions safely and adequately.

Initial certification examinations and requalification tests

In 2013, the initial certification examinations and requalification tests programs at all NPPs met regulatory requirements for initial certification of workers and renewal of certification of workers. This is an improving trend.

A control room operator works at the Bruce NPP. Key safety-related positions at nuclear facilities must have personnel who have been certified by the CNSC as being qualified, trained and capable of performing their duties.

Work organization and job design

Minimum shift complement

At all NPPs, the minimum shift complement requirements are given in the operating licence and licensee's documentation. The minimum shift complement details are well known to licensee staff and readily retrievable. There are processes being followed to ensure that minimum shift complement is maintained on each shift and that staff are qualified for designated positions.

Table 2 shows that each licensee employs a number of certified persons in excess of the minimum requirements set by the licence condition(s) in the CNSC operating licence for each facility. Additionally, although a minimum shift complement is not prescribed for the senior health physicist (SHP) position, the number of certified SHPs employed at each site is deemed sufficient to ensure personnel and public safety.

In 2013, all licensees made progress towards analyzing and validating the minimum staff complements at their respective facilities. CNSC staff are reviewing submissions from OPG, New Brunswick (NB) Power and Hydro-Québec regarding the analyzed minimum complement requirements at each facility. CNSC staff observed integrated validation exercises conducted at Bruce Power and Darlington in 2013. Pickering will conduct a second validation exercise in 2014 to demonstrate that challenges noted in its 2010 exercise have been addressed. CNSC staff are satisfied with the progress of NPP licensees in re-evaluating their minimum shift complements.

Table 2: Number of valid certifications per station and per certified position

NPP		Reactor operator	U0O[a]	Shift supervisor	Subtotal (less SHPs)	SHP[b]	Total (actual)	Location of details of minimum shift complement[c]
Bruce A	Minimum	30	10	10	50	4	84	2.1 and 2.2
	Actual	39	24	17	80			
Bruce B	Minimum	30	10	10	50	3	86	2.1 and 2.2
	Actual	45	19	19	83			
Darlington	Minimum	30	10	10	50	2	89	3.2
	Actual	49	19	19	87			
Pickering 1, 4	Minimum	20		10	30	3	63	3.2
	Actual	42		18	60			
Pickering 5-8	Minimum	30		10	40	3	83	3.2
	Actual	58		22	80			
Gentilly-2	Minimum	6		6	12	3	18	3.2 and 3.3
	Actual	7		8	15			
Point Lepreau	Minimum	6		6	12	2	20	3.2 and 3.3
	Actual	11		7[d]	18			

Notes:

a. There are no Unit 0 Operator (U0O) positions at Pickering 1, 4, Pickering 5-8, Gentilly-2 and Point Lepreau stations – the corresponding cells are therefore left empty and shaded in dark grey.
b. The SHP position is not subject to a minimum shift complement requirement, however, licensees are required to have at least one SHP per station.
c. Location in operating licences and/or licence conditions handbooks.
d. Included in this number is a shift supervisor who retired on December 31, 2013.

Fitness for duty

Through inspections and desktop reviews, CNSC staff carried out compliance verification activities on hours of work at all NPPs in 2013. CNSC staff confirmed that all NPPs have procedures that specify station requirements related to hours of work and processes in place that enable them to monitor compliance with their hours of work limits.

Station hours of work procedures met the requirements; however, they were not always aligned with the CNSC's expectations (e.g., application to casual construction trades and contractors, outages). In addition, there have been exceedances of hours of work limits and CNSC staff will continue to closely monitor these.

2.3 Operating performance

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

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

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Operating performance	SA	SA	FS	SA	SA	SA	SA

Operating performance encompasses the following specific areas:

- conduct of licensed activity
- procedures (no significant observations to report)
- reporting and trending
- outage management performance
- safe operating envelope
- severe accident management and recovery (no significant observations to report)
- accident management and recovery (no significant observations to report)

Conduct of licensed activity

Throughout 2013, 19 reactors operated in Canada. Pickering Units 2 and 3 are in safe storage. During the year, Gentilly-2 continued to transition to safe storage and is presently in a core defuelled state. There were no serious process failures at any of the NPPs.

"Number of unplanned transients" denotes the unplanned reactor power transients due to all causes while the reactor was operating and not in a guaranteed shutdown state. Unplanned transients include stepbacks, setbacks, and reactor trips where the trip resulted in a reactor shutdown. Unexpected power reductions can indicate problems within the plant and/or place unnecessary strain on systems. CNSC staff will continue to monitor trends in this indicator.

Table 3 shows the number of power reductions from actuation of the shutdown, stepback or setback systems. All transients were controlled properly and, where necessary, power reduction was initiated by the reactor control systems. The stepbacks and setbacks are gradual power changes to eliminate potential risks to plant operations.

Table 3: Number of unplanned transients

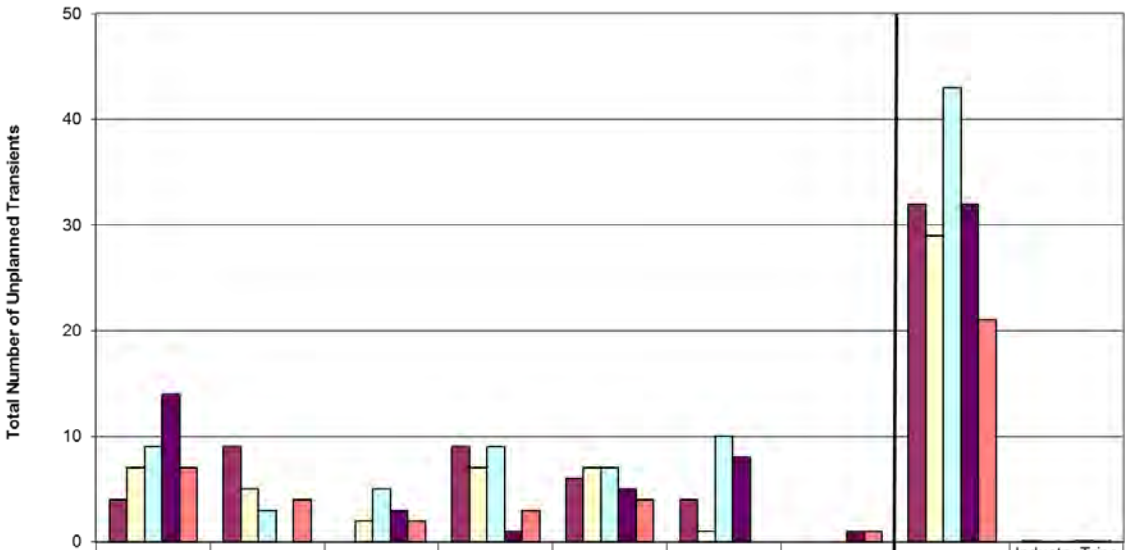
NPP	Number of operating reactors	Number of hours of operation	Unplanned transients at stations				Number of trips per 7,000 operating hours**
			Un-planned reactor trips*	Step-backs	Set-backs	Total	
Bruce A	4	32,727	3	1	3	7	0.64
Bruce B	4	31,502	1	3	0	4	0.22
Darlington	4	33,410	0	1	1	2	0.0
Pickering 1, 4	2	15,631	1	0	2	3	0.45
Pickering 5-8	4	29,430	2	1	1	4	0.48
Gentilly-2	n/a						
Point Lepreau	1	2,208	0	0	1	1	0.0
Industry total	19	144,908	7	6	8	21	0.34

* Automatic reactor trips only; does not include manual reactor trips or trips during commissioning testing.

** Nuclear power industry performance target is less than 0.5 reactor trips per 7,000 operating hours.

Figure 2 shows the individual station and industry trend in the number of unplanned transients from 2009 to 2013. For three stations and the industry total, the number of unplanned transients decreased.

Figure 2: Trend details for the number of unplanned transients for stations and industry



	Bruce A	Bruce B	Darlington	Pickering 1, 4	Pickering 5-8	Gentilly-2	Point Lepreau	Industry Total	Industry Trips per 7,000 Hours
2009	4	9	0	9	6	4	n/a	32	0.48
2010	7	5	2	7	7	1	n/a	29	0.54
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

Note: "Not applicable" (n/a) in the above table for Gentilly-2 and Point Lepreau are due to the reactors being shutdown 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 and the transition to safe storage.

Figure 3 shows the number of unplanned reactor trips per 7,000 operating hours for the Canadian nuclear power industry in comparison to international nuclear power industry values as published by the World Association of Nuclear Operators (WANO). As shown in figure 3, the reactor trip rate increased slightly in 2013, from 0.30 to 0.34, but it remains within the industry performance target of 0.5 unplanned trips per 7,000 operating hours. In addition, the change in the reactor trip rate is not significant.

The industry average was one unplanned reactor trip per 20,700 hours or about 32% better than the nuclear power industry performance target of less than 0.5 reactor trips per 7,000 hours of operation (or 1 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

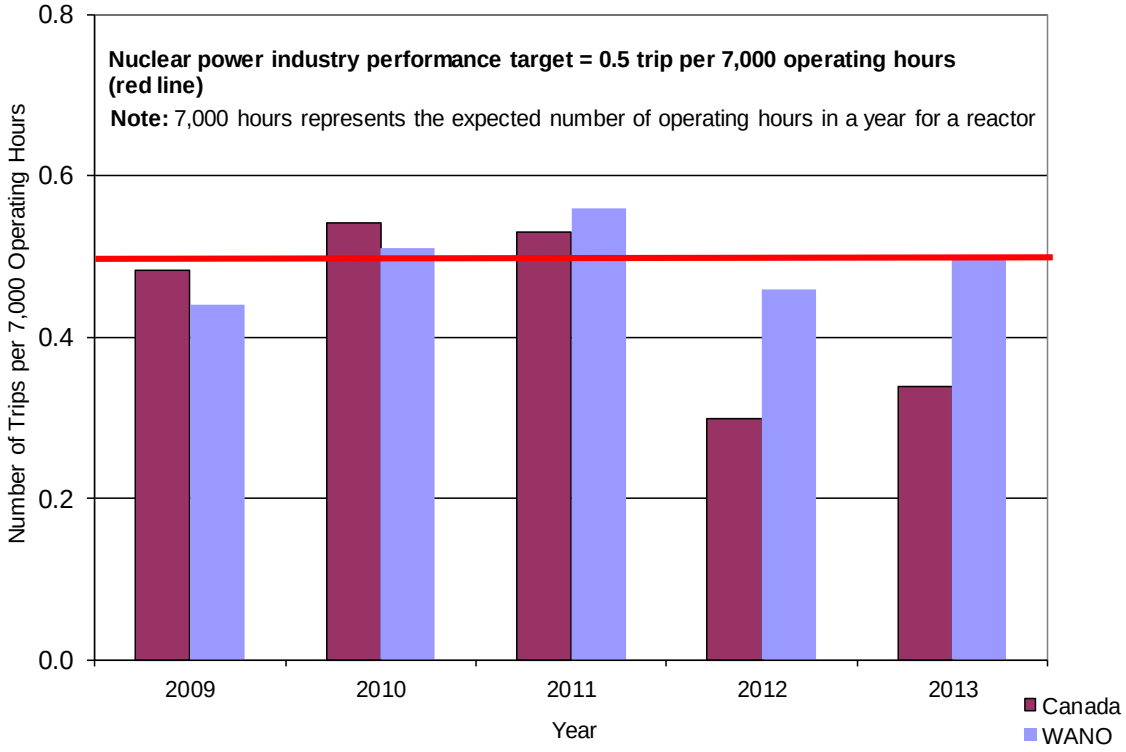
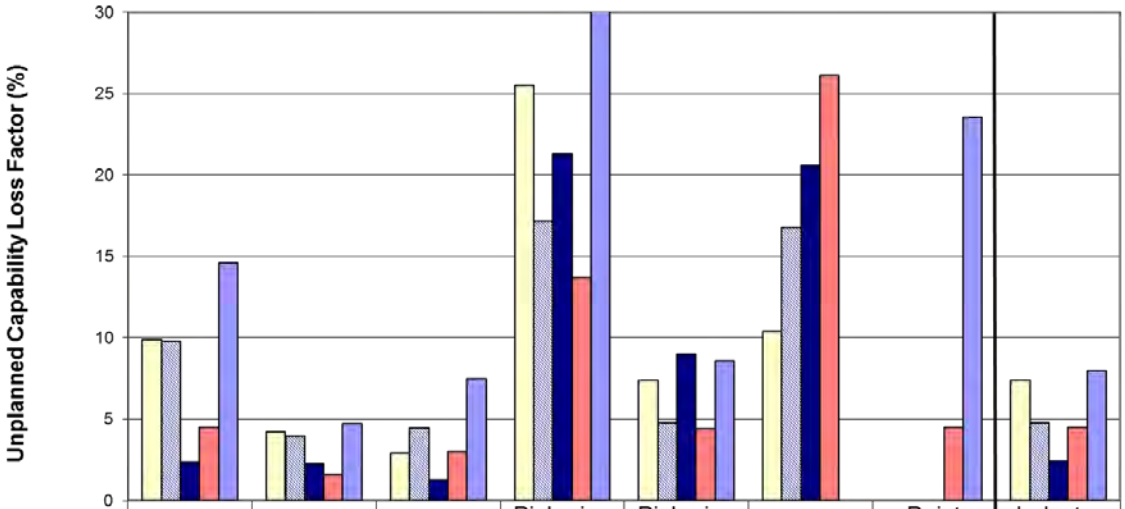


Figure 4 shows the "unplanned capability loss factor" (UCLF) from 2009 to 2013 for Canadian NPP licensees and the industry, and presents the median value for the industry (consistent with WANO methodology). The UCLF is the percentage of the reference electrical output for the station not produced during the period due to unplanned circumstances. The UCLF indicates how a unit is managed, operated and maintained, in order to avoid forced outages. The UCLF is both an economic indicator and a reflection of the overall management of the plant.

As shown in figure 4:

- the increase in the industry UCLF, from 4.5% to 8.0%, is due to the increased value for all Canadian NPPs with the highest values observed by Pickering 1, 4, Point Lepreau and Bruce A
- the increased UCLF values for Bruce A and Point Lepreau are attributed to the return to service of units after refurbishment (an increase in the UCLF value is typical for units that have returned to operations after a long lay-up)
- the increased UCLF value for Pickering 1, 4 is attributed to unplanned outages and outage extensions

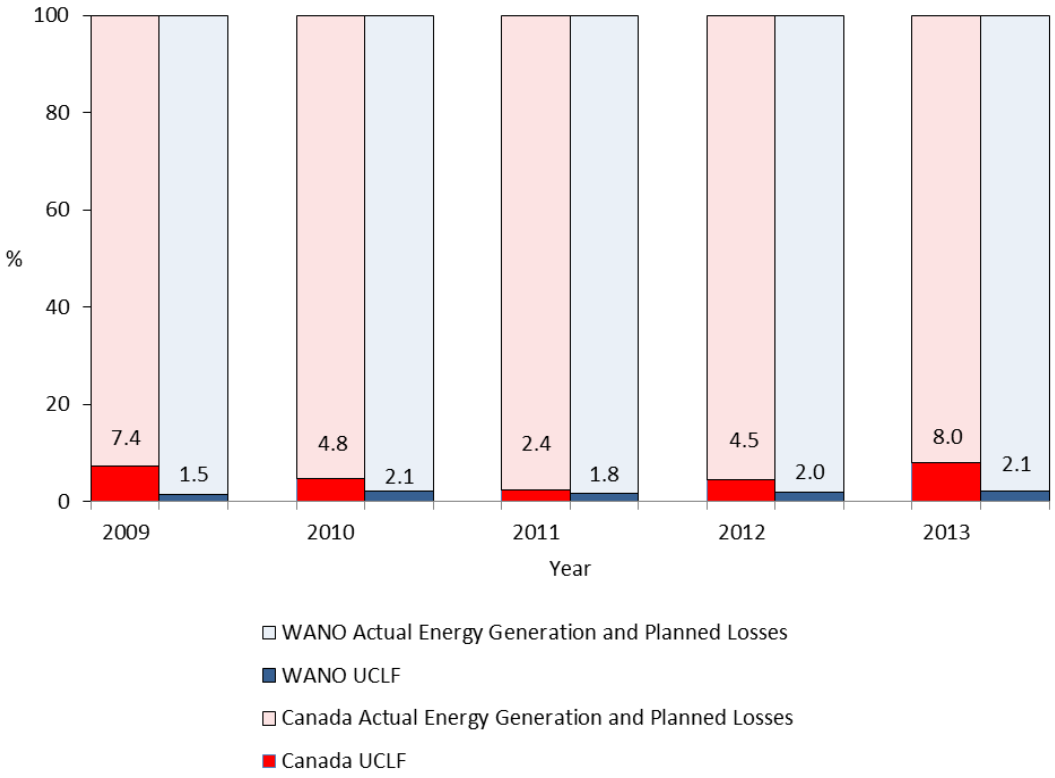
Figure 4: Trend details for unplanned capability loss factor for stations and industry



	Bruce A	Bruce B	Darlington	Pickering 1, 4	Pickering 5-8	Gentilly-2	Point Lepreau	Industry Median
2009	9.9	4.2	2.9	25.5	7.4	10.4	0.0	7.4
2010	9.8	4.0	4.5	17.2	4.8	16.8	0.0	4.8
2011	2.4	2.3	1.3	21.3	9.0	20.6	0.0	2.4
2012	4.5	1.6	3.0	13.7	4.4	26.1	4.5	4.5
2013	14.6	4.7	7.5	30.3	8.6	n/a	23.5	8.0

Figure 5 shows the UCLF 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 higher than the world median values. The difference between the world and the Canadian industry values 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 unplanned capability loss factor compared to WANO values



Reporting and trending

All licensees are required to submit quarterly reports on operations and performance indicators and annual and quarterly compliance monitoring reports, as described in S-99, *Reporting Requirements for Operating Nuclear Power Plants* [4]. NPP licensees complied with the submission of reports as per S-99.

Outage management performance

All licensees met CNSC expectations for outage executions, outage safety and work management. The outages were completed by the licensees with a high level of efficiency and effectiveness.

Safe operating envelope

All licensees are required to establish a safe operating envelope (SOE) program according to the requirements of N290.15-10, *Requirements for the safe operating envelope of nuclear power plants* [5]. CNSC staff conducted inspections for SOE programs and no compliance issues were identified.

Bruce Power, OPG and NB Power completed the development and implementation of their SOEs and have now entered their maintenance phase. Assessment of compliance will be part of on-going CNSC compliance monitoring activities.

Following the decision to end commercial operation at Gentilly-2, Hydro-Québec ceased development of its SOE program. Since nuclear fuels have been removed from the reactor core and Gentilly-2 has ended operation, a SOE program is no longer applicable for Gentilly-2.

2.4 Safety analysis

The safety analysis SCA pertains to the maintenance of 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 implementation of the fundamental safety functions of 'control, cool and contain' through a 'defence-in-depth' strategy. Risk contributors are considered and assessed using probabilistic safety analysis to identify challenges to physical barriers. However, appropriate safety margins should be applied to address uncertainties and limitations of probabilistic safety approaches.

In 2013, the industry average for safety analysis was "satisfactory", unchanged from the previous year. Overall, based on the information assessed, CNSC staff concluded that the safety analysis SCA at NPPs met all applicable regulatory requirements.

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Safety analysis	SA	SA	SA	SA	SA	SA	SA

Safety analysis encompasses the following specific areas:

- deterministic safety analysis
- probabilistic safety analysis
- criticality safety (no significant observations to report)
- severe accident analysis
- environmental risk assessment
- management of safety issues (including R&D programs)

Deterministic safety analysis

CNSC staff reviewed the topics, listed below, to continue to develop an overall assessment of deterministic safety analysis.

Safety analysis improvement program

The CANDU Owners Group (COG) / CNSC initiative on safety analysis improvement and implementation of RD-310, *Safety Analysis for Nuclear Power Plants* [6] has progressed into the implementation phase. The RD-310 implementation allows the identified safety analysis improvements to be addressed in a systematic and graded manner. In implementing RD-310, the industry had adopted a three-phase approach:

- phase 1: preparation and development of a framework for transition to compliance with RD-310
- phase 2: identification of generic gaps against RD-310 and development of principles and guidelines for safety analysis to comply with RD-310
- phase 3: development and execution of station-specific plans to update safety reports for compliance with RD-310

Industry completed the phase 1 and phase 2 work activities to establish a common approach to address analysis and to develop the *Principle and Guidelines for Deterministic Safety Analysis* (COG-11-9026 R2) for RD-310 compliance.

The industry effort is now moving through phase 3, and progress in implementing the plans is on track. Plant-specific safety analysis improvement activities and prerequisites required to revise safety report analyses for RD-310 compliance have been identified and are planned for execution. Please note that the Commission approved the replacement of RD-310 by REGDOC-2.4.1, *Deterministic Safety Analysis* [7] in May 2014.

Impact of aging on the safety analysis

Aging of the reactor heat transport system changes certain characteristics of the system; this has resulted in gradual degradation of the safety margins. As the reactor core aging progresses with time, the integrated impact of simultaneous aging effects in various structures, systems and components (SSCs) on the overall safety case of the NPP needs to be addressed and the existing safety margins need to be quantified.

Licensees have aging management programs in place that includes systematic monitoring of aging-related parameters important to safety analysis, along with assessment of the impact of the change in core conditions on existing safety margins. CNSC staff reviewed the Bruce Power and OPG programs to monitor and assess the impact of heat transport system aging on safety analysis and found them satisfactory.

Assessment of safety analysis program

Safety analysis programs at NPPs control all activities that affect the quality of the results and identify the quality assurance standards to be applied. These programs include documented procedures and instructions for the complete safety analysis process. CNSC staff completed an in-depth review of Bruce Power's deterministic safety analysis program in 2011. The goal was to determine the extent to which analysis tools, procedures and activities are in compliance with applicable standards and guidelines. The review covered all main elements of preparation and conduct of safety analysis, along with the use of analysis results. CNSC staff plan to undertake similar evaluations of deterministic safety analysis programs for all licensees in the future.

Large loss of coolant accident

The work aimed at resolving the large loss of coolant accident (LOCA) safety margin issue was completed and submitted by licensees in late 2013. CNSC staff are reviewing the proposed large LOCA analysis framework, referred to as the composite analytical approach (CAA). In the meantime, the CNSC large LOCA interim regulatory position, which established a set of action levels and acceptance criteria to all NPPs, would remain in effect until completion of site-specific implementation of the CAA. The interim position has been developed by CNSC staff in case a research, analytical or plant operation finding, which would have an adverse impact on large LOCA safety margins, emerges during this period.

Independent technical panel on shutdown system effectiveness criteria

In late 2010, COG members and CNSC staff initiated a joint project to reassess criteria to demonstrate shutdown system effectiveness at ensuring fuel and fuel channel integrity for various design-basis events, many of which are affected by heat transport system aging. The independent technical panel created to accomplish this task issued its final report in November 2011. The panel proposed new acceptance criteria, taking into account the effects of aging on both fuel and fuel channel integrity. CNSC staff are currently reviewing the technical basis for these new criteria as well as the applicability to licensing. CNSC staff expect to have a position on the new criteria by the end of 2014.

Probabilistic safety analysis

As a complementary method of assessing risk contributors, all NPP licensees must conduct probabilistic safety assessments according to S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [8]. Licensees are required to develop, periodically review and update their PSAs. The PSA reports, their methodologies and their updates are reviewed by CNSC staff using well accepted international guidance to ensure compliance with S-294.

As a condition of relicensing the Pickering site in 2013, the Commission included a regulatory hold point in the licence. The hold point made it necessary for OPG to provide a revised PSA for Pickering A (now referred to as Pickering 1, 4) that meets the requirements of S-294, an updated PSA for both Pickering A and Pickering B (now referred to as Pickering 5-8) that takes into account Fukushima Daiichi enhancements and a whole-site PSA or a PSA methodology for the whole site. OPG submitted the required reports in early 2014 and have requested removal of the hold point. The request was heard by the Commission at the May 7, 2014 public hearing. As of the end of May 2014, the Commission was in deliberation on this issue.

Bruce Power committed to submit the remaining confirmatory S-294 elements by July 2014.

All licensees have submitted their required methodologies in compliance with S-294 and CNSC staff are now reviewing or have completed the reviews. CNSC staff reported that all licensees are in compliance with S-294. Please note that the Commission approved the replacement of S-294 by REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [9] in May 2014.

Severe accident analysis

To mitigate consequences of a severe accident, G-306, *Severe Accident Management Programs for Nuclear Reactors* [10], describes the CNSC expectations that the licensees develop and implement measures for:

- preventing the escalation of a reactor accident into an event involving severe damage to the reactor core
- mitigating the consequences of an accident involving severe damage to the reactor core
- achieving a safe, stable state of the reactor and plant over the long term following a severe accident

All NPP licensees have completed their severe accident management guidelines (SAMGs) implementation in accordance with Fukushima action item 3.1.1, “Development and Implementation of SAMG” (see appendix G for details). Other SAMG-related Fukushima action items for all Canadian NPPs are closed. CNSC staff are reviewing the site-specific SAMG implementations.

Environmental risk assessment

Environmental risk assessments performed at all sites have demonstrated adequate provision for the protection of the environment and public as verified by ongoing monitoring. The environmental monitoring programs are under review at each site as part of the ongoing implementation of N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [11], for the identification of changes needed to comply with the standard.

Programs to verify adequate provision for fish protection from thermal discharge and intake water withdrawal effects of condenser cooling water systems are being developed and implemented by the licensees at all sites with direction from the CNSC and advice from fisheries regulatory

agencies such as the Department of Fisheries and Oceans (DFO) and Environment Canada (EC).

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 and to categorize them in order of risk importance to complement the ongoing work, at that time, on generic action items.

By May 2014, from the original 21 CANDU safety issues (CSIs), ten remained to be reassessed in the highest risk category (Category 3). 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 those CSIs were related to large loss of coolant accidents (LLOCA), and seven were non-LLOCA-related.

The LLOCA analytical solution project execution plan was published in March 2010. This high-level plan identifies the major tasks and deadlines. For non-LLOCA issues, the industry has applied to re-categorize more than half of the issues into lower risk categories, based on empirical and analytical evidence and actions taken. The industry and CNSC staff are monitoring and coordinating the implementation of the plan for re-categorization of the remaining issues.

Industry is making progress on the LLOCA and non-LLOCA CSIs, and CNSC staff are monitoring their efforts (see appendix C for more information on CSIs, including their status). There are no safety concerns arising from their continuous reassessment efforts.

2.5 Physical design

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

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

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Physical design	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
- 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 single topic with significant observations, equipment qualification, is reported on below.

Equipment qualification

Each licensee's equipment qualification rating is based on the performance of its environmental qualification (EQ) program. The EQ program ensures that all required SSCs, equipment and barriers are capable of performing designated safety functions in postulated harsh environments resulting from design-basis accidents.

Overall, the industry continued to perform well in this area, and all stations are rated "satisfactory". EQ programs are compliant with N290.13-05, *Environmental qualification of equipment for CANDU nuclear power plants* [12], and have been implemented at all sites. Although all licensees have mature EQ programs, there are still areas for continuous improvement, notably in EQ program sustainability (e.g., implementation of appropriate procedural controls to validate and preserve equipment qualification, and continuous and sufficient condition monitoring of EQ equipment, cables, steam barriers and their surrounding environment and timely documentation updates on the request of CNSC staff). Licensees are working towards addressing these areas and CNSC staff are monitoring the progress. There are no safety concerns arising from this continuous improvement effort.

Structure design

There were no significant reportable design issues or modifications on the structural design during 2013. CNSC staff concluded that the structural design continued to meet the requirements for design basis for all licensees.

System design

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

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

The industry has continued to maintain and improve the reliability of instrumentation and control (I&C) systems through replacement projects and maintenance activities. Overall, all stations met the applicable regulatory requirements in the area of I&C and were rated as "satisfactory".

Service water, including emergency service water systems

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

- the removal of the heat in the reactor core (such as moderator heat exchanger cooling and end-shield cooling)
- cooling functions to ensure proper functioning of SSCs important to safety (such as instrument air compressors and boiler room air cooling units)

During 2013, the service water systems functioned well at each station. Results of site inspections by CNSC staff determined there were no compliance issues.

Electrical power systems

The electrical power systems are important for cooling, controlling, containing and monitoring the reactor and auxiliary systems. The systems are designed, operated and maintained to supply power to safety-related loads to meet the nuclear safety requirements of the plant.

A CNSC site staff member inspects an instrument panel at the pumphouse that draws cooling water.

During 2013, the overall performance of the electrical power systems was satisfactory across all stations. At Bruce A, the qualification of a qualified power system standby diesel generator still remains an on-going issue. Bruce Power is in the process of addressing and resolving this issue. CNSC staff will continue to follow-up with respect to the upcoming licence renewal.

All stations have backup electrical provisions that are designed to be available when Group I electrical power systems[1] may not be available (for example, during seismic events).

Fire protection design

The implementation of the fire protection programs at NPPs was adequate during 2013. With the exception of a fire at Pickering Unit 1 in the lube oil purifier in the turbine hall, reported to the Commission on January 16, 2013 (see table 19 for details), there were no significant reportable events during the year that had a bearing on the licensed NPPs fire protection programs' or their implementation in 2013. Gentilly-2 is revising its fire protection program due to its change in operating status. To date, NB Power has made a significant investment in upgrades for fire protection at Point Lepreau. However, Point Lepreau faced challenges while implementing the transient material and combustible material controls program (see section 3.5.5 for details). CNSC staff are continuing to monitor and have observed improvements in this area.

CNSC staff's evaluation of fire protection at each NPP confirmed that the licensees' provision of measures met the CNSC's safety performance expectations.

Seismic qualification

CNSC staff have found that all licensees have established seismic qualifications, for each site.

All licensees are implementing enhancements in the areas of plant management, facilities and equipment, and core control processes through action items that were raised following the Fukushima Daiichi accident. CNSC staff are satisfied that the licensees' work is progressing towards the overall deadline of December 2015.

Robustness design

Robustness design covers the physical design of nuclear facilities for sufficient robustness against

[1] To address the various electrical requirements within a NPP, electrical power systems are subdivided according to groups (I and II), classes (I, II, III and IV) and divisions (odd and even).

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 provided to CNSC staff through an exchange of correspondence, including the submission of detailed aircraft impact assessments. Licensees have demonstrated, through analysis using conservative initial assumptions and significant safety margins, that vital areas and critical SSCs are protected to the extent that no offsite consequences are expected for general aviation aircraft impact.

Components design

All licensees confirmed that structures, systems and components (SSCs) important to safety and security continued to meet the requirement of the design basis in all operational states.

Cables

OPG implemented a cable surveillance program in 2013, at both Darlington and Pickering, in accordance with CNSC requirements. All units at Darlington have been inspected. Pickering Units 5 to 8 have been inspected, with satisfactory results. Testing on Pickering Unit 1 will be performed during the next planned outage. Based on the results of this test, OPG will decide whether to perform further tests on Pickering Unit 4.

Fuel design

The industry had a higher than normal fuel bundle defect rate, mostly as a result of fretting defects at recently restarted units. Bruce Power continues to work on resolving a vibrational issue, related to acoustically active channels, that has damaged a small number of fuel bundles. The resultant number of fuel defects is low and is not safety significant. Pickering has implemented its corrective action plan to address the issue of iron oxide deposits on fuel. There was no bowing and no effects on cooling the fuel as a result of the deposits. Inspection results are showing an improving trend and that fuel defect rates have not been affected by the deposits. The Pickering deposit issue did not result in a safety significant finding. CNSC staff will continue to monitor the corrective actions.

All operating NPPs met fuel design regulatory requirements during 2013. Licensees continue to establish activities and submit information to resolve outstanding issues. CNSC staff will continue to follow-up, monitor and review submitted information from licensees.

2.6 Fitness for service

The fitness for service SCA covers activities that affect the physical condition of SSCs to ensure that they remain effective over time. This includes programs that ensure all equipment is available to perform their intended design function when called upon to do so. The industry average rating for fitness for service was “satisfactory”, unchanged from the previous year.

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

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Fitness for service	SA	SA	SA	SA	SA	SA	SA

Fitness for service encompasses the following specific areas:

- equipment fitness for service / equipment performance
- maintenance
- structural integrity
- aging management
- chemistry control
- periodic inspection and testing

Equipment fitness for service / equipment performance

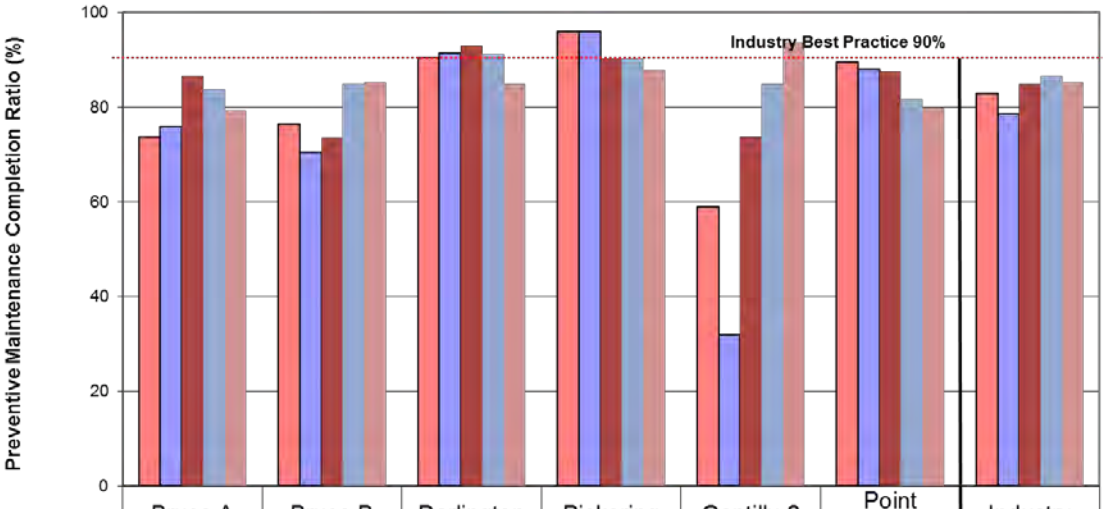
All licensees met regulatory requirements in this specific area and safety and control measures implemented were effective.

Maintenance

Maintenance inspections carried out in 2013 did not identify any major compliance issues. CNSC staff routinely monitors several maintenance performance indicators, including preventive maintenance completion ratio (PMCR) and maintenance backlogs.

The PMCR performance indicator (PI) is the ratio of preventive maintenance work orders completed on safety-related equipment divided by the total maintenance work orders (preventive maintenance plus corrective maintenance work orders) completed on safety-related equipment. The PMCR monitors the effectiveness of the preventive maintenance program in minimizing the need for corrective maintenance activities. As shown in figure 6, the PMCR values for Canadian NPPs decreased slightly to approximately 85% in 2013. Bruce A, Darlington, Pickering and Point Lepreau experienced decreases in their PMCR values.

Figure 6: Trend details for preventive maintenance completion ratio for stations and industry



	Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry
2009	73.7	76.5	90.5	95.9	58.9	89.6	83.0
2010	76.0	70.5	91.4	96.0	31.9	88.1	78.6
2011	86.6	73.7	93.0	90.2	73.7	87.6	85.0
2012	83.7	84.9	91.2	90.2	84.9	81.8	86.7
2013	79.4	85.2	85.0	87.8	93.6	79.9	85.3

Although 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. In particular, the corrective maintenance backlog and the deficient maintenance backlog (also referred to as "elective maintenance backlog") are reviewed. There will always be a certain level of backlog, due to normal work management process and equipment aging. Both corrective and deficient (or elective) maintenance backlog levels at most sites improved during 2013. CNSC staff will continue to focus on these backlogs until all stations meet industry best practice levels.

Regulatory standard S-210, *Maintenance Programs for Nuclear Power Plants* [13] has been incorporated into the licence of all NPPs and implemented by licensees. In December 2012, the new regulatory document, RD/GD-210, *Maintenance Programs for Nuclear Power Plants* [14], was published. RD/GD-210 retains the same requirements as S-210; therefore, no plan is needed by licensees to transition to RD/GD-210. All licensees are in compliance with the requirements given in RD/GD-210.

Structural integrity

All licensees continued to inspect and to demonstrate structural integrity of NPP components and structures, such as those for pressure boundary systems, containment systems or safety significant balance-of-plant systems, in accordance with the station's periodic inspection programs (PIPs) and the applicable standards.

To develop the engineering methodologies and analytical tools to assess the fitness for service of pressure tubes operating beyond their original assumed design life initially projected to be 210,000 effective full power hours, OPG, Bruce Power and the AECL developed a fuel channel life management project (FCLMP) under the administration of the CANDU Owners Group (COG). The licensees have submitted all of the technical documents for this project, and CNSC staff have completed their review of these submissions. Consistent with CNSC guidance, the licensees have sought interim acceptance of their plans to address their power reactor operating licence requirements using two FCLMP deliverables: new pressure tube fracture toughness models, and new methodologies for probabilistic "leak before break" assessments. CNSC staff have accepted the licensees' plans.

The CNSC staff's PIP compliance monitoring activities include the review of governing program documents, inspection reports, and disposition of inspection findings, submitted in accordance with the relevant CSA standards and S-99, *Reporting Requirements for Operating Nuclear Power Plants* [4]. CNSC staff also monitored the licensees' quarterly pressure boundary reports, operations reports and specific event reports, for evidence of degradation of safety significant SSCs.

Inspections and tests were performed by the licensees on the pressure boundary and concrete containment SSCs, in compliance with the scope of N285.4, *Periodic inspection of CANDU nuclear power plant components* [15], N285.5, *Periodic inspection of CANDU nuclear power plant containment components* [16], and N287.7, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants* [17]. CNSC staff reviewed the results of these inspections and tests and identified no component degradation that would affect nuclear safety.

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* [18].

Overall, the special safety systems performed well in terms of meeting their unavailability targets with the exceptions as noted in section 3. Notwithstanding backup systems in place, licensees took appropriate actions to address the temporary impairments, and corrective actions to prevent recurrence are in progress or have been completed.

The "number of missed mandatory safety system tests" indicates the degree of completion of tests required by licence conditions. It is a measure of the licensee's ability to successfully complete routine tests on safety-related systems, and to calculate the predicted availability of systems. Data for the stations and industry as a whole is shown in table 4 and figure 7.

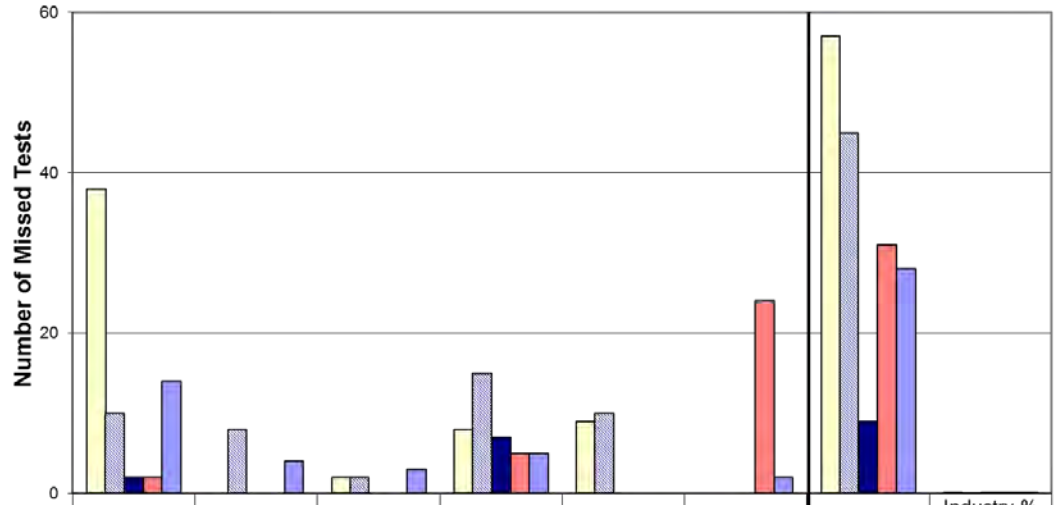
The number of missed mandatory safety system tests decreased from 31 in 2012 to 28 in 2013. The total number of tests performed was 68,270. The overall industry percentage of missed tests remained very low at 0.04%. The number of missed tests represents negligible risk since the tests will be performed in the next outage or shortly after the required time. Also, the safety systems involved in the tests have sufficiently high redundancy to ensure continuous safety system availability. The relatively high number of missed safety system tests at Bruce A is associated with the return-to-service activities, and did not affect the safety of the NPP.

Table 4: Missed mandatory safety system tests for 2013

NPP	Total number of tests	Missed mandatory safety system tests				Missed tests [%]
		Special safety systems	Standby safety systems	Safety-related process systems	Total	
Bruce A	12,942	2	4	8	14	0.11
Bruce B	9,629	2	1	1	4	0.04
Darlington	14,400	0	2	1	3	0.02
Pickering	17,216	2	1	2	5	0.03
Gentilly-2	1,564	0	0	0	0	0.00
Point Lepreau	12,519 *	0	1	1	2	0.02
Industry total	68,270	6	9	13	28	0.04

* Includes 4,415 operating manual tests

Figure 7: Trend details of missed mandatory safety system tests for stations and industry



	Bruce A	Bruce B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry Total	Industry % Missed Tests
2009	38	0	2	8	9	n/a	57	0.06%
2010	10	8	2	15	10	n/a	45	0.05%
2011	2	0	0	7	0	n/a	9	0.01%
2012	2	0	0	5	0	24	31	0.03%
2013	14	4	3	5	0	2	28	0.04%

Aging management

All operating NPPs have implemented processes and programs that ensure the condition of SSCs important to safety is understood and that required activities are in place to ensure the health of these SSCs as the plant ages. These NPPs have matured component-specific aging management programs (also known as lifecycle management programs, or LCMPs) for the major primary heat transport components of their CANDU reactors (feeders, pressure tubes and steam generators). All NPPs have finalized, or are in the process of finalizing aging management programs for their concrete containment structures. CNSC staff will conduct onsite inspections in accordance with the compliance verification program to confirm the licensees' implementation of their aging management programs for containment structures.

Chemistry control

Canadian NPPs maintained good chemistry performance as indicated by S-99 [4] performance indicators. Important nuclear safety-related chemistry parameters such as moderator liquid poison and moderator cover gas deuterium were maintained within specification limits.

Periodic inspections and testing

Inspection and testing of NPP components and structures, such as those for pressure boundary systems, containment systems or safety significant balance-of-plant systems, are mandatory requirements in all operating licences. Applicable CSA standards and CNSC regulatory documents define these requirements, which are continually updated by the responsible organization to reflect important operating experience. As a result, all operating NPPs have inspection and testing programs in place to provide ongoing monitoring of the fitness for service and structural integrity of their safety significant SSCs.

Results of these inspections and tests are submitted to CNSC staff, after every inspection campaign, in accordance with relevant CSA standards and S-99, *Reporting Requirements for Operating Nuclear Power Plants* [4]. CNSC staff perform desktop reviews of the submissions and conducts regular onsite inspections to verify the licensees' implementation of their periodic inspection and testing programs. During the reporting period, CNSC staff did not identify compliance issues affecting safety in this area.

A CSA Standard is currently under development to establish consistent periodic inspection program (PIP) requirements for balance-of-plant pressure boundary systems and components that may impact nuclear safety. The current project schedule has a planned release date for the new standard by the end of 2014. The future adoption of this standard in operating licences will establish consistent, industry-wide program requirements comparable to the current PIPs for nuclear pressure boundary systems.

2.7 Radiation protection

The radiation protection SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. This program must ensure that 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.

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

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Radiation protection	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 and reported to the National Dose Registry. The 2013 NPP Report presents and

analyzes these dose records in terms of annual collective dose[2], average measurable effective dose[3], and the distribution of doses among the monitored individuals.

Figures 8, 9 and 10 present the measurable doses (average and maximum) and dose distributions based on the dose records provided by each NPP to the National Dose Registry.

Application of ALARA

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

In 2013, the collective dose for monitored individuals at all Canadian NPPs was 16.1 person-sieverts (p-Sv). This represents an approximate 32% decrease compared to the industry-wide collective dose reported for 2012 (of 23.7 p-Sv). The number of persons that received a measurable dose in 2013 decreased by approximately 19% compared to 2012 values (from 9,164 in 2012 to 7,426 in 2013).

The annual average effective measurable dose in 2013 for all Canadian NPPs was 2.17 millisieverts (mSv), an approximate reduction of 24% from the 2012 value of 2.86 mSv.

Figure 8 shows the average measurable effective doses to workers at each Canadian NPP for the period 2009 to 2013. This figure shows that for 2013 the average measurable effective dose at each station ranged from 0.25 to 2.95 mSv per year.

The observed industry-wide decreases in worker occupational exposures (e.g., lower industry-wide collective and average dose per worker) can be accounted for, in part by, a reduction in higher exposure work activities (e.g., completion of refurbishment activities). However, it is also noted that the implementation of ALARA initiatives at Canadian NPPs such as shielding enhancements, source term reduction, and improved work planning and control, also contributed to further reductions in the collective dose. The annual collective effective dose for workers at each NPP is presented in appendix D.

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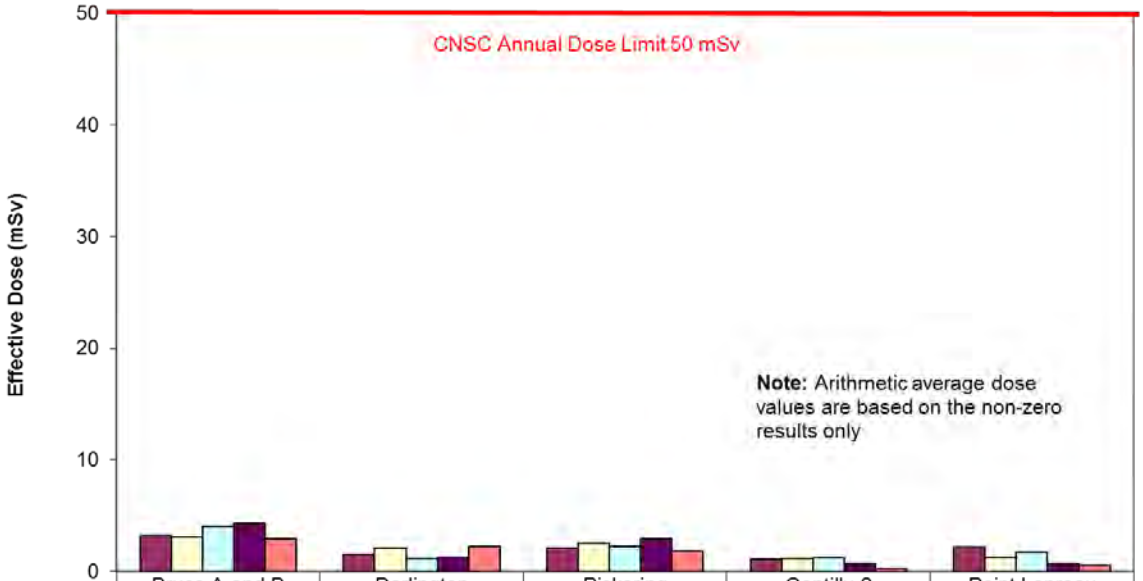
2 The annual collective dose is the sum of the effective doses received by all the workers at that NPP in a year. It is measured in person-sieverts (p-Sv).

3 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 8: Average effective doses to workers at each Canadian nuclear power plants, 2009 to 2013



	Bruce A and B	Darlington	Pickering	Gentilly-2	Point Lepreau
2009	3.20	1.55	2.09	1.09	2.18
2010	3.04	2.14	2.54	1.15	1.22
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

Worker dose control

As required by the *Radiation Protection Regulations*, all Canadian NPP licensees implemented radiation protection programs to control the doses received by nuclear energy workers (NEWs).

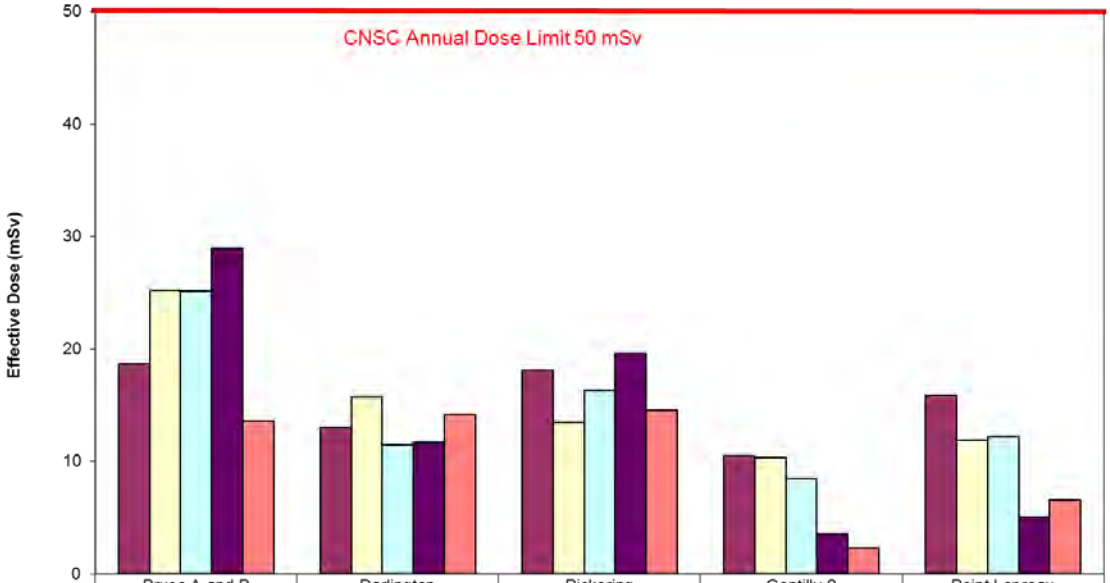
In addition to regulatory dose limits[4], all Canadian NPPs have established action levels[5] for worker exposures that are set below the regulatory dose limits. During 2013, no worker at any NPP received a radiation dose that exceeded the regulatory dose limits.

The maximum annual individual effective doses as reported for each NPP for the period 2009 to 2013 are presented in figure 9. In 2013, the maximum individual effective dose received at a single station was 14.50 mSv, at Pickering.

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

5 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.

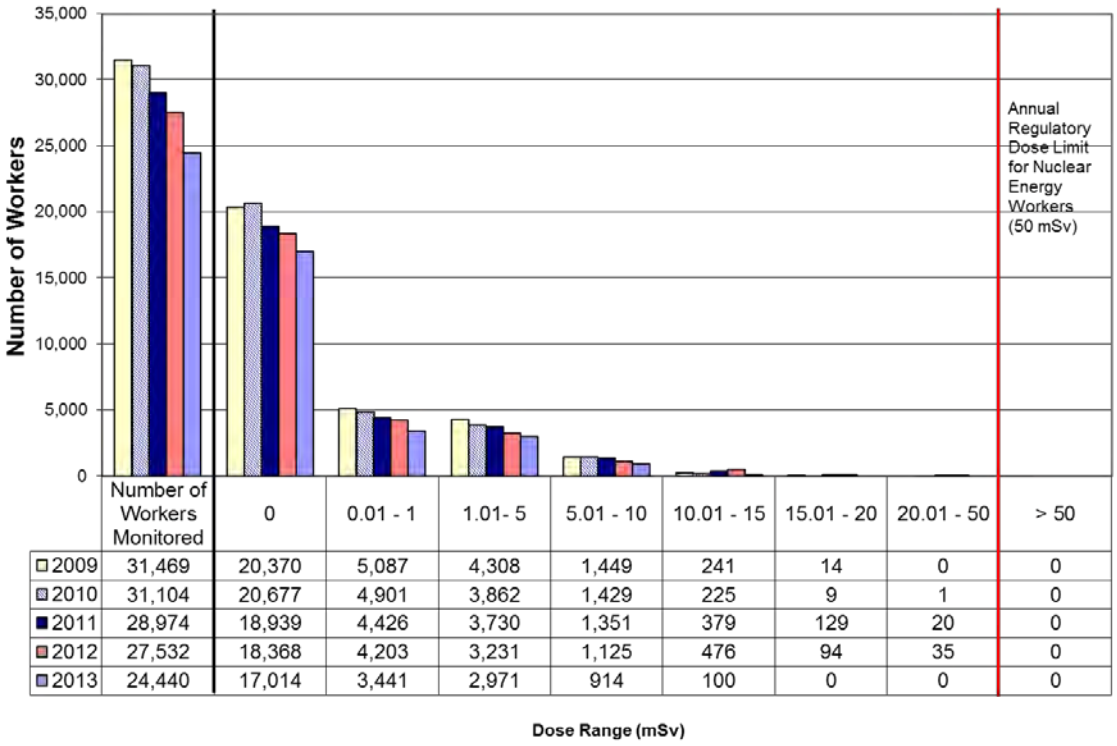
Figure 9: Maximum effective doses to workers at each Canadian nuclear power plants, 2009 to 2013



	Bruce A and B	Darlington	Pickering	Gentilly-2	Point Lepreau
2009	18.68	13.05	18.06	10.50	15.92
2010	25.18	15.74	13.47	10.36	11.88
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

Figure 10 provides the distribution of annual effective doses to workers at all Canadian NPPs from 2009 to 2013 according to dose information provided by each licensee and validated against the information in the National Dose Registry. In addition, figure 10 shows that in 2013, there were no reported individual workers who received doses above 15 mSv per year (a reduction from 129 individuals reported in 2012) and that approximately 84% of worker doses reported were at or below the annual dose limit of 1 mSv for non-NEW workers.

Figure 10: Distribution of annual effective doses to workers at Canadian NPPs, 2009 to 2013



	Number of Workers Monitored	0	0.01 - 1	1.01- 5	5.01 - 10	10.01 - 15	15.01 - 20	20.01 - 50	> 50
2009	31,469	20,370	5,087	4,308	1,449	241	14	0	0
2010	31,104	20,677	4,901	3,862	1,429	225	9	1	0
2011	28,974	18,939	4,426	3,730	1,351	379	129	20	0
2012	27,532	18,368	4,203	3,231	1,125	476	94	35	0
2013	24,440	17,014	3,441	2,971	914	100	0	0	0

Radiation protection program performance

CNSC staff performed regulatory oversight activities in the area of radiation protection at all NPPs during 2013 in order to verify compliance of the NPP radiation protection programs with regulatory requirements. This regulatory oversight consisted of reviews of RP program and performance documents and radiation protection-specific inspections at all NPPs. Regular on-going surveillance by onsite inspectors was also performed.

Through these oversight activities, CNSC staff confirmed that all Canadian NPP licensees have adequately implemented their RP programs to control occupational exposures to workers.

Radiological hazard control

All NPP licensees have implemented radiation protection programs to ensure that there are adequate measures in place 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 that control the direction of air flow, air monitoring instrumentation and radiation monitoring equipment at zone boundaries. All NPP licensees continued to implement their workplace monitoring programs to protect workers and demonstrate that levels of radioactive contamination are controlled within the site boundary.

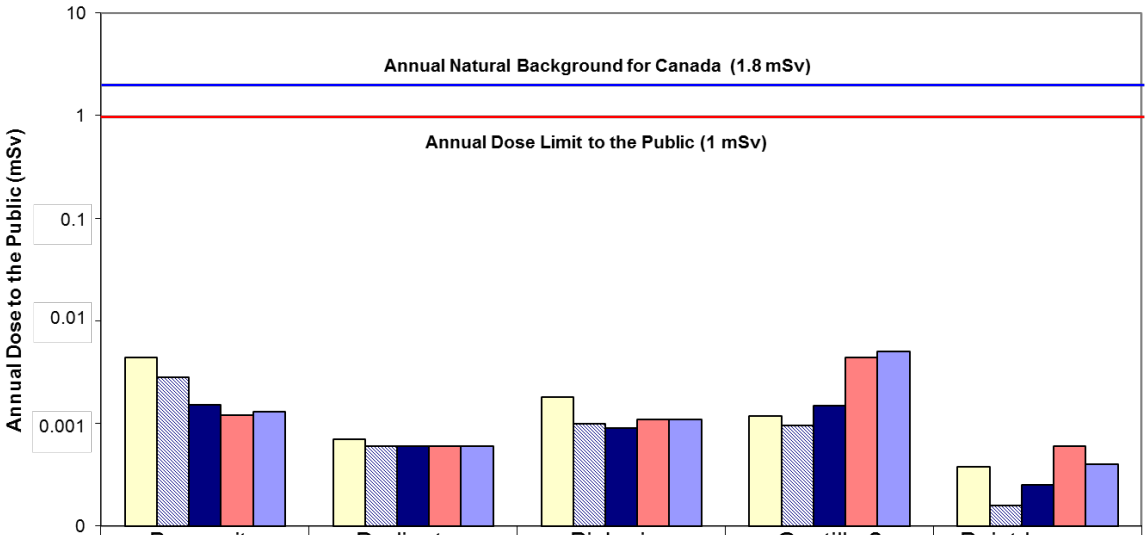
Estimated dose to public

The dose to the public for both airborne emissions and liquid releases from 2009 to 2013 are provided in figure 11 (please note the use of a logarithmic scale). This figure shows that the doses to the public are well below the regulatory public annual dose limit of 1 mSv.

These values can be compared with the 1.8 mSv that an average person in Canada is expected to receive each year from natural background radiation. Also of note is that the worldwide average effective dose from natural radiation is 2.4 mSv per year.

The comparison shows that the 2013 doses to the public for Canadian NPPs are within the general range of the 2009 to 2012 values for most stations.

Figure 11: Comparison of estimated dose to public from Canadian nuclear power plants, 2009 to 2013*



	Bruce site	Darlington	Pickering	Gentilly-2	Point Lepreau
2009	0.0044	0.0007	0.0018	0.0012	0.0004
2010	0.0029	0.0006	0.0010	0.0010	0.0002
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

Annual Dose (mSv)

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

2.8 Conventional health and safety

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

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

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Conventional health and safety	FS	FS	FS	SA	SA	FS	FS

Conventional health and safety encompasses the following specific areas:

- performance
- practices
- awareness

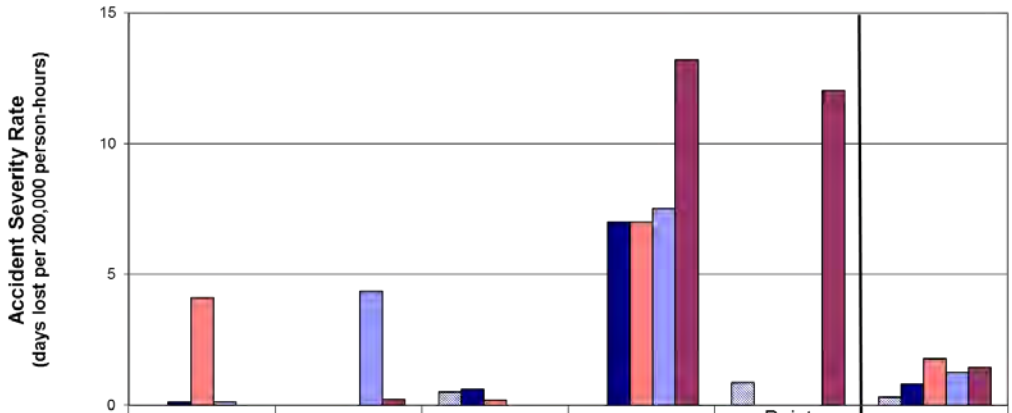
Performance

The accident severity rate (ASR) and accident frequency (AF) are two of the parameters that measure the effectiveness of the 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 a site. 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 a site.

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

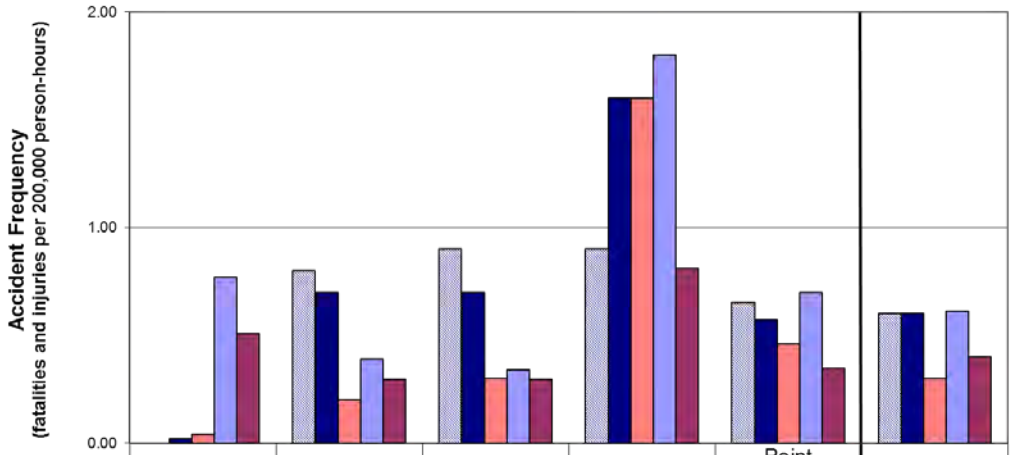
- the ASR values for the industry as a whole increased slightly from 1.2 in 2012 to 1.4 in 2013. Bruce A and B and Pickering achieved the lowest ASR, a value of zero. The ASR for Gentilly-2 and Point Lepreau increased on account of four lost time injuries (two at each plant). These are detailed in the stations write-ups. Please see sections 3.4.8 and 3.5.8, respectively
- the AF value for the industry as a whole decreased slightly from 0.61 in 2012 to 0.40 in 2013. Specifically, the AF decreased for all licensees. Pickering had the lowest AF value in 2013 of approximately 0.29

Figure 12: Trend details of accident severity rate for stations and industry



	Bruce A & B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry
2009	0.0	0.0	0.5	0.0	0.9	0.3
2010	0.1	0.0	0.6	7.0	0.0	0.8
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

Figure 13: Trend details of accident frequency for stations and industry

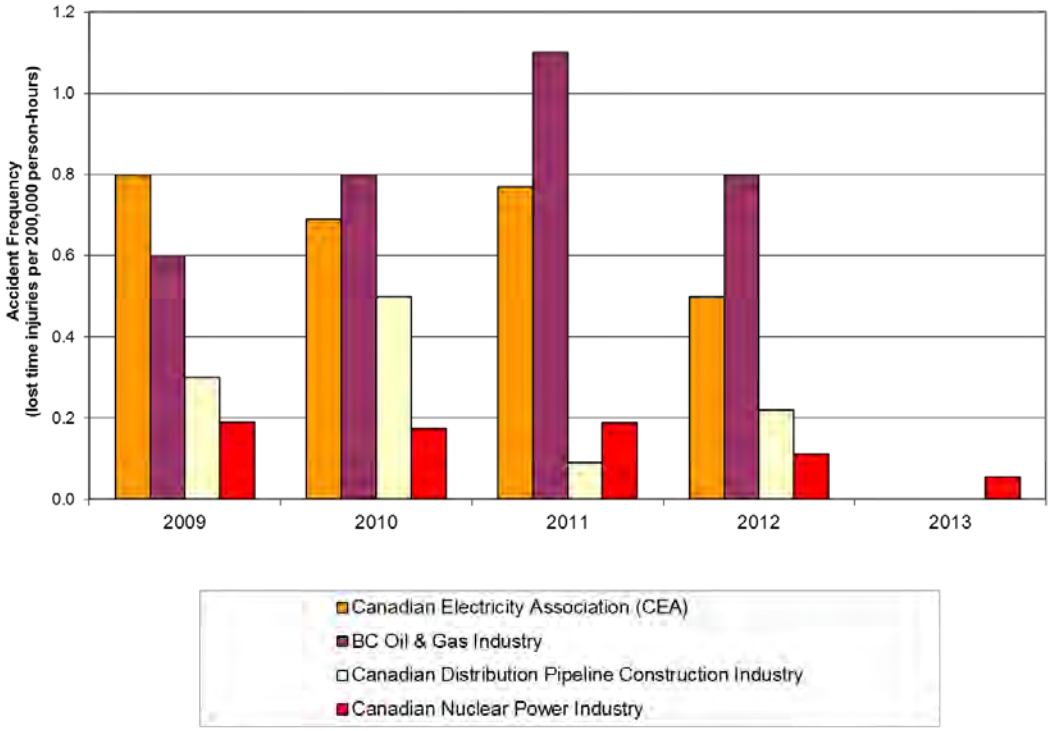


	Bruce A & B	Darlington	Pickering	Gentilly-2	Point Lepreau	Industry
2009	0.00	0.80	0.90	0.90	0.65	0.60
2010	0.02	0.70	0.70	1.60	0.57	0.60
2011	0.04	0.20	0.30	1.60	0.46	0.30
2012	0.77	0.39	0.34	1.80	0.70	0.61
2013	0.51	0.30	0.29	0.81	0.35	0.40

Figure 14 shows the AF values for the Canadian nuclear power industry from 2009 to 2013 in comparison with values from selected energy-related Canadian industries. The Canadian industries shown in the figure are Canadian Electricity Association (CEA) members, the BC upstream oil and gas industry, and the Canadian distribution pipeline construction industry.

As shown in figure 14, the AF value for the Canadian nuclear power industry is much lower than those of the selected Canadian energy-related industries. Note that for this graph, only the AF values calculated using the number of lost time injuries (LTIs) are considered. The AF calculation for figure 14 does not include the number of fatalities and medically treated injuries (MTIs).

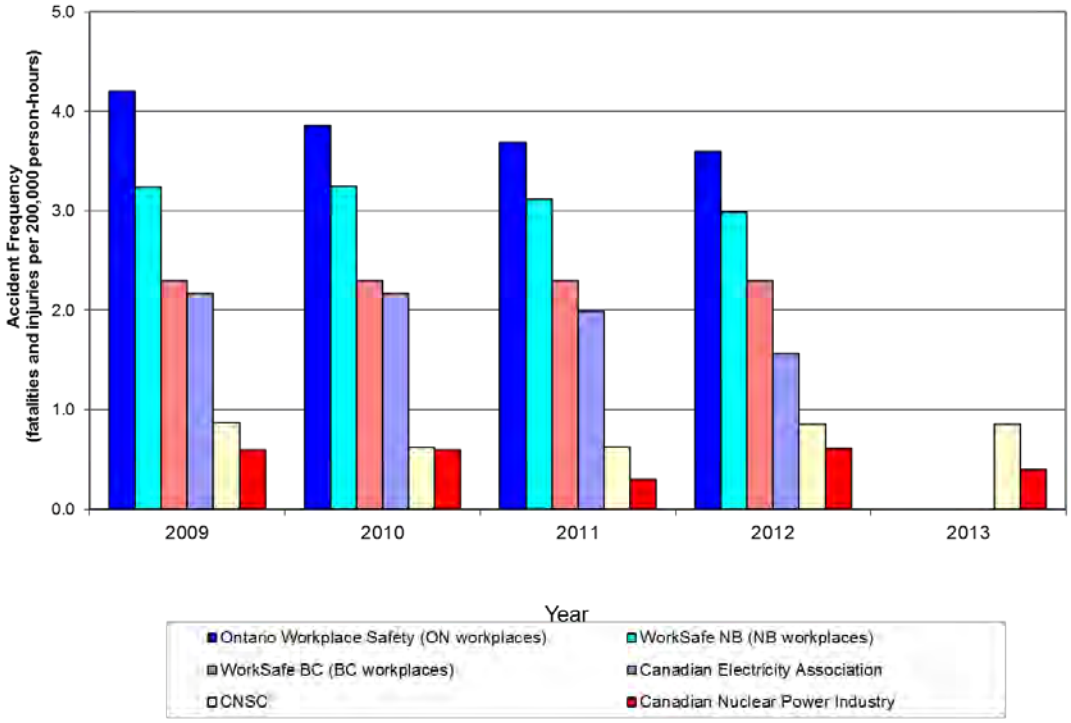
Figure 14: Trend details of accident frequency (based on LTIs only) within the Canadian energy industry



In addition to the information provided in figure 14, figure 15 shows the AF values for Canadian workplaces, where the AF values are based on fatalities, lost time injuries and medically treated injuries. As shown in figure 15, the Canadian nuclear power industry's AF is lower than that of other Canadian workplaces.

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

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



Practices

Each licensee has a conventional health and safety program that was implemented in compliance with applicable portions of the *Canada Labour Code* and/or referenced provincial legislation.

Awareness

NPP licensees met CNSC performance objectives and requirements for housekeeping and management of hazards in accordance with their operating licences and licence conditions handbooks. There were instances of improperly stored transient material including combustible and hazardous material; however, these deficiencies have been addressed to the satisfaction of CNSC staff.

2.9 Environmental protection

The environmental protection 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 the result of licensed activities. The industry average rating for environmental protection was "satisfactory", unchanged from the previous year.

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

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Environmental protection	SA	SA	SA	SA	SA	SA	SA

Environmental protection encompasses the following specific areas:

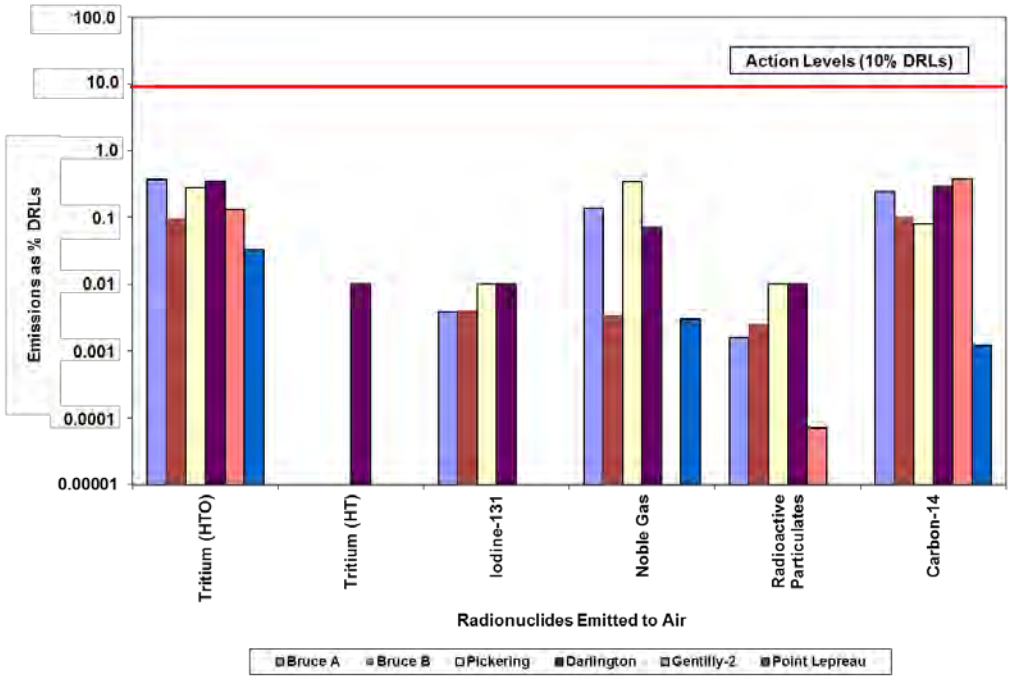
- effluent and emissions control (releases)
- environmental management system (no significant observations to report)
- assessment and monitoring (no significant observations to report)
- protection of the public (no significant observations to report)

Effluent and emissions control (releases)

Airborne emissions and liquid releases for 2013 are shown in figures 16 and 17. Note that a logarithmic scale is used for the purpose of direct comparison of the radionuclides. Licensees establish action levels that are set at 10 percent of the derived release limits (DRLs). The DRLs are stated in each operating licence/licence conditions handbook and are given in appendix E, "Derived Release Limits (DRLs) for Canadian NPPs". DRLs represent release limits to the environment that will not result in the public annual dose limit exceeding the regulatory limit of 1 mSv per year. Action levels, if reached, would indicate a loss of control of part of the licensee's environmental program and the need for specific actions to be taken and reported to the CNSC.

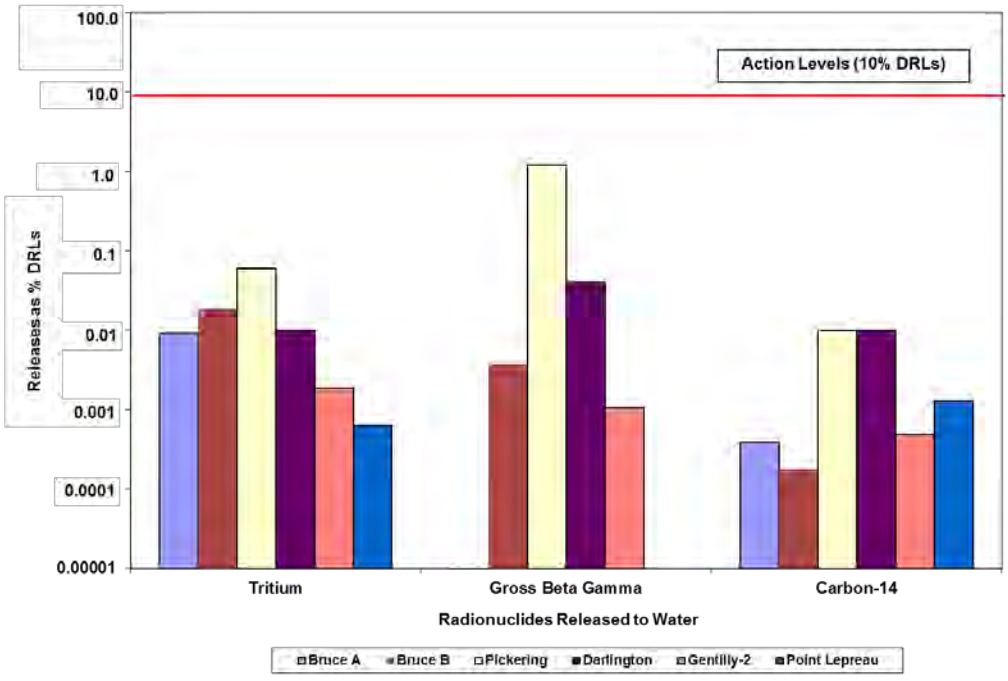
During 2013, all releases were well below action levels and almost negligible in comparison with the regulatory limits.

Figure 16: Radionuclides emitted to air by Canadian nuclear power plants in 2013*



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

Figure 17: Radionuclides emitted to water by Canadian nuclear power plants in 2013*



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

2.10 Emergency management and fire protection

The emergency management and fire protection SCA covers emergency plans and emergency preparedness programs for dealing with radiological, nuclear and conventional emergencies, and also includes the results of exercise participation 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 2.5, Physical design. 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.

Overall, 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.

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Emergency management and fire protection	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 criteria set out in the operating licences and licence conditions handbooks. The programs were maintained 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 at their respective facilities. CNSC staff verified the response programs against the regulatory criteria set out in the operating licences and licence conditions handbooks. Maintenance of proficiency within this area was achieved through training programs, drills and exercise programs.

Emergency power generators are available to provide electrical power in the event the NPP becomes disconnected from the grid.

Fire emergency preparedness and response

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

2.11 Waste management

The waste management SCA covers internal waste-related programs that form part of the facility's operations up to the point where the waste is removed from the facility. This SCA also covers any planning for eventual decommissioning of the facility. The industry average rating for the waste management SCA in 2013 was "satisfactory", unchanged from the previous year.

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

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Waste management	SA	SA	SA	SA	SA	SA	SA

Waste management encompasses the following specific areas:

- waste characterization
- waste minimization
- waste management practices
- decommissioning plans

Waste characterization

There were no significant issues from compliance verification activities to report in this specific area for 2013.

Waste minimization; Waste management practices

All NPP licensees maintain an effective waste management program for radioactive and hazardous wastes that promotes minimization, segregation, storage and handling.

Decommissioning plans

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

With the closure of the Gentilly-2 in late 2012, Hydro-Québec's decommissioning plan as well as the related cost estimate and financial guarantee is no longer current. The revisions of these documents are expected to be submitted by the end of March 2015.

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 after the end of normal operations under the authority of a

decommissioning licence during a period of three or four decades prior to the onset of active dismantling. This period allows for radioactive decay and for the development of appropriate facilities to manage the resulting radioactive wastes.

2.12 Security

The security SCA covers the programs that licensees are required to implement and that support the security requirements stipulated in the regulations, in their licences, in orders, or in expectations for their facility or activity. The industry average rating for security was "fully satisfactory", an improvement from a "satisfactory" rating in 2012.

Overall, based on the information assessed, CNSC staff concluded that the security SCA at NPPs met or exceeded all applicable regulatory requirements.

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Security	FS	FS	FS	FS	SA	SA	FS

Security encompasses the following specific areas:

- facilities and equipment (no significant observations to report)
- response arrangements (no significant observations to report)
- security practices (no significant observations to report)
- drills and exercises (no significant observations to report)

Evaluations are based on findings made throughout the year during inspections, desktop reviews, field rounds and follow-ups on the licensee's progress on enforcement actions, as well as on various means of performance testing. The performance testing program encompasses limited-scope and force-on-force exercises and continues to test and validate each licensee's security program to ensure that it is adequate, effective and in compliance with regulatory requirements.

All licensees continue to maintain and implement effective security programs in accordance with CNSC requirements. Overall, the industry is trending towards improvement within this SCA.

CNSC staff observed that, since 2013, the industry has continued to improve cyber security through self-assessments and by implementing systematic cyber security programs. CNSC staff are satisfied with the industry's overall progress in this area.

2.13 Safeguards and non-proliferation

The safeguards and non-proliferation SCA covers the programs and activities required for the successful implementation of the obligations arising from the Canada/International Atomic Energy Agency (IAEA) safeguards agreements as well as all other measures arising from the *Treaty on the Non-Proliferation of Nuclear Weapons* [19]. The industry average rating for safeguards and non-proliferation was "satisfactory", unchanged from the previous year.

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

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Safeguards and non-proliferation	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
- operational and design information
- safeguards equipment, containment and surveillance

The scope of the non-proliferation program for the NPPs is limited to the tracking and reporting of foreign obligations and origins of nuclear material, as required by RD-336, *Accounting and Reporting of Nuclear Material* [20]. 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 NPP licensees complied with the CNSC's regulatory requirements, in accordance with RD-336 [20].

The CNSC launched its new nuclear material accountancy reporting e-business system in November 2013, allowing licensees to electronically upload their nuclear materials accountancy reports through the CNSC's secure website. The system is now available to all licensees and it is the CNSC's preferred option for receiving accountancy information.

Access and assistance to the IAEA

All NPP licensees granted access and assistance to the IAEA both for inspection activities and for the maintenance of the IAEA's equipment.

Operational and design information

All NPP licensees submitted to the IAEA and CNSC their annual operational programs with quarterly updates as well as the annual update pursuant to the *Additional Protocol* [21], in a timely manner. While minor issues at the beginning of the year were identified in reports to the IAEA and CNSC from NB Power, CNSC staff noted the improvement of reporting at NB Power and strong performance of the other licensees in the timely submission of the required information.

Safeguards equipment, containment and surveillance

There was no major IAEA equipment installation in 2013; however, licensees were cooperative in supporting the maintenance and upgrade of IAEA equipment, including the core discharge monitors at Darlington and Bruce B, and surveillance equipment at Darlington, Pickering and Bruce A and B.

2.14 Packaging and transport

The packaging and transport 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 determined to be "satisfactory", unchanged from the previous year.

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

Safety and control area	Rating						
	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
	A	B					
Packaging and transport	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 (no significant observations to report)

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 transport of substances contaminated with radioactive materials in liquid and solid form, samples containing nuclear substances and tritiated heavy water.

Transportation of used fuel at an OPG facility.

Packaging and transport

NPP licensees are required to have appropriate training for personnel involved in the handling, offering for transport and transport of dangerous goods, and are required to issue a training certificate to those workers in accordance with the *Transportation of Dangerous Goods Regulations* (TDGR) [22].

Many NPP licensees maintain a fleet of vehicles used for the transport of nuclear substances and maintain a list of third party carriers that they may use for shipments of nuclear substances.

NPP licensees must comply with both the *Packaging and Transport of Nuclear Substances Regulations* (PTNSR) and the TDGR [22] requirements 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 PTNSR and TDGR [22].

No transport events were reported under the PTNSR by NPP licensees within the reporting period.

3. Nuclear Power Plant Safety Performance

This section is organized by station, with performance ratings provided for each SCA. The ratings reflect the CNSC staff's evaluation of how well the licensees' programs met regulatory requirements and expectations to protect the overall health, safety and security of persons and the environment, in addition to meeting 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.

3.1 Bruce A and Bruce B

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

The Bruce A station has four CANDU reactors with 904 MWe (megawatts electrical) at Units 1-4, which were fully operational throughout 2013. The Bruce B station has four CANDU reactors with 915 MWe at Units 5-8, and all four units were fully operational throughout 2013. Bruce A and B are part of the Bruce Nuclear Power Development site on the shores of Lake Huron. The site also contains two OPG waste management facilities, and the demonstration Douglas Point AECL power reactor.

This report groups the Bruce A and B 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 the two stations.

The 2013 safety performance ratings for Bruce A and B are shown in table 5. Based on the observations and assessments of the SCAs, CNSC staff concluded that Bruce A and B operated safely. The integrated plant ratings (IPRs) were both "satisfactory" (SA), unchanged from the previous year under the current SCA framework.

Table 5: Performance ratings for Bruce A and B

Safety and control area	Rating		Industry average
	Bruce A	Bruce B	
Management system	SA	SA	SA
Human performance management	SA	SA	SA
Operating performance	SA	SA	SA
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	SA	SA	SA
Security	FS	FS	FS
Safeguards and non-proliferation	SA	SA	SA
Packaging and transport	SA	SA	SA
Integrated plant rating	SA	SA	SA

Note:

- 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; general trends are not identified here (refer to section 2 for industry-wide observations)

3.1.1 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 is required to maintain compliance with N286-05, *Management system requirements for nuclear power plants* [23]. CNSC staff verified that the licensee continued to maintain and improve an effective management system at Bruce A and B.

Change management

Bruce Power's activities to control design changes were managed in accordance with current accepted procedures.

Safety culture

Bruce Power conducted a self-assessment of safety culture in 2013. This assessment was implemented for Bruce A, Bruce B, and Bruce Power Corporate as three distinct self-assessments in parallel. CNSC staff observed the conduct of the safety culture assessment and agreed with its preliminary implementation at Bruce Power. Once the final report is issued, CNSC staff will follow-up with a detailed review in time for the licence renewal process.

Business continuity
CNSC staff confirmed that Bruce Power was adequately prepared to invoke its contingency plans for events including labour action in order to ensure that the minimum staff complement at their facilities was not affected.

3.1.2 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
A human performance inspection conducted in 2013 confirmed that Bruce Power continued to make gains in the area of human performance over the past year.

Personnel training
Both Bruce A and Bruce B stations have a well-documented, defined and robust systematic approach to training (SAT)-based training system. The implementation of this system for the training programs at Bruce A and B in 2013 met regulatory requirements. Identified weaknesses in the implementation of the training system are being addressed by Bruce Power in time for the relicensing process and do not represent an increased risk to nuclear safety.

Initial certification examinations and requalification tests
The initial certification examinations and requalification tests programs for the certified staff at Bruce A and B met all regulatory requirements.

In 2013, CNSC staff conducted an inspection of the authorized nuclear operator (ANO) simulator-based certification examination. CNSC staff concluded that Bruce Power met the requirements of its program as well as CNSC requirements.

Work organization and job design
Bruce Power complies with the regulatory requirements for the minimum shift complement, although attention is required to ensure that no additional minimum shift complement non-compliances occur. CNSC staff conducted an inspection and verified that records of minimum shift complement were retrievable and complete.

Fitness for duty
Bruce A continued to address exceedances of hours of work limits. The majority of these exceedances occurred during the summer vacation period. CNSC staff will continue to follow-up and closely monitor this issue. Bruce Power is currently training and qualifying more ANOs.

In 2013, CNSC staff conducted an inspection on fatigue management in relation to exceedances of hours of work limits, which demonstrated that Bruce Power is taking a number of measures to mitigate the risk of fatigue-related errors.

3.1.3 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 "satisfactory" rating, unchanged from the previous year.

Conduct of licensed activity

Throughout 2013, Bruce Power continued to operate within its *Operating Policies and Principles* (OP&Ps) and the *Operational Safety Requirements* (OSRs).

Bruce A experienced three unplanned reactor trips, one stepback and three setbacks. Bruce B experienced one unplanned reactor trip, three stepbacks and no setbacks. It should be noted that the transients were controlled properly by the licensee and that stepbacks and setbacks address issues at domains far below that of regulatory concern. Consequently, there was no impact on nuclear safety.

The power history graphs for the Bruce A and B nuclear reactor units for 2013 can be seen in appendix F. These graphs show the occurrences (and causes) of outages and the associated power reductions during the year.

CNSC staff conducted inspections, including field and control room inspections. No significant operations-related compliance issues were identified.

Procedures

CNSC staff found that Bruce Power's procedures met CNSC requirements in 2013.

Reporting and trending

Bruce Power is required to submit quarterly reports on operations and performance indicators as described in S-99, *Reporting Requirements for Operating Nuclear Power Plants* [4]. CNSC staff did not identify any significant regulatory issues from these reports.

Outage management performance

Bruce A scheduled one planned maintenance outage and experienced five forced outages. Bruce B scheduled three planned outages and experienced one forced outage. Details are found in Appendix F. All outages were completed safely.

Accident management and recovery

Bruce Power executed a site exercise in October 2013 to validate enhancements to its Emergency Response Program. This exercise demonstrated field operations for a common mode failure event using minimum shift complement resources and concurrent procedure use. All areas of improvement identified by CNSC staff following the exercise have been addressed by Bruce Power. CNSC staff found that Bruce Power's accident management and recovery programs met requirements in 2013 and they will continue to monitor Bruce Power's progress.

3.1.4 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.

CNSC staff have reviewed Bruce Power's program to monitor and assess the impact of heat transport system aging on safety analysis and found it satisfactory. The stations have adequate safety margins and these meet the required acceptance criteria for safe operation of the NPP.

Probabilistic safety analysis

In 2013, Bruce Power submitted probabilistic safety assessment reports required to demonstrate compliance with S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [8]. These submissions are being reviewed by CNSC staff. The remaining confirmatory elements of the S-294 scope will be submitted by July 2014.

The Bruce A and B preliminary results show that the core damage frequency and large release frequency for internal events and for external events meet the safety goal limits.

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 2013. Bruce Power's criticality safety program is satisfactory.

Severe accident analysis

Bruce Power has completed the severe accident management guidelines (SAMGs) implementation in accordance with Fukushima action item (FAI) 3.1.1, "Development and Implementation of SAMGs" (see appendix G for details). Other SAMG-related FAIs are closed. CNSC staff will follow-up on SAMG implementation through site-specific action items.

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 CNSC requirements. Work is ongoing towards documenting an environmental risk assessment consistent with N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [24].

The risk assessment for fish continued to be updated through the results from the Bruce A environmental assessment follow-up program and ongoing industry and/or academic whitefish research programs.

3.1.5 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

Equipment qualification

The environmental qualification (EQ) program is fully implemented at all Bruce A and B

operating units. Bruce Power demonstrated EQ compliance with the related governing document, by maintaining adequate EQ program sustainability.

Human factors in design

Bruce Power is in the process of updating the Human Factors Engineering Program Plan in advance of the relicensing application. CNSC staff will continue to monitor these updates.

System design

Electrical power systems

In September 2013, CNSC staff performed an inspection of the electrical power systems at Bruce B. This inspection confirmed that electrical power systems are being maintained and tested to ensure that they are able to perform their design functions. The qualification of the qualified power supply (QPS) standby diesel generator 2 (SDG2) at Bruce A remains an on-going issue. Bruce Power is in the process of qualifying the QPS SDG2 using the industry-proven process defined in EPRI NP-5652, *Guideline for the Utilization of Commercial Grade Items in Nuclear Safety Related Applications* [25] in time for the licence renewal process. The SDG2 qualification issue has minimal impact on safety.

A CNSC Inspector reviewing electrical equipment with a Bruce Power engineer.

Fire protection design

The fire protection program at Bruce A and B met applicable CNSC requirements. Bruce Power continued its activities to improve fire protection at all facilities through the implementation of procedural and physical upgrades as recommended within the code compliance review of the facilities with respect to N293-07, *Fire protection for CANDU nuclear power plants* [26], and the revised Fire Hazard Assessments and Fire Safe Shutdown Analysis. The proposed modifications are expected to increase the safety margins of the facility with respect to fire protection.

Components design

Fuel design

Bruce Power has a well-developed reactor fuel inspection program. In 2013, Bruce Power began loading 37M fuel, which will offset the effects of aging in the heat transport system.

Bruce Power continues to work on resolving a vibrational issue, related to acoustically active channels, that has damaged a small number of fuel bundles. The resultant number of fuel defects is low and is not safety significant.

3.1.6 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 inspections and compliance verifications, CNSC staff were satisfied with the overall equipment performance at Bruce A and B in 2013.

Maintenance

The maintenance program performance at both Bruce A and B remained satisfactory with improvements observed on maintenance backlog reduction. The preventive maintenance completion ratio (PMCR) was 79% for Bruce A and 85% for Bruce B. Bruce Power reduced its corrective maintenance backlogs at both Bruce A and B, reaching the industry best practices. The deficient (or elective) maintenance backlogs remain above the industry best practice, and are being continuously monitored by CNSC staff.

Structural integrity

CNSC staff compliance monitoring activities in 2013 indicate that the structures, systems and components (SSCs) important for safe operation continued to meet structural integrity requirements.

Structural integrity of pressure tubes was assured through the conduct of periodic in-service inspections and assessment of the resulting findings. Bruce Power continued to participate with its industry partners in the fuel channel life management project (FCLMP), which is intended to strengthen estimates and confirm fitness for service of pressure tubes for continued operation.

Reliability of systems important to safety

The reliability program at Bruce A and B continued to meet regulatory requirements as described in RD/GD-98, *Reliability Programs for Nuclear Power Plants* [18].

For Bruce A, all special safety systems met their unavailability targets in 2013, with the exceptions of the emergency coolant injection system (ECIS) and shutdown system 2 (SDS2) for Units 1 and 2. For Bruce B, all special safety systems met their unavailability targets in 2013, with the exceptions of the ECIS, negative pressure containment and SDS2. Notwithstanding backup systems in place, Bruce Power took appropriate actions to address the temporary impairments, and corrective actions to prevent recurrence have been completed at Bruce A, and are in progress at Bruce B.

Aging management

Bruce Power has performed a gap assessment between RD-334, *Aging Management for Nuclear Power Plants* [27] and the utility's existing procedures. Bruce Power has also implemented processes and programs that ensure the condition of SSCs important to safety is understood and

that required activities are in place to ensure the health of these SSCs as the plants age. Component condition assessments and aging management program reviews for the plants have been completed by Bruce Power and are being reviewed by CNSC staff. Please note that the Commission approved the replacement of RD-334 by REGDOC-2.6.3, *Aging Management* [28] in March 2014.

Chemistry control

Bruce A and B have a mature chemistry control program that meets regulatory requirements. This was reconfirmed through a chemistry compliance inspection conducted in October 2013.

Periodic inspections and testing

Bruce Power has adequate periodic inspection programs (PIPs) in place for all containment structures and components and for all pressure boundary components such as pressure tubes, feeders, steam generators and significant balance-of-plant components. In March 2013, CNSC staff conducted an inspection to monitor the implementation of Bruce B's PIP activities. CNSC staff concluded that Bruce Power's overall implementation of the PIPs met regulatory requirements in 2013.

In September 2013, Bruce Power submitted a request for deferrals of the Bruce A and B Station Containment Outage and Vacuum Building Outage for two years and one year, respectively, due to the implementation of Fukushima action items. Based on the results of ongoing testing and monitoring, and Bruce Power's commitment to continue these activities, CNSC staff accepted the request for deferrals. CNSC staff concluded there is no impact on nuclear safety provided the activities planned during the Containment and Vacuum Building Outages are completed during the 2015 outage.

3.1.7 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

CNSC staff did not identify any regulatory non-compliances or areas requiring improvement in 2013. All areas for improvement identified in 2012 related to the implementation of Bruce Power's ALARA program were addressed in 2013. Bruce Power has established a five-year ALARA plan that includes numerous dose reduction initiatives. In October 2013, during the compliance inspection, CNSC staff noted the successful implementation of ALARA initiatives at Bruce A and B to reduce worker exposures.

Worker dose control

Bruce Power continued to comply with the regulatory requirements to measure and record doses received by workers. No worker or member of the public received a radiation dose in excess of the regulatory dose limits or action levels established in the Bruce Power radiation protection (RP) program. The dose information for Bruce A and B is provided in section 2.7 and appendix D.

In October 2013, CNSC staff conducted a focused inspection of worker dose control at Bruce A and B and confirmed compliances with the requirements.

Radiation protection program performance

Bruce Power's RP program performance satisfies the requirements of the *Radiation Protection Regulations* and includes performance indicators to monitor RP program performance. The RP program documents and supporting procedures are maintained current, taking into consideration operating experience and industry best practices.

In 2013, there were no regulatory findings in this area. The oversight applied in implementing and continuously improving this program has been effective in protecting workers.

Radiological hazard control

There were no action level exceedances with respect to radiological hazards, including surface contamination at either Bruce A or Bruce B.

A CNSC inspector uses a whole-body monitor to detect radiation levels. This precautionary measure is used at NPPs, to ensure that no radioactive contamination is spread outside of the premises by workers or inspectors.

CNSC staff confirmed that Bruce Power complies with the requirements for radiological hazard control and has improved from the previous year.

Estimated dose to public

The reported dose to the public from the Bruce site (which includes Bruce A, Bruce B, Central Maintenance and Laundry Facility, Western Waste Management Facility, and the decommissioned Douglas Point reactor) was 0.0013 mSv, well below the public dose regulatory limit of 1 mSv.

3.1.8 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

Bruce Power achieved about 15.9 million hours without a lost time injury (LTI) by the end of 2013. There were no LTIs at Bruce A or Bruce B in 2013.

As reported by the licensee, for Bruce A and B, combined:

- the accident severity rate (ASR) was zero, a decrease from 0.1 in 2012
- the accident frequency (AF) was 0.51, a decrease from 0.77 in 2012

The ASR value showed that there were no lost days due to work-related injuries; this value remains outstanding in comparison with industry practices.

Practices

Bruce A and B were compliant with the relevant requirements of the *Occupational Health and Safety Act of Ontario* and the *Labour Relations Act*, and Bruce Power's *Occupational Health and Safety Policy*.

Awareness

Bruce A and B met CNSC requirements in this area in 2013. Through field inspections conducted at both Bruce A and B, CNSC staff identified some minor issues that were adequately addressed by the licensee during the year.

3.1.9 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 (releases)

Bruce Power has implemented and maintained an environmental monitoring program that met applicable regulatory requirements. Based on the review of licensee's reports, CNSC staff concluded that the radiological releases from Bruce A and B remained below their regulatory limits and action levels.

Bruce Power updated its derived release limits (DRLs) and action levels in accordance with N288.1-08, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities* [29]. The new DRLs were reviewed and accepted by CNSC staff in May 2013. In January 2014, the Commission approved and issued amended operating licences to Bruce Power with the updated DRLs.

Groundwater monitoring at the Bruce site indicated no adverse impact on the groundwater environment due to operation.

Bruce Power continued to make satisfactory progress in the implementation of the remedial measures with respect to hydrazine releases into the environment. The Ministry of Environment (MOE) reviewed the 2013 emergency water system (EWS) annual report pertaining primarily to the hydrazine content of Bruce B discharges. The reported concentrations of hydrazine were below levels of concern for aquatic life. Based on the 2013 EWS report, MOE has no environmental concerns.

Environmental management system

Bruce Power has established and implemented an environmental management program to assess environmental risks associated with its nuclear activities, and to ensure that these activities are conducted such that adverse environmental effects are prevented or mitigated.

Protection of the public
There were no hazardous substances released from Bruce A and B that posed unacceptable risk to the environment or the public during 2013.

The reported annual radiation dose to the public from the Bruce site was 0.13% of the public dose limit.

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 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 emergency preparedness and response
The CNSC conducted an inspection of the planned emergency exercise at Bruce A and B in 2013. The inspection team concluded that overall, Bruce Power demonstrated its readiness to respond to a nuclear emergency.

Fire emergency preparedness and response
CNSC staff performed a fire drill inspection in 2013 to evaluate the response capabilities of the industrial fire brigade. CNSC staff concluded that Bruce Power has maintained and implemented an effective and well-documented emergency management and fire response program. Bruce Power is currently in the process of constructing a new fire training ground for its industrial fire brigade. This is expected to be completed by the end of 2014.

3.1.11 Waste management

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

Waste minimization
Bruce Power's nuclear waste management program sets requirements for the minimization, segregation and handling, assessment of hazard levels, monitoring and processing of all radioactive waste. During 2013, all radioactive waste was disposed of properly in accordance with regulations and Bruce Power's operating procedures.

Waste management practices
Bruce Power was in compliance with the requirements for management and control of radioactive waste in 2013. A compliance inspection of hazardous waste management was conducted in September 2013. Results of the inspection indicated that Bruce Power's hazardous waste management program met CNSC requirements.

Decommissioning plans
OPG maintains decommissioning plans and an associated consolidated financial guarantee for all of its Ontario facilities including the Bruce A and B nuclear generating stations operated by

Bruce Power. The associated decommissioning plan, consolidated financial guarantee and cost estimate for Bruce A and B were reviewed and accepted by the Commission in 2012 and remained current in 2013. CNSC staff concluded that Bruce A and B met regulatory requirements for decommissioning plans.

3.1.12 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.

Facilities and equipment

Bruce Power demonstrated effective maintenance of facilities and equipment. During the year, Bruce Power installed a new console and improved the layout of the Security Monitoring Room. The nuclear response force has been equipped with a new fleet of response vehicles and armoured vehicles.

Drills and exercises

Bruce Power's security introduced its offsite response force (Ontario Provincial Police) to its tabletop exercises to improve communication, and to enhance coordination and command and control capabilities. Testing of the security operations during these exercises confirmed the effectiveness of the enhancements.

3.1.13 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.

Access and assistance to the IAEA

The IAEA did not select Bruce A and B for a physical inventory verification (PIV) in 2013. Instead, CNSC staff performed a physical inventory taking (PIT) evaluation of Bruce Power's preparedness for a PIV in order to provide assurance to the IAEA that the licensee properly conducted a PIT and was prepared for a PIV. CNSC staff were satisfied from the results of the PIT evaluation that Bruce Power was sufficiently prepared for an IAEA PIV had it been selected.

Safeguards equipment, containment and surveillance

Bruce Power supported IAEA equipment operation and maintenance activities including those related to the core discharge monitor, surveillance system and bundle counters to ensure the effective implementation of both safeguards measures and nuclear non-proliferation commitments at Bruce A and B.

3.1.14 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.

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* [4]. In addition, CNSC staff performed an inspection of transportation of dangerous goods (Class 7) radioactive material to verify Bruce Power's compliance with regulatory requirements found in the *Packaging and Transportation of Nuclear Substances Regulations* (PTNSR) and the *Transportation of Dangerous Goods Regulations* [22].

3.2 Darlington

Darlington is located on the north shore of Lake Ontario, in the Darlington township, the Clarington municipality, and the Durham regional municipality. The facility is 5 kilometres outside the town of Bowmanville, and about 10 kilometres southeast of Oshawa. The facility is owned by Ontario Power Generation Incorporated (OPG), a Canadian corporation with its head office located in Toronto.

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 935 MWe (megawatts electrical), and a tritium removal facility.

The 2013 safety performance ratings for Darlington are shown in table 6. Based on the observations and assessments of the SCAs, CNSC staff concluded that Darlington operated safely. The integrated plant rating (IPR) was "fully satisfactory" (FS), unchanged from the previous year under the current SCA framework.

Table 6: Performance ratings for Darlington

Safety and control area	Rating	Industry average
Management system	SA	SA
Human performance management	SA	SA
Operating performance	FS	SA
Safety analysis	SA	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	SA	SA
Security	FS	FS
Safeguards and non-proliferation	SA	SA
Packaging and transport	SA	SA
Integrated plant rating	FS	SA

Note:

- 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; general trends are not identified here (refer to section 2 for industry-wide observations)

3.2.1 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

Darlington is required to maintain compliance with N286-05, *Management system requirements for nuclear power plants* [23]. OPG Corporate has begun the implementation of a centre-led matrix organization through their "Business Transformation Initiatives" (BTI). The BTI have resulted in changes to the organization and the management system. Based on review of the OPG top tier governing documents, CNSC identified that the nuclear management system documentation requires re-alignment to reflect the change.

This area has been assessed as satisfactory as CNSC oversight activities have not identified any significant safety or systematic implementation deficiencies as a result of the BTI changes.

Organization

As indicated above, OPG Corporate has begun the implementation of a center-led matrix organization through its BTI. The BTI have resulted in changes to the OPG Nuclear organizational configuration. CNSC staff are closely monitoring these organizational changes and their alignment with the management system documentation.

CNSC staff raised an action item, requesting OPG to provide more clarity in its top tier governing documents. Resolution of this action item will improve CNSC staff's oversight and monitoring of the re-alignment of the organization.

Change management

Records were provided by OPG Nuclear staff indicating that the organization was changed as per the licensee's documentation. The change process was reviewed and CNSC staff raised an action item for OPG to clarify some information in its governing documentation for management system and organization. CNSC staff will continue to monitor the change process.

Safety culture

OPG conducted a self-assessment of safety culture in 2012. From the results submitted in 2013, OPG concluded that Darlington has a healthy safety culture, combined with a strong respect for nuclear safety that is not compromised by production priorities. OPG also concluded that the nuclear safety message is communicated frequently and consistently at Darlington and activities that affect the core are conducted with particular care and caution. Areas for improvement were identified in the report and corrective actions planned and/or implemented. CNSC staff reviewed this report and identified no additional concerns.

Configuration management

The component condition assessment inspection conducted in 2013 in support of the Darlington integrated safety review (ISR) identified deficiencies within its configuration management process. The deficiencies were determined not to be safety significant or systematic. Corrective action is on-going and is being monitored by CNSC staff.

Records management

Darlington's performance in this area was satisfactory. Implementation of records management was effective and continues to be monitored by CNSC staff on an on-going basis.

Management of contractors
CNSC staff conducted a component condition assessment inspection in 2013 and identified deficiencies with respect to how contractors are managed at OPG. The interface between OPG technical staff and supply chain staff was identified as an area requiring improvement. OPG is working to address this issue and CNSC staff will continue to monitor and assess progress in this area.

Business continuity
CNSC staff confirmed that Darlington was adequately prepared to invoke its contingency plans for events, including labour action, in order to ensure that the minimum staff complement at its facility was not affected.

3.2.2 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.

Personnel training
OPG continued to have a well-documented, defined and robust systematic approach to training (SAT)-based training system. Implementation of this system for the training programs at Darlington met the regulatory requirements. Through compliance activities, CNSC staff identified some weaknesses with respect to certain job families. These weaknesses are being corrected and do not represent an increased risk to nuclear safety.

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 2013, CNSC staff conducted an inspection of the Unit 0 control room operator simulator-based certification examination. CNSC staff concluded that OPG met the requirements of its program as well as CNSC requirements.

Work organization and job design
Darlington met the regulatory requirements for the minimum shift complement. CNSC staff conducted an inspection and verified that records of minimum shift complement were retrievable and complete.

Darlington has implemented the minimum complement coordination program to ensure compliance. This program monitors the minimum shift complement at all times and identifies any violations immediately, should they occur.

Fitness for duty
CNSC staff conducted an inspection on the hours of work in 2013, which concluded that Darlington is in compliance with its documentation on this subject, as referenced in the Darlington licence conditions handbook.

3.2.3 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 activity

Throughout 2013, Darlington continued to operate with a high level of performance. OPG consistently operated within the limits of the Darlington licence, the *Operating Policies and Principles* (OP&Ps) and the *Operational Safety Requirements* (OSRs).

Darlington experienced no unplanned reactor trips, one stepback and one setback. It should be noted that the transients were controlled properly by the licensee and that stepbacks and setbacks address issues at domains far below that of regulatory concern. Consequently, there was no impact on nuclear safety.

The power history graphs for the Darlington nuclear reactor units for 2013 can be seen in appendix F. These graphs show the occurrences (and causes) of outages and the associated power reductions during the year.

CNSC staff conducted inspections, including field and control room inspections. No significant operations-related compliance issues were identified. Darlington has continued to demonstrate a high degree of compliance in this area.

Procedures

CNSC staff found that OPG procedures met CNSC requirements in 2013.

Reporting and trending

OPG is required to submit quarterly reports on operations and performance indicators as described in S-99, *Reporting Requirements for Operating Nuclear Power Plants* [4]. CNSC staff did not identify any significant regulatory issues from these reports.

An event involving the shutdown of a heat transport feed pump occurred at Darlington in September 2012 and led to continued discussions well into 2013. Notwithstanding the differences of opinion on some aspects of the event, the licensee responded to the recommendations of CNSC staff to prevent recurrence.


Outage maintenance work at Darlington.

Outage management performance

Darlington scheduled two planned maintenance outages and experienced five forced outages. Details are found in Appendix F. The outages were managed and completed with a high level of efficiency and effectiveness.

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 it 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 safely stored in stainless steel containers within a concrete vault. The operation of the tritium removal facility did not exceed any environmental limits.

3.2.4 Safety analysis

Based on the information assessed, CNSC staff concluded that the safety analysis 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.

Deterministic safety analysis

Darlington has an effective, well-managed program for performing deterministic safety analysis. CNSC staff have reviewed OPG's program to monitor and assess the impact of heat transport system aging on safety analysis and found it satisfactory. The station has adequate safety margins and these meet the required acceptance criteria for safe operation of the NPP.

Probabilistic safety analysis

In 2013, OPG submitted probabilistic safety assessment reports required to demonstrate compliance with S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [8]. In addition, OPG has submitted the required methodology guides in compliance with S-294 [8]. CNSC staff accepted these guides and continue to review the required PSA reports.

As a follow-up from the 2013 Pickering Licence Renewal Hearing, OPG is developing a methodology for Darlington's whole-site PSA, an approach for the aggregation of risks from different hazards as well as from the units and an approach for crediting emergency mitigating equipment (EME), such as portable pumps, portable generators, hoses/connections, personnel communication equipment, etc., in the PSA models. This is ongoing and is being undertaken in collaboration with the nuclear industry in Canada as a whole.

The Darlington results show that the core damage frequency and large release frequency for internal events and for external events meet the safety goal limits.

Severe accident analysis

Darlington has completed the severe accident management guidelines (SAMGs) implementation in accordance with Fukushima action item (FAI) 3.1.1, "Development and Implementation of SAMG" (see appendix G for details). Other SAMG-related FAIs are closed. CNSC staff review of the site-specific SAMG implementation is planned.

Environmental risk assessment

OPG continued to maintain and implement an effective environmental risk assessment and management program at Darlington in accordance with CNSC requirements. Work is ongoing towards documenting an environmental risk assessment consistent with N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [24]. Risk assessment continued to be informed by baseline monitoring results and reports from the Darlington Refurbishment/Life Extension environmental assessment (EA).

3.2.5 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

Equipment qualification

The environmental qualification (EQ) program is fully implemented in all Darlington operating units. Darlington demonstrated EQ compliance in accordance with its governing document by maintaining EQ program sustainability.

System design

Fire protection design

The fire protection program at Darlington met applicable CNSC requirements. CNSC staff have reviewed Darlington's Fire Hazard Assessment (FHA) and found that the current FHA requires improvement related to documentation. OPG has provided an acceptable path forward to address these concerns, and CNSC staff will continue to monitor progress in this area.

Safety systems

On May 4, 2013, Darlington experienced an electrical disturbance that occurred with the Unit 4 Main Output Transformer and resulted in a turbine generator trip. This event was promptly reported to CNSC staff and also to the Commission. A preliminary review was conducted by CNSC staff in May 2013 and a report on follow-up actions submitted by OPG, which is currently being reviewed.

Components design

Fuel design

OPG has a well-developed reactor fuel inspection program. Fuel performance at Darlington was acceptable in 2013, although there has been an increase in the number of fuel defects found in operating units. OPG is investigating the root cause and CNSC staff will continue to monitor progress in this area. OPG has begun loading 37M fuel in all operating units, which will offset the effects of aging in the heat transport system.

3.2.6 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, a decrease from the previous year.

In 2012, there was a reorganization conducted by CNSC of the specific areas and review topics within the SCA framework. The reorganization within this SCA may have been a contributing factor to the decrease in the Darlington rating from "fully satisfactory" in 2012 to "satisfactory" in 2013; however, it should not be assumed to account entirely for the change.

Equipment fitness for service / equipment performance

On the basis of inspections and compliance verifications, CNSC staff were satisfied with the overall equipment performance at Darlington.

Maintenance

The maintenance program performance at Darlington was satisfactory. The preventive maintenance completion ratio (PMCR) was 85%. The corrective maintenance backlog and deficient/elective maintenance backlog at Darlington were both in the top quartile of the industry.

Structural integrity

CNSC staff compliance monitoring activities in 2013 indicate that the structures, systems and components (SSCs) important for safe operation continued to meet structural integrity requirements.

Structural integrity of pressure tubes was assured through the conduct of periodic in-service inspections and assessment of the resulting findings. OPG continued to participate with their industry partners in the fuel channel life management project (FCLMP), which is intended to strengthen estimates and confirm fitness for service of pressure tubes for continued operation.

OPG has also developed a long-term plan to ensure spacer integrity and mobility, including experiments on spacers removed from in-service pressure tubes. CNSC staff have reviewed and accepted this plan.

Reliability of systems important to safety

The reliability program at Darlington continued to meet regulatory requirements as described in RD/GD-98, *Reliability Programs for Nuclear Power Plants* [18].

All special safety systems at Darlington met their unavailability targets in 2013, with the exceptions of the shutdown system 2 (SDS2), the emergency cooling injection, and the negative pressure containment systems. Notwithstanding backup systems in place, OPG took appropriate actions to address the temporary impairments, and corrective actions to prevent recurrence are in progress.

Aging management

OPG has implemented an integrated aging management program to ensure that the condition of SSCs important to safety is well understood and that the required activities are in place to assure the health of these SSCs while the plant ages. OPG reviewed this program to ensure its alignment with RD-334, *Aging Management for Nuclear Power Plants* [27]. Darlington has also submitted component condition assessments and aging management program reviews, as part of the ISR for the refurbishment project. CNSC staff conducted an inspection on the component condition assessment process, which identified areas for improvement. OPG has submitted a corrective action plan to address these issues and CNSC staff are currently reviewing this plan.

Darlington continued to update its lifecycle management programs (LCMPs) for the long term management of major pressure boundary components. The LCMPs meet the requirements of RD-334 [27].

Periodic inspections and testing

Darlington has periodic inspection programs (PIPs) in place for all containment structures and components and for all pressure boundary components such as pressure tubes, feeders, steam

generators and significant balance-of-plant components. CNSC staff concluded that the implementation of the PIPs satisfied regulatory requirements.

In 2013, the licensee submitted a request for the extension of the leakage rate test interval for the main containment structure at Darlington. CNSC staff are reviewing the request.

3.2.7 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

Darlington has a mature ALARA program that integrates ALARA into planning, scheduling and work control. CNSC staff verified that Darlington's five-year ALARA plan includes dose reduction initiatives established in consideration of operational experience and industry best practices. CNSC staff also have verified through inspection activities that OPG has implemented numerous ALARA initiatives at Darlington to reduce worker exposures, including setting challenging dose targets in work planning.

Worker dose control

Darlington continued to comply with the regulatory requirements to measure and record doses received by workers. No worker or member of the public received a radiation dose in excess of the regulatory dose limits. The dose information for Darlington is provided in section 2.7 and appendix D.

In 2013, CNSC staff conducted inspections of worker dose control at Darlington and confirmed compliance with the requirements.

Radiation protection program performance

Darlington applies OPG's corporate RP program, which satisfies the requirements of the *Radiation Protection Regulations* and includes performance indicators to monitor program performance. The RP program documents and supporting procedures are maintained current, taking into consideration operating experience and industry best practices.

CNSC staff confirmed that challenging goals and targets have been established and met. In 2013, there were no negative findings in this area. Positive findings were noted with respect to setting of dose targets and monitoring individual exposures. The RP program documents and the oversight applied in implementing and continuously improving this program have been effective in protecting workers.

Radiological hazard control

There were no action level exceedances with respect to radiological hazards, including surface contamination, at Darlington.

CNSC staff confirmed that OPG complies with the requirements for radiological hazard control with a number of positive findings noted with respect to effective contamination control and the adequate use of warning signs and barriers.

Estimated dose to public
The reported dose to the public from Darlington was 0.0006 mSv, well below the public dose regulatory limit of 1 mSv.

3.2.8 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, unchanged from the previous year.

Performance
Darlington has demonstrated significant improvements in the number of lost days and lost time injuries. As reported by the licensee, the accident severity rate for Darlington decreased from 4.4 to 0.2, and the accident frequency decreased from 0.39 to 0.30. The two 2013 accident performance indicator values for Darlington are lower than the Canadian nuclear power industry average, and the accident frequency is among the lowest for Canadian NPPs.

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

Awareness
Darlington continued to maintain a safe and efficient working environment. Improvements have been made with respect to the storage of ladders and tagging of scaffolding, and reports of non-compliances in this area have declined noticeably from 2012 to 2013.

3.2.9 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 (releases)
OPG has implemented and maintained an environmental monitoring program that met applicable regulatory requirements. Based on the review of the licensee's reports, CNSC staff concluded that the radiological releases from Darlington remained below their regulatory limits and action levels.

Groundwater monitoring at the Darlington site indicated no adverse impact on the groundwater environment due to operation.

Environmental management system
OPG has established and implemented an environmental management program to assess environmental risks associated with its nuclear activities, and to ensure that these activities are conducted such that adverse environmental effects are prevented or mitigated.

Protection of the public

There were no hazardous substances released from Darlington that posed unacceptable risk to the environment and the public during 2013.

The reported annual radiation dose to the public from Darlington was 0.06% of the public dose limit.

3.2.10 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.

CNSC staff examine emergency portable pumps at Darlington. Portable pumps strengthen the emergency preparedness of an NPP.

Nuclear emergency preparedness and response

The CNSC conducted an inspection of the planned emergency exercise at Darlington in 2013. The inspection team concluded that, overall, OPG demonstrated its readiness to respond to a nuclear emergency. A major joint nuclear emergency response exercise, "Unified Response" is planned for Darlington in 2014.

Fire emergency preparedness and response

Darlington continues to implement a comprehensive fire response capability that includes effective procedures, training and maintenance of proficiency. CNSC staff concluded that OPG has maintained and implemented an effective and well-documented emergency management and fire response program at Darlington.

3.2.11 Waste management

Based on the information assessed, CNSC staff concluded that the waste 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.

Waste characterization; Waste minimization; Waste management practices

OPG maintains an effective waste management program at Darlington for radioactive and hazardous wastes that promotes minimization, segregation, storage and handling. Field inspection observations revealed no deficiencies in 2013.

Decommissioning plans

OPG maintains decommissioning plans and an associated consolidated financial guarantee for all of its Ontario facilities. The associated decommissioning plan, consolidated financial guarantee and cost estimate for Darlington were reviewed and accepted by the Commission in 2012 and remained current in 2013. CNSC staff concluded that Darlington met regulatory requirements for decommissioning plans.

3.2.12 Security

Based on the information assessed, CNSC staff concluded that the security 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 from "satisfactory" in the previous year.

Facilities and equipment
Darlington demonstrated effective maintenance of facilities and equipment. OPG undertook a variety of activities in 2013 with respect to equipment modernization, including armoured vehicle replacement, radio communication upgrades and new technology for search screening activities.

Response arrangements
Improvements in this area were noted, particularly with respect to the integration of the Darlington emergency response team and Durham Regional Police Service into drills and exercises. This expansion and inclusive involvement is resulting in enhanced interoperability as well as command and control cohesion in challenging exercises. These items were validated during a successful performance testing exercise at the site, where other opportunities for improvement were observed and that, subsequently, resulted in further program enhancement.

Security practices
Darlington continued to make significant improvements in 2013 in the areas of procedural updates and compliance, as well as in strengthening the site access security clearance process and access control measures.

3.2.13 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.

Access and assistance to the IAEA
The IAEA conducted a physical inventory verification (PIV) in 2013 to verify the non-diversion of safeguarded nuclear materials.

Safeguards equipment, containment and surveillance
Darlington supported the IAEA equipment operation and maintenance activities including those related to the core discharge monitor re-wiring at Unit 2. CNSC staff will continue to work with both the IAEA and OPG to ensure that lessons learned from Unit 2 core discharge monitor re-wiring are incorporated into upgrades scheduled at the other units.

3.2.14 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.

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* [4].

3.3 Pickering

Pickering is located on the north shore of Lake Ontario, in the city of Pickering and the regional municipality of Durham, in Ontario. The facility lies 32 kilometres northeast of Toronto and 21 kilometres southwest of Oshawa. The facility is owned by Ontario Power Generation Incorporated (OPG), a Canadian corporation with its head office located in Toronto.

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 has a gross electrical output of 542 MWe (megawatts electrical) for Pickering 1, 4 (this refers to Pickering Units 1 and 4) and 540 MWe for Pickering 5-8 (this refers to Pickering Units 5 to 8).

Construction of the facility started in 1966 and the first criticality of a reactor unit was in 1971. The in-service dates for Units 1 to 4 ranged from 1971 to 1973; for Units 5 to 8, from 1983 to 1986.

The 2013 safety performance ratings for Pickering are shown in table 7. Based on the observations and assessments of the SCAs, CNSC staff concluded that Pickering operated safely. The integrated plant rating was “satisfactory”, unchanged from the previous year under the current SCA framework.

Table 7: Performance ratings for Pickering

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

Note:

- 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; general trends are not identified here (refer to section 2 for industry-wide observations)

3.3.1 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

Pickering is required to maintain compliance with N286-05, *Management system requirements for nuclear power plants* [23]. OPG Corporate has begun the implementation of a centre-led matrix organization through its "Business Transformation Initiatives" (BTI). The BTI have resulted in changes to the organization and the management system. Based on review of the OPG top tier governing documents, the CNSC identified that the nuclear management system documentation requires re-alignment to reflect the change.

This area has been assessed as satisfactory as CNSC oversight activities have not identified any significant safety or systematic implementation deficiencies as a result of the BTI changes.

Organization

In 2012, Pickering completed the amalgamation of the Pickering A and B operating organizations. This resulted in a clear improvement in the implementation of common programs in 2013, as operating activities benefited from the transfer of best practices between the two plants.

As indicated above, OPG Corporate has begun the implementation of a center-led matrix organization through its BTI. The BTI have resulted in changes to the OPG Nuclear organizational configuration. CNSC staff are closely monitoring these organizational changes and their alignment with the management system documentation.

CNSC staff raised an action item, requesting OPG to provide more clarity in its top tier governing documents. Resolution of this action item will improve CNSC staff's oversight and monitoring of the organization.

Change management

Records were provided by OPG Nuclear staff indicating that the organization had been changed as per the licensee's documentation. The change process was reviewed and CNSC staff raised an action item for OPG to clarify some information in its governing documentation for management system and organization. CNSC staff will continue to monitor the change process.

Safety culture

OPG conducted a safety culture self-assessment in 2012. The results were submitted to the CNSC in February 2013 and CNSC staff have reviewed it and found the self-assessment satisfactory. Pickering also continued to improve its management oversight and field presence through

updating its policies and programs related to safety culture. The assessment indicated that the communication of safety culture at OPG Pickering has improved**.**

Configuration management
Configuration management was not directly assessed during this period. It was indirectly assessed through other compliance related activities. No safety significant deficiencies were identified.

Records management
Pickering's performance in this area was satisfactory. Implementation of records management was effective and continues to be monitored by CNSC staff on an on-going basis.

Business continuity
CNSC staff confirmed that Pickering was adequately prepared to invoke its contingency plans for events including labour action in order to ensure that the minimum staff complement at their facilities was not affected.

3.3.2 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.

Personnel training
OPG continued to have a well-documented, defined and robust systematic approach to training (SAT)-based training system. Implementation of this system for the training programs at Pickering met the regulatory requirements. Through compliance activities, CNSC staff identified some weaknesses with respect to certain job families. These weaknesses are being corrected and do not represent an increased risk to nuclear safety.

Initial certification examinations and requalification tests

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

In 2013, CNSC staff conducted an inspection of the authorized nuclear operator (ANO) simulator-based certification examination. CNSC staff concluded that OPG met the requirements of its program and the CNSC requirements.

Work organization and job design

Pickering met the regulatory requirements for the minimum shift complement. CNSC staff conducted an inspection and verified that records of minimum shift complement were retrievable and complete.

Pickering has implemented the minimum complement coordination program to monitor the minimum shift complement at all times and identify and report any violations.

Fitness for duty

Compliance with hours of work limits by licensee staff are being monitored by CNSC staff. CNSC staff concluded that Pickering is in compliance with its documentation on this subject, as referenced in the Pickering licence conditions handbook.

3.3.3 Operating performance

CNSC staff concluded that the operating performance 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.

Conduct of licensed activity

Throughout 2013, Pickering continued to operate within its *Operating Policies and Principles* (OP&Ps) and the *Operational Safety Requirements* (OSRs).

Pickering 1, 4 experienced one unplanned trip, and two setbacks (Pickering 1, 4 does not have stepbacks). Pickering 5-8 experienced two unplanned reactor trips, one setback and one stepback. It should be noted that the transients were controlled properly by the licensee and that stepbacks and setbacks address issues at domains far below that of regulatory concern. Consequently, there was no impact on nuclear safety.

A CNSC Inspector verifying a control panel.

The power history graphs for the Pickering nuclear reactor units for 2013 can be seen in appendix F. These graphs show the occurrences (and causes) of outages and the associated power reductions during the year.

CNSC staff conducted inspections, including field and control room inspections. No significant operations-related compliance issues were identified.

Procedures

Based upon compliance verification activities carried out by CNSC staff in 2013, it was noted that Pickering continued to improve the efficiency and technical accuracy of its procedures. CNSC staff found that OPG procedures met CNSC requirements in 2013.

Reporting and trending

OPG is required to submit quarterly reports on operations and performance indicators as described in S-99, *Reporting Requirements for Operating Nuclear Power Plants* [4]. CNSC staff did not identify any significant regulatory issues from these reports.

Outage management performance

Pickering 1, 4 scheduled two planned maintenance outages and experienced five forced outages. Pickering 5-8 scheduled two planned maintenance outages and experienced four forced outages. Details are found in Appendix F. All outages were completed safely.

In 2013, CNSC staff reported to the Commission the presence of iron oxide deposits on the fuel bundles in Unit 1. OPG implemented corrective actions, and increased monitoring. Throughout 2013, CNSC staff observed a downward trend in the size and number of deposits.

3.3.4 Safety analysis

Based on the information assessed, CNSC staff concluded that the safety analysis 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.

Deterministic safety analysis

Pickering has an effective, well-managed program for performing deterministic safety analysis. CNSC staff have reviewed OPG’s program to monitor and assess the impact of heat transport system aging on safety analysis and found it satisfactory. The station has adequate safety margins and these meet the CNSC’s acceptance criteria.

Probabilistic safety analysis

OPG submitted the full probabilistic safety assessment (PSA) reports for Pickering B (now referred to as Pickering 5-8). As well, OPG submitted all PSA reports for Pickering A (now referred to as Pickering 1, 4). As of the end of 2013, CNSC staff were reviewing the PSA reports.

At the May 2013 Pickering Licence Renewal Hearing, the Commission directed OPG to incorporate the impact of Fukushima enhancements into its PSAs and also to develop a PSA or PSA methodology for the whole site before the release of the regulatory hold point for Pickering. The regulatory hold point prohibits the operation of Pickering B beyond 210,000 effective full power hours, which is the original assumed design life of the pressure tubes. OPG submitted the required reports in early 2014 and requested the removal of this hold point at the May 7, 2014 public hearing. As of the end of May 2014, the Commission was in deliberation on this issue.

The Pickering results show that the core damage frequency and large release frequency, calculated individually for internal events and for each external event, meet the safety goal limits.

Severe accident analysis

Pickering has completed the severe accident management guidelines (SAMGs) implementation in accordance with Fukushima action item (FAI) 3.1.1, "Development and Implementation of SAMG" (see appendix G for details). Other SAMG-related FAIs are closed. CNSC staff review of the site-specific SAMG implementation is planned.

Environmental risk assessment

OPG continued to maintain and implement an effective environmental risk assessment and management program at Pickering in accordance with CNSC requirements. Work is ongoing towards documenting an environmental risk assessment consistent with N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [24].

Open action items on the risk management program on fish are being addressed by the licensee in a manner that is acceptable to CNSC staff.

3.3.5 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

Equipment qualification

The environmental qualification (EQ) program is fully implemented at all Pickering operating units. Revisions to the EQ program implementation have been submitted by OPG and are currently under review. CNSC staff will continue to monitor OPG's progress in this area.

System design

Electrical power systems

OPG continued to resolve issues identified in the last electrical power systems' inspection in 2012 with regards to battery replacement and standby generator work. CNSC staff will continue to monitor OPG's progress on the corrective actions, which are all of low safety significance.

Fire protection design

The fire protection program at Pickering met applicable CNSC requirements.

Pickering Unit 1 experienced a fire in the lube oil purifier in the turbine hall in January 2013. Based on the review of the root causes and inspections, CNSC staff concluded the fire response was appropriate, timely and followed station emergency procedures including notifications to the different stakeholders. The fire did not challenge the nuclear safety of the facility. CNSC staff reported this event to the Commission on January 16, 2013 and the issue was closed.

The site underground fire water distribution system experienced failures that affected the Pickering NPP and the Pickering Nuclear Waste management facility. CNSC staff accepted the interim measures implemented by OPG to compensate for piping unavailability during repair. The interim measures were in effect from October 2013 until the system was returned to service on December 15, 2013. CNSC staff will continue to monitor.

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 iron oxide deposits on the fuel. There was no bowing and no effects on cooling the fuel as a result of the deposits. Inspection results are showing an improving trend and that fuel defect rates have not been affected by the deposits. CNSC staff will continue to monitor the corrective actions.

3.3.6 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 were satisfied with the overall equipment performance at Pickering.

Fuel bundles. Each bundle is about the same size as a fireplace log.

Maintenance

The maintenance program performance at Pickering remained satisfactory. The corrective maintenance backlog was in the average range of the industry. The deficient/elective maintenance backlog remained in the top quartile of the industry. The preventive maintenance completion ratio was around 88%, which indicated an overall effective preventive maintenance program.

Structural integrity

CNSC staff compliance monitoring activities in 2013 indicate that the structures, systems and components (SSCs) important for safe operation continued to meet structural integrity requirements.

Structural integrity of pressure tubes was assured through the conduct of periodic in-service inspections and assessment of the resulting findings. OPG continued to participate with their industry partners in the fuel channel life management project (FCLMP), which is intended to strengthen estimates and confirm fitness for service of pressure tubes for continued operation.

Reliability of systems important to safety

The reliability program at Pickering continued to meet regulatory requirements as described in RD/GD-98, *Reliability Programs for Nuclear Power Plants* [18].

All special safety systems at Pickering met their unavailability targets in 2013.

Aging management

Pickering has implemented an integrated aging management program to ensure that the condition of SSCs important to safety is understood, and that required activities were in place to assure the health of these SSCs while the plant ages. The program meets the requirements in RD-334, *Aging Management for Nuclear Power Plants* [27]. OPG conducted component condition assessments and aging management program reviews for continued operation of Pickering 5-8.

Pickering continued updating, on a regular basis, its lifecycle management plans (LCMPs) for the long term management of major pressure boundary components. The LCMPs meet the requirements of RD-334 [27].

Chemistry control

Pickering has a mature chemistry control program that meets regulatory requirements. Chemistry optimization efforts to control the fuel bundle iron oxide deposits in Pickering Unit 1 have been effective.

Periodic inspections and testing

In September 2013, CNSC staff conducted an inspection of Pickering's periodic inspection programs and confirmed that the regulatory requirements were met.

3.3.7 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, an improvement from a "satisfactory" in the previous year.

Application of ALARA

Pickering has established a mature ALARA program. In 2013, Pickering continued to implement its ALARA program which, integrates ALARA into planning, scheduling and work control.
CNSC staff have verified that Pickering's five-year ALARA plan includes dose reduction initiatives based on a review of operational experience and industry best practices.
CNSC staff verified that outage planning included the establishment of challenging dose targets.
CNSC staff verified through inspection activities that OPG had implemented numerous ALARA initiatives at Pickering to reduce worker exposures.

Worker dose control

Pickering continued to comply with the regulatory requirements to measure and record doses received by workers. 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 (RP) program. The dose information for Pickering is provided in section 2.7 and in appendix D.

In 2013, CNSC staff conducted inspections of worker dose control at Pickering and confirmed compliances with the requirements. Positive findings were noted with respect to setting dose targets and monitoring individual exposures.

Radiation protection program performance
Pickering applies OPG's corporate RP program which, satisfies the requirements of the *Radiation Protection Regulations* and includes performance indicators to monitor program performance. The RP program documents and supporting procedures are maintained current, taking into consideration operating experience and industry best practices.

CNSC staff confirmed that challenging goals and targets have been established and met. The oversight applied in implementing and continuously improving this program has been effective in protecting workers.

Radiological hazard control
There were no action level exceedances with respect to radiological hazards, including surface contamination at Pickering.

CNSC staff confirmed that OPG complies with the requirements for radiological hazard control with a number of positive findings noted with respect to contamination control and use of decontamination facilities.

Estimated dose to public
The reported dose to the public from Pickering was 0.0011 mSv, well below the public dose regulatory limit of 1 mSv.

3.3.8 Conventional health and safety

Based on the information assessed, CNSC staff concluded that the conventional health and safety 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.

Performance
As reported by the licensee, the accident severity rate for Pickering remained at zero the same as in 2012 and the accident frequency decreased from 0.34 to 0.29. The two 2013 accident performance indicator values for Pickering are the lowest among the Canadian NPPs. The ASR value showed that there were no lost days due to work-related injuries and this value remains outstanding in comparison with industry practices.

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

Awareness
For 2013, housekeeping at Pickering met CNSC requirements. In 2012, the Ministry of Labour (MOL) investigation on the grinding of asbestos containing material (ACM) gaskets on Unit 1 resulted in an order to OPG to ensure that all ACMs are clearly identified. OPG has created the Asbestos Management Program to comply with the MOL orders on asbestos remediation and has obtained Joint Health and Safety Committee agreement on this issue. The program has been

initiated and will require continuing momentum to achieve its final goal which is to ensure that all ACMs are clearly identified.

3.3.9 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 (releases)

OPG has implemented and maintained an environmental monitoring program that met applicable regulatory requirements. Based on the review of licensee's reports, CNSC staff concluded that the radiological releases from Pickering remained below their regulatory limits and action levels.

Groundwater monitoring at the Pickering site indicated no adverse impact on the groundwater environment due to operation.

Environmental management system

OPG has established and implemented an environmental management program to assess environmental risks associated with its nuclear activities, and to ensure that these activities are conducted such that adverse environmental effects are prevented or mitigated.

Protection of the public

There were no hazardous substances released from Pickering that posed unacceptable risk to the environment and the public during 2013.

The reported annual radiation dose to the public from Pickering was 0.11% of the public dose limit.

3.3.10 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.

Nuclear emergency preparedness and response

The CNSC conducted an inspection of the planned emergency exercise at Pickering in 2013. The inspection team concluded that, overall, OPG demonstrated its readiness to respond to a nuclear emergency.

Fire emergency preparedness and response

Pickering continues to implement a comprehensive fire response capability that includes effective procedures, training and maintenance of proficiency. CNSC staff concluded that OPG has maintained and implemented an effective and well-documented emergency management and fire response program at Pickering.

3.3.11 Waste management

Based on the information assessed, CNSC staff concluded that the waste 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.

Waste characterization; Waste minimization
OPG maintains an effective waste management program at Pickering for radioactive and hazardous wastes that promotes minimization, segregation, storage and handling.

Waste management practices
A compliance inspection of radioactive and hazardous waste management was conducted in May 2013. Results of the inspection indicated that Pickering's radioactive and hazardous waste management program met CNSC requirements.

Decommissioning plans
OPG maintains decommissioning plans and an associated consolidated financial guarantee for all of its Ontario facilities. The associated decommissioning plan, consolidated financial guarantee and cost estimate for Pickering were reviewed and accepted by the Commission in 2012 and remained current in 2013. CNSC staff concluded that Pickering met regulatory requirements for decommissioning plans.

3.3.12 Security

Based on the information assessed, CNSC staff concluded that the security 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 from "satisfactory" for the previous year.

Facilities and equipment
Pickering demonstrated effective maintenance of facilities and equipment, and met regulatory requirements. The licensee realized equipment modernization, including armoured vehicle replacement, radio communication upgrades and new technology for search screening activities.

Response arrangements
Improvements in this area were noted, particularly with respect to the integration of the onsite emergency response teams and Durham Regional Police Service for drills and exercises. This expansion and inclusive involvement is leading to enhanced interoperability and command and control cohesion in challenging exercises.

Security practices
Pickering continued to make significant improvements in 2013 in the areas of procedural updates and compliance, along with strengthening of the site access security clearance process and access control measures.

3.3.13 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.

Access and assistance to the IAEA
The IAEA did not select Pickering for a physical inventory verification (PIV) in 2013. Instead, the CNSC performed an evaluation of Pickering's preparedness for a PIV to provide assurance to the IAEA that the facility had properly conducted a physical inventory taking and was prepared for a PIV, if it had been selected.

Safeguards equipment, containment and surveillance
Pickering supported the IAEA equipment operation and maintenance activities including those related to the upgrade of the surveillance system and bundle counters.

3.3.14 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.

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* [4]. In addition, CNSC staff performed an inspection of transportation of dangerous goods (Class 7) radioactive material to verify OPG's compliance with regulatory requirements in the *Packaging and Transportation of Nuclear Substances Regulations* (PTNSR) and the *Transportation of Dangerous Goods Regulations* [22].

3.4 Gentilly-2

Gentilly-2, operated by Hydro-Québec, is located on the south shore of the Saint Lawrence river, in the Bécancour municipality, 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 Québec government decided in 2012 to close Gentilly-2. The reactor was shut down on December 28, 2012 and has since been undergoing a transition to a safe storage state.

The 2013 safety performance ratings for Gentilly-2 are shown in table 8. 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 under the current SCA framework.

Table 8: Performance ratings for Gentilly-2

Safety and control area	Rating	Industry average
Management system	**SA**	**SA**
Human performance management	**SA**	**SA**
Operating performance	**SA**	**SA**
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**	**SA**
Security	**SA**	**FS**
Safeguards and non-proliferation	**SA**	**SA**
Packaging and transport	**SA**	**SA**
Integrated plant rating	**SA**	**SA**

Note:

- 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; general trends are not identified here (refer to section 2 for industry-wide observations)

3.4.1 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

In 2013, Hydro-Québec met the requirements of N286-05, *Management system requirements for nuclear power plants* [23]. As a result of the closure of Gentilly-2, updates to the management system framework and organizational documents were made in 2013. Hydro-Québec submitted a transition plan that reflects the anticipated organizational changes. CNSC staff verified that the implementation of these changes complied with regulatory requirements.

Organization

The operating organization at Gentilly-2 has been undergoing a transition since the announcement of the permanent closure of the NPP was made in 2012. Staff complement was lowered progressively in 2013 while the licensee proceeded with defueling, drills and preparatory work required to put the plant into a safe storage state and planning the future decommissioning of the plant. In response to a request from the CNSC, Hydro-Québec submitted a transition plan that shows the status of the organizational changes being made. CNSC staff will continue to monitor the organizational structure changes and verify compliance at the plant.

3.4.2 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.

Personnel training

In 2013, Hydro-Québec continued to implement a training program based on the systematic approach to training (SAT). The permanent closure of Gentilly-2 and the operations required to place the plant into a safe storage state had a major impact on staff training needs. Many of the training activities required to support normal operation are no longer required while other training activities are needed during the transition to safe storage state. CNSC staff reviewed and accepted Hydro-Québec's action plans and procedures to remove from service and lay-up plant systems. CNSC staff are also attending focused technical meetings to verify that Hydro-Québec is implementing the measures needed to meet its staff training needs. Furthermore, CNSC staff are monitoring Hydro-Québec`s progress for the development and implementation of training for the employees who will remain onsite during the safe storage state.

Initial certification examinations and requalification tests

In 2013, the initial certification examinations and requalification tests program for the certified staff at Gentilly-2 were put on hold following the announcement of the permanent closure of the NPP.

No initial certification examinations and requalification tests were administered by the licensee in 2013.

Work organization and job design

Gentilly-2 met the regulatory requirements for the minimum shift complement. CNSC staff conducted an inspection and verified that records of minimum shift complement were retrievable and complete.

The shift crew complement was lowered after reactor defueling was completed. The makeup of the crews remains in compliance with applicable regulatory requirements.

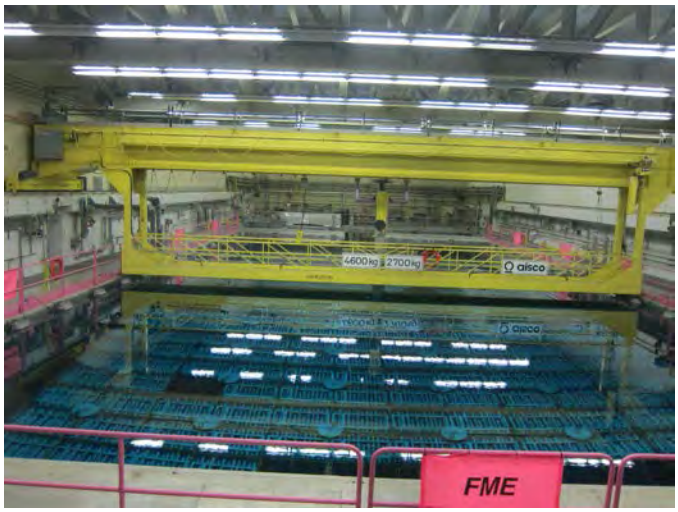
3.4.3 Operating performance

Based on the information assessed, CNSC staff concluded that the operating performance 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.

Conduct of licensed activity

Gentilly-2 did not produce any electrical power in 2013.

Defueling of the reactor was completed on September 3, 2013. All 4,560 fuel bundles were transferred without incident to the irradiated fuel bay. Operational activities for the transition to the safe storage state, including emptying and draining several plant systems, were conducted safely throughout 2013.



Irradiated fuel bays are designed to cool used fuel. After 6 to 10 years in wet storage, the nuclear fuel can be safely transferred to dry storage in concrete canisters.

CNSC staff conducted inspections, including field and control room inspections and no significant operations-related compliance issues were identified.

Procedures

CNSC staff identified weaknesses in development, modification and implementation of procedures at Gentilly-2. Hydro-Québec developed an improvement plan to address this issue.

In response to a CNSC request, Hydro-Québec submitted action plans and procedures to remove from service and lay-up plant systems, before these related operations began. CNSC staff confirmed that the action plans met regulatory requirements.

Reporting and trending

Hydro-Québec is required to submit quarterly reports on operations and performance indicators as described in S-99, *Reporting Requirements for Operating Nuclear Power Plants* [4]. CNSC staff did not identify any significant regulatory issues from these reports.

3.4.4 Safety analysis

Based on the information assessed, CNSC staff concluded that the safety analysis 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.

Following the shutdown of the NPP, and in preparation for completion of reactor defueling and fuel bundle transfer and storage, an irradiated fuel bay safety analysis was submitted in December 2012. Furthermore, an assessment of reactor defueling scenarios was submitted in 2013. CNSC staff found these submissions to be acceptable.

3.4.5 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

Equipment qualification

Hydro-Québec maintained an acceptable environmental qualification program commensurate with the level of risk.

System design

Fire protection design

In 2013, the fire protection program was in a transition to take into account the lower risk level following permanent shutdown of the NPP. Hydro-Québec submitted a revision of this program to CNSC staff in February 2014. A review of this program, that takes into account the requirements of N293-07, *Fire protection for CANDU nuclear power plants* [26], was on-going at the time of writing this report.

3.4.6 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

The maintenance program performance at Gentilly-2 remained satisfactory. The preventive maintenance completion ratio (PMCR) for Gentilly-2 was 94% in 2013.

Structural integrity; periodic inspection and testing; aging management

An update of the programs in the fitness for service SCA was expected before or shortly after the permanent shutdown of the NPP. Hydro-Québec is currently revising its programs to reflect the defuelled status of the plant.

Hydro-Québec has committed to implementing aging management and inspection programs in accordance with regulatory requirements by November 30, 2014. CNSC staff will continue to provide regulatory oversight in this area.

Reliability of systems important to safety

The reliability program at Gentilly-2 continued to meet regulatory requirements commensurate with the defuelled status of the plant.

3.4.7 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 implemented its ALARA program, which integrates the ALARA principle into planning, scheduling and work control. ALARA plans were developed for work and activities that presented a higher risk, in order to ensure the protection of personnel against radiation. CNSC staff have reviewed these ALARA plans and confirmed that the radiation protection measures implemented by Hydro-Québec were satisfactory.

Worker dose control

Hydro-Québec met the regulatory requirements with regards to measuring and recording staff radiation doses. No worker or member of the public received a radiation dose in excess of regulatory limits, and no incidents occurred that resulted in a reportable dose in excess of Hydro-Québec's action levels. The dose information for Gentilly-2 is provided in section 2.7 and in appendix D.

In 2013, Hydro-Québec satisfactorily addressed all opportunities for improvement raised through a CNSC staff alpha monitoring and control inspection conducted in 2012. CNSC staff will continue to verify effective implementation of corrective actions through the on-going compliance verification activities.

Radiation protection program performance

Gentilly-2's radiation protection (RP) program satisfies the requirements of the *Radiation Protection Regulations*. The RP program implements a series of standards and procedures for the conduct of radiological activities at Gentilly-2 to achieve and maintain high standards of RP including the control of occupational exposures to workers.

Radiological hazard control

There were no action level exceedances with respect to radiological hazards, including surface contamination at Gentilly-2.

A radiological hazard control focused inspection was performed at Gentilly-2 in 2013. The inspection identified areas for improvement, particularly in the area of calibration and maintenance of radiation protection (RP) instruments. Following the inspection, the licensee prioritized the maintenance and calibration of RP instruments needed during the radiological activities planned for the transition period. During 2014, CNSC staff will continue to monitor the

implementation of the part of this plan that will address the remaining instruments.

Estimated dose to public
The reported dose to the public from Gentilly-2 was 0.005 mSv, well below the public dose regulatory limit of 1 mSv.

3.4.8 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
As reported by the licensee, the accident severity rate (ASR) increased from 7.5 to 13.2, and the accident frequency decreased from 1.80 to 0.81. The increase in the ASR was on account of two lost time injuries that resulted in a total of 49 lost days of work.

Practices
Gentilly-2 was compliant with the relevant provisions of the Québec provincial law (*An Act respecting occupational health and safety)* and relevant regulations.

Awareness
In 2013, housekeeping at Gentilly-2 met CNSC requirements. During field inspections, however, CNSC staff identified minor non-compliances that, in all cases, were corrected immediately once the licensee was informed.

3.4.9 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 (releases)
Hydro-Québec has implemented and maintained an environmental monitoring program that met applicable regulatory requirements. Based on the review of the licensee's reports, CNSC staff concluded that the radiological releases from Gentilly-2 remained below their regulatory limits and action levels.

Assessment and monitoring
Hydro-Québec continued to monitor the environment in accordance with the programs in place. CNSC staff did not assess these programs in 2013, but a follow-up visit was conducted in October 2013, which allowed closing three action notices pertaining to the Hydro-Québec residual hazardous materials management program.

Protection of the public
There were no hazardous substances released from Gentilly-2 that posed unacceptable risk to the environment or the public during 2013. Hydro-Québec continued to monitor non-radiological parameters in accordance with its environmental monitoring program.

The reported annual radiation dose to the public from Gentilly-2 was 0.5% of the public dose limit.

3.4.10 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.

Nuclear emergency preparedness and response

No emergency exercise was conducted in 2013 as the plant was in the shutdown state and in transition to the safe storage state. CNSC staff are satisfied that this does not have any impact on safety, considering the status of the plant.

Fire emergency preparedness and response

During an inspection of the Fire Emergency Response Team performed in November 2013, CNSC staff confirmed that Hydro-Québec met fire response requirements.

3.4.11 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.

Decommissioning plans

Based on a recommendation from Hydro-Québec, the Québec government announced final closure of the plant earlier than anticipated, in December 2012. Hydro-Québec's original decommissioning plan, developed in 2010, as well as the related financial guarantee is no longer current. The revision of the Hydro-Québec decommissioning plan and of the related financial guarantee is expected by the end of March 2015.

3.4.12 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

Gentilly-2 maintains a security force of qualified nuclear security officers to meet the requirements of the *Nuclear Security Regulations*. The security force employs a response strategy based on defense-in-depth and the graded approach. This security force is working with its offsite response force to revise the memorandum of understanding so that it aligns to current station conditions.

3.4.13 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.

Access and assistance to the IAEA
The IAEA conducted a physical inventory verification (PIV) in 2013 to verify the non-diversion of safeguarded nuclear materials.

Operational and design information
In addition to the information provided in section 2.13, Hydro-Québec provided regular updates to the CNSC and the IAEA on the status of, and schedule for, reactor defueling activities.

Safeguards equipment, containment and surveillance
Hydro-Québec supported the operation of IAEA equipment. In December 2013, the licensee notified the CNSC that a safeguards seal was accidently broken at the CANSTOR dry storage site for used fuel. A secondary seal maintained IAEA safeguards coverage and CNSC staff confirmed that Hydro-Québec was taking appropriate measures to protect IAEA safeguards equipment.

3.4.14 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 onsite monitoring activities and a review of the reports submitted in accordance with S-99, *Reporting Requirements for Operating Nuclear Power Plants* [4].

3.5 Point Lepreau

Point Lepreau is located on the Lepreau Peninsula, 40 kilometres southwest of Saint John. The station is owned and operated by New Brunswick Power Nuclear Corporation (NB Power), and consists of a single CANDU reactor with a rated capacity of 705 MWe (megawatts electrical).

The 2013 safety performance ratings for Point Lepreau are shown in table 9. 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 under the current SCA framework.

Table 9: Performance ratings for Point Lepreau

Safety and control area	Rating	Industry average
Management system	SA	SA
Human performance management	SA	SA
Operating performance	SA	SA
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	SA
Security	SA	FS
Safeguards and non-proliferation	SA	SA
Packaging and transport	SA	SA
Integrated plant rating	SA	SA

Note:

- 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; general trends are not identified here (refer to section 2 for industry-wide observations)

3.5.1 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
NB Power's management system was in compliance with the requirements of N286-05, *Management system requirements for nuclear power plants* [23]. CNSC staff verified that the licensee continued to maintain and improve an effective management system at Point Lepreau.

Safety culture
A safety culture committee, comprising of managers and workers, was established in 2013 to review and assess station occurrences related to safety culture.

Records management
Point Lepreau's performance in this area was satisfactory. Implementation of records management was effective and continues to be monitored by CNSC staff on an on-going basis.

Business continuity
NB Power's 2011 business continuity plan for Point Lepreau was submitted and was reviewed by CNSC staff during the 2012 licence renewal. NB Power continued to be adequately prepared in 2013 to invoke its contingency plans to maintain or restore critical business function in the event of disabling circumstances, such as a pandemic or severe weather.

3.5.2 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's human performance program continued to evolve in 2013. The Human Performance Steering Committee, comprising of senior management, has implemented several initiatives to strengthen human performance.

Personnel training
Point Lepreau continued to have a documented and defined systematic approach to training (SAT)-based training system. Implementation of this system for the training programs at Point Lepreau met the regulatory requirements. Through compliance activities, CNSC staff identified some weaknesses reported in the implementation of the training system with respect to certain job families. These weaknesses are being corrected and do not represent an increased risk to nuclear safety.

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

In 2013, CNSC staff conducted inspections of control room operator and shift supervisor simulator-based requalification tests. CNSC staff concluded that NB Power met the requirements of its program as well as CNSC requirements.

Work organization and job design
Point Lepreau met the regulatory requirements for the shift complement. CNSC staff conducted

an inspection and verified that records of minimum shift complement were retrievable and complete.

Fitness for duty
Compliance with hours of work limits by licensee staff are being monitored by CNSC staff. CNSC staff concluded that Point Lepreau is in compliance with its documentation on this subject as referenced in its licence conditions handbook. Minor weaknesses with respect to quarterly reporting are being addressed by Point Lepreau.

3.5.3 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 activity
NB Power operates its facilities within the bounds of the *Operating Policies and Principles* (OP&Ps) and the *Operational Safety Requirements* (OSRs).

Point Lepreau experienced no unplanned reactor trips, no stepbacks and one setback. It should be noted that the transient was controlled properly by the licensee and that stepbacks and setbacks address issues at domains far below that of regulatory concern. Consequently, there was no impact on nuclear safety.

The power history graph for the Point Lepreau nuclear reactor unit for 2013 can be seen in appendix F. This graph shows the occurrences (and causes) of outages and the associated power reductions during the year.

CNSC staff conducted inspections, including field and control room inspections. No significant operations-related compliance issues were identified.

Procedures
Point Lepreau has a documented process for the development, implementation, and use of procedures, however, inspections conducted in 2013 identified findings relating to procedural non-adherence at Point Lepreau. NB Power has recently provided a plan to address this issue. CNSC staff accepted the plan and are monitoring its implementation.

Reporting and trending
NB Power is required to submit quarterly reports on operations and performance indicators as described in S-99, *Reporting Requirements for Operating Nuclear Power Plants* [4]. CNSC staff did not identify any significant regulatory issues from these reports.

Outage management performance
Point Lepreau scheduled one planned maintenance outage and experienced one forced outage. Details are found in Appendix F. Both outages were completed safely.

3.5.4 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

Point Lepreau has an effective, well-managed program for performing deterministic safety analysis. The station has adequate safety margins and these meet the CNSC's acceptance criteria for safe operation of the NPP.

Probabilistic safety analysis

During 2013, CNSC staff did not identify any compliance issues at Point Lepreau in this area. Previously, NB Power submitted the required methodology guides and probabilistic safety assessment (PSA) reports in compliance with S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [8].

NB Power is in the process of completing its periodic update to the PSA methodologies and PSA reports in compliance with S-294 [8]. The update is expected to be submitted to the CNSC by October 2015.

Severe accident analysis

Point Lepreau has completed the severe accident management guidelines (SAMGs) implementation in accordance with Fukushima action item (FAI) 3.1.1, "Development and Implementation of SAMG" (see appendix G for details). The implementation of the severe accident management program is being evaluated by CNSC staff. The results of the evaluation are being documented and will be communicated to the licensee once completed.

Environmental risk assessment

NB Power continued to maintain and implement an effective environmental risk assessment and management program at Point Lepreau in accordance with CNSC requirements. An intake fish mortality monitoring and reporting program commenced in July 2013.

It should be noted that NB Power has prepared a draft environmental risk assessment and is presently working on reviews and gap analysis of the existing environmental protection programs according to N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [24].

3.5.5 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.

Design governance

Equipment qualification

NB Power has updated its environmental qualification program as part of life extension. CNSC staff will continue to monitor NB Power's progress.

Site characterization

As a part of renewal of the Point Lepreau licence, the Commission required that NB Power complete a site-specific seismic hazard assessment. The site-specific seismic hazard assessment is ongoing and will be completed by December 31, 2014.

System design

Fire protection design

CNSC staff continue to monitor NB Power's progress towards compliance with N293-07, *Fire protection for CANDU nuclear power plants* [26]. Compliance with N293-07 is required by December 2014.

To demonstrate that the objectives of N293-07 [26] are being achieved, NB Power has implemented compensatory measures that will remain in place until permanent solutions are implemented. CNSC staff found that NB Power experienced some difficulties in administering the space allocation and transient material process. However, NB Power implemented corrective measures to ensure effective implementation of this process.

NB Power submitted the code compliance review, fire hazard analysis and fire safe shutdown analysis. CNSC staff had comments on the documents, and NB Power is in the process of addressing the comments.

The design of the facility's fire protection systems and the ongoing improvements are a noted strength that continues to improve the safety margins at Point Lepreau.

Improvements to the fire protection program and its implementation at Point Lepreau are ongoing. To date, NB Power has made a significant investment in upgrades for fire protection at Point Lepreau. CNSC staff will continue to monitor the progress on this issue and will report progress to the Commission on its overall evaluation of NB Power's compliance with N293-07 [26] before the end of 2014.

Components design

Fuel design

NB Power has a well-developed reactor fuel inspection program. Fuel performance at Point Lepreau was acceptable in 2013.

3.5.6 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 were satisfied with the overall equipment performance at Point Lepreau.

Maintenance

The maintenance program performance at Point Lepreau remained satisfactory. CNSC staff

reviews and inspections did not identify any safety significant maintenance issues. Point Lepreau's preventive maintenance completion ratio (PMCR) was approximately 80% in 2013. The corrective maintenance backlog was in the average of industry. The deficient/elective maintenance backlog was higher than the average of industry. CNSC staff are continuing to monitor the licensee's measures to reduce the backlog through routine maintenance-related desktop reviews and inspections.

Structural integrity

There have been no occurrences or inspection results to suggest structural integrity of components has degraded since return to service of the station, following the refurbishment outage.

CNSC staff monitoring of licensee submitted reports, lead to the conclusion that pressure boundary and containment structures, systems and components (SSCs) important to safety met structural integrity requirements established in the design basis. In particular, during the reporting period, CNSC staff reviewed the periodic inspection reports on the reactor building leak rate test and were satisfied with the results.

Point Lepreau was also required to perform inspections to ensure the structural integrity of safety significant balance-of-plant pressure retaining systems and components and safety-related structures. CNSC staff monitored Point Lepreau's pressure boundary and quarterly operations reports and found no evidence of safety significant degradation of balance-of-plant components.

Reliability of systems important to safety

The reliability program at Point Lepreau continued to meet regulatory requirements as described in RD/GD-98, *Reliability Programs for Nuclear Power Plants* [18].

All special safety systems at Point Lepreau met their unavailability targets in 2013, with the exception of the containment system. Notwithstanding backup systems in place, NB Power took appropriate actions to address the temporary impairments, and corrective actions to prevent recurrence are in progress.

Aging management

NB Power has implemented processes and programs that ensure the condition of SSCs important to safety is understood and that required activities are in place to ensure the health of these SSCs as the plant ages. Since the Point Lepreau process documents related to aging management were developed prior to the issue of RD-334, *Aging Management for Nuclear Power Plants* [27], a gap assessment and an update will be completed by NB Power. Point Lepreau has well developed lifecycle management programs for major pressure boundary components. NB Power had submitted to CNSC staff a revised aging management and periodic inspection program for the concrete containment structure at Point Lepreau. This revised document was assessed and found acceptable by CNSC staff.

Chemistry control

Point Lepreau has a mature chemistry control program that meets regulatory requirements. This was reconfirmed through a chemistry compliance inspection conducted in 2013.

Periodic inspections and testing

CNSC staff continued to monitor compliance with periodic inspection programs (PIPs) requirements established in Point Lepreau operating licence and concluded that the implementation of the PIPs satisfied all regulatory requirements except for the fuel channel PIP.

After a 2013 review of the updated pressure tube PIP, CNSC staff requested that NB Power provide additional information regarding the proposed fuel channel PIP. NB Power had committed to submit a revision by the end of 2013; however, as of the time of publishing this report, NB Power had not submitted the revision.

3.5.7 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

In 2013, Point Lepreau continued to implement its ALARA program. A five-year ALARA plan is scheduled for completion in the second quarter of 2014.

Worker dose control

Point Lepreau continued to comply with the regulatory requirements to measure and record doses received by workers. No worker or member of the public received a radiation dose in excess of the regulatory dose limits or action levels established in the Point Lepreau radiation protection (RP) program. The dose information for Point Lepreau is provided in section 2.7 and appendix D.

In 2013, a substantial focus was placed on improving the performance indicators related to tritium uptakes and electronic personal dosimeter alarms.

Radiation protection program performance

The Point Lepreau RP program satisfies the requirements of the *Radiation Protection Regulations* and includes performance indicators to monitor program performance. In 2013, NB Power implemented a number of "RP Key Activities" (e.g. training and observations on RP fundamentals, RP planning process improvements) to improve overall performance. Additional activities are scheduled for implementation in calendar year 2014.

In 2013, NB Power introduced additional performance indicators to monitor RP program performance. CNSC staff confirmed that challenging goals and targets have been established and met.

Radiological hazard control

There were no action level exceedances with respect to radiological hazards, including surface contamination at Point Lepreau.

NB Power informed CNSC staff that implementation of the radiation protection program enhancements in the area of alpha monitoring and control was completed by December 2012. CNSC staff conducted an inspection of this new program in 2013. CNSC staff concluded that the alpha monitoring arrangements had improved since 2012; however, they noted deficiencies with the implementation of the program. NB Power initiated corrective measures to ensure complete implementation and CNSC staff are monitoring the licensee's progress.

Performance indicators in the area of radiological hazard have been established and are monitored on an on-going basis to improve performance.

Estimated dose to public
The reported dose to the public from Point Lepreau was 0.0004 mSv, well below the public dose regulatory limit of 1 mSv.

3.5.8 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 the licensee, the accident severity rate (ASR) for Point Lepreau increased to 12.0 from zero in 2012 and the accident frequency decreased from 0.70 to 0.35. The accident frequency for Point Lepreau is among the lowest for Canadian NPPs. The increase in the ASR was due to two training lost time injuries that resulted in a strained Achilles tendon and an injury to a knee.

Practices
Point Lepreau was compliant with the relevant portions of the *New Brunswick's Occupational Health and Safety Act*, the *Worker's Compensation Act* and the *Workplace Health, Safety and Compensation Commission Act*.

3.5.9 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 (releases)
NB Power has implemented and maintained an environmental monitoring program that met applicable regulatory requirements. Based on the review of licensee's reports, CNSC staff concluded that the radiological releases from Point Lepreau remained below their regulatory limits and action levels.

Groundwater monitoring at the Point Lepreau site indicated no adverse impact on the groundwater environment due to operation.

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 that these activities are conducted such that adverse environmental effects are prevented or mitigated.

Assessment and monitoring
An inspection on effluent monitoring (nuclear substances) was conducted at Point Lepreau in 2013 and identified areas for improvements that were addressed by the licensee.

Protection of the public
There were no hazardous substances released from Point Lepreau that posed unacceptable risk to the environment and the public during 2013.

The reported annual radiation dose to the public from Point Lepreau was 0.04% of the public dose limit.

3.5.10 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.

Nuclear emergency preparedness and response
No emergency exercise was conducted in 2013; however, Point Lepreau continued to be proactive in updating this program.

Fire emergency preparedness and response
NB Power implemented a full time industrial fire brigade and continued to train and exercise to enhance performance capabilities. CNSC staff performed enhanced regulatory oversight in this specific area due to performance issues identified during some of the drills. The industrial fire brigade showed improvement with the implementation of additional training. NB Power has also acquired additional equipment to enhance firefighting capabilities.

3.5.11 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 minimization
CNSC staff are satisfied that NB Power has taken the necessary steps to minimize, segregate and characterize the nuclear wastes generated as a result of operating Point Lepreau. NB Power has an *Operating Policies and Principles* (OP&P) document in place that describes its nuclear waste management within the NPP.

Waste management practices
The Point Lepreau site includes the solid radioactive waste management facility (SRWMF). This site is not co-located with the power reactor, so waste must be transported for a short distance inside the exclusion zone, and CNSC staff provides regulatory oversight for the waste transfers. Waste storage includes very short-lived storage within the NPP before being transferred for long-term storage at the SRWMF. NB Power maintains an effective waste management program at

Point Lepreau for radioactive and hazardous wastes. Findings from 2013 reflected minor issues that were adequately addressed by the licensee.

Decommissioning plans

NB Power's maintains a decommissioning plan, and associated cost estimate and financial guarantee for Point Lepreau. The decommissioning plan and associated cost estimate and financial guarantee were reviewed and accepted by the Commission in 2011 and remained current for Point Lepreau in 2013. Consequently, CNSC staff concludes that NB Power's decommissioning plan, cost estimate and financial guarantee met regulatory requirements.

3.5.12 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", unchanged from the previous year.

Security systems at an NPP facility.

Drills and exercises

Point Lepreau Security continues to conduct security exercises with the offsite response force. NB Power conducted a force-on-force exercise in June of 2013 where the licensee demonstrated effective intervention capabilities against a credible threat. The physical protection systems were realistically tested and assessed.

3.5.13 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.

Access and assistance to the IAEA

The IAEA did not select Point Lepreau for a physical inventory verification (PIV). Instead, CNSC staff performed a physical inventory taking (PIT) evaluation in order to provide assurance to the IAEA that the facility properly conducted a PIT and was prepared for a PIV.

Operational and design information

NB Power did not submit the first quarterly update to its 2013 operational program and a number of other required reports to the IAEA and CNSC by the required deadlines. As a result and following the issuance of two CNSC directives, NB Power implemented the required corrective actions to address these findings. CNSC staff will continue to monitor the NB Power submissions.

Safeguards equipment, containment and surveillance

NB Power supported the IAEA equipment operation and maintenance activities, including the installation and commissioning of detectors for the monitoring of used fuel at the Point Lepreau SRWMF.

3.5.14 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.

CNSC staff reached this conclusion based onsite monitoring activities and a review of the reports submitted in accordance with S-99, *Reporting Requirements for Operating Nuclear Power Plants* [4].

4. Industry Regulatory Developments

This section provides detailed information on various regulatory developments and issues for the nuclear power industry. In recognition of the complexity and ongoing nature of many regulatory issues, the reporting period for this section is 17 months (January 2013 through May 2014).

4.1 Licensing

Between January 2013 and May 2014, the power reactor operating licences (PROL) for Pickering A and B were amended for two months and then renewed as a single-site licence for five years. The operating licence for Darlington was renewed in February 2013 for a 22-month period (effective until December 31, 2014).

Licence renewal applications were received during 2013 from Bruce Power for Bruce A and B and from OPG for Darlington. As mentioned above, the licence for Darlington is scheduled to expire in 2014. In March 2014, Bruce Power applied for, and the Commission approved, an amendment of the licence period for seven months until May 31, 2015.

The 2013 Pickering relicensing hearing resulted in the introduction of new CNSC regulatory documents and CSA standards into its power reactor operating licence as shown in table 10. The new documents have been introduced in the spirit of continuous regulatory improvement and will also be included in the other NPP licences as they are renewed.

Table 10: New documents added to the 2013 Pickering power reactor operating licence

Standard title
CSA standard N288.4, *Environmental Monitoring Program at Class I nuclear Facilities and Uranium Mines and Mills*
CNSC regulatory document RD-353, *Testing the Implementation of Emergency Measures*
CSA standard N292.3, *Management of Low and Intermediate Level Radioactive Waste*
CNSC regulatory document RD-321, *Criteria for Physical Protection Systems and Devices at High Security Sites*
CNSC regulatory document RD-361, *Criteria for Explosive Substance Detection, X-ray Imaging and Metal Detection Devices at High Security Sites*

Memorandum of understanding between the Department of Fisheries and Oceans and CNSC

On December 16, 2013, a memorandum of understanding (MOU) was signed between the CNSC and the Department of Fisheries and Oceans (DFO). Under the MOU, the CNSC now reviews licence applications for potential impacts to fish and fish habitats and informs DFO of all applications where a *Fisheries Act* authorization is anticipated. The CNSC also monitors mitigation measures, offset and compliance with *Fisheries Act* authorizations. The issuance of *Fisheries Act* authorizations remains the responsibility of the DFO minister.

4.2 Public communication

Reports and presentations to the Commission related to power reactor regulation

During 2013, the Commission was kept informed of events and activities at NPPs through a total of five *Status reports on power reactors* presented by CNSC staff at public meetings. One of the status reports was presented at a Commission meeting held in Toronto, in the vicinity of the Darlington and Pickering sites. 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 14 presentations to the Commission related to NPP issues and regulation during 2013. These presentations covered topics such as a status update on the *CNSC Integrated Action Plan* [1], Decommissioning of Gentilly-2, emergency plans, and others.

Event initial reports

Throughout the year, licensees are required to notify the CNSC of significant events – ones that have a public and media interest, or may pose potential risks to security, to the health and safety of persons, or to the environment.

Overall, six event initial reports (EIRs) were submitted during the period of January 2013 to May 2014. Summary details of the EIRs are provided in section 5 of this report for each site.

The number of EIRs in a given year is not indicative of the safety of Canada's NPPs. For example, the events reported during 2013 and early 2014 were of low safety significance that did not require immediate regulatory action by CNSC. The general topics of the submitted reports included fire protection, environmental protection, and health and safety.

Public information and disclosure programs

In accordance with their operating licences, all licensees in Canada are required to implement public information and disclosure programs. These programs are supported by disclosure protocols, which outline the type of information on the facility and its activities that will be shared with the public (e.g., incidents, major changes to operations, periodic environmental performance reports, etc.) and how that information will be shared.

In 2013, licensees completed or continued the transition to comply with RD/GD-99.3, *Public Information and Disclosure* [2], which was published in 2012. By December 2013, all licensees had posted their disclosure protocols and were disclosing information whenever established criteria were triggered.

Licensees submitted annual reports detailing the activities conducted under their programs for the period. These have been reviewed by CNSC staff. Some best practices and innovative ways for licensees to share information were noted as follows:

- NB Power proactively informed community members about the preliminary results of the seismic study being completed as part of post-Fukushima response activities
- OPG proactively disseminated information about the relicensing process of its facilities, through various channels of communications
- Bruce Power developed innovative tools such as new iPad apps and special-purpose websites and held its first telephone town hall meeting, attracting over 10,000 participants

Members of OPG's Pickering and Darlington Community Advisory Councils visit the new training facility built for the refurbishment of Darlington.

Aboriginal consultation activities

CNSC staff conducted several consultation activities with a number of Aboriginal communities in relation to the 2013 Pickering licence renewal as well as in preparation for the 2014 Darlington and 2015 Bruce Power NPP operating licence renewals.

For the Pickering licence renewal, CNSC staff commenced Aboriginal consultation activities in 2012 and continued to consult with Aboriginal communities in 2013, prior to the public hearing for renewal. For both the Darlington and Bruce licence renewals, CNSC staff commenced consultation activities in 2013, including letters of information with details regarding the licence applications, notice of participant funding availability, and follow-up telephone calls. Aboriginal groups were also encouraged to participate in the regulatory review process for these licence renewals, including the public hearings anticipated in 2014.

Aboriginal groups that have requested to be kept informed of activities at NPPs will be provided copies of the draft 2013 NPP Report and notified of the opportunity to observe the presentation of this report to the Commission.

As the 2013 NPP Report is for informational purposes only and no decision is requested from the Commission, the duty to consult is not required.

4.3 Update on 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* [30] was published on October 28, 2011. CNSC staff subsequently embarked on a series of consultations with stakeholders and the public to seek input and increase their understanding of what happened at Fukushima Daiichi, and 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* [1] was published and it is now largely implemented.

The *CNSC Integrated Action Plan* [1] consolidated all public and stakeholder comments and recommendations received during public consultations on the *CNSC Fukushima Task Force Report* [30]. 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 (EAC) entitled, *Examining the Response of the Canadian Nuclear Safety Commission to the 2011 Japanese Nuclear Event* [31] and another by the International Atomic Energy Agency (IAEA) Integrated Regulatory Review Service (IRRS) follow-up mission entitled, *2011 IRRS Follow-up Mission Report* [32]. The *CNSC Integrated Action Plan* [1] is applied across all major nuclear facilities, in a risk-informed approach. The implementation of the action plan was prioritized into short-, medium- or long-term actions, with implementation dates of 2012, 2013, and 2015, respectively.

The fourth update report on the progress made (Update No. 4) by each NPP licensee was submitted to the CNSC in early 2014. The report provided details on activities completed to date by NPP licensees, together with statuses on the implementation of the Fukushima follow-up activities. Specifically, the report presented progress achieved by the NPP licensees in implementing the *CNSC Integrated Action Plan* [1] to address safety improvements aimed at strengthening defence-in-depth, and enhancing onsite emergency response. Appendix G presents the status of the Fukushima action items (FAIs) as of May 1, 2014. Updates on these action items are available in section 5, under "Updates on significant regulatory issues" for each site.

As reported last year in the 2012 NPP Report, all short-term FAIs for Canadian NPPs, related to lessons learned in the aftermath of the Fukushima Daiichi nuclear accident, were closed to the satisfaction of CNSC staff as per deadlines established in the *CNSC Action Integrated Plan* [1]. During 2013, all medium-term FAIs were closed with the exception of a few related to probabilistic safety assessment for external hazard assessment pending completion of review by CNSC staff. The Canadian nuclear power industry is on track to complete all enhancements by the December 2015 deadline set forth in the *CNSC Integrated Action Plan* [1].

To follow through on the closure of Fukushima action items in the *CNSC Integrated Action Plan* [1], station-specific action items were raised where necessary. CNSC staff will continue to monitor FAI implementation at Canadian NPPs through 22 station-specific action items as part of its compliance verification program. Annual updates on FAI implementation will be provided to the Commission as part of the NPP Report.

Post-Fukushima Daiichi safety improvements

The measures undertaken by NPP licensees to strengthen reactor defence-in-depth fall into three general categories: design upgrades, guides and procedures, and safety assessments. As a concept, defence-in-depth is structured in five levels, Levels 1 through 5. The general objective of defence-in-depth is to ensure that a single failure, whether equipment or human, at one level of defence (and even combinations of failures at more than one level), will not jeopardize defence-in-depth at subsequent levels [33]. The concept of defence-in-depth is applied to all organizational, behavioural and design-related safety and security activities to ensure that they are subject to overlapping provisions. The post-Fukushima Daiichi safety improvements applied to enhance the defence-in-depth concept of operating NPPs in Canada, including the objectives of each level and the corresponding means essential for achieving the objective, are summarized in table 11.

Compliance oversight of Fukushima-related plant modifications and equipment implementation

CNSC site staff have carried out compliance inspections and walkdowns to verify Fukushima-related plant modifications and emergency mitigating equipment implementations at Canadian NPPs. These focused inspections were completed as part of the overall CNSC compliance verification program with the objective of ensuring that licensees have procured, installed and/or assembled all components to which they committed in the dispositioning of the respective FAIs.

NPP emergency mitigating equipment includes portable emergency power generators.

In order to achieve this objective, a list of all installed or procured equipment relevant to addressing FAI closure criteria was obtained from each licensee. A specific inspection guide was developed for each of these pieces of equipment and/or modifications, which included a cross-reference to the related FAI. This inspection guide identified the component to be verified, a brief description of the component or system, its location and name plate data where applicable. CNSC site inspectors were tasked to visually confirm that each of these components was in fact installed in the field, and to assess its readiness for service.

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 capability to deploy these resources within a specified mission time may be required. This is to be demonstrated in the field during planned outages, commissioning tests, drills or exercises, etc. CNSC staff have been present at these drills and exercises to observe and review performance tests and, where possible, to identify the need for any further testing or compliance activities.

Table 11: Post-Fukushima Daiichi enhancements to defence-in-depth

Level	Description	Objectives	Design upgrade	Guides/procedures	Safety assessments
Level 1	Prevention of abnormal operation and failures	Prevent deviations from normal operation, and to prevent failures of structures, systems and components (SSCs)			
Level 2	Control of abnormal operation and detection of failures	Detect and intercept deviations from normal operation in order to prevent Anticipated Operational Occurrences (AOOs) from escalating to accident conditions, and to return the plant to a state of normal operation			▪ Reassessment of AOOs to confirm adequacy of plant operational safety
Level 3	Control of accidents within the design basis	Minimize the consequences of accidents by providing inherent safety features, failsafe design, additional equipment, and mitigating procedures	▪ Irradiated fuel bays (IFBs): makeup water capabilities and instrumentation		▪ Reassessment of design basis accidents to confirm adequacy of plant safety
Level 4	Control of severe plant conditions, including prevention of accident progression and mitigation of consequences of severe accidents	Ensure that radioactive releases caused by severe accidents are kept as low as practicable	▪ Emergency mitigating equipment (EME) and connections – Provision of an alternate and independent supply of makeup water to Steam Generator/Primary Heat Transport/Calandria (moderator)/Shield Tank. – Provision to open Main Steam Safety Valves after station blackout ▪ Installation/enhancement of	▪ Emergency mitigating equipment guidelines (EMEGs) ▪ Severe accident management guidelines (SAMGs)	▪ External hazards assessment: re-evaluation of site-specific magnitudes of external events, including multi-unit and IFB events for: – high winds, – seismic margin assessment / seismic probabilistic safety assessment, – tsunami, and flooding ▪ Demonstration of adequacy or provision of additional

Level	Description	Objectives	Design upgrade	Guides/procedures	Safety assessments
			Filtered Containment Venting ▪ Installation of Passive Hydrogen Recombiners ▪ Installation of Shield tank (or Calandria vault) overpressure relief ▪ Upgrades of power systems to improve reliability, longevity of battery supply, improved backup for critical loads – Improved load shedding to extend battery availability – Battery charging capability and uninterruptible power supply (UPS) system backup – Upgrades to power supply for key instrumentation (e.g., Emergency Filtered Air Discharge System (EFADS)) ▪ Protection against flooding (barriers, water-tight doors) ▪ Instrumentation upgrades arising from qualification for severe accident conditions		relief capacity to the reactor during severe accident ▪ Structural integrity assessment of IFBs for temperatures above design values ▪ Reassessment of Main Control Room and Secondary Control Room habitability ▪ Instrumentation qualification for severe accident conditions ▪ Assessment of an airplane crash
Level 5	Mitigation of radiological consequences of significant releases of radioactive materials	Mitigate the radiological consequences of potential releases of radioactive materials that may result from accident conditions	▪ Onsite and offsite emergency response centres ▪ Regional Emergency Response Support Centre (RERSC) available to all Canadian NPP operators ▪ Emergency Operations Centre	▪ Integrated Emergency Plans ▪ Provincial Nuclear Emergency Response Plan ▪ Regional and Municipal Emergency Response Plans	▪ Study of Consequences of a Hypothetical Severe Nuclear Accident ▪ Plume dispersion and dose modeling

CNSC site staff have confirmed 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. Additionally, CNSC staff have witnessed three separate large-scale exercises that were designed to test various components, emergency mitigating equipment (EME), and performance standards. The licensees have made some enhancements as a result of these exercises, and CNSC staff will continue to monitor implementation.

In the long-term, these improvements to the design and availability of EME will be integrated into the licensees systems and programs and monitored through the CNSC's baseline compliance verification program.

Robustness analysis of external hazards

Robustness analysis of external hazards addresses events caused by human activities (such as, an explosion) and includes: analysis reassessment, infrastructure and response plans, and the effectiveness of severe accident management guidelines. The CNSC Task Force review of external hazards was presented to the Commission in a supplemental Commission Member Document (CMD), CMD 12-M23A: *CNSC Action Plan for External Hazards – Explosions at the Reactor Site* (Protected), which included the hazards and risks associated with an explosion at the reactor site. The related FAIs were outlined in this CMD and were derived to address, in a systematic manner, threat scenarios, including beyond-design-basis threats. Licensees' submissions to address the related FAIs were received in early 2014, as per established action plan given in the CMD. CNSC staff are currently reviewing the licensees' submissions and plan to provide a status update (in-camera) at the December 2014 Commission meeting.

IAEA peer reviews and IAEA action plan

Canada continued to demonstrate its commitment to global nuclear safety through its participation in the peer review process of the *Convention on Nuclear Safety* (referred to as the *Convention*). Canada's *National Report on Nuclear Safety* [34] for the *Convention* (prepared in collaboration with industry stakeholders and various federal and provincial authorities responsible for emergency management and preparedness) covered the period April 2010 to March 2013. It was published in August 2013 and presented at the Sixth Review Meeting of Contracting Parties to the *Convention* in March 2014.

In keeping with the expectations set-out in the *CNSC Integrated Action Plan* [1], the CNSC will be making formal requests to the IAEA Secretariat to initiate preparations for the conduct of an IAEA-led operational safety review team (OSART) mission at each Canadian NPP starting in 2015. These missions would provide opportunities for Canadian NPP operators to benefit from the dissemination of information on industry best practices and to broaden their experience and knowledge. The OSART will assist with reinforcing enhancements made through the lessons learned in response to the Fukushima Daiichi accident. The conduct of the OSART will involve input from both the industry and the CNSC.

In January 2013 the CNSC initiated informal discussions with the IAEA to determine the feasibility of a potential International Seismic Safety Centre "Site & External Events Design" (SEED) review service mission for all Canadian NPPs. CNSC staff are currently collecting industry feedback on the re-evaluation of site-specific seismic hazards. Following the completion of this re-evaluation phase, a pre-SEED mission to define the scope of a full SEED mission is expected to take place before the end of 2014; formal undertakings will afterwards be initiated by the IAEA.

The *IAEA Action Plan on Nuclear Safety* [35] was adopted by the IAEA Board of Governors in September 2011. It describes numerous actions planned by the IAEA to strengthen nuclear safety worldwide in response to the Fukushima Daiichi accident. The CNSC has contributed significantly to both the development of the plan and the execution of its various actions (e.g., its leadership in the preparation of the *IAEA Fukushima Comprehensive Report*, which is scheduled for publication in late 2014).

4.4 New-build project annual update

On August 17, 2012 a panel of the Commission announced its decision to issue a power reactor site licence (PRSL) to OPG for the Darlington New Nuclear Project (DNNP) at the Darlington nuclear site. The PRSL is valid for 10 years – from August 17, 2012 to August 17, 2022.

Site of the OPG-proposed Darlington New Nuclear Project located to the east of the existing Darlington NPP (top of photo).

Commission Member Document, CMD 13-M32 was presented to the Commission on August 22, 2013. It provided information on DNNP-related activities starting from the issuance on the Joint Review Panel (JRP) report in August 2011 up to July 2013 at which time the work under the OPG/CNSC protocol[6] and CNSC pre-licensing vendor design reviews were completed.

OPG submitted its 2013 Darlington New Nuclear Project Annual Report to CNSC staff on March 31, 2014, covering activities from March 16, 2013 to March 26, 2014. During 2013, the government of Ontario released a *Long-Term Energy Plan* [36], which indicated that the new nuclear project will be deferred because the demand for electricity is lower than previously forecast. However, the government of Ontario has indicated that it will work with OPG to maintain the PRSL. OPG is now focused on continuing the collection of information to assist the site-specific design activities to be undertaken after a vendor is selected. OPG has identified the following work activities that can be pursued in 2014 (the details of the activities are provided further in the text):

[6] http://www.nuclearsafety.gc.ca/eng/pdfs/Protocols/May-2012-Protocol-Between-Ontario-Power-Generation-and-CNSC-Darlington-New-Nuclear-Project_e.pdf

- Bank swallow monitoring and mitigation
- Deep water aquatic characterization
- Site geotechnical and seismic hazard investigation
- Round whitefish action plan
- Supporting CNSC activities to engage stakeholders in developing policy for land use around nuclear generating stations

OPG's submitted plans included the use of the DNNP site as a temporary staging area to support ongoing operation and planned refurbishment of the existing Darlington nuclear generating station. The area will be restored to its existing condition once the work activities have been completed.

In 2013, OPG did not have any reportable events for the DNNP.

Bank swallow monitoring and mitigation

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

Surveys of the bank swallow burrows at the Darlington site and surrounding area have been conducted since 2008. On February 25, 2014, OPG provided the 2013 results of the bank swallow burrow census and the monitoring of bank swallow artificial nesting habitat designs. CNSC staff did not identify any issues with the 2013 results. In 2014, OPG intends to test the artificial earthen embankment and continue to support the Bank Swallow Working Group.

Deep water aquatic characterization

For a once-through condenser cooling system (note that this is the current proposed option), OPG will need to mitigate the risk of adverse effects from operation, including impingement and entrainment of fish, as well as, thermal excursions and plumes, by relocating the system intake and diffuser structures in water beyond the near-shore habitat zone where the existing cooling water system structures are located.

The *DNNP Deep Water Aquatic Habitat Characterization Final Study Report* was submitted to CNSC staff in 2014 for information. In general, OPG indicated that there does not appear to be any unique habitat features that would serve to concentrate fish in one area. In 2014, OPG's goal is to establish a methodology for characterization of off-shore habitat that is acceptable to the CNSC, the Department of Fisheries and Oceans (DFO) and Environment Canada (EC).

Site geotechnical and seismic hazard investigation

OPG will need to undertake detailed site evaluation assessments to ensure that the site is suitable for an NPP and meets the requirements of RD-346, *Site Evaluation for New Nuclear Power Plants* [37]. Final results of the geotechnical studies will be provided to the CNSC following selection of a vendor by the Province of Ontario.

In 2014, OPG plans to decommission groundwater monitoring wells that were used specifically for the environmental assessment (i.e., not used for the final studies).

Round whitefish action plan

The round whitefish is a native species that is on the decline for reasons not well known. According to the Ontario Ministry of Natural Resources' (OMNR) Lake Ontario Fisheries Management Unit, the round whitefish species is a valued component of a healthy fish community. The species' range in Lake Ontario appears to be limited to the Canadian shoreline from Pickering to Brighton.

The round whitefish action plan (RWAP) was developed as a means to manage, from the DNNP, a wide range of potential issues affecting the aquatic environment. These issues include thermal discharge effects (physical and temperature), cooling water intake impingement/entrainment, and habitat alteration or loss. The RWAP has since also been cited in supporting documentation for licensing hearings for the Pickering and Darlington refurbishment environmental assessment.

In 2014, CNSC staff informed OPG of the need to include a round whitefish population study as part of the RWAP. The OMNR's – Lake Ontario Fisheries Management Unit has agreed to lead the design of the study and coordinate its implementation. OMNR's leadership role is supported by the CNSC, EC and the DFO. CNSC staff will continue to have discussions with OPG to define expectations for the role of OPG in the RWAP. The results of the study will help with the management of the round whitefish population in Lake Ontario and determine if there is a need for further risk management at OPG sites.

Land use planning

The JRP was of the opinion that a situation where residential areas are located within 3 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, taking into consideration the lessons learned from the Fukushima Daiichi nuclear accident.

Given this, the JRP directed recommendations towards the CNSC, the government of Ontario and the municipality of Clarington regarding land use planning. The recommendations were in relation to:

- development of policy for land use around nuclear generating stations
- provincial prevention of sensitive and residential development within 3 kilometres of the site boundary
- municipal prevention of sensitive and residential development within 3 kilometres of the site boundary
- management of development in vicinity of the project site to ensure capacity for evacuation

In 2013, the CNSC undertook activities towards addressing the JRP recommendations for land use planning. The CNSC engaged provincial, regional and municipal stakeholders, as well as OPG, in developing a policy for land use around NPPs. Individual meetings were initially held in February 2013, followed by a workshop in June 2013 with all stakeholders.

The Province of Ontario's Ministry of Municipal Affairs and Housing has since replaced its 2005 Provincial Policy Statement with a 2014 Provincial Policy Statement[7] (effective April 30, 2014), which significantly strengthens land use planning in the vicinity of NPPs.

[7] The Provincial Policy Statement can be found at http://www.mah.gov.on.ca/Page215.aspx

The Provincial Policy Statement applies province-wide and its policies set out the government of Ontario's land use vision. The CNSC will continue to work with stakeholders in 2014 to address the JRP recommendations and commends the Ministry on the completion of a significant undertaking that was accomplished thoughtfully and inclusively, seeking and incorporating comments from a large and diverse pool of stakeholders.

Federal court decision on OPG's Darlington new-build project

On May 14, 2014, Mr. Justice Russell of the Federal Court released his decision regarding both the judicial review of the environmental assessment – conducted by a Joint Review Panel under the former *Canadian Environmental Assessment Act* (1992) – and the power reactor site licence issued by the Commission to OPG.

This decision indicated that the environmental assessment failed to comply with the *Canadian Environmental Assessment Act* (1992) in three areas:

- gaps in the bounding scenario regarding hazardous substance emissions and onsite chemical inventories
- consideration of used fuel
- deferral of the analysis of a severe common cause accident

The environmental assessment report was not quashed and set aside in its entirety. It is to be returned to the Panel (or a duly constituted panel) for further consideration and determination of the specific areas set out above in accordance with the reasons to the judgment.

While the power reactor site licence was ultimately quashed owing to deficiencies with the environmental assessment, the court was satisfied that the licencing process was reasonable (aside from those established deficiencies).

5. Nuclear Power Plant Regulatory Developments

This section provides detailed information on various regulatory developments and issues for each NPP, including licensing, major projects and descriptions of event initial reports. Information in this section is kept as current as allowed by the annual NPP Report deadlines. In recognition of the complexity and ongoing nature of many regulatory issues, the reporting period for this section is 17 months (January 2013 through May 2014).

5.1 Bruce A and B

5.1.1 Licensing

The Bruce A and B licences were renewed for a five-year period on October 30, 2009 (effective until October 31, 2014), under the CNSC's licence reform project. In 2013, Bruce Power applied to the Commission for the renewal of the Bruce A and B operating licences, requesting a licensing period of five years, and the applications are now under consideration. In March 2014, Bruce Power applied for, and the Commission approved, an amendment of the licence period until May 31, 2015. This amendment will allow an appropriate level of public participation in the public hearing process.

Licence amendments

The Bruce A licence and the Bruce B licence were each amended twice between January 1, 2013 and May 31, 2014. Table 12 shows details of the amendments.

Table 12: Amendments to the Bruce A and Bruce B power reactor operating licences

Power reactor operating licence # - Effective date	Amendment requests
15.01/2014, January 23, 2014, Bruce A	Added RD/GD-99.3, *Public Information and Disclosure* [2] and updated Bruce Power's derived release limits (DRLs)
	Updated DRLs according to CSA standard N290.13, *Environmental qualification of equipment for CANDU nuclear power plants* [12] and updated Bruce Power's environmental action levels (ALs)
16.01/2014, January 23, 2014, Bruce B	Added RD/GD-99.3, *Public Information and Disclosure* [2] and updated Bruce Power's derived release limits (DRLs)
	Updated DRLs according to CSA standard N290.13, *Environmental qualification of equipment for CANDU nuclear power plants* [12] and updated Bruce Power's environmental action levels
15.00/2015 May 1, 2014 Bruce A	Licence number changed to PROL 15.00/2015 with an effective date of May 1, 2014
	Licence period changed with validity from November 1, 2009 to May 31, 2015
16.00/2015 May 1, 2014 Bruce B	Licence number changed to PROL 16.00/2015 with an effective date of May 1, 2014
	Licence period changed with validity from November 1, 2009 to May 31, 2015

Revisions to the licence conditions handbooks

Between January 2013 and May 2014, four revisions were made to the Bruce A licence conditions handbook (LCH), and two revisions were made to the Bruce B LCH. These revisions

included a total of 16 changes to the Bruce A LCH and 14 changes to the Bruce B LCH. The more significant changes are shown in table 13.

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

Table 13: Significant changes to the LCHs for Bruce A and Bruce B

Section	Description of change	Revision type	LCH
3.1	In section 3.1 (Preamble and compliance verification criteria (CVC)), the boundary of authorization from the operational perspective has been updated as the safe operating envelope limits and conditions, according to CSA standard N290.15-10, *Requirements for the safe operating envelope of nuclear power plants* [5].	Administrative	Bruce A and B
4.1	Clarification of the CVC for fitness for service, indicating that operation beyond 210,000 effective full power hours is not permitted unless approved by the Commission.	Technical	Bruce A and B
4.3*	CSA N287.7-08, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plant components* [17] information (vacuum building leakage rate test results/dates) has been updated and information regarding lifecycle management plans for balance-of-plant has been added.	Administrative	Bruce A and B
5.5	In the CVC of section 5.5, some dates were changed in order to adequately assess the impact of external events for both S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [8] implementation, and post-Fukushima follow-up actions.	Administrative	Bruce A and B
5.6	In the CVC of section 5.6, Bruce Power's "Consolidated Plan" supporting text has been changed.	Administrative	Bruce A and B
6.1 and 6.2	In the CVC of sections 6.1 and 6.2, a minor text clarifications for the Pressure Boundary have been made before the licence renewal process, which started in 2013.	Technical	Bruce A and B
7.1 *	In the CVC of section 7.1, CNSC regulatory guide G-217, *Licensee Public Information Programs* [38], has been replaced with RD/GD-99.3, *Public Information and Disclosure* [2].	Administrative	Bruce A and B
8.1*	In section 8.1, Table 2 (Summary of Routine Environmental Reporting) has been updated.	Administrative	Bruce A and B
9.1*	Added CNSC regulatory guide G-129, *Keeping Radiation Exposures and Doses "As Low As Reasonably Achievable (ALARA)"* [39].	Technical	Bruce A and B
9.2	The section 9.2 (CVC) has been updated due to Bruce Power's radiation protection action levels have been revised to include alpha.	Technical	Bruce A and B
10*	Two additional CNSC expectations for the site security program from the *Nuclear Security Regulations* have been added.	Technical	Bruce A and B
10.2	The use of the updated qualification for the course of fire for nuclear response force has been added.	Administrative	Bruce A and B
11.1*	RD-336, *Accounting and Reporting of Nuclear Material* [20] has been added.	Technical	Bruce A and B
13.3*	Added pre-requisites to increase above 50% power (for Unit 2 only) and above 90% power (for Unit 1 only)	Technical	Bruce A
13.4	Security requirements have been added for the storage and management of the fuel assemblies due to nuclear facility-specific	Technical	Bruce A

Section	Description of change	Revision type	LCH
	for Bruce A.		

* This change was previously reported in the 2012 NPP Report as the revision was made in the first quarter of 2013 (within the reporting periods for both the 2012 NPP Report and the 2013 NPP Report).

5.1.2 Updates on major projects and initiatives

Bruce A environmental assessment follow-up program

At Bruce A, Bruce Power continued to implement the environmental assessment (EA) follow-up monitoring program (FUMP) related to the refurbishment project and to verify the EA conclusion that there have been no significant adverse environmental effects due to this project. CNSC staff continued to work with Environment Canada, Aboriginal groups and other stakeholders on environmental issues that have arisen through the EA FUMP, such as potential effects on smallmouth bass and lake and round whitefish.

Bruce Power commenced post-refurbishment operations phase EA follow-up monitoring. Studies include monitoring the impingement and entrainment of fish species, and monitoring for thermal effects with the four units now back in operation at Bruce A.

Fisheries research programs are being conducted by Bruce Power, independent of the Bruce A EA FUMP. The results of these programs will be used in design and analysis work for effects on fish in the Bruce A EA FUMP. The research programs include an industry-sponsored CANDU Owners Group (COG) initiative and a university-based program (at McMaster, Regina, Guelph, and Calgary).

37M fuel bundle

The 37M fuel bundle design is a minor modification of the fuel design currently in use. The central element of the 37M fuel bundle has a reduced diameter, which allows more coolant to flow through the centre of the bundle and results in increased heat transfer to the coolant. This will offset the effects of heat transport system aging.

CNSC staff provided consent to Bruce Power to use 37M fuel in Bruce A reactors in January 2013. Fuelling of Bruce A started in March 2013. CNSC staff have reviewed all safety aspects of Bruce Power's submissions for core loading of the 37M fuel bundles for the Bruce A and B reactors. CNSC staff provided consent for Bruce B reactors to use 37M fuel in December 2013. Fuelling of Bruce B started in March 2014. Implementation of the new fuel is being closely monitored by CNSC staff.

5.1.3 Updates on significant regulatory issues

Large break loss of coolant accident margin restoration

The Bruce A and B units remain derated from original nominal design output: Bruce A at 92.5% due to turbine generator limitations, and Bruce B at 93% in order to ensure that adequate safety margins are being maintained.

In September 2013, Bruce Power submitted a report on the composite analytical approach (CAA) methodology to address large break loss of coolant accident (LBLOCA) safety margin issues. The key element of the CAA methodology involves systematic reclassification of LBLOCA events to

the beyond-design-basis accident category based on their extremely low frequency. Currently, this report is under assessment by CNSC staff.

Given the long timeline associated with completion of LBLOCA safety issues, CNSC staff formulated an interim regulatory position with respect to these issues. This interim position established a set of action levels and acceptance criteria applicable to all NPPs irrespective of their existing LBLOCA safety margins. This interim position will remain in effect until the CAA has been accepted by CNSC staff.

Neutron overpower protection

Bruce Power continued to use a new neutron overpower protection (NOP) methodology to assess safety significant aging conditions. The NOP system is composed of fast-response in-core detectors that provide measurements of neutron flux throughout the core.

To support its position that the current NOP trip setpoints are adequate for safe operation of its stations, Bruce Power submitted, in September 2013, proposed physical, operational and analytical measures and compensatory actions, along with relevant empirical evidence.

In January 2014, CNSC staff completed a review of the Bruce Power submission on the proposed NOP trip setpoint values. An evaluation was conducted applying the CNSC risk-informed decision making (RIDM) process in order to determine the adequacy of the proposed NOP trip setpoint values due to aging conditions until August 2017. Based on the results of the RIDM process, CNSC staff conditionally accepted Bruce Power's approach and the values for NOP trip setpoints proposed for the next three years.

Response to the Fukushima Daiichi accident

Bruce Power has made considerable progress in addressing Fukushima action items (FAIs) at Bruce A and B in 2013. Out of the 36 FAIs applicable to nuclear power plants, Bruce Power has completed 32 for both stations. The remaining FAIs are on track for completion as per the established timeline in the *CNSC Integrated Action Plan* [1] (see appendix G).

The measures undertaken in 2013 by Bruce Power and the status of defence-in-depth and onsite emergency response are described below for the following areas:

- ***Procurement of backup emergency mitigating equipment:*** This includes the provision of various emergency mitigating equipment (EME) including portable diesel pumps and diesel generators/portable uninterruptible power supplies to supply essential fuel cooling through multiple paths and to supply power to key monitoring equipment in the event of a severe accident. Bruce Power has completed all short-term modifications to allow emergency water to be added to the steam generators and irradiated fuel bays using EME pumps. To address the longer term, Bruce Power has also assessed the effectiveness of various additional methods of providing cooling water to the reactor cores to prevent or mitigate a severe accident. These additional cooling methods involve the ability to provide makeup water to the calandria, heat transport system and shield tank using EME pumps. CNSC staff completed the assessment of the Bruce Power submission and concluded that the Bruce Power EME achievements and plans are acceptable; therefore related FAI 1.7.1 is closed.

- ***Demonstration of adequacy or provision of additional relief capacity to the reactor during a severe accident:*** Bruce Power carried out an engineering assessment to determine the feasibility of installing shield tank overpressure protection, focused on the installation of rupture discs on the shield cooling system. Bruce Power concluded that the installation will

be feasible and committed to the installation of additional shield tank overpressure protection. CNSC staff agreed that this meets the closure criteria and, has closed FAIs 1.2.2 and 1.2.3. CNSC staff will monitor implementation of this design upgrade through a station-specific action item.

- ***Severe accident management guidelines:*** Bruce Power reported that they will complete the site-specific SAMGs to include multi-unit and IFB events by March 31, 2015. This will include the use of EME and associated equipment modifications (i.e., quick connects and temporary fittings) to support SAMG actions. The submitted information meets the closure criteria for FAIs 3.1.2 and 3.1.3. Moreover, Bruce Power has initiated validation activities to demonstrate SAMG effectiveness through table-top drills and exercises, including single-unit events, multi-unit events and IFB events. Bruce Power's five year plan for exercises and drills calls for one SAMG drill per station in alternating years - with Bruce A targeted to begin in June 2014 and Bruce B to begin in December 2015. Since the demonstration is a multi-year effort, Bruce Power is considered to have met the closure criteria of all SAMG-related FAIs on the basis of an approved implementation plan. Therefore, related FAIs 3.1.2, 3.1.3 and 3.1.4 are closed.

- ***Modeling improvements of external hazard:*** Bruce Power requested closure of related FAIs 2.1.1 and 2.1.2 based on a summary of preliminary information, which was limited to the seismic probabilistic safety assessment (PSA). However, Bruce Power has submitted neither the evaluations of the external hazards that were not screened out (i.e., to be analyzed), in particular seismic, wind and external flooding (FAI 2.1.1), nor the evaluations for the effect of those hazards on its plants (FAI 2.1.2). Based on information provided by Bruce Power as part of S-294 compliance, all external hazard assessments and external hazard PSAs (seismic, wind and flooding) will be submitted by July 2014. CNSC staff extended the deadline to July 2014 for FAIs 2.1.1 and 2.1.2. Therefore, FAIs 2.1.1 and 2.1.2 will remain open pending submission of this information.

- ***Instrumentation survivability during severe accident conditions:*** Bruce Power has taken a three phase approach to address the survivability assessment for instrumentation and equipment for severe accident management (FAI 1.8.1). Phases 1 and 2 of the project were to develop a CANDU Owners Group (COG) generic methodology for performing survivability assessments applicable to all CANDU NPPs. Both phases 1 and 2 of the project have been completed. Bruce Power has submitted the COG generic methodology report to the CNSC for review. A survivability assessment, specific to Bruce Power NPPs, will be carried out in Phase 3 of the project. Bruce Power provided a work plan and schedule for developing the Bruce Power specific assessment methodology and a schedule for performing the station-specific assessment. CNSC staff concluded that information contained in Bruce Power’s submission is acceptable. Therefore, FAI 1.8.1 is closed on the basis of an approved implementation plan.

CNSC staff will continue to monitor FAI implementation at Bruce A and B through its established compliance verification program. Annual updates on FAI implementation will be provided to the Commission as part of the NPP Report.

5.1.4 Public communication

Event initial reports

One event initial report (EIR) was submitted for Bruce A and B from January 2013 to May 2014, as shown in table 14. The EIR event had low safety significance.

Table 14: Event initial reports for Bruce A and B

Subject	Brief description
Bruce B, Unit 8 - Total loss of Class IV power *	On February 3, 2013, Unit 8 had a total loss of Class IV power event due to post-maintenance testing on the System Service Transformer. The unit safely shut down as designed and backup power was restored immediately. Some auxiliary equipment failures occurred during the transient, but were adequately addressed by operator action. This event was reported under S-99 reporting [4] and has been disclosed on the licensee's and CNSC's websites. CNSC staff conducted an inspection on the incident and concluded that there were no worker injuries, no radiological consequences and no significant environmental releases. In addition, it was concluded that the licensee had taken the necessary actions to ensure that the unit remained in a safe state at all times. Unit 8 was returned to service on February 11, 2013, subsequent to CNSC staff approval. This event was reported to the Commission through CMD 13-M13 on February 20, 2013. CMD 13-M13 completed CNSC staff notification to the Commission on this event.

* This event was previously reported in the 2012 NPP Report.

Aboriginal consultation and engagement activities

CNSC staff continued to work together and cooperate with the First Nations and Métis peoples in the Bruce Peninsula region, with respect to nuclear projects to ensure personnel safety and environmental protection.

The CNSC and Bruce Power have continued working with the Saugeen Ojibway Nation (SON) to address the SON's concerns related to whitefish studies. Bruce Power has provided the CNSC and the SON with annual updates on its progress in meeting the requirements of its follow-up monitoring program. To further address the SON's concerns with respect to the aquatic impact of the Bruce A and Bruce B sites, Bruce Power has funded a collaborative research program with the SON and the University of Guelph on intake entrainment, lake whitefish population discrimination and combined stressor population modeling. The SON also participate in reviews of other site-based research projects on lake and round whitefish involving other universities and the CANDU Owners Group (COG). These projects include lake whitefish population modeling, whitefish population genetic structuring, thermal and contaminant effects criteria and monitoring.

5.2 Darlington

5.2.1 Licensing

Darlington's licence was renewed in February 2013 for a 22-month period (effective until December 31, 2014). The Darlington licence has been issued under the new licence format with the accompanying licence conditions handbook (LCH).

In December 2013, OPG submitted an application to the Commission for the renewal of the operating licence for Darlington. The licence renewal process will be based on periodic implementation of Darlington's integrated safety review.

Study of consequences of a hypothetical severe nuclear accident

During the environmental assessment (EA) of the refurbishment and continued operation of Darlington, the Commission directed CNSC staff to identify and model a generic large release from a hypothetical severe accident, estimating the doses, factoring in protective actions; and, finally, determining human health and other consequences. Three hypothetical scenarios were assessed with short, medium and long release durations. The magnitude of the radionuclide release was equal to or greater than releases previously examined in NPP EAs and comparable to a nuclear accident at Darlington with a probability of occurrence in the range of one in 10 million. CNSC staff plan to present the results of this study to the Commission in June 2014.

Licence amendments

The Darlington licence has not been amended since the beginning of its licence period, March 1, 2013.

Revisions to the licence conditions handbook

Darlington's LCH was issued on March 1, 2013. Two revisions were made to the Darlington LCH between January 2013 and May 2014. These revisions were primarily to align the Darlington LCH with the Pickering LCH and the most recent LCH template. Other changes included some updates to titles and numbers of OPG documents referenced, which are reviewed and tracked by CNSC staff as part of the LCH-amendment process. The revisions included a total of 25 changes to the LCH and most were administrative in nature. The technical changes are shown in table 15.

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

Table 15: Significant changes to the LCH for Darlington

Section	Description of change	Revision type
1.4	Clarification of CNSC expectations with respect to land use and management around the facility, including parks, trails, etc.	Technical
3.1	Revision 11 of D-PROC-OP-009, *Minimum Shift Complement* replaced by Revision 12.	Technical
4.1	CNSC agreement for the use of rod based guaranteed shutdown state.	Technical
7.1	Change of status of compliance verification criteria (CVC) for N285.4 [15] as it pertains to CNSC acceptance for the use of Revision 3 of COG feeder fitness for service guidelines	Technical
7.1	Clarification of the CVC for fitness for service, indicating that	Technical

Section	Description of change	Revision type
	operation beyond 210,000 effective full power hours is not permitted unless approved by the Commission.	
10.1	Clarifications with respect to OPG's environmental protection program, including contaminated land management.	Technical

5.2.2 Updates on major projects and initiatives

Refurbishment / life extension

CNSC staff completed their assessment of OPG's integrated safety review (ISR) and provided their response to OPG in July 2013. Some minor items remain outstanding and continue to be resolved. OPG submitted its global assessment report (GAR) and integrated implementation plan (IIP) in December 2013. The GAR and IIP are currently under review and CNSC staff will send their assessment to OPG in 2014.

In addition, OPG submitted its emerging issues report in early 2014, which addressed operating experience gained and ISR codes and standards which have been revised between the ISR code effective dates of July 2008 and December 2013. At the time of writing this report, CSNC staff were assessing this submission and any potential changes that may be required to the GAR and IIP as a result. OPG intends to submit a revision to the GAR and IIP following the completion of the CSNC staff's assessment.

Darlington refurbishment environmental assessment follow-up program

As directed by the record of decision on the Darlington refurbishment EA, OPG developed a more detailed follow-up program in consultation with the CNSC, the Department of Fisheries and Oceans (DFO) and other stakeholders and issued it in October 2013. OPG continues to work with CNSC, the DFO and Environment Canada (EC) on detailed sampling plans for the pre-refurbishment phase regarding aquatic-related matters. These studies are expected to be completed before the first unit refurbishment outage anticipated in 2016.


Turbine hall, located on the non-nuclear side of the Darlington NPP.

The information for the EA follow-up monitoring program (FUMP) design and analysis will come from the results of the round whitefish action plan (RWAP) led by Ontario Ministry of Natural Resources (OMNR) in collaboration with OPG, CNSC, EC and DFO (see section 5.3.3) and research by Candu Owner's Group (COG) on Lake Ontario round whitefish temperature effects criteria to be published later in 2014.

Fuel channel life management project

In 2009, Bruce Power, OPG and Atomic Energy of Canada Limited (AECL) jointly initiated a comprehensive R&D project, referred to as the fuel channel life management project (FCLMP) to investigate the feasibility of operating pressure tubes beyond their original assumed design life. OPG is seeking to ensure operational flexibility for its Darlington units – through compiling critical data on aging-related issues that might otherwise limit the life of the fuel channels. In 2012, a protocol was signed that provides governing roles and responsibilities between the

licensees and CNSC staff.

This project will address issues affecting life-limiting degradation mechanisms in fuel channels. Two of the highest priority areas affecting continuing operation are:

- possible contact between pressure tube and calandria tube stemming from spacer integrity and/or spacer movement
- higher concentration of hydrogen in the pressure tube and its effect on material properties such as fracture toughness with increasing hours of operation

In 2013, Darlington continued to participate in the FCLMP developing engineering methodologies and models to ensure the fitness for service of pressure tubes for continued operation. In particular, licensees developed engineering models to predict fracture toughness of pressure tubes as the hydrogen level increases and probabilistic leak before break in order to demonstrate that the risk associated with the uninspected core is within the acceptable limits. CNSC staff are conducting technical reviews of the models and methodologies.

Days-based maintenance

OPG has implemented "days-based maintenance" at both Pickering and Darlington to remove non-essential maintenance personnel and activities from a shift configuration.

Validations were performed by OPG, independently analyzed by the consultant group, AMEC-NSS Ltd. and observed by CNSC staff in advance of requests made to amend the current minimum shift complement (MSC) at Darlington. In 2013, the licensee continued to refine and implement minor changes to its MSC at Darlington following the completion of analyses with respect to maintenance and Emergency Response Organization staff conducted in 2012.

CNSC staff will continue to monitor the implementation of this project as part of its compliance verification program.

5.2.3 Updates on significant regulatory issues

Intake fish impingement and entrainment

Darlington impinges and entrains fish of many species despite the use of an offshore submerged porous veneer velocity cap intake. As committed to during the Darlington refurbishment EA, OPG is expected to submit to DFO an application for authorization pursuant to clause 35(2) of the *Fisheries Act* before the first unit refurbishment outage, which is anticipated in 2016.

Response to the Fukushima Daiichi accident

OPG has made considerable progress in addressing Fukushima action items (FAIs) at Darlington. Out of the 36 FAIs applicable to Canadian NPPs, OPG has completed 35 (see appendix G). The remaining FAI is on track for completion by the end of 2014.

The measures undertaken in 2013 by OPG and the status for defence-in-depth and onsite emergency response are described below for the following areas:

- ***Procurement of backup emergency mitigating equipment:*** This includes the provision of various emergency mitigating equipment (EME) including portable diesel pumps and diesel generators/portable uninterruptible power supplies to supply essential fuel cooling through multiple paths, and to supply power to key monitoring equipment in the event of a severe accident.

The provision of makeup water to critical systems, as presented by OPG, is being undertaken in two phases. Phase 1 of accident mitigation uses strategies to cool and contain the reactor core using passive water inventories in situ, as well as portable pumps, generators and uninterruptible power supplies. Cooling can be achieved by makeup to steam generators, the primary heat transport system, moderator or irradiated fuel bay as necessary. Phase 2 addresses containment pressure, water recovery and hydrogen mitigation strategies. Phase 2 will re-power the plant equipment required to mitigate containment pressure rise and will recover the water from the sump while introducing strategies to mitigate hydrogen buildup and ensure irradiated fuel bay (IFB) cooling is maintained. CNSC staff concluded that OPG's provision of EME is sound and therefore FAI 1.7.1 is closed (for both the Darlington and Pickering sites).

- ***Severe accident management guidelines:*** OPG reported in their January 31, 2014 submission, that the severe accident management guidelines (SAMGs) documentation is being updated to incorporate the station-specific recommendations from the (generic) CANDU Owners Group report, with planned completion in mid-2014. OPG has provided a plan and schedule for inclusion of multi-unit events in Pickering and Darlington SAMGs. Based on the above, OPG has met the closure criteria set forth for FAI 3.1.2. Therefore, FAI 3.1.2 is closed for all OPG stations.

  CNSC staff are in the process of reviewing the generic technical basis document for inclusion of multi-unit and IFB events in SAMGs and site-specific SAMG updates.

  In addition, to meet the closure criterion for FAI 3.1.4, OPG has held table-top drills and exercises, including single-unit events, multi-unit events and IFB events, to demonstrate SAMG effectiveness. Large scale SAMG drills and exercises were included in the 2013 emergency preparedness drill program and were conducted as follows:
  - Darlington - August 28 and 29, 2013
  - Pickering 1, 4 - September 23, 2013
  - Pickering 5-8 - November 1, 2013

  In addition, multi-unit SAMG exercises are planned for 2015 to demonstrate effectiveness of SAMG implementation for multi-unit events.

  Since the demonstration is a multi-year effort and OPG has met the closure criterion, FAI 3.1.4 is closed for the OPG stations.

  CNSC staff are reviewing OPG's plans, schedules, scope, methods and results of table-top drills and exercises to demonstrate SAMG effectiveness.

- ***Instrumentation survivability during severe accident conditions:*** CNSC staff review of the COG generic equipment and instrumentation survivability assessment methodology is ongoing for the instrumentation and equipment survivability under severe accident conditions. Any issues identified with the generic methodology will be communicated to OPG in a station-specific action item. CNSC staff concluded that OPG's assessment (Update No. 4) meets the closure criteria for FAI 1.8.1; therefore, FAI 1.8.1 is closed for both Pickering and Darlington.

In addition, OPG requested closure of FAI 1.9.1 for Darlington, to address habitability of control facilities during a severe accident (deadline is the end of 2014). CNSC staff reviewed OPG's

submission and concluded that the information provided demonstrated good progress. However, CNSC staff requested that OPG complete a more exhaustive review specific to non-radiological hazards for the Darlington units, than that established by the COG (generic) habitability methodology. Therefore, FAI 1.9.1 remains open for Darlington, pending disposition of CNSC staff comments.

Furthermore, OPG has committed to additional future enhancements under the refurbishment project for Darlington, many of which are targeted for completion prior to the first unit refurbishment in late 2016. These include the provision of a containment filtered venting system for severe accidents, and the installation of a third emergency power generator. As reported in 2012, FAIs related to these activities were closed on the basis of an approved implementation plan.

CNSC staff will continue to monitor FAI implementation at Darlington through its established compliance verification program. Annual updates on FAI implementation will be provided to the Commission as part of the NPP Report.

5.2.4 Public communication

Event initial reports

Two event initial reports (EIRs) were submitted for Darlington from January 2013 to May 2014, as shown in table 16. The EIR events had low safety significance.

Table 16: Event initial reports for Darlington

Subject	Brief description
Contractual worker injured when excavated wall collapsed	On January 15, 2013, a contractual worker was thrown across a trench box when an excavated wall collapsed. The worker hit his shoulder and earth covered a significant part of his body. He was transported to a local hospital and found through assessment to have a dislocated shoulder. The worker was involved in installing a water pipe in a trench north of the Darlington site for new domestic water and sewer lines. OPG project staff halted excavations on the site and the Ministry of Labour investigated the incident.
Overheated exhaust fan causing smoke *	On February 5, 2013, an exhaust fan bearing located in the East Fuelling Facility Auxiliary Area overheated, resulting in smoke. There were no injuries or serious damage to the plant. CNSC staff confirmed that there was no risk to the public, workers or the environment. This event has been disclosed on the licensee and CNSC websites. This event was reported to the Commission through CMD 13-M13 on February 20, 2013. CMD 13-M13 completed CNSC staff notification to the Commission on this event.

* This event was previously reported in the 2012 NPP Report.

5.3 Pickering

5.3.1 Licensing

The Pickering A and Pickering B licences were amended in June 2013 for a two month period until August 31, 2013. The two operating licences were combined into a single-site licence for Pickering in August 2013 and renewed for a five-year period (effective until August 31, 2018).

Regulatory hold point for fitness for service of the pressure tubes

In the operating licence for Pickering, the Commission included a regulatory hold point for the reassessment of operation of the pressure tubes beyond the original assumed design life initially projected to be 210,000 hours of effective full power operation.

The hold point, as requested by the Commission also covers the completion of the probabilistic safety assessment for Pickering A that meets the requirements of S-294, *Probabilistic Safety Assessments (PSA) for Nuclear Power Plants* [8]. The updated PSA models are to account for the Fukushima enhancements and the development of a methodology for multi-unit station PSAs. OPG has requested the removal of the hold point by the Commission. This request was heard by the Commission at the May 7, 2014 public hearing. As of the end of May 2014, the Commission was in deliberation on this issue.

OPG plans to operate Pickering until 2020 and then shut down the facility and end its commercial operation.

Licence amendments

The combined Pickering operating licence that was renewed in August 2013 has not been amended during the reporting period.

Revisions to the licence conditions handbook

Between January 2013 and August 2013, the Pickering A and the Pickering B LCHs were each revised once. These revisions included a total of two changes to the Pickering A LCH and three changes to the Pickering B LCH (shown in table 17). Between August 2013 and May 2014, one revision was made to the combined Pickering LCH (shown in table 18).

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

Table 17: Changes to the LCH for Pickering A and Pickering B (prior to the single-site licence)

Section	Description of change	Revision type	LCH
3.2.2	Removed compliance verification criteria (CVC) text related to OPG's radiation protection requirements document, as this document has been superseded by the responsible health physicist role document.	Technical	Pickering A and B
3.5.2	Updated text under CVC describing status of PSA methodologies	Administrative	Pickering A and B
Table D.2	Added new consent to table and deleted the expired consent	Administrative	Pickering B

Table 18: Change to the LCH for Pickering (after the single-site licence)

Section	Description of change	Revision type
7.1	Clarification of the CVC for fitness for service, indicating that operation beyond 210,000 effective full power hours is not permitted unless approved by the Commission.	Technical

5.3.2 Updates on major projects and initiatives

Fuel channel life management project

In 2009, Bruce Power, OPG and Atomic Energy of Canada Limited (AECL) jointly initiated a comprehensive R&D project, referred to as the fuel channel life management project (FCLMP) to investigate the feasibility of operating pressure tubes beyond their original assumed design life. In 2012, a protocol was signed that provides governing roles and responsibilities between the licensees and CNSC staff.

This project will address issues affecting life-limiting degradation mechanisms in fuel channels. Two of the highest priority areas affecting continued operation are:

- possible contact between pressure tube and calandria tube stemming from spacer integrity and/or spacer movement
- higher concentration of hydrogen in the pressure tube and its effect on material properties such as fracture toughness with increasing hours of operation

In 2013, Pickering continued to participate in the FCLMP, developing engineering methodologies and models to ensure the fitness for service of pressure tubes for continued operation. In particular, licensees developed engineering models to predict fracture toughness of pressure tubes as hydrogen levels increase, and probabilistic leak before break in order to demonstrate that the risk associated with the uninspected core is within the acceptable limits. CNSC staff are conducting technical reviews of the models and methodologies.

End-of-life project activities

OPG continues with planning and implementing measures to ensure safe operation of the Pickering nuclear plant to the end of commercial operations. The continued operations plan (COP) covers the safe operation of Pickering Units 5 to 8 in the end-of-life phase. Some areas of focus are the periodic inspection program and the aging management plan as these units approach the end of operation. The sustainable operations plan (SOP) covers all units at Pickering and is focused on the changes required by the decision to cease operations in 2020. Topics in the SOP include staff resourcing reviews, employee retention and engagement, and changes to the preventive maintenance program. The first version of the stabilization activity plan (SAP) covering the activities after 2020 will be submitted in 2015. This phase of the shutdown involves defueling the reactors and removing the heavy water from systems to minimize the radiation hazards in the plant.

OPG has made good progress in dispositioning actions related to the COP, with only 9 of 95 actions remaining to be addressed. All actions are scheduled to be addressed by 2015 in preparation for closure of this phase. Twenty-one actions in the SOP were consolidated into a single action item entitled “people strategy” in the consolidated end-of-life action log (CAL).

This action involves changes in staffing levels and its impact on the whole of OPG. OPG is at approximately the halfway point in the SOP, with 89 of 152 actions remaining to be addressed. The SOP is scheduled to be completed by December 2020.

CNSC staff are satisfied with the safety and control measures in place and are confident that the end of commercial operation at Pickering will proceed safely.

5.3.3 Updates on significant regulatory issues

Fish mortality

In the 2008 NPP Report, fish mortality due to cooling water intake (impingement and entrainment) and discharge (thermal plume) was raised as a major issue. OPG is making progress in addressing this issue. CNSC staff are satisfied with the progress made by OPG in this area.

Intake fish impingement and entrainment

OPG has developed and installed mitigation measures to reduce fish impingement by 80% and offsets to reduce entrainment by 60% in accordance with direction from CNSC and as advised by the Department of Fisheries and Oceans (DFO). Offsets are measures undertaken by OPG to compensate for entrainment fish loss. Since design improvements to the seasonal barrier net mitigation measures were implemented in July 2011, OPG has consistently met (or bettered) the impingement targets. Preliminary results received by OPG stated that annual fish biomass impinged in 2012 and 2013 ranged from 1,500 kg to 2,900 kg, a significant reduction from the 4,000 kg to 4,800 kg in each of the first two years of net operations. Residual issues remaining for OPG to resolve are the specific fish habitat offsetting for winter impingement of northern pike, a species of concern, and the final method of compliance monitoring and reporting.

Thermal plume

Acting on advice from Environment Canada (EC), the CNSC placed an action on OPG to study round whitefish mortality caused by the Pickering 5-8 thermal plume. OPG responded with several years of study and completed reports on habitat mapping, winter spawning habitat water temperatures and a review of potential mitigation options. Thermal plume risk to round whitefish was offset using indirect measures since there was no direct plume mitigation that was cost effective and feasible. OPG implemented an action to increase the number of mature round whitefish locally, by eliminating lethal sampling of this species for annual radiological fish tissues by using an alternative more common species. Another measure will require multi-agency coordination under the round whitefish action plan (RWAP) developed by OPG, the CNSC, EC, the DFO and Ontario Ministry of Natural Resources (OMNR). This measure will involve a fish population study to demonstrate, as they will with the Darlington New Nuclear Project, that the Pickering round whitefish are not isolated but are biologically linked to other round whitefish populations known to exist in unexposed areas further east in Lake Ontario. A RWAP meeting was held in November 2013 after which OMNR proposed to lead the study design and coordinate its implementation with sampling starting in the fall of 2014 (through partnerships with OPG and others).

Response to the Fukushima Daiichi accident

OPG has achieved closure on 35 of the 36 Fukushima action items (FAIs) for Pickering, meeting the closure criteria for each (see appendix G). Following CNSC staff assessment of the OPG January 2014 submission (Progress Update No.4), 15 FAIs were closed for Pickering. Where

required, CNSC staff have opened site-specific action items to follow-up the implementation of FAIs as per the established compliance verification program.

The update provided for Darlington in section 5.2.3 encompasses updates to both Pickering and Darlington. The measures undertaken in 2013 by OPG that are specific to Pickering and the status for defence-in-depth and onsite emergency response are described below for the following areas:

- ***Modeling improvements of external hazards:*** OPG has submitted all external hazard site-specific assessments and external hazard probabilistic risk assessments required for S-294 compliance. FAIs 2.1.1 and 2.1.2 were therefore closed for Pickering on the basis of an approved implementation plan. CNSC staff's detailed review is ongoing. A station-specific action item will be raised, if necessary.

- ***Demonstration of adequacy or provision of additional relief capacity to the reactor during a severe accident:*** FAI 1.2.1 was closed for Pickering 5-8. OPG provided a reassessment to confirm that the safety margin related to the relief of overpressure in the calandria vault was adequate. The reassessment was deemed acceptable by CNSC staff to demonstrate adequate safety margin that ensures calandria vault integrity during a severe accident.

- ***Containment venting:*** Pickering 1, 4 and 5-8 are equipped with filtered containment venting installed to handle design basis accidents. To further protect containment integrity, OPG committed to enhance the power supply for the existing filtered air discharge system, as well as the power and cooling water supplies for the air cooling units. These design upgrades will supplement the measures put in place to maintain containment integrity, such as, deployment of emergency mitigating equipment to arrest accident progression to a severe accident state in case of failure of backup power systems onsite.

CNSC staff will continue to monitor FAI implementation at Pickering through the established compliance verification program. Annual updates on FAI implementation will be provided to the Commission as part of the NPP Report.

5.3.4 Public communication

Event initial reports

Two event initial reports (EIRs) were submitted for Pickering from January 2013 to May 2014, as shown in table 19. The EIR events had low safety significance.

Table 19: Event initial reports for Pickering

Subject	Brief description
Fire in Pickering 1, 4 turbine hall *	On January 1, 2013, a fire occurred in the turbine hall of Unit 1 as a result of equipment failure. The fire was extinguished by OPG staff and there were no employee injuries. CNSC staff reviewed the event and determined that appropriate measures were taken by OPG. This event was reported to the Commission through CMD 13-M4 on January 16, 2013. CMD 13-M4 completed CNSC staff notification to the Commission on this event.

Subject	Brief description
Manual Shutdown at Pickering Units 1 and 4	During system engineering environmental qualifications (EQ) walkdowns conducted by OPG, a number of EQ electrical connectors were found misaligned. To ensure proper alignment of the connectors throughout the station, a technical operability evaluation was initiated. During the initial part of this evaluation, 461 connectors were inspected across Units 1-8. Three connectors on Unit 1 and two on Unit 4 were found to be misaligned. As a result, on June 5, 2013, Units 1 and 4 were taken off-line manually per procedure to complete repairs and inspect connectors in inaccessible areas. A total of 559 connectors were inspected since the discovery. OPG conservatively decided to shut down the units to perform the EQ inspections and completed all repairs. OPG performed a root cause investigation and implemented a corrective action plan. CNSC staff have been monitoring OPG's progress through meetings and routine updates. OPG has taken the appropriate measures in this event to protect the public, workers and the environment. This event was reported to the Commission through CMD 13-M42 on August 21, 2013. CMD 13-M42 completed CNSC staff notification to the Commission on this event.

* This event was previously reported in the 2012 NPP Report.

5.4 Gentilly-2

5.4.1 Licensing

The Gentilly-2 licence was renewed in June 2011 for a five-year period (effective until June 30, 2016). However, Gentilly-2 was removed from commercial operation on December 28, 2012.

The licence is currently being reviewed to update it for safe storage and future decommissioning of the site.

Licence amendments
No amendments were made to the plant licence from January 2013 to May 2014.

Revisions to the licence conditions handbook
Gentilly-2's licence conditions handbook (LCH) was issued on February 12, 2012. No revisions were made to the Gentilly-2 LCH from January 2013 to May 2014.

5.4.2 Updates on major projects and initiatives

Progress of transition to safe storage state
On October 3, 2012, Hydro-Québec announced its intention not to proceed with the refurbishment of the plant facilities. In accordance with licence conditions, the plant was operated until December 28, 2012 and then placed in a guaranteed shutdown state.

Defueling of the reactor core started on January 17, 2013 and was completed on September 3, 2013. The used fuel is now stored in the irradiated fuel bay where it will stay for a minimum of six years, following which it will be transferred to the CANSTOR dry storage site for used fuel.

As requested by CNSC staff, Hydro-Québec must submit, 60 days before they are to be implemented, the action plans and procedures to drain, remove from service and lay-up plant systems that may have an impact on safety and the environment. Focused technical meetings involving CNSC and Hydro-Québec staff are being held to facilitate the review of these action plans and procedures. CNSC staff reviews are performed in collaboration with staff of the Québec Ministry of Sustainable Development, Environment, Wildlife and Parks and of Environment Canada. In 2013, Hydro-Québec undertook operations to drain secondary side systems (i.e., feedwater system, back-up feedwater tank and steam generators), in compliance with relevant regulatory requirements.

Hydro-Québec requested authorization to drain the high pressure section of the emergency core cooling (ECC) system on November 13, 2013. This request was reviewed and approved by CNSC staff on January 9, 2014. The work was put on hold because higher than expected concentrations of heavy water were detected in one section of the ECC system piping when the sampling and analysis portion of the Hydro-Québec action plan was performed. This discovery did not have any impact on safety but required revisions to the procedure to drain the system. Hydro-Québec reported on the impact of this issue on the ECC system draining operations at a meeting held on February 12, 2014 and CNSC staff were satisfied with the measures taken.

On January 4, 2014, Hydro-Québec started to drain the heat transport system and its auxiliary systems in accordance with a procedure reviewed by CNSC staff. At the time of writing this

report, draining of the heat transport system is drawing to a close and Hydro-Québec is proceeding with the installation of the equipment needed to dry the system and its components. Hydro-Québec submitted the action plan and procedures to be used for draining the moderator system on February 21, 2014, following a focused meeting between CNSC and Hydro-Québec staff on February 18, 2014. At the time of writing this report, Hydro-Québec is pursuing its preparatory work to drain the moderator system, in parallel with the CNSC staff review. Draining of this system will begin once the Hydro-Québec preparatory work and the CNSC staff review have been satisfactorily completed.

Major projects and initiatives planned for the first half of 2014, other than removal from service and lay-up of several plant systems, include repairs to the irradiated fuel bay lining and transfer of the spent resins from the plant storage tank to the solid radioactive waste management facility. Focused technical meetings involving Hydro-Québec and CNSC staff were held on October 11 and November 22, 2013 as well as on February 7, 2014 to facilitate the review of Hydro-Québec action plans and procedures. CNSC staff are satisfied that these plans and procedures met the regulatory requirements and will ensure the safe conduct of these operations.

5.4.3 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. Updates to this protocol were subsequently made on April 29, 2013 and March 3, 2014. A Hydro-Québec/CNSC liaison committee was set up immediately after the protocol was signed and bi-weekly meetings were held throughout 2013 to address operational issues as well as issues related to the implementation of the current licence and regulations.

On January 29, 2014, following a series of meetings and exchanges, Hydro-Québec submitted Revision 2 of the final operation plan (FOP) as well as several supporting documents. Hydro-Québec and CNSC staff held a working-level meeting on February 19, 2014 to clarify some issues and facilitate CNSC staff review. The FOP and its supporting documents should provide the information needed to prepare the next LCH. CNSC staff completed the review of Revision 2 of the FOP and accepted it on May 5, 2014.

The Hydro-Québec/CNSC working group met several times during 2013 to address specialized regulatory and technical issues, including the changes that should be made to the operating licence and the LCH following completion of reactor defueling, removal from service and lay-up of several plant systems. Following these meetings, Hydro-Québec requested, in February 2014, a modification to its licence based on the results achieved by this working group. At the time of writing this report, CNSC staff review of this request to modify the Hydro-Québec licence is in progress.

Response to the Fukushima Daiichi accident

Having ended commercial operation at the Gentilly-2 nuclear station in December 2012, Hydro-Québec began transitioning the reactor to a safe storage state in preparation for decommissioning. As a result, most of the Fukushima action items (FAIs) were suspended for the Gentilly-2 station with the exception of those related to improving mitigation measures for the irradiated fuel bays (IFBs) and enhancing emergency response. Therefore, progress on Fukushima safety improvements for Gentilly-2 reported in this NPP Report (and for future updates) is limited to actions related to IFBs and emergency response.

In response to the *CNSC Integrated Action Plan* [1], 36 FAIs were derived and are described in appendix G. Hydro-Québec continues to address and finalize the implementation of these FAIs.

Of the 36 FAIs, 19 are applicable to Gentilly-2. By the end of 2013, all but seven actions were closed. Hydro-Québec submitted a Fukushima update in early March 2014, which included a request for closure of all of the remaining FAIs for Gentilly-2. Five more FAIs were closed, and CNSC staff's review of the submission for the remaining two FAIs (2.1.1 and 2.1.2) was ongoing at the time of writing this report (see appendix G).

- ***Evaluation of structural integrity of irradiated fuel bays:*** Hydro-Québec has provided an assessment of the structural integrity of the irradiated fuel bay (IFB) at elevated temperatures. CNSC staff are satisfied with this evaluation and therefore FAI 1.6.1 has been closed. The analysis for FAI 1.6.1 also demonstrated that no additional mitigating measures were needed to protect the IFB structural integrity; therefore, related FAI 1.6.2 has been closed. Since draining of the IFB was precluded, additional hydrogen mitigation was not required; therefore FAI 1.5.1 has also been closed.

- ***Severe accident management guidelines:*** Following a review of the Hydro-Québec FAI update, CNSC staff concluded that severe accident management guidelines (SAMGs) were adequate for Gentilly-2 to protect against beyond-design-basis accidents involving the irradiated fuel bay. Therefore, FAI 3.1.3 has been closed. (Note: FAIs 3.1.1 and 3.1.4 were previously suspended for Hydro-Québec).

- ***Modeling improvements of external hazard:*** The Hydro-Québec request for closure of FAIs 2.1.1 and 2.1.2 was still under review by CNSC staff at the time of writing of this report.

In addition, CNSC staff found Hydro-Québec's submission contained sufficient information to meet the closure criteria for FAI 1.9.1 on the habitability of control facilities during a severe accident. FAI 1.9.1 has therefore been closed.

CNSC staff will continue to monitor FAI implementation at Gentilly-2 through its established compliance verification program, and site-specific action items. Annual updates on FAI implementation will be provided to the Commission as part of the NPP Report.

5.4.4 Public communication

Event initial reports

No event initial reports (EIRs) were submitted for Gentilly-2 from January 2013 to May 2014.

5.5 Point Lepreau

5.5.1 Licensing

The Point Lepreau licence was renewed in February 2012 for a five-year period (effective until June 30, 2017). As a prerequisite for continued operation of the plant, the Commission in its relicensing decision in 2012, included a regulatory hold point for NB Power compliance with N293-07, *Fire protection at CANDU nuclear power plants* [26] by December 31, 2014. In addition, the Commission required that NB Power complete a site-specific seismic hazard assessment and disclose the results through its public information program.

Regulatory hold point for fire protection compliance

To ensure that NB Power implements an adequate emergency management and fire protection program in an acceptable timeframe, the Commission found it necessary to include a regulatory hold point for NB Power's compliance with N293-07, *Fire protection for CANDU nuclear power plants* [26], for Point Lepreau. This hold point serves as a pre-requisite for continued operation of the plant.

To meet this hold point, the licensee must demonstrate that the Point Lepreau emergency management and fire protection program is in compliance with N293-07 by December 31, 2014. This would include additional fire-related analysis, revisions to operating procedures and practices, revisions to the fire protection program, additional training of staff, installation of emergency response equipment, as well as physical modifications to the station. NB Power submitted the code compliance review, fire hazard analysis and fire safe shutdown analysis. CNSC staff had comments on the documents and NB Power is in the process of addressing the comments. Resubmissions by NB Power are scheduled for the spring of 2014.

As well, to demonstrate that the objectives of N293-07 are being achieved, NB Power had to implement compensatory measures. These measures are required to remain in place until permanent solutions are implemented by the end of 2014.

NB Power presented its view on the current status of this project to the Commission during the Commission meeting held on February 5, 2014. During this meeting, NB Power stated that it is confident that compliance with N293-07 will be demonstrated prior to the end of 2014.

CNSC staff will continue to monitor NB Power's progress and plan to report to the Commission on the overall evaluation of NB Power's compliance with N293-07 before the end of 2014.

Site-specific seismic hazard assessment

In its decision to renew the Point Lepreau licence in 2012, the Commission required that NB Power complete a site-specific seismic hazard assessment and share the results through its public information program.

The site-specific seismic hazard assessment is ongoing. NB Power submitted preliminary results to the CNSC at the end of 2012, and this information was posted on the licensee's website. At the request of the CNSC, Natural Resources Canada (NRCan) staff reviewed this preliminary evaluation. NRCan's review provided information on how NB Power's work compares to NRCan's for seismic hazards in the same area, and minor comments were provided. CNSC staff endorsed the NRCan report and provided the results of the review to NB Power.

By the end of 2014, NB Power will submit to the CNSC the final hazard assessment along with any further evaluations and plans for corrective actions (if necessary). This seismic assessment is being tracked under Fukushima action item 2.1.2 (see appendix G for details).

Licence amendments

The Point Lepreau licence was amended once between January 2013 and May 2014. The licence amendment was due to a licence transfer from New Brunswick Power Nuclear Corporation to New Brunswick Power Corporation. Table 20 shows details of this amendment.

Table 20: Amendments to Point Lepreau power reactor operating licence

Power reactor operating licence # - Effective date	Amendment requests
17.02/2017 – October 1, 2013	On April 23, 2013, New Brunswick Power Nuclear Corporation submitted a request to the CNSC for the transfer of the Point Lepreau Nuclear Generating Station power reactor operating licence from New Brunswick Power Nuclear (NBPN) to New Brunswick Power (NB Power). The request by NBPN for licence transfer was to reflect the decision of the government of New Brunswick to reintegrate the separate operating companies of NB Power, which were established through a corporate reorganization in 2004, back into a single vertically integrated utility. NBPN's application was to ensure alignment with the new electricity act for New Brunswick, which came into effect on October 1, 2013. The Commission approved NBPN's request for transfer on September 6, 2013 and the transfer was completed with the coming into force of the new electricity act.

Revisions to the licence conditions handbook

Point Lepreau's LCH was issued on February 20, 2012. Between January 2013 and May 2014, two revisions were made to the Point Lepreau LCH. These revisions included a total of 43 changes to the LCH, mostly administrative in nature. The more significant changes are shown in table 21. The majority of these are technical in nature.

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

Table 21: Significant changes to the LCH for Point Lepreau

Section	Description of change	Revision type
1.1, 3.4, 3.5, 11.2, 16.2, 16.4, Appendix D, E, G	Removed compliance and verification criteria (including related documents) in multiple areas of the LCH due to the completion of the Point Lepreau refurbishment	Administrative
4.2	Updated information on compliance strategy for CSA standard N290.15 – 2010 Edition	Technical
5.1	Updated information on the 2012 Safety Report	Technical
6.2	Updated information on site-specific seismic hazards assessment	Technical
7.1	Clarification of the compliance verification criteria for fitness for service, indicating that operation beyond 210,000 effective full power hours is not permitted unless approved by the Commission.	Technical
7.3	Updated acceptance status of periodic inspection programs and	Technical

Section	Description of change	Revision type
	included fitness-for-service guidelines for steam generators	
8.1	Removed text on alpha hazards as radiation protection program enhancements had been implemented	Administrative
10.1	Updated information on compliance with CSA standard N288.4	Technical
10.2, Appendix D	Updated information on compliance with CSA standard N288.1	Technical
10.2	Updated terminology related to derived release limits	Technical
11.1, 4.2, Appendix E.2	Updated information on severe accident management plan	Technical
16.1	Updated information on financial guarantee	Administrative
16.4	Updated milestones for continued operation hold point related to CSA standard N293-07	Administrative

5.5.2 Updates on major projects and initiatives

Environmental monitoring

NB Power continued to maintain and implement an effective environmental risk assessment and environmental monitoring program consistent with the N288 standards. Work is progressing on an environmental risk assessment as per N288.6-12, *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* [24], with final completion expected by late 2014. In 2013, CNSC staff reviewed and accepted NB Power's implementation plan to address the results of a gap analysis on environmental monitoring against N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [11], noting the need for additional monitoring and documentation.

Intake fish impingement and entrainment

In 2013, at the CNSC's request, NB Power provided the CNSC with a high level plan for intake fish impingement and entrainment monitoring. As part of this plan, NB Power commenced impingement sampling in consultation with the CNSC and the Department of Fisheries and Oceans and has made additional modifications to its impingement monitoring plan, reflective of these ongoing consultations. Entrainment monitoring is scheduled to start in the spring of 2014. A final report on the results of fish impingement and entrainment monitoring is scheduled to be ready for early in 2015.

5.5.3 Updates on significant regulatory issues

Response to the Fukushima Daiichi accident

In response to the *CNSC Integrated Action Plan* [1], 36 Fukushima action items (FAIs) were derived and are described in appendix G.

Of the 36 FAIs, 21 applied to Point Lepreau. By the end of 2013, all but nine action items had been closed. NB Power submitted its FAI update at the end of January 2014, and CNSC staff review of this submission resulted in the closure of an additional six FAIs. Currently, there are three active FAIs for Point Lepreau, all of which are expected to be completed by the end of 2014.

Prior to the Fukushima Daiichi accident, NB Power had completed extensive reviews and safety upgrades in support of the Point Lepreau life extension and refurbishment project. Some of these reviews and safety upgrades, such as the installation of passive autocatalytic recombiners (PARs)

and the emergency filtered containment venting system, were performed to specifically address severe accidents such as the station blackout scenario experienced at Fukushima Daiichi. Additional activities and reviews completed to date or ongoing in response to the Fukushima events are as follows:

The emergency containment filtered ventilation system at Point Lepreau. The system provides additional filtering capability in case of a severe accident.

- ***Procurement of backup emergency mitigating equipment:*** NB Power is in the process of purchasing emergency mitigating equipment (EME). Later in 2014, NB Power will also be constructing a separate storage facility to house the EME at the Point Lepreau site.

  In 2013, NB Power provided a plan and schedule for the evaluation of alternate coolant makeup to the reactor. Design upgrades included the installation of additional connections to the primary heat transport system, steam generators, and moderator system, as well as some modifications to electrical systems. Some of these installations and modifications were to be completed during the spring 2014 outage, while others will be done throughout 2014. Therefore, FAI 1.7.1 was closed on the basis of an approved implementation plan.

- ***Evaluation of structural integrity of irradiated fuel bays:*** NB Power completed a structural integrity analysis on the reinforced concrete structure of the Point Lepreau irradiated fuel bay (IFB) under the beyond design basis condition where the cooling water temperature rises to 100°C due to a station blackout. The analysis concluded that the IFB structure will not collapse when the temperature reaches 100°C. However, crack initiation and propagation is expected to occur with temperature rise. The analysis recommended controlling the in-bay temperature such that it does not reach 100°C. In addition, NB Power indicated that it will take the mitigating measures to address the IFB leakage event due to the development of a small crack at the interface of the wall and base slab of the IFB structure. NB Power provided a detailed plan and schedule for the mitigating actions. Based on the review of the mitigation plans, CNSC staff accepted that rapid draining of the IFB is precluded and hydrogen mitigation in the IFB area is therefore not needed. Therefore, related FAIs 1.5.1, 1.6.1 and 1.6.2 were closed.

- ***Modeling improvements of external hazard:*** As per a Commission request, NB Power agreed to submit a revised seismic hazard assessment to staff. CNSC staff are tracking this commitment under FAIs 2.1.1 and 2.1.2. In their submission (Update No.4), NB Power provided further information on the progress of the work related to seismic, tsunami and wind external hazards with their completion date of December 31, 2014.

- ***Instrumentation survivability during severe accident conditions:*** CNSC staff review of the CANDU Owners Group (COG) generic equipment and instrumentation survivability assessment methodology for the instrumentation and equipment survivability under severe accident conditions is ongoing. CNSC staff found the generic methodology acceptable, and

therefore related FAI 1.8.1 is closed. If necessary, any issues identified with the generic methodology will be communicated to NB Power in future site-specific action items.

CNSC staff will continue to monitor FAI implementation at Point Lepreau through its established compliance verification program. Annual updates on FAI implementation will be provided to the Commission as part of the NPP Report.

5.5.4 Public communication

Event initial reports

One event initial report (EIR) was submitted for Point Lepreau from January 2013 to May 2014, as shown in table 22. The EIR event had low safety significance.

Table 22: Event initial reports for Point Lepreau

Subject	Brief description
Release of light water containing hydrazine from Point Lepreau	On November 4, 2013 NB Power reported to CNSC site office staff that non-radioactive water containing a low concentration of dissolved hydrazine had been released from Point Lepreau. Prior to this date, regularly scheduled environmental sampling conducted by NB Power at a pre-selected storm drain sampling point in the area surrounding the station had shown traces of hydrazine but below reportable levels. In accordance with station procedures, NB Power conducted additional rounds of sampling to obtain the environmental data required to confirm the release, to assess its impact, and to identify its source. The source of the leak was traced back to a condensate polisher relief valve (a feed water system component) that opened and discharged water containing dissolved hydrazine into an inactive sump. The contents of the inactive sump were subsequently released into the environment. Licensee staff promptly shut down and isolated the inactive sump to prevent further releases. The results from subsequent environmental samples confirmed that the concentration of hydrazine detected was decreasing and that the source had been correctly identified and isolated. This event was reported to the Commission through CMD 13-M53 on December 9, 2013. Additional reporting was made on February 5, 2014 after CNSC staff reviewed the cause analysis report provided by NB Power. This report confirmed the event was caused by a design issue with the condensate polisher that caused the opening of a relief valve during operation at low power levels. NB Power also identified the unavailability of sump pumps as a contributing factor for this event. NB Power is in the process of modifying the condensate polisher procedure to prevent recurrence. This corrective measure will be in place until a permanent solution is implemented through a design change. The discharge flow path of the sump pump that released the water from the inactive sump to the environment through a storm drain (drainage ditch) has also been re-routed. Finally, improvements to the sump pump maintenance program are being implemented to improve the pump's reliability. This event has been disclosed on the licensee and CNSC websites. This event was reported to the Commission through CMD 13-M53 and 14-M4. These two CMDs completed the CNSC staff notification to the Commission on this event.

6. Summary and Conclusions

This report summarizes the CNSC staff's assessment of the safety performance of nuclear power plant (NPP) licensees and of the industry as a whole in 2013. The report also provides information on CNSC staff evaluation of how well licensees are meeting 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 activities against relevant requirements, expectations and performance objectives.

CNSC staff concluded that NPPs in Canada were operated safely during 2013, and that licensees made adequate provision 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.

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 limit
- no workers 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 their licence conditions concerning Canada's international obligations

Table 23 summarizes the 2010–13 ratings for Canada's NPPs. For each station, the SCAs are presented along with the industry averages and the integrated plant ratings (IPRs) that measure a plant's overall safety performance. Overall, the trend is one of maintaining and/or improving performance in terms of SCA ratings and IPRs. Specifically, in 2013:

- a total of 11 SCAs for the NPPs were rated as "fully satisfactory" (FS). This is the highest number since the SCA framework was introduced in 2010, and it is an increase of two from the previous maximum recorded in 2012
- in the conventional health and safety and the security SCAs, the Canadian nuclear power industry achieved an average rating of "fully satisfactory" – four of the six stations received ratings of "fully satisfactory" for these two SCAs
- the IPRs were "fully satisfactory" for Darlington and "satisfactory" (SA) for all other stations
- no SCA received a rating of "below expectations" (BE) or "unacceptable" (UA), and this was also the case in the final results for 2011 and 2012

Table 23: Trends of ratings from 2010 to 2013

Safety and control area	Year	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
		A	B					
Management system	2010	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Human performance management	2010	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Operating performance	2010	SA	SA	FS	SA	SA	SA	SA
	2011	SA	SA	FS	SA	SA	SA	SA
	2012	SA	SA	FS	SA	SA	SA	SA
	2013	***SA***	***SA***	***FS***	***SA***	***SA***	***SA***	***SA***
Safety analysis	2010	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Physical design	2010	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Fitness for service	2010	SA	SA	FS	SA	SA	SA	SA
	2011	SA	SA	FS	SA	SA	SA	SA
	2012	SA	SA	FS	SA	SA	SA	SA
	2013	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Radiation protection	2010	BE	SA	FS	SA	SA	SA	SA
	2011	SA	SA	FS	SA	SA	SA	SA
	2012	SA	SA	FS	SA	SA	SA	SA
	2013	***SA***	***SA***	***FS***	***FS***	***SA***	***SA***	***SA***
Conventional health and safety	2010	SA	SA	FS	SA	SA	SA	SA
	2011	FS	FS	FS	SA	SA	SA	SA
	2012	FS	FS	FS	SA	SA	FS	FS
	2013	***FS***	***FS***	***FS***	***SA***	***SA***	***FS***	***FS***
Environmental protection	2010	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Emergency management and fire protection	2010	SA	SA	SA	SA	SA	BE	SA
	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Waste management	2010	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Security	2010	FS	FS	SA	SA	SA	SA	SA
	2011	FS	FS	SA	SA	SA	SA	SA
	2012	FS	FS	SA	SA	SA	SA	SA
	2013	***FS***	***FS***	***FS***	***FS***	***SA***	***SA***	***FS***

Safety and control area	Year	Bruce		Darlington	Pickering	Gentilly-2	Point Lepreau	Industry average
		A	B					
Safeguards and non-proliferation	2010	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Packaging and transport	2010	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA
	2012	SA	SA	SA	SA	SA	SA	SA
	2013	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Integrated plant rating	2010	SA	SA	FS	SA	SA	SA	SA
	2011	SA	SA	FS	SA	SA	SA	SA
	2012	SA	SA	FS	SA	SA	SA	SA
	2013	***SA***	***SA***	***FS***	***SA***	***SA***	***SA***	***SA***

Furthermore, as shown in table 23, in 2013, within the industry:

- Darlington received four “fully satisfactory” ratings (in operating performance, radiation protection, conventional health and safety, and security). The number of “fully satisfactory” SCAs for Darlington remained unchanged from 2012, at four. The safety performance rating for security improved from “satisfactory” in 2012 to “fully satisfactory” in 2013. However, CNSC staff determined that the rating for fitness for service at Darlington for 2013 returned to “satisfactory” from “fully satisfactory”
- Bruce A and B each received two “fully satisfactory” safety performance ratings (in conventional health and safety, and in security), unchanged from 2012
- Pickering received two “fully satisfactory” safety performance ratings (in radiation protection and in security), an improvement for both SCAs from 2012
- Point Lepreau received a “fully satisfactory” safety performance rating in conventional health and safety, unchanged from 2012
- In summary, there were 11 “fully satisfactory” ratings across the SCAs. Improvements resulted in increases in the safety performance ratings for Pickering in radiation protection and in security to “fully satisfactory” and for Darlington in security to “fully satisfactory”. The fitness for service rating for Darlington returned to “satisfactory” in 2013 from “fully satisfactory” in 2012. The number of “fully satisfactory” ratings increased by two from 2012

During 2013, CNSC staff observed 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* [1] and implemented by NPP licensees address safety improvements aimed at strengthening defence-in-depth, and enhancing onsite emergency response. All Canadian NPP licensees have made considerable progress in addressing and implementing FAIs at their stations. Specifically, for this reporting period, all medium-term FAIs to be completed by the end of 2013 are closed with the exception of a few related to probabilistic safety assessment for external hazard assessment pending completion of review by CNSC staff. The Canadian nuclear power industry is on track to complete all enhancements by the December 2015 deadline set forth in the *CNSC Integrated Action Plan* [1]. For details see appendix G.

Appendix A: 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) that are grouped according to their functional areas of management, facility and equipment, or core control processes.

These SCAs are further divided into 70 specific areas that define the key components of the SCA. The functional areas, SCAs and the specific areas that are used in the CNSC's safety performance evaluation for 2013 are given in table A.1.

Table A.1: The CNSC's functional areas, safety and control areas and specific areas for assessing licensee safety performance

Functional area	Safety and control area (SCA)	Specific area
Management	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
Facility and equipment	Safety analysis	Deterministic safety analysis
		Probabilistic safety analysis
		Criticality safety
		Severe accident analysis
		Environmental risk assessment
		Management of safety issues (including R&D programs)
	Physical design	Design governance
		Site characterizations
		Facility design
		Structure design
		System design
		Components design

Functional area	Safety and control area (SCA)	Specific area
	Fitness for service	Equipment fitness for service / equipment performance
		Maintenance
		Structural integrity
		Aging management
		Chemistry control
		Periodic inspections and testing
Core control processes	Radiation protection	Application of 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
	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 IAEA
		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

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

Performance objectives

There is an effective management system that integrates provisions to address all regulatory and other requirements to enable the licensee to achieve its safety objectives, continuously monitor its performance against those objectives, and maintain a healthy safety culture.

Configuration management is the process of identifying and documenting the characteristics of the NPP's structures, systems and components (SSCs) (including computer systems and software) and ensuring that the changes to these characteristics are properly developed, assessed, approved, issued, implemented, verified, recorded and incorporated into the plant documentation. The licensee is required to ensure that all the systems important to safety meet the design requirements, and that the plant documentation reflects the physical plant.

2. Human performance management

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

Performance objectives

Licensee staff are sufficient in number in all relevant job areas and have the necessary knowledge, skills, procedures and tools in place to safely carry out their duties.

3. Operating performance

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

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

The safety analysis SCA includes maintenance of the safety analysis that supports the overall safety case for the facility. Safety analysis is a systematic evaluation of the potential hazards associated with the conduct of a proposed activity or facility and considers the effectiveness of preventive measures and strategies in reducing the effects of such hazards. For NPPs, safety analysis is primarily deterministic in demonstrating the effectiveness of implementation of the fundamental safety functions of 'control, cool and contain' through a 'defence-in-depth' strategy. Risk contributors are considered and assessed using probabilistic safety analysis to identify challenges to physical barriers. However, appropriate safety margins should be applied to address uncertainties and limitations of probabilistic safety analysis.

Performance objectives

There is demonstration of the acceptability of the consequences of design-basis events, and protective systems can adequately control power, cool the fuel and contain any radioactivity that could be released from the plant.

5. Physical design

The physical design SCA relates to activities that affect the ability of structures, systems and components (SSCs) to meet and maintain their design basis, as new information arises over time and taking into account changes in the external environment.

Performance objectives

There is confirmation that SSCs important to nuclear safety and security continue to meet their design basis in all operational states until the end of their design life.

6. Fitness for service

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

Performance objectives

SSCs, the performance of which may affect safety or security, remain available, reliable and effective, and consistent with the design, analysis, and quality control measures.

In the specific area of aging management, licensees are expected to establish, implement and improve programs for managing aging and obsolescence of SSCs. These programs ensure that required safety functions are always maintained throughout the life of each facility.

7. Radiation protection

The radiation protection SCA covers the implementation of a radiation protection program in accordance with the *Radiation Protection Regulations*. This program must ensure that 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

The conventional health and safety SCA covers the implementation of a program to manage workplace safety hazards and to protect personnel and equipment.

Performance objectives

Conventional health and safety work practices and conditions achieve a high degree of personnel safety.

9. Environmental protection

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

Performance objectives

The environment and the health and safety of persons are protected by the licensee taking all reasonable precautions, including identifying, controlling and monitoring the release of nuclear substances and hazardous substances to the environment.

10. Emergency management and fire protection

The emergency management and fire protection SCA covers emergency plans and emergency preparedness programs that exist for emergencies and for non-routine conditions including any results of

exercise participation. This also includes conventional emergency and fire response. This SCA includes the fire response rating, while fire protection operations, design and analysis are discussed and rated in the appropriate SCA of operating performance, safety analysis or physical design.

Performance objectives

Adequate provisions are made for preparedness and response capability that would mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment, the health and safety of persons and the maintenance of national security.

A comprehensive fire protection program is implemented to minimize the risk to the health and safety of persons and to the environment from fire, through appropriate fire protection system design, fire safety analysis, fire safe operation and fire prevention.

11. Waste management

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

Performance objectives

There is full development, implementation and auditing of a facility- and waste stream-specific waste management program 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; and a decommissioning plan is maintained.

Decommissioning consists of those actions taken in the interest of health, safety, security and the environment to retire a licensed facility or site permanently from service and render it to a predetermined end-state condition. In accordance with the *Class I Nuclear Facilities Regulations*, all power reactor licensees must maintain an acceptable decommissioning plan that sets out how the nuclear facility will be decommissioned in the future. This plan must be reviewed and updated by the licensee on a regular five-year schedule. The plan also forms the basis of developing the cost estimate for decommissioning; hence, the associated financial guarantee that assures that funds for decommissioning will be available when the facility is ready to be dismantled.

All NPPs in Canada have a financial guarantee that has been accepted by the Commission. In all cases, the decommissioning strategy proposed by the licensees must allow for an extended period of storage with surveillance after the end of normal operations under the authority of a decommissioning licence that would last for three or four decades prior to the onset of active dismantling. This period allows for radioactive decay and for the development of appropriate facilities to manage the resulting radioactive wastes.

12. Security

The security SCA covers the programs required to implement and support the security requirements stipulated in the regulations, in their licence, in orders, or in expectations for their facility or activity.

Performance objectives

Loss, theft or sabotage of nuclear material or sabotage of the licensed facility are prevented.

13. Safeguards and non-proliferation

The safeguards and non-proliferation SCA covers the programs and activities required for the successful implementation of the obligations arising from the Canada/IAEA safeguards agreements as well as all other measures arising from 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

Safeguards consist of a system of inspection and other verification activities undertaken by the IAEA to evaluate Canada's compliance with its obligations in accordance with its safeguards agreement for the peaceful use of nuclear energy. The CNSC requires licensees to maintain a program and appropriate procedures to ensure that safeguards can be effectively implemented at the facility level in a manner consistent with these obligations. CNSC staff evaluate each licensee's program and procedures, along with their implementation, to assess compliance with the regulations and licence conditions.

For NPPs, the non-proliferation program is limited to the tracking and reporting of foreign obligations and origins of nuclear material. This tracking and reporting assists the CNSC in implementing Canada's bilateral nuclear cooperation agreements with other countries.

14. Packaging and transport

The packaging and transport SCA covers the programs for the safe packaging and transport of nuclear substances to and from the licensed facility.

Performance objectives

All shipments leaving the site adhere to the *Packaging and Transport of Nuclear Substances Regulations* and the *Transportation of Dangerous Goods Regulations* [22].

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

NPP licensees are required to have appropriate training for personnel involved in the handling, preparation for transport, and transport of dangerous goods and are required to issue training certificates 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 and maintain a list of third-party carriers who may be used for shipments of nuclear substances.

NPP licensees must comply with both the *Packaging and Transport of Nuclear Substances Regulations* and the *Transportation of Dangerous Goods Regulations* for all shipments of nuclear substances leaving a site. They must prepare and maintain documentation demonstrating that the packages used to transport nuclear substances meet the requirements specified in the *Packaging and Transport of Nuclear Substances Regulations* and the *Transportation of Dangerous Goods Regulations*.

Appendix B: Rating Definitions and Methodology

B.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 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 area 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 area 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 overall area 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 an unreasonable risk. Issues are not being addressed effectively, no appropriate corrective measures have been taken, and no alternative plan of action has been provided. Immediate action is required.

B.2 Rating methodology

The methodology for rating licensees is a detailed one which relies on multiple sources of inputs that are derived primarily from CNSC staff findings. These findings are based on regulatory activities such as inspections, field rounds, follow-ups on the licensee's progress on enforcement actions and desktop reviews. The methodology is not based entirely on a computational system; it also requires engineering judgment and inputs from the regulatory program managers for rating results that are on the rating interfaces.

The rating methodology is based upon ratings made at three distinct levels:

- Specific areas
- Safety and control areas (SCAs)
- Overall plant (also known as the integrated plant rating (IPR))

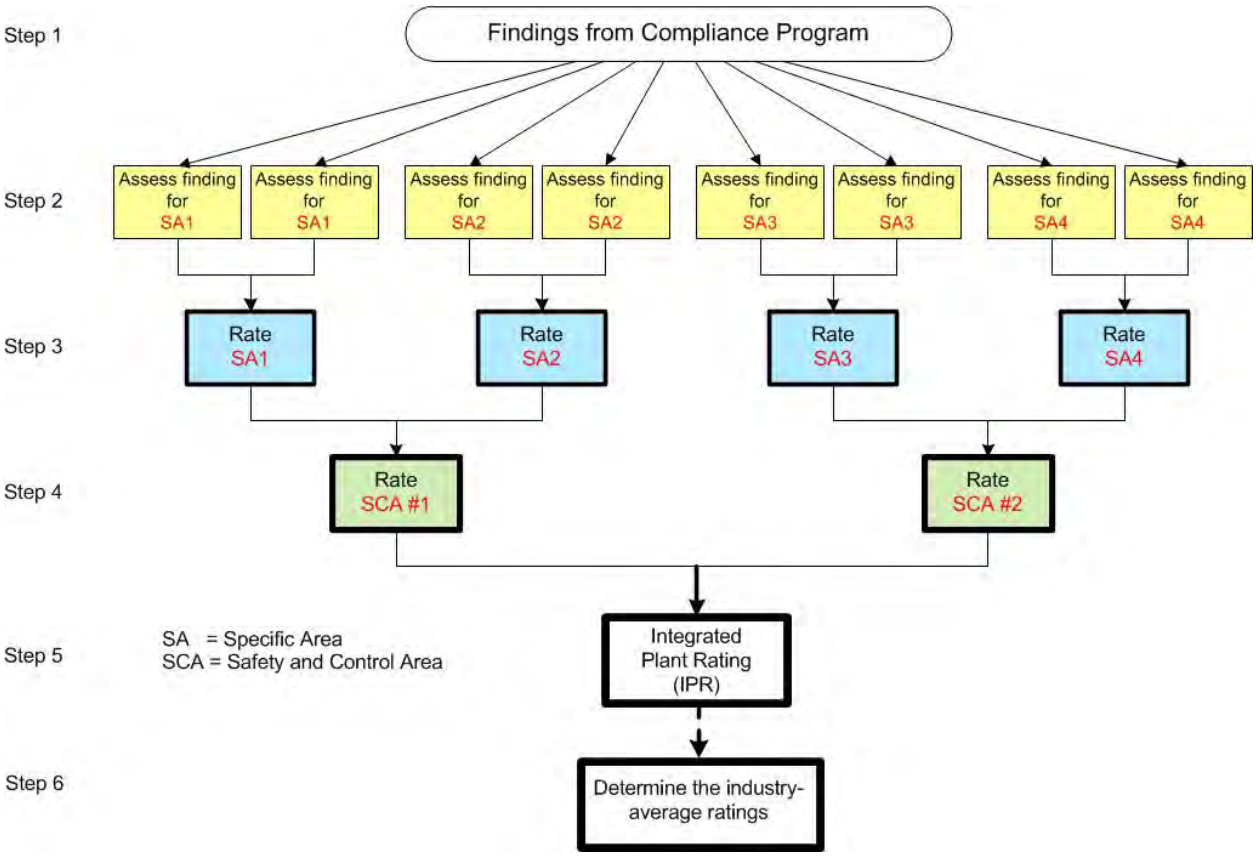
The significance of findings within a specific area is used to determine the performance rating within that specific area for a plant. This rating process results in performance ratings for each of the SCAs, as given in appendix A.

An algorithm is applied to determine the individual SCA performance rating for each station. The algorithm converts that SCA's specific area ratings to numeric values (based on a conversion table), computes the average value, and converts that average value (based on a rating grid) into an SCA performance rating. The result is 14 SCA performance ratings for each of the six Canadian NPPs.

For each NPP, its IPR 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 IPR for the NPP.

Figure B.1 shows a graphical representation of the methodology to determine the IPR for each NPP. To simplify the process, only four specific areas are shown.

Figure B.1: Methodology for determining performance ratings



Steps shown, from top to bottom, are as follows:

Step 1: Identify the findings

The findings are identified for each specific area using information from a variety of sources, including inspections, field rounds, follow-ups on the licensee's progress on enforcement actions and desktop

reviews. Findings are evaluated against a set of compliance criteria developed for each specific area that measures the degree of conformity with legal requirements.

Step 2: Assess the findings
CNSC staff evaluate the findings against the compliance criteria and assign an assessment: high, medium, low, negligible or positive. The assessment of the finding depends on the degree of negative impact on the effectiveness of the specific area, as defined here:

High: Major negative impact on effectiveness of safety and control measures in the specific area; evidence of breakdown

Medium: Significant negative impact on effectiveness of safety and control measures in the specific area

Low: Small negative impact on effectiveness of safety and control measures in the specific area

Negligible: Insignificant impact on effectiveness of safety and control measures in the specific area

Positive: Evidence that the specific area is effective

Step 3: Rate the specific area
CNSC staff consider the relevant findings for the specific area and determine the effectiveness using a CNSC-developed guideline. The findings are judged in the context of the performance objective for the relevant SCA. The assessed effectiveness categories for all findings of a specific area are converted into a performance rating of FS, SA, BE, or UA:

FS: Safety and control measures were highly effective

SA: Safety and control measures were sufficiently effective

BE: Safety and control measures were marginally ineffective

UA: Safety and control measures were significantly ineffective

The performance rating definitions are applied for the rating of the specific areas, SCAs and IPRs.

Step 4: Rate the SCA
The specific area ratings are converted to an integer-based value. The 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: Determine the integrated plant rating
The IPR 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. The 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: Determine the industry-average ratings
In addition, the industry-average ratings are determined by averaging the individual SCA and IPR ratings for all the stations. The SCA ratings for each NPP are used to determine the overall industry-average rating for each SCA, and the individual IPRs for each NPP are used to determine the average IPR for the overall industry.

Summary

The annual ratings are based upon a methodology which employs, at its foundation, the significance of findings from inspections, field rounds, follow-ups on the licensee's progress on enforcement actions and desktop reviews conducted by CNSC staff. In addition, CNSC staff judge, using engineering and professional inputs, the effectiveness of the safety and control measures associated with the specific area to determine its rating.

Once all the specific area ratings have been determined, the SCA values are determined, using the integer-based values obtained from the conversion of their specific area ratings, and then converted to performance ratings. A similar process is used for the IPR using the SCA values.

A FS rating 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 that the licensee 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 the ratings across the nuclear power industry and between each annual NPP Report.

The complete results for 2013 are shown in table 1 (in the Executive Summary), and the four-year trend is shown in table 23 (in section 6, Summary and Conclusions).

Appendix C: Research and Development Efforts in Support of NPP Regulation

This appendix provides information on research and development (R&D) activities being conducted by the industry and CNSC to enhance the safety of NPP operations.

C.1 Industry R&D activities

The CANDU Owners Group (COG) R&D program and the Industry Standard Toolset (IST) program are sponsored by three Canadian utilities - Bruce Power, OPG and NB Power, by the Romanian Societatea Nationala NuclearElectrica, and by Atomic Energy of Canada Limited. In 2012-13 the Korea Hydro and Nuclear Power Company sponsored the Safety and Licensing and IST R&D Programs. In 2012-13 Hydro Québec sponsored the Safety and Licensing R&D program. As specified in COG-12-9007, *COG R&D Program Overview: 2012/13* [40], 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

The CNSC has reviewed during the year submissions from the industry on the work plans, analysis methodology and results for these ongoing safety analysis programs.

C.2 CNSC R&D activities

CNSC regulatory research and evaluation

The CNSC's research program is active in various safety and control areas (SCAs). These activities listed by SCA include the following.

Human performance management

In 2013, the CNSC completed the project *Review of criteria for assessing shift schedules in the nuclear industry* (R546.1).

Safety analysis

The *Statistical analysis of common cause failure data* (R507.3) project was completed in 2013. This work will improve knowledge of "common cause failures" and assist the CNSC in the support of safety and reliability analyses. Another important study, *Incorporating ageing effects into PSA applications* (R322.3), currently in progress, will allow the CNSC to incorporate aging effects into probabilistic safety assessments (PSAs).

Fitness for service

The CNSC completed a major study, *Probabilistic assessment of leak rates through steam generator tubes* (R131.2). This project consolidated data on CANDU and pressurized water reactor steam generator tube degradation mechanisms and resulting leak rates. The consolidated data will enable staff to evaluate with better confidence the integrity of steam generator tubes for the existing reactor fleet. A probabilistic assessment methodology for leak rate modeling was developed and implemented for the models in the steam generator integrity code – CANTIA (CANDU Tube Inspection Assessment). The end result is improved probabilistic leak rate predictions for steam generator tubes. Another project, *Loading of steam*

generator tubes during main steam line breaks (R430.3), currently in progress, will give the CNSC a better understanding of the impact of a main steam-line break on steam generator tubes.

Radiation protection

In this area, the CNSC is currently working on the study *Characterization of alpha radiation hazards: Bio-solubility of radionuclides within CANDU reactor aerosols and implications for internal dosimetry* (R531.1).

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, where the safety assessment has been based on conservative assumptions, and where 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 the safe operation of the facility, 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 C.1. Since January 2013, as shown in table C.2, two CSIs were re-categorized for all licensees to a lower safety significance category where appropriate measures are in place to maintain safety margins and CNSC staff will continue to monitor the licensees' management of these safety issues. Ten CSIs requiring further experimental and/or analytical studies were pending resolution, as shown in tables C.3 and C.4. Three of these are related to large loss of coolant accidents (LLOCAs), while the remaining seven belong to the group of non-LLOCA issues.

For the non-LLOCA issues (table C.4), all CSIs except fuel bundle / element behaviour under post dry-out conditions (PF 18) have been either re-categorized (for specific sites) or information for re-categorization is being assessed by CNSC staff. The resolution of the non-LLOCA CSIs is expected by the end of 2014. This is a revision from the end of 2013 as given in the 2012 NPP Report. The reasons for the change are the need for discussions between CNSC and licensees' staff to clarify requirements, non-availability of a regulatory document and the fact that not all licensees have demonstrated a generic solution for implementation under site-specific action items.

Table C.1: Categories of CSI safety significance

Category	Meaning
1	The issue has been satisfactorily addressed in Canada.
2	The issue is a concern in Canada. However, the licensees have appropriate control measures in place to address the issue and to maintain safety margins.
3	The issue is a concern in Canada. Measures are in place to maintain safety margins, but further experiments and/or analyses are required to improve knowledge and understanding of the issue, and to confirm the adequacy of the measures.

Table C.2: Details of the CSIs re-categorized to Category 2 for all licensees

CSI	Title	Brief description	Notes	Re-categori-zation date
PF 12	Channel voiding during a LLOCA	Licensees have been asked to adequately validate the computer codes used for prediction of overpower transients for CANDU reactors.	Site-specific action items were opened to address the residual issues.	May 2013
CI 1	Fuel channel integrity and effect on core internals	Safety-related functions in nuclear power plants 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, licensee programs for management of aging of other systems and components have not been systematically implemented.	May 2014

Table C.3: Details of the Category 3 LLOCA CSIs

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 the reactor behaviour under accident conditions are subject to some uncertainties.	The CNSC has developed an interim regulatory position, which 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 the industry.	Under review by CNSC
PF 9	Fuel behaviour in high temperature transients			
PF 10	Fuel behaviour in power pulse transients			

Table C.4: Details of the Category 3 non-LLOCA CSIs

CSI	Title	Brief description	Notes	Target date
GL 3	Aging of equipment and structures	Safety-related functions in nuclear power plants 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, licensee programs for management of aging of other systems and components have not been systematically implemented.	December 2014 (Remains for Point Lepreau)
PF 19	Impact of aging on safe plant operation			December 2014 (Remains for Point Lepreau)
PF 20	Analysis methodology for neutron/regional	The neutron/regional overpower trip setpoint function is designed to provide the reactor trip for the	Licensees provided physical, operational, and analytical measures, as well as relevant	September 2014

CSI	Title	Brief description	Notes	Target date
	overpower	analyzed core states prior to fuel dry-out. The trip setpoint is designed to prevent any potential fuel damage, primarily for slow loss of regulation (SLOR) events.	empirical evidence to enhance the confidence in the values of installed trip setpoints. Industry will continue to propose activities and time frame for developing and qualifying a practical method for derivation of neutron overpower protection trip setpoints.	
PSA 3	Design of the balance of plant – steam protection	This issue is applicable to the multi-unit stations where steam line breaks and feedwater line breaks are the largest contributors to core damage frequency and large release frequency, accounting for about 70 percent to 80 percent. These line breaks could lead to widespread damage of many electrical cabinets and systems.	Licensees need to consider practicable measures to reduce the probability of consequential failures of support systems to control, cool, and contain (e.g., instrument air; electrical; heating, ventilation, and air conditioning; emergency forced air discharge system; air cooling units).	September 2014 (Remains for Bruce A and B and Pickering)
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.	The industry has to provide systematic analysis for protecting structures, systems and components from the effects of postulated pipe rupture.	December 2014 (Remains for Pickering and Point Lepreau)
AA 3	Computer code and plant model validation	Specific validation programs have been established for industry standard computer codes that provide the necessary confidence in the safety analyses being performed.	Further work is required by industry to demonstrate that the existing code validation, in general, complies with the requirements that would allow a full qualification of these codes.	September 2014
PF 18	Fuel bundle/ element behaviour under post dry-out conditions	Specific models, such as fuel bundle deformation, require improvements to increase the confidence in the prediction of fuel element or fuel channel failure.	Licensees need to present experimental or analytical evidence to clarify the conditions for fuel deformation and for fuel sheath failure (e.g., dry-out, fuel temperature, timing of failure), and for the consequential failure of fuel channels.	September 2014

Appendix D: NPP Collective Effective Doses

The following figures provide a five-year trend (from 2009 to 2013) of the annual collective effective doses (hereafter referred to as collective doses) to workers at each station. This information has been broken down to illustrate the operational state of the reactor when the dose was received (i.e., during operation or during outages/refurbishment), and the pathways of exposure (i.e., internal or external). Note that the figures provide the doses received by the same group of workers.

For each NPP:

- The first figure provides collective doses received during routine operations (day-to-day) versus doses received during outages/refurbishment. The collective dose shown for routine operations and outages/refurbishment includes both external and internal doses.
- The second figure provides 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 the workers at that NPP in a year. It is measured in person-sievert (p-Sv). There is no regulatory dose limit for the annual collective dose; however, it is used internationally as a benchmark for assessing the reactor dose performances.

For routine operations, variations between years are attributed, in part, to how long the plant operated during each year, as well as typical dose rates associated with the operation of the station.

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 the dose rates associated with the outage work.

The external dose is the portion of the dose that was received from radiation sources outside the body, while the internal dose is the portion received from radioactive material taken into the body.

In 2013, approximately 89 percent of the collective dose was due to outage activities, and most of the radiation dose received by the workers came from external exposure. Approximately 11 percent of the dose received was from internal exposure, with tritium being the main contributor to the internal dose of exposed workers.

Note: Caution should be used when comparing the collective dose data between NPPs; such a comparison is not entirely appropriate, due to the differences between individual stations (such as design, age, operation and maintenance).

D.1 Annual collective doses at Bruce A and B

In 2013, Bruce Power was effective in controlling worker radiological exposures at Bruce A and B.

Bruce A

Figures D.1 to D.2 present the collective doses at Bruce A Units 1 to 4.

At Bruce A, all four units were operational with a total of 132 outage days. Outage activities at Bruce A accounted for approximately 74% of the total collective dose. Outage work included repairs to the annulus gas system for Unit 1 and maintenance activities related to the Unit 4 outage that began in 2012 and carried over to early 2013.

Routine operations accounted for approximately 26% of the total Bruce A collective dose. Internal dose was approximately 6% of the total Bruce A collective dose.

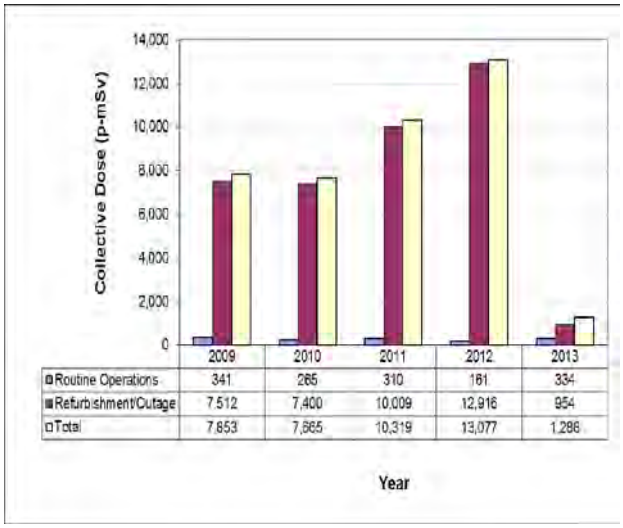
Bruce B

Figures D.3 and D.4 reflect the collective doses at Bruce B Units 5 to 8.

At Bruce B, all four units were operational with a total of 158 outage days. The performance of three planned outages in 2013 accounted for higher collective doses compared to 2012 (which had one planned outage). Outage activities at Bruce B accounted for approximately 91% of the total Bruce B collective dose.

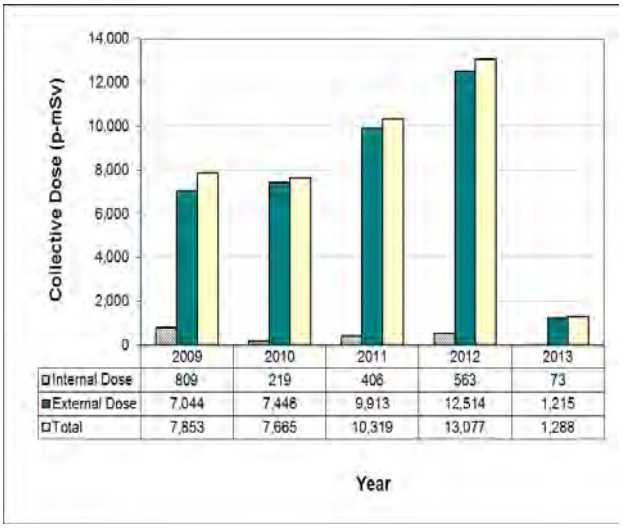
Routine operations accounted for 9% of the total station collective dose. Internal dose was approximately 6% of the total Bruce B collective dose.

Figure D.1: Collective dose by operational state for Bruce A – Units 1 to 4



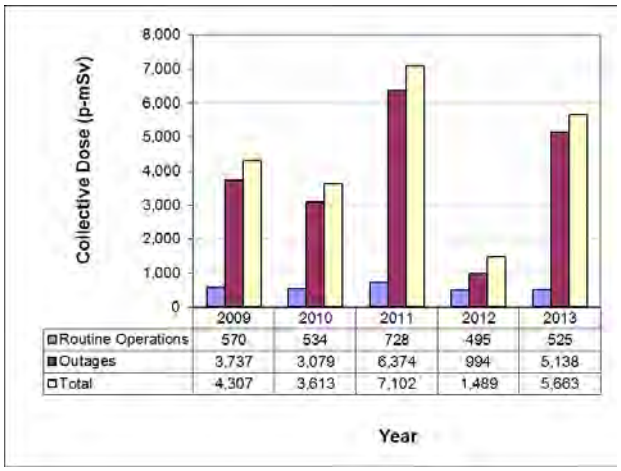
	2009	2010	2011	2012	2013
Routine Operations	341	265	310	161	334
Refurbishment/Outage	7,512	7,400	10,009	12,916	954
Total	7,853	7,665	10,319	13,077	1,286

Figure D.2: Collective dose from internal and external exposures for Bruce A – Units 1 to 4



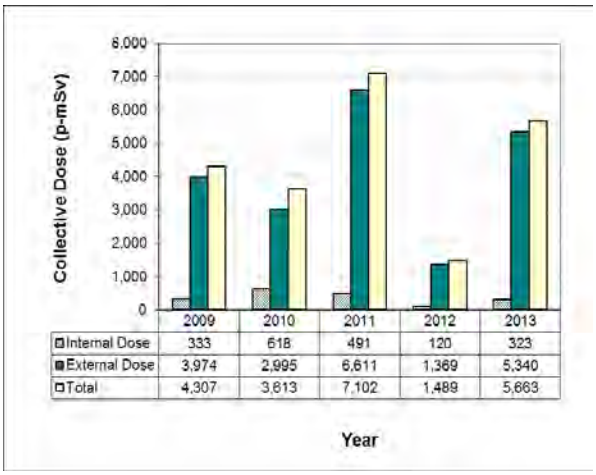
	2009	2010	2011	2012	2013
Internal Dose	809	219	406	563	73
External Dose	7,044	7,448	9,913	12,514	1,215
Total	7,853	7,665	10,319	13,077	1,288

Figure D.3: Collective dose by operational state for Bruce B – Units 5 to 8



	2009	2010	2011	2012	2013
Routine Operations	570	534	728	495	525
Outages	3,737	3,079	6,374	994	5,138
Total	4,307	3,613	7,102	1,489	5,663

Figure D.4: Collective dose from internal and external exposures for Bruce B – Units 5 to 8



	2009	2010	2011	2012	2013
Internal Dose	333	618	491	120	323
External Dose	3,974	2,995	6,611	1,369	5,340
Total	4,307	3,613	7,102	1,489	5,663

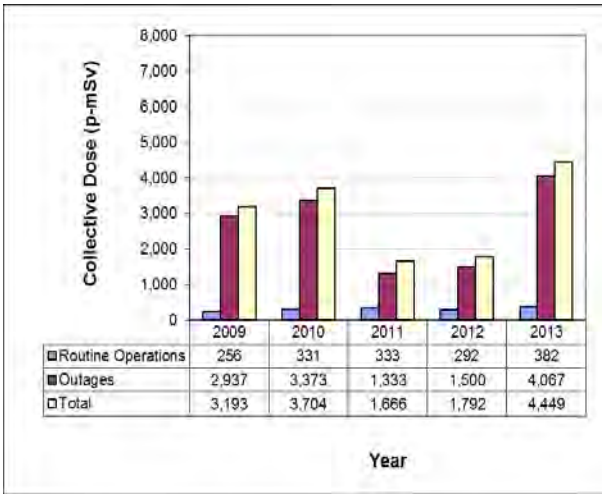
D.2 Annual collective doses at Darlington

In 2013, OPG was effective in controlling worker radiological exposures at Darlington. Figures D.5 and D.6 present the collective doses at Darlington Units 1 to 4.

At Darlington, all four units were operational with a total of 234 outage days. The performance of two planned outages, the extensions to these outages, and five forced outages in 2013 account for higher collective doses compared to 2012 (which had one planned outage). Outages to perform maintenance and inspection activities including a single fuel channel replacement, boiler inspections, feeder inspections, and primary heat transport valve maintenance accounted for 91% of the total station dose.

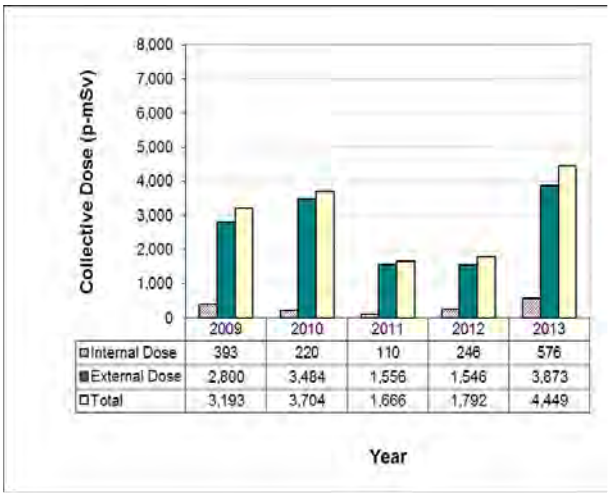
Routine operations accounted for approximately 9% of the total collective dose. Internal dose was approximately 13% of the total collective dose.

Figure D.5: Collective dose by operational state for Darlington – Units 1 to 4



	2009	2010	2011	2012	2013
Routine Operations	256	331	333	292	382
Outages	2,937	3,373	1,333	1,500	4,067
Total	3,193	3,704	1,666	1,792	4,449

Figure D.6: Collective dose from internal and external exposures for Darlington – Units 1 to 4



	2009	2010	2011	2012	2013
Internal Dose	393	220	110	246	576
External Dose	2,800	3,484	1,556	1,546	3,873
Total	3,193	3,704	1,666	1,792	4,449

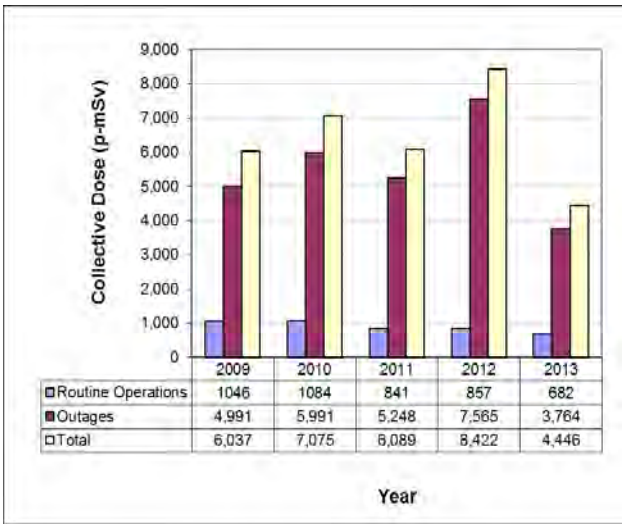
D.3 Annual collective doses at Pickering

In 2013, OPG was effective in controlling worker radiological exposures at Pickering. Figures D.7 and D.8 present the collective doses at Pickering Units 1 to 8

Pickering Units 1 and 4 and Units 5 to 8 were operational with a total of 467 outage days. Units 2 and 3 continued to remain in a safe storage state. Outage activities to perform maintenance and inspection activities accounted for approximately 84% of the total station collective dose.

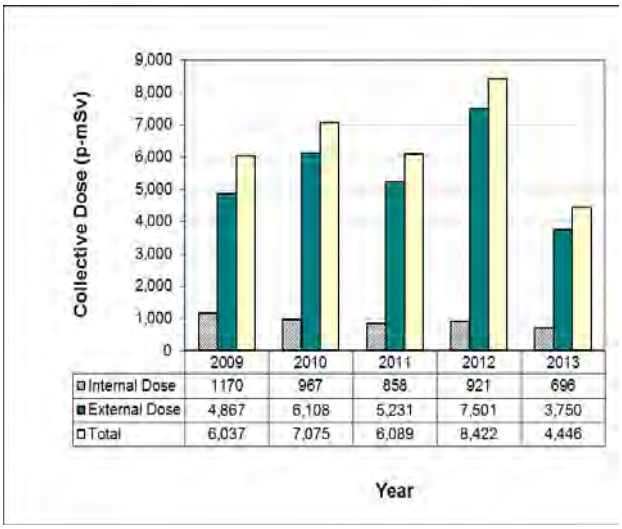
Routine operations accounted for approximately 16% of the total collective dose. Internal dose was approximately 16% of the total collective dose.

Figure D.7: Collective dose by operational state for Pickering – Units 1 to 8



	2009	2010	2011	2012	2013
Routine Operations	1046	1084	841	857	682
Outages	4,991	5,991	5,248	7,565	3,764
Total	6,037	7,075	6,089	8,422	4,446

Figure D.8: Collective dose from internal and external exposures for Pickering – Units 1 to 8



	2009	2010	2011	2012	2013
Internal Dose	1170	967	858	921	698
External Dose	4,867	6,108	5,231	7,501	3,750
Total	6,037	7,075	6,089	8,422	4,446

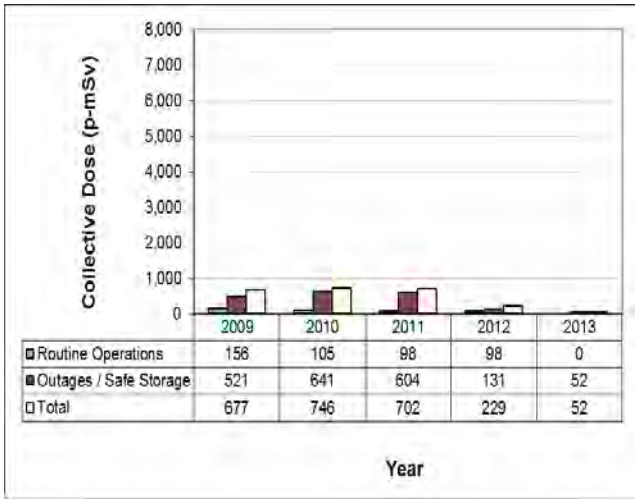
D.4 Annual collective doses at Gentilly-2

In 2013, Hydro-Québec was effective in controlling worker radiological exposures at Gentilly-2. Figures D.9 and D.10 present the collective doses at Gentilly-2.

At Gentilly-2, there was a reduction in the collective doses due to a reduction in radiological work activities associated with the transition from an operational unit to a safe storage state. In 2013, key activities in this transition period were defueling the reactor core, maintenance activities at the reactor face and removal of purification resins.

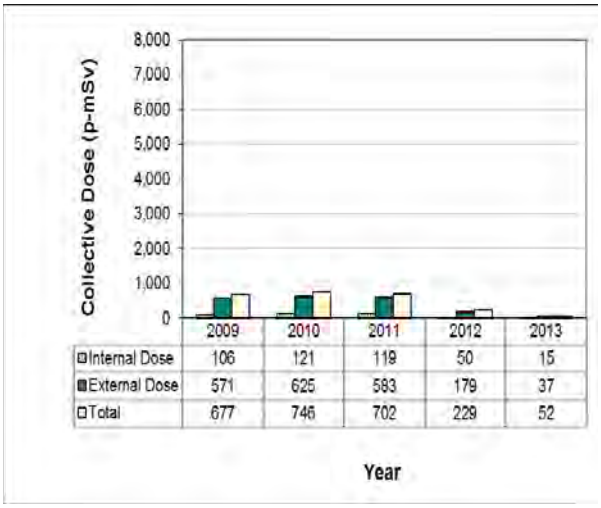
The entire station collective dose total is attributed to safe storage transition activities. Internal dose was approximately 29% of the total station collective dose.

Figure D.9: Collective dose by operational state for Gentilly-2



	2009	2010	2011	2012	2013
Routine Operations	156	105	98	98	0
Outages / Safe Storage	521	641	604	131	52
Total	677	746	702	229	52

Figure D.10: Collective dose from internal and external exposures for Gentilly-2



	2009	2010	2011	2012	2013
Internal Dose	106	121	119	50	15
External Dose	571	625	583	179	37
Total	677	746	702	229	52

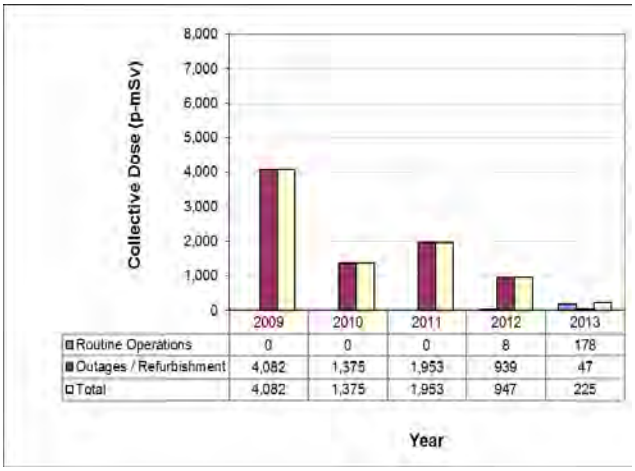
D.5 Annual collective doses at Point Lepreau

In 2012, NB Power was effective in controlling worker radiological exposures at Point Lepreau. Figures D.11 and D.12 present the collective doses at Point Lepreau.

Point Lepreau was operational with a total of 18 outage days and a 19 day period with reactor power decreased to less than 0.1% full power to support necessary maintenance activities related to improvements to the boiler feed water chemistry and turbine turning gear repairs. Outage activities at Point Lepreau accounted for approximately 21% of the total station collective dose.

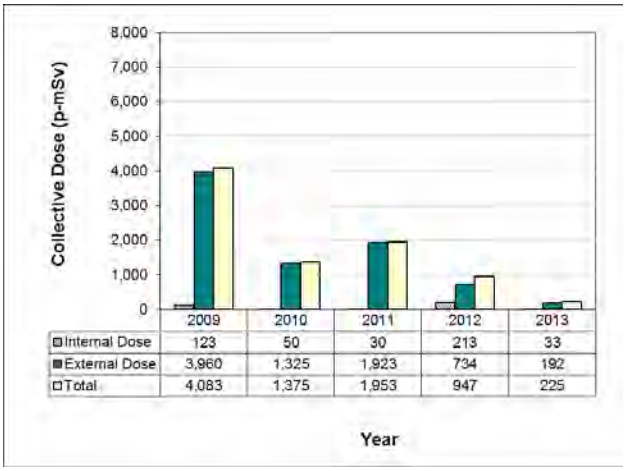
Routine operations accounted for approximately 79% of the total station collective dose. Internal dose was approximately 15% of the total station collective dose.

Figure D.11: Collective dose by operational state for Point Lepreau*



	2009	2010	2011	2012	2013
Routine Operations	0	0	0	8	178
Outages / Refurbishment	4,082	1,375	1,953	939	47
Total	4,082	1,375	1,953	947	225

Figure D.12: Collective dose from internal and external exposures for Point Lepreau*



	2009	2010	2011	2012	2013
Internal Dose	123	50	30	213	33
External Dose	3,960	1,325	1,923	734	192
Total	4,083	1,375	1,953	947	225

* Refurbishment began in April 2008. The unit returned to commercial operations on November 23, 2012.

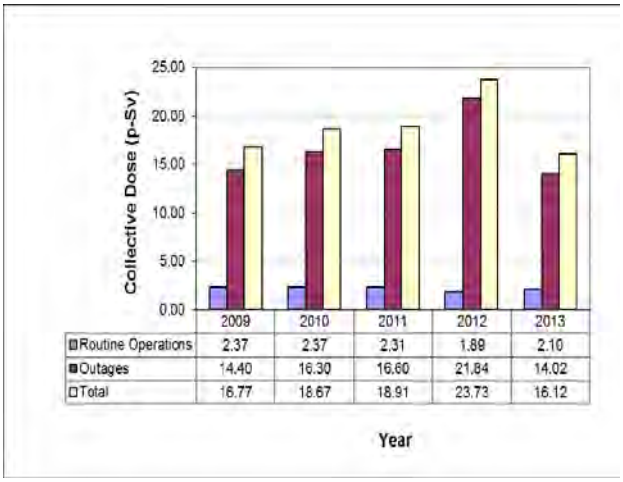
D.6 Average collective doses for all Canadian NPPs in operation

Nineteen reactor units were operational in 2013.

As shown in figures D.13 and D.14, the total collective doses and the average collective dose per unit at operating Canadian NPPs decreased in comparison with previous years. This result is attributed in part to the completion of refurbishment activities at Point Lepreau and Bruce A, Units 1 and 2 in in 2012. In addition, extensive outage programs at Bruce A Unit 3 and Pickering were also completed in 2012.

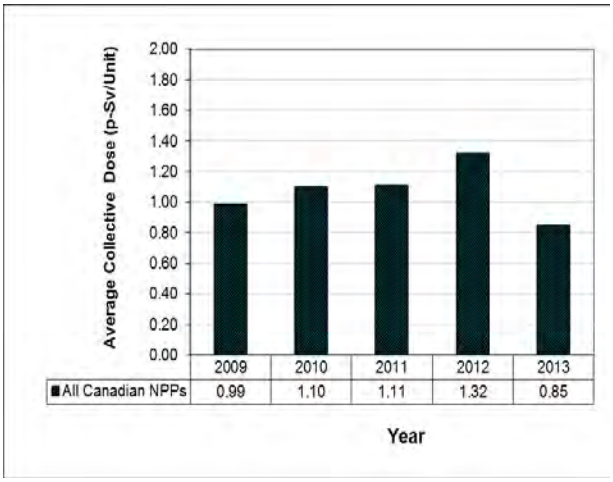
It is also recognized that the 2013 annual collective dose per unit of 0.85 p-Sv is below the historical low values of approximately 1 p-Sv per unit observed from 2009 to 2012. The implementation of ALARA initiatives such as improved shielding, source term reduction activities and improved work planning have contributed to an overall reduction in collective dose per unit across the Canadian industry.

Figure D.13: Collective dose by operational state for operating Canadian NPPs, from 2009 to 2013



	2009	2010	2011	2012	2013
Routine Operations	2.37	2.37	2.31	1.89	2.10
Outages	14.40	16.30	16.60	21.84	14.02
Total	16.77	18.67	18.91	23.73	16.12

Figure D.14: Average collective dose for operating Canadian NPPs, from 2009 to 2013



	2009	2010	2011	2012	2013
All Canadian NPPs	0.99	1.10	1.11	1.32	0.85

Appendix E: Derived Release Limits (DRLs) for Canadian NPPs

For the calculation of radiation doses received by members of the public from routine releases at 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) and/or intake of contaminated foods. Such radiation doses to members of the public are subject to statutory limits, which are set out in sections 13 and 14 of the *Radiation Protection Regulations*.

Since 1987, DRL calculations have been based on a method recommended by the Canadian Standards Association (CSA) in the standard published as CAN/CSA N288.1-M87. In 2008, a new revision of this standard was published as CSA-N288.1-08, *Guidelines for calculating derived release limits for radioactive materials in airborne and liquid effluents for normal operation of nuclear facilities* [29].

The DRLs for gaseous and liquid effluents from Canadian NPPs can be found in tables E.1 and E.2. The units of measurements for noble gases are either terabecquerel for individual radionuclides or terabecquerel-million electron volts for mixtures of radionuclides.

Table E.1: DRLs for gaseous effluents

Nuclear power plant	Tritium [a] (TBq)	Iodine-131 (TBq)	Noble gases (TBq)	Particulates (TBq)	Carbon-14 (TBq)
Bruce A [1]	1.98×10^5	1.14	1.12×10^5 [c]	1.73 [f]	6.34×10^2
Bruce B [2]	3.16×10^5	1.35	2.17×10^5 [c]	3.61 [f]	7.56×10^2
Darlington [3]	5.9×10^4 (HTO) 8.5×10^5 (HT) [b]	1.4	4.5×10^4	0.67	3.5×10^2
Pickering 1, 4 [4]	1.2×10^5	9.8	3.2×10^4	0.49	2.2×10^3
Pickering 5-8 [5]	1.9×10^5	8.9	4.7×10^4	0.72	2.0×10^3
Gentilly-2 [6]	8.6×10^4	0.3	7.7×10^4 [c]	1.2	2.0×10^2
Point Lepreau [7]	2.8×10^5	6.0×10^1	1.2×10^5 [d]	1.8 [e]	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. NB Power uses the DRL for Kr-88 as the most restrictive radionuclide representative of the group
e. NB Power uses the DRL for Co-60 as the most restrictive radionuclide representative of the group
f. Particulate (beta/gamma)

Table E.2: DRLs for liquid effluents

Nuclear power plant	Tritium [a] (TBq)	Gross beta-gamma activity (TBq)	Carbon-14 (TBq)
Bruce A [1]	2.3×10^{6}	4.58×10^{1}	1.03×10^{3}
Bruce B [2]	1.84×10^{6}	5.17×10^{1}	1.16×10^{3}
Darlington [3]	5.3×10^{6}	7.1×10^{1}	9.7×10^{2}
Pickering 1, 4 [4]	3.7×10^{5}	1.7	3.2×10^{1}
Pickering 5-8 [5]	7.0×10^{5}	3.2	6.0×10^{1}
Gentilly-2 [6]	1.2×10^{7}	1.8×10^{2}	2.4×10^{3}
Point Lepreau [7]	4.6×10^{7}	3.9×10^{1} [b]	3.3×10^{2}

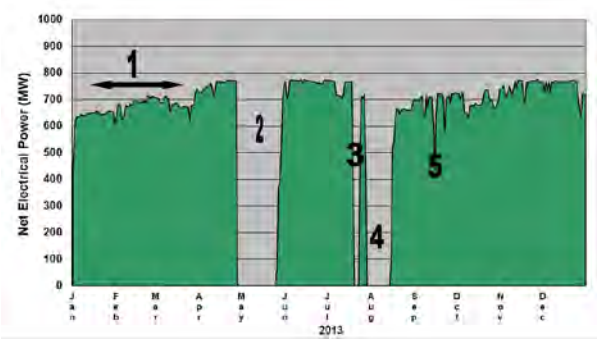
a. Tritium oxide (HTO)
b. NB Power uses the DRL for Co-60 as the most restrictive radionuclide representative of the group

1 Canadian Nuclear Safety Commission. (May 2014). *Nuclear Power Reactor Operating Licence Bruce Nuclear Generating Station A* (PROL 15.00/2015), Appendix C: Derived Release Limits.
2 Canadian Nuclear Safety Commission. (May 2014). *Nuclear Power Reactor Operating Licence Bruce Nuclear Generating Station B* (PROL 16.00/2015), Appendix C: Derived Release Limits.
3 Ontario Power Generation. (October 2011). *Derived Release Limits for Darlington Nuclear Generating Station*, NK38-REP-03482-10001-R01 (as referenced in LCH-DNGS-R000 for PROL 13.00/2014).
4 Canadian Nuclear Safety Commission. (September 2013). *Licence Conditions Handbook* (LCH-PNGS-R000 for PROL 48.00/2018).
5 Canadian Nuclear Safety Commission. (September 2013). *Licence Conditions Handbook* (LCH-PNGS-R000 for PROL 48.00/2018).
6 Hydro-Québec. (2003). *Limites opérationnelles dérivées pour les rejets aériens de Gentilly-2* (found in Section A.3 of PERP 10.01/2016).
7 Canadian Nuclear Safety Commission. (September 2013). *Nuclear Power Reactor Operating Licence Point Lepreau Nuclear Generating Station* (PROL 17.02/2017), Appendix A.3: Derived Release Limits.

Appendix F: 2013 Power History Graphs for Canadian Reactor Units

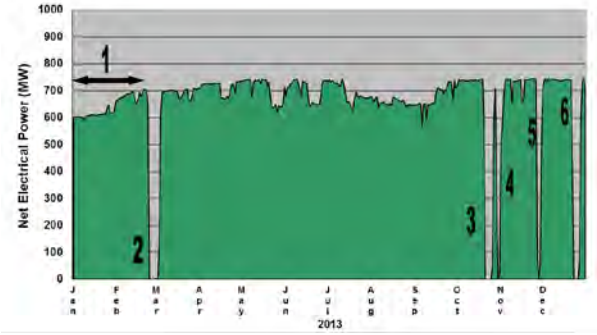
The 2013 power history graphs for licensed Canadian nuclear power reactor units are shown below in Figures F.1 to F.20. The graphs show the occurrences of outages (forced or planned) and the associated power reductions during the year. A brief explanation of the power reductions are given for each graph.

Figure F.1: Power history for Bruce A, Unit 1



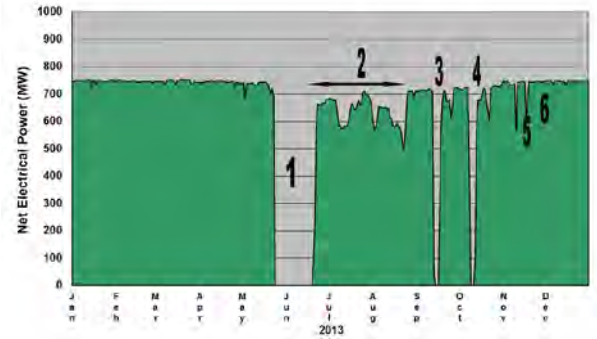
1 continued return to service following shutdown in previous calendar year
2 planned outage for maintenance and testing of fuel channel annulus gas system
3 forced outage due to external problem with electrical grid
4 forced outage due to valve problem during testing of shutdown safety system
5 reduction needed for main steam condenser cleaning

Figure F.2: Power history for Bruce A, Unit 2



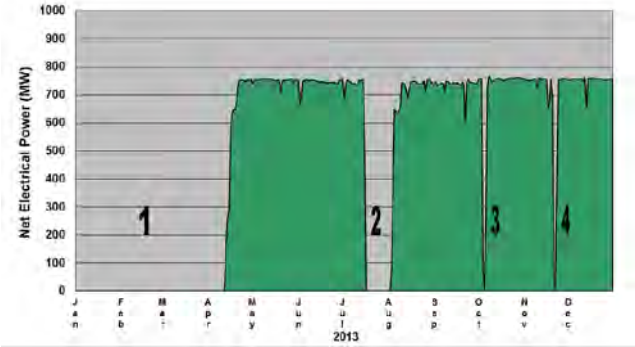
1 continued return to service following shutdown in previous calendar year
2 forced outage for fuelling equipment repairs
3 forced outage due to problem in the switchyard
4 forced outage due to problem during turbine testing of turbine governor valve
5 forced outage due to loss of instrument air supply on power level control equipment
6 forced outage due to boiler steam leak

Figure F.3: Power history for Bruce A, Unit 3



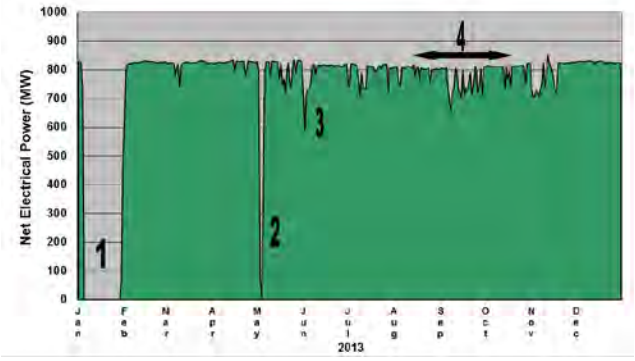
1 forced outage due to an external electrical grid event which was extended for maintenance on moderator valve
2 reductions needed for main steam condenser cleaning
3 forced outage due to loss of vacuum on main steam condenser
4 forced outage due to shutdown of heat transport pump
5 reduction due to an external electrical grid event
6 reduction due to an external electrical grid event

Figure F.4: Power history for Bruce A, Unit 4



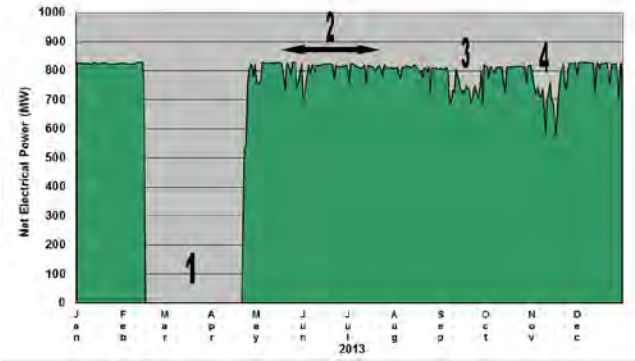
1 continuation of planned outage to replace the low pressure turbine rotors and generator
2 forced outage due to ground fault on main electrical output line
3 forced outage due to steam leak in high pressure service water
4 forced outage due to problem with fuelling machine trolley

Figure F.5: Power history for Bruce B, Unit 5



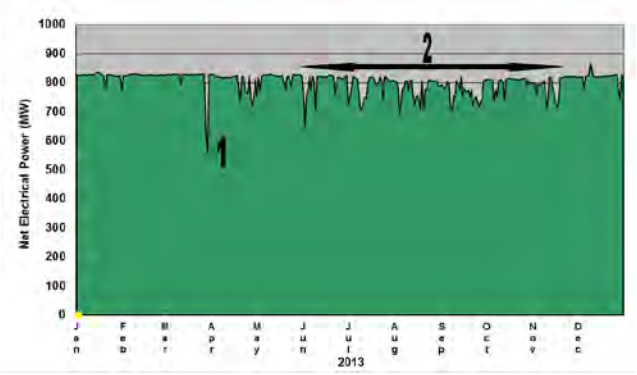
1 planned outage for harvest of irradiated cobalt production assemblies
2 forced outage due to an external electrical grid event
3 reduction due to an external electrical grid event
4 reductions due to external electrical grid events

Figure F.6: Power history for Bruce B, Unit 6



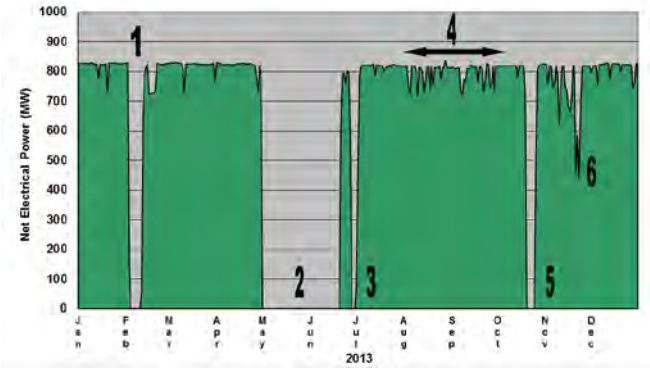
1 planned outage for maintenance and component inspections
2 reductions due to external electrical grid events
3 reductions due to external electrical grid events
4 reductions due to external electrical grid events

Figure F.7: Power history for Bruce B, Unit 7



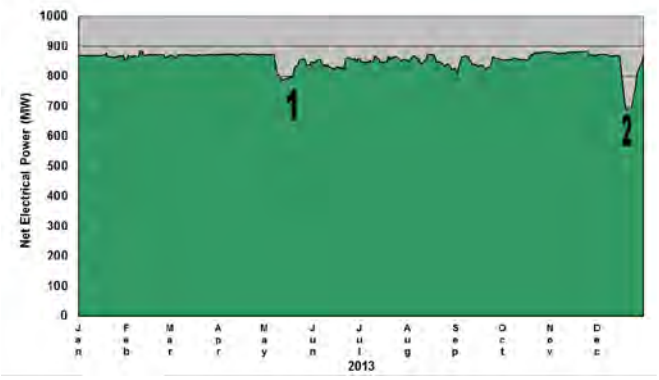
1 reduction due to turbine shutdown to repair leak of hydraulic control fluid
2 reductions due to external electrical grid events

Figure F.8: Power history for Bruce B, Unit 8



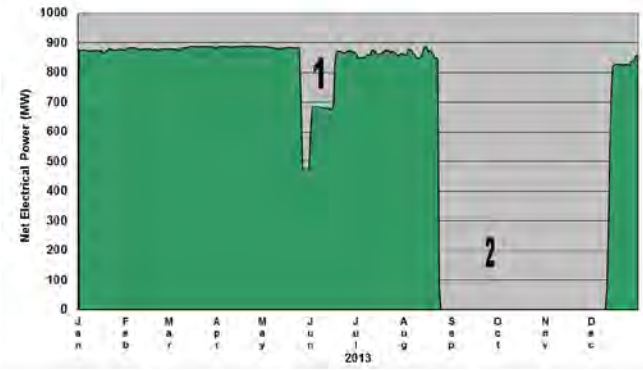
1 forced outage due to loss of electrical supply during maintenance testing
2 planned outage for maintenance and component inspections
3 forced outage due to high vibration on turbine bearing
4 reductions due to external electrical grid events
5 forced outage due to leak in instrument line on heat transport system
6 reductions due to turbine shutdowns due to protection alarms

Figure F.9: Power history for Darlington, Unit 1



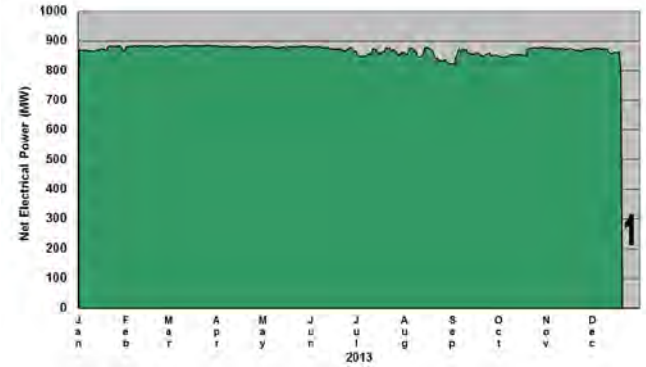
1 reduction due to inspection of low pressure heater
2 reduction due to delay in availability of fuel trolley

Figure F.10: Power history for Darlington, Unit 2



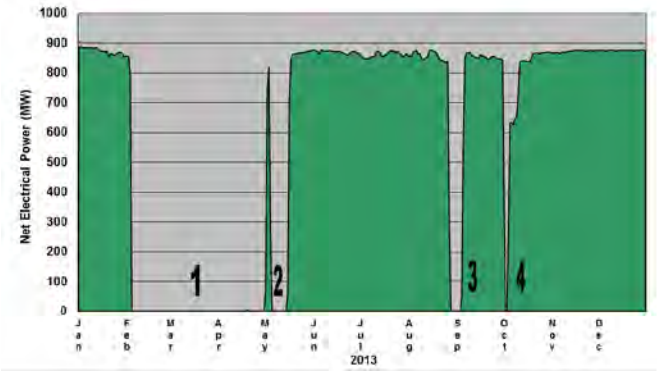
1 reduction due to leak in a fuel channel closure plug
2 forced outage due to leak from heat transport pump followed by planned outage for maintenance of fuel channels and feeders

Figure F.11: Power history for Darlington, Unit 3



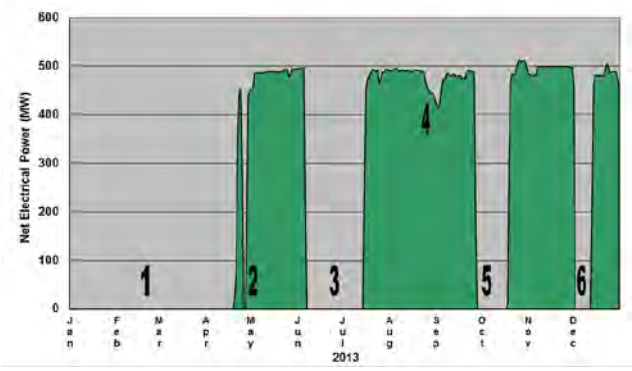
1 forced outage due to leak on boiler feed pipe

Figure F.12: Power history for Darlington, Unit 4



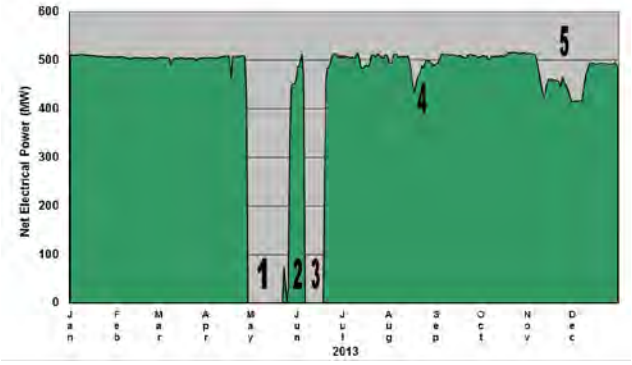
1 planned outage for maintenance on fuel channels and feeders
2 forced outage due to failure of main output transformer
3 forced outage due to leak in heat transport system
4 forced outage due to problem with main output transformer

Figure F.13: Power history for Pickering, Unit 1



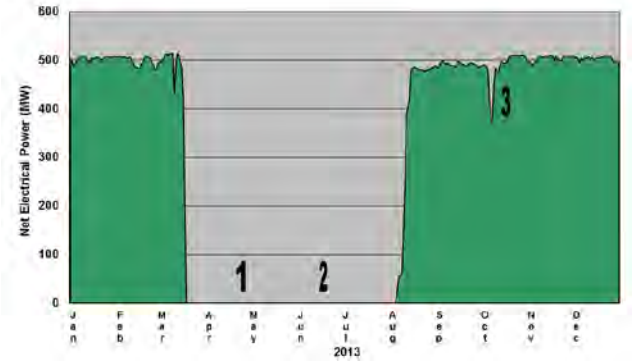
1 forced outage due to lube oil fire followed by repairs and maintenance
2 forced outage due to loss of vacuum on main steam condenser
3 forced outage needed to inspect and repair environmentally qualified electrical connectors
4 reduction due to problems with fuelling equipment and maintenance of condenser cooling water pump
5 forced outage due to problem in the switchyard
6 forced outage to repair leak in feedwater heater

Figure F.14: Power history for Pickering, Unit 4



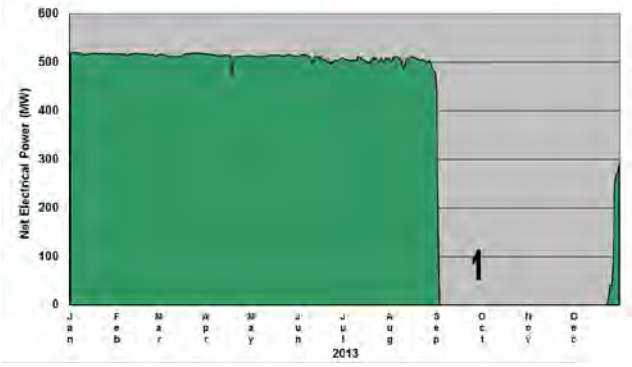
1 planned outage to upgrade emergency coolant injection and fuel handling systems
2 forced outage due to moderator inlet valve failure
3 forced outage needed to inspect and repair environmentally qualified electrical connectors
4 reduction due to problem with fuelling equipment
5 reduction due to problem with fuelling equipment

Figure F.15: Power history for Pickering, Unit 5



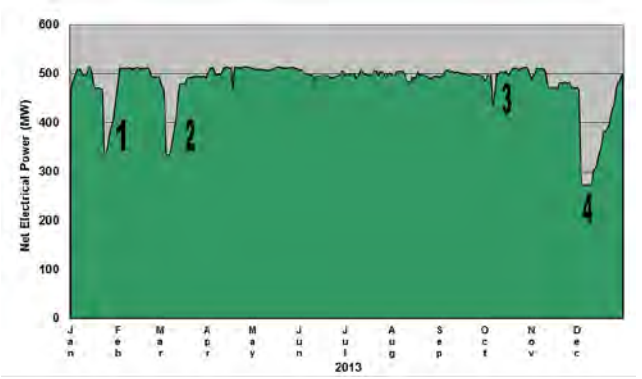
1 planned outage for maintenance of boilers, heat transport, turbine and fuel handling equipment
2 outage extended due to problem with main output transformer
3 reduction due to lake debris restricting cooling water intake

Figure F.16: Power history for Pickering, Unit 6



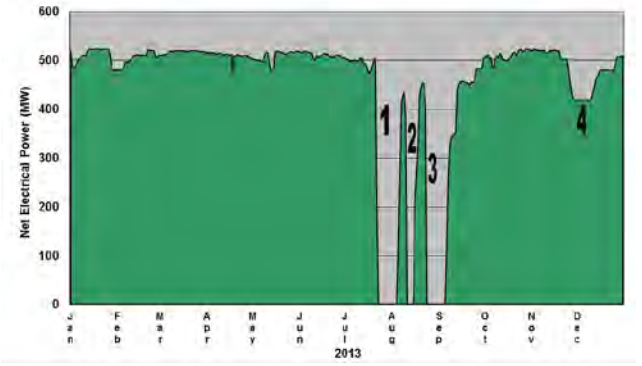
1 planned outage for maintenance of pumps, turbine and generator

Figure F.17: Power history for Pickering, Unit 7



1 reduction due to problem with fuelling equipment
2 reduction due to problem with fuelling equipment
3 reduction due to lake debris restricting cooling water intake
4 reduction due to problem with fuelling equipment

Figure F.18: Power history for Pickering, Unit 8



1 forced outage due to a computer control fault
2 forced outage due to a turbine test failure
3 forced outage due to fuelling equipment problems
4 reduction due to problems with fuelling equipment and correction of adjuster rod positioning

Figure F.19: Power history for Gentilly-2

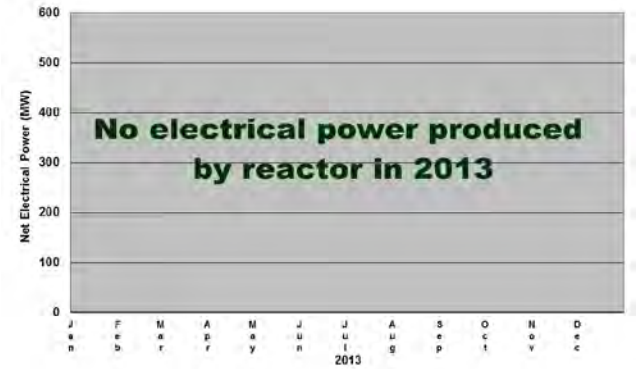
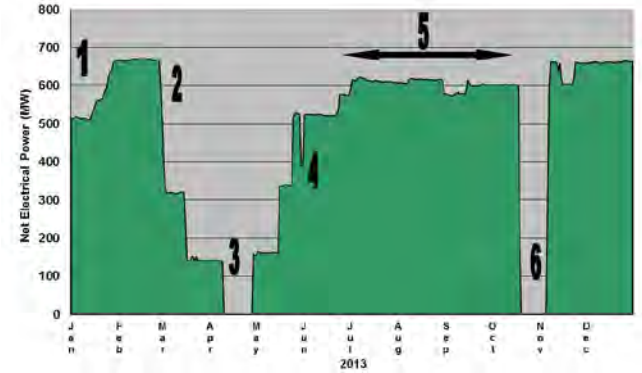


Figure F.20: Power history for Point Lepreau



1 continued return to service following shutdown in previous calendar year
2 reduction due to problem with fuelling equipment
3 forced outage for maintenance of boiler feedwater and turbine turning gear
4 reduction due to external power grid
5 reduction due to main steam line vibration
6 planned outage for maintenance of a governor valve on the turbine

Appendix G: Status of Action Items Applicable to NPPs

Table G.1 provides the status of the action items (AIs) that apply to each station as of May 1, 2014, followed by a description of each AI. Each NPP AI will only be closed once all the stations have produced the required deliverable and it has been accepted by the CNSC. In some cases, station-specific AIs may then be opened to track the performance of further deliverables.

A complete description of these NPP AIs can be found in the *CNSC Integrated Action Plan* [1].

Table G.1: Status of Fukushima action items applicable to nuclear power plants (as of May 1, 2014)

	Darlington				Pickering 1, 4				Pickering 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				√				√				√				A				A				√				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			A				A				A				A				A				A				√	
AI 1.10.1	√				√				√				√				√				√				S			
AI 1.10.2	√				√				√				√				√				√				S			
AI 1.11.1	√				√				√				√				√				√				S			
AI 2.1.1		√				√				√				A				A					A			A		
AI 2.1.2		√				√				√				A				A					A			A		
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	0	2	18	15	0	2	18	15	0	2	18	13	0	1	18	13	0	1	18	13	0	2	18	13	1	2
Active	0	0	1	0	0	0	1	0	0	0	1	0	0	2	1	1	0	2	1	1	0	0	3	0	0	2	0	0

* A description of each Fukushima action item (FAI) follows on the next page A - Active S - Suspended for Gentilly-2 NA - Not Applicable

√ Closed A Closure Requested/Under Review

FAI	Fukushima Action Items
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 adequacy of the existing means to protect containment integrity and prevent uncontrolled release 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 PARs as quickly as possible. December 2012.
1.5.1	An evaluation of the potential for hydrogen generation in the 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 (PHTS), 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 upgrade 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 I&C, if needed. December 2012.
1.10.2	A plan and schedule for deployment of identified upgrades. A target of 8 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.
2.1.2	Evaluate if the current site-specific design protection for each external event assessed in

FAI	Fukushima Action Items
	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 RD-310. December 2013.
3.1.1	Where 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 modeling 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 modeling, 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 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 modeling tools specific to each NPP. December 2012.

Acronyms and Abbreviations

ACM	asbestos containing material
AECL	Atomic Energy of Canada Limited
AF	accident frequency
AI	action item
ALARA	as low as reasonably achievable
ANO	authorized nuclear operator
ASR	accident severity rate
BTI	Business Transformation Initiatives
CAA	composite analytical analysis
CAL	consolidated end-of-life action log
CANDU	Canada Deuterium-Uranium
CANSTOR	CANDU storage (for used fuel)
CEA	Canadian Electricity Association
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group
COP	continued operations plan
CSA	Canadian Standards Association (as referenced in titles of standards; the association itself is now known as “CSA Group”)
CSI	CANDU safety issue
CVC	compliance verification criteria
CVP	compliance verification program
DFO	Department of Fisheries and Oceans
DNNP	Darlington New Nuclear Project
DRL	derived release limit
EA	environmental assessment
EC	Environment Canada
ECC	emergency core cooling
ECIS	emergency coolant injection system
EFPH	effective full power hour(s)
EIR	event initial report
EME	emergency mitigating equipment
EPG	emergency power generator
EPRI	Electric Power Research Institute
EQ	environmental qualification
EWS	emergency water supply
FAI	Fukushima action item
FCLMP	fuel channel life management project
FHA	fire hazard assessment
FOP	final operation plan
FUMP	follow-up monitoring program
GAR	global assessment report
HTS	heat transport system
I&C	instrumentation and control
IAEA	International Atomic Energy Agency
IFB	irradiated fuel bay
IIP	integrated implementation plan
INPO	Institute of Nuclear Power Operations
IPR	integrated plant rating

ISR	integrated safety review
IST	industry standard toolset
JRP	Joint Review Panel
LBLOCA	large break loss of coolant accident
LCH	licence conditions handbook
LCMP	lifecycle management program
LLOCA	large loss of coolant accident
LTI	lost time injury
MOE	Ministry of Environment
MOL	Ministry of Labour
MOU	Memorandum of Understanding
MSC	minimum shift complement
MTI	medically treated injury
MWe	megawatts electrical (that is, megawatts of electrical power)
NB Power	New Brunswick Power Nuclear Corporation
NEI	Nuclear Energy Institute
NEW	nuclear energy worker
NOP	neutron overpower protection
NPP	nuclear power plant
NRCan	Natural Resources Canada
NSCA	*Nuclear Safety and Control Act*
OMNR	Ontario Ministry of Natural Resources
OPG	Ontario Power Generation
OP&Ps	*Operating Policies and Principles*
OPEX	operating experience
OSART	Operational safety review team
OSRs	*Operational Safety Requirements*
PARs	passive autocatalytic recombiners
PHTS	primary heat transport system
PI	performance indicator
PIP	periodic inspection program
PIT	physical inventory taking
PIV	physical inventory verification
PMCR	preventive maintenance completion ratio
PROL	power reactor operating licence
PRSL	power reactor site licence
PSA	probabilistic safety assessment
PTNSR	*Packaging and Transport of Nuclear Substances Regulations*
QPS	qualified power supply
R&D	research and development
RIDM	risk-informed decision making
RP	radiation protection
RWAP	round whitefish action plan
SAMG	severe accident management guideline
SAP	stabilization activity plan
SAT	systematic approach to training
SCA	safety and control area
SDG	standby diesel generator
SDS	shutdown system
SEED	site and external events design
SHP	senior health physicist

SOE	safe operating envelope
SON	Saugeen Ojibway Nations
SOP	sustainable operations plan
SRWMF	Solid Radioactive Waste Management Facility
SSCs	structures, systems and components
TDGR	*Transportation of Dangerous Goods Regulations*
U0O	Unit 0 operator
UCLF	unplanned capability loss factor
WANO	World Association of Nuclear Operators

Glossary

accident frequency (AF)
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 (ASR)
A measure of the total number of days lost due to a work-related injury for every 200,000 person-hours.

becquerel (Bq)
The unit of measure for the quantity of radioactive material. One Bq is equal to the decay of one atom per second.

beyond-design-basis accident (BDBA)
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 established by section 8 of the 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 (CMD)
A document prepared for Commission hearings and meetings by CNSC staff, proponents and intervenors. Each CMD is assigned a specific identification number.

derived release limit (DRL)
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 accident (DBA)
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.

effective full power hour (EFPH)
The period over which a component sees service that equals the amount of full service the component would have experienced if it was operated continuously over a full hour.

feeder
There are several hundred channels in the reactor that contain fuel. The feeders are pipes attached to each end of the channels 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.

generic action item (GAI)
Refers to those unresolved safety-related issues which, in addition to being applicable to several CANDU plants, have been singled out by CNSC staff as requiring corrective actions to be taken by the licensees, within a reasonable time frame.

guaranteed shutdown state (GSS)
The reactor shall be considered to be in a guaranteed shutdown state if there is sufficient negative reactivity to ensure subcriticality in the event of any process failure, and 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.

International Atomic Energy Agency (IAEA)
An independent international organization related to the United Nations system. The IAEA, located in Vienna, works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies. The IAEA reports annually to the UN General Assembly and, when appropriate, to the Security Council regarding non-compliance by states with respect to their safeguards obligations, as well as on matters relating 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 the applicable laws and regulations
- the conditions and safety and control measures described in the facility's or activity's licence and the documents directly referenced in that licence
- the safety and control measures described in the licence application and the 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 the nuclear facility and to ensure adequate emergency response capability. Also referred to as "minimum staff complement".

mSv
Millisievert. See also sievert.

MWe
Megawatts electrical; that is, megawatts of electrical power.

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 (PSA)
For an NPP or nuclear fission reactor, a comprehensive and integrated assessment of the safety of the plant or reactor. The safety assessment considers the probability, progression and consequences of equipment failures or transient conditions to derive numerical estimates that provide a consistent measure of the safety of the plant or reactor, 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, and analyzes the containment behaviour, evaluates the radionuclides released from the failed fuel and quantifies the releases to the environment
- a Level 3 PSA starts from the Level 2 results, and 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 (PRA).

risk
The chance of injury or loss, defined as a measure of the probability and severity of an adverse effect (consequences) 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
A modern approach to the classification of accidents, one that considers a full spectrum of possible events, including the events of greatest consequence to the public.

root cause analysis
An objective, structured, systematic and comprehensive analysis designed to determine the underlying reason(s) for a situation or event, which is conducted with a level of effort consistent with the safety significance of the event.

safety-related system
As defined in the CSA Group publication CSA-N285.0-08, *General requirements for pressure-retaining systems and components in CANDU nuclear power plants*, and that is referenced in the nuclear power plant licence, "those systems and their related components and supports that, by failing to perform in accordance with the design intent, have the potential to impact the radiological safety of the public or nuclear power plant personnel. Those systems and their components involve

- "the regulation (including controlled startup 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 regulatory document S-99, *Reporting Requirements for Operating Nuclear Power Plants*, that 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
A failure of a process structure, system or component:

- that leads to a systematic fuel failure or a significant release from the nuclear power plant, or
- that could lead to a systematic fuel failure or a significant release in the absence of action by any special safety system

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 (Sv)
Unit of dose, corresponding to the rem (1 Sv = 100 rem). One sievert is defined as one joule of energy absorbed per kilogram of tissue (1 Sv = 1 J/kg) multiplied by an appropriate, dimensionless, weighting factor.

special safety system
One of the following systems of an NPP: shutdown system no. 1, shutdown system no. 2, 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 (SSCs)
A general term encompassing all of the elements (items) of a facility or activity that contribute to protection and safety, except human factors. Structures are the passive elements: buildings, vessels, shielding, etc. A system comprises several components, assembled in such a way as 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 (SAT)
A logical approach to training that consists of the following phases:

- the analysis phase during which the competencies in terms of knowledge and skills required to work in a position are identified
- the design phase during which the competency requirements for a position are converted into training objectives and a training plan is produced
- the development phase during which the training material needed to meet the training objectives is prepared
- the implementation phase during which the training is conducted using the material developed
- the 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 (SIS)
Structures, systems and components (SSCs) 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.

TBq
Terabecquerel. See also 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 the unavailability targets.

World Association of Nuclear Operators (WANO)
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 practice.

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