Canada's Nuclear Regulator

CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2012





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CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2012

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Publishing history

June 2013	Public consultation
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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 A and Pickering B Nuclear Generating Stations (Pickering, Ontario)

Executive Summary

Each year, the Canadian Nuclear Safety Commission (CNSC) publishes 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 2012* ("2012 NPP Report") summarizes the safety performance of the Canadian nuclear power industry as a whole, as well as the performance of each NPP.

In 2012:

- seven NPPs were operating at five sites in three provinces
- the year opened with 17 operational reactor units
- Bruce A Units 1 and 2 restarted after undergoing refurbishment
- Point Lepreau was relicensed, and restarted after undergoing refurbishment
- Gentilly-2 was operational throughout 2012, and was shut down and ended commercial operation in December
- the year ended with 19 operational reactor units

Overall performance highlights

Through inspections, reviews and assessments, CNSC staff concluded that the NPPs operated safely during 2012. The evaluations of all findings for the safety and control areas (SCAs) show that, overall, NPP licensees made adequate provisions for the protection of the health, safety and security of Canadians 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 workers at any NPP received a radiation dose that exceeded the regulatory limits
- the frequency and severity of non-radiological injuries to workers was minimal
- no radiological releases from the stations exceeded the regulatory limits
- licensees complied with their licence conditions concerning Canada's international obligations

Table 1 summarizes the 2012 ratings for Canada's NPPs. This table presents the SCAs for each station, the industry averages, and the integrated plant ratings that measure a plant's overall safety performance. The rating categories are "fully satisfactory" (FS), "satisfactory" (SA), "below expectations" (BE) and "unacceptable" (UA).

The integrated plant ratings in 2012 were "fully satisfactory" for Darlington and "satisfactory" for all other stations. These ratings are unchanged from the previous two years. None of the licensees received an integrated plant rating of "below expectations" or "unacceptable".

Table 1: Canadian nuclear power plant safety performance ratings for 2012

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

Performance highlights of each NPP

Bruce A and B

The 2012 integrated plant ratings for Bruce A and B were both "satisfactory", unchanged from 2011. While most SCA ratings were "satisfactory", CNSC staff assigned "fully satisfactory" performance ratings in two areas:

- conventional health and safety
- security

In October, the "Huron Challenge – Trillium Resolve" emergency management exercise was held at the Bruce Power site. This provincial exercise demonstrated that the licensee has an effective program and is able to respond to severe threats to the facility.

Bruce A successfully completed the Unit 1 and 2 refurbishment activities and returned both units to service.

Darlington

The 2012 integrated plant rating for Darlington was "fully satisfactory", unchanged from 2008. While most SCA ratings were "satisfactory", CNSC staff assigned "fully satisfactory" performance ratings in four areas:

- operating performance
- fitness for service
- radiation protection
- conventional health and safety

In November, the Institute of Nuclear Power Operations (INPO) honoured Darlington with an INPO Award of Excellence – positive recognition by industry peers of Darlington's continuous achievements in operational excellence and safety.

The Commission held an extensive public hearing to consider the environmental assessment completed for the refurbishment of four units at Darlington. The hearing also included the renewal of the Darlington operating licence. The licence renewal enables Ontario Power Generation (OPG) to prepare its application to cover the proposed refurbishment project, including CNSC-mandated safety reviews to ensure the facility continues to meet stringent standards.

Pickering A and B
The 2012 integrated plant ratings for Pickering A and B were both "satisfactory", unchanged from 2011. CNSC staff assigned all SCA ratings as "satisfactory".

During 2012, OPG continued to address previously identified compliance issues in the area of personnel certification, through improvements such as implementing a new on-the-job training program.

Gentilly-2
The 2012 integrated plant rating for Gentilly-2 was "satisfactory", unchanged from 2011. CNSC staff assigned all SCA ratings as "satisfactory".

Near the end of December 2012, Hydro-Québec ended commercial operation at Gentilly-2 and began transitioning the reactor to safe storage in preparation for future decommissioning.

Point Lepreau
The 2012 integrated plant rating for Point Lepreau was "satisfactory", unchanged from 2011. CNSC staff assigned most SCA ratings as "satisfactory" and the site achieved "fully satisfactory" in conventional health and safety.

The Commission renewed New Brunswick Power's licence for the operation of Point Lepreau. The reactor returned to commercial operation in November 2012 after successfully completing refurbishment work.

Response to the Fukushima Daiichi accident

The Canadian nuclear power industry is on track to complete all Fukushima action items (FAIs) by December 2015.

The FAIs were established to address the recommendations of the CNSC Fukushima Task Force for enhancements to Canadian NPPs in response to the Fukushima Daiichi accident. All licensees made satisfactory progress in implementing the FAIs. By the end of 2012, all 18 short-term FAIs were closed for Bruce Power and OPG and were either closed or being reviewed for closure for the other licensees. This status is consistent with the deadlines established in the *CNSC Action Plan*.

Public information and disclosure program

All licensees progressed towards meeting the deadline of December 2013 to ensure that their public information and disclosure programs meet the requirements of RD/GD-99.3, *Public Information and Disclosure*, a regulatory document published by the CNSC in 2012.

Safety and control area framework

CNSC staff use the SCA framework in evaluating safety performance. During 2012, CNSC staff conducted a review of the specific areas within the framework. Some of the recommended changes have been adopted in this 2012 NPP Report. The complete revised SCA framework will be implemented in next year’s 2013 NPP Report.

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CNSC Staff Integrated Safety Assessment of Canadian Nuclear Power Plants for 2012

1. Overview

The Canadian Nuclear Safety Commission (CNSC) regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians 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 provisions for meeting the CNSC's mandate.

Each year, to support this mandate, 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 2012* (commonly referred to as the "2012 NPP Report").

This assessment aligns with 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, document assessments, desktop reviews, event 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 2012 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 2012 calendar year (January to December)
- the assessment and ratings of the safety performance for each licensed station, covering the 2012 calendar year (January to December)
- detailed information on licensing and other regulatory issues pertaining to each licensed station, covering an extended period of January 2012 to April 2013 (to permit the most up-to-date view of issues at each station)

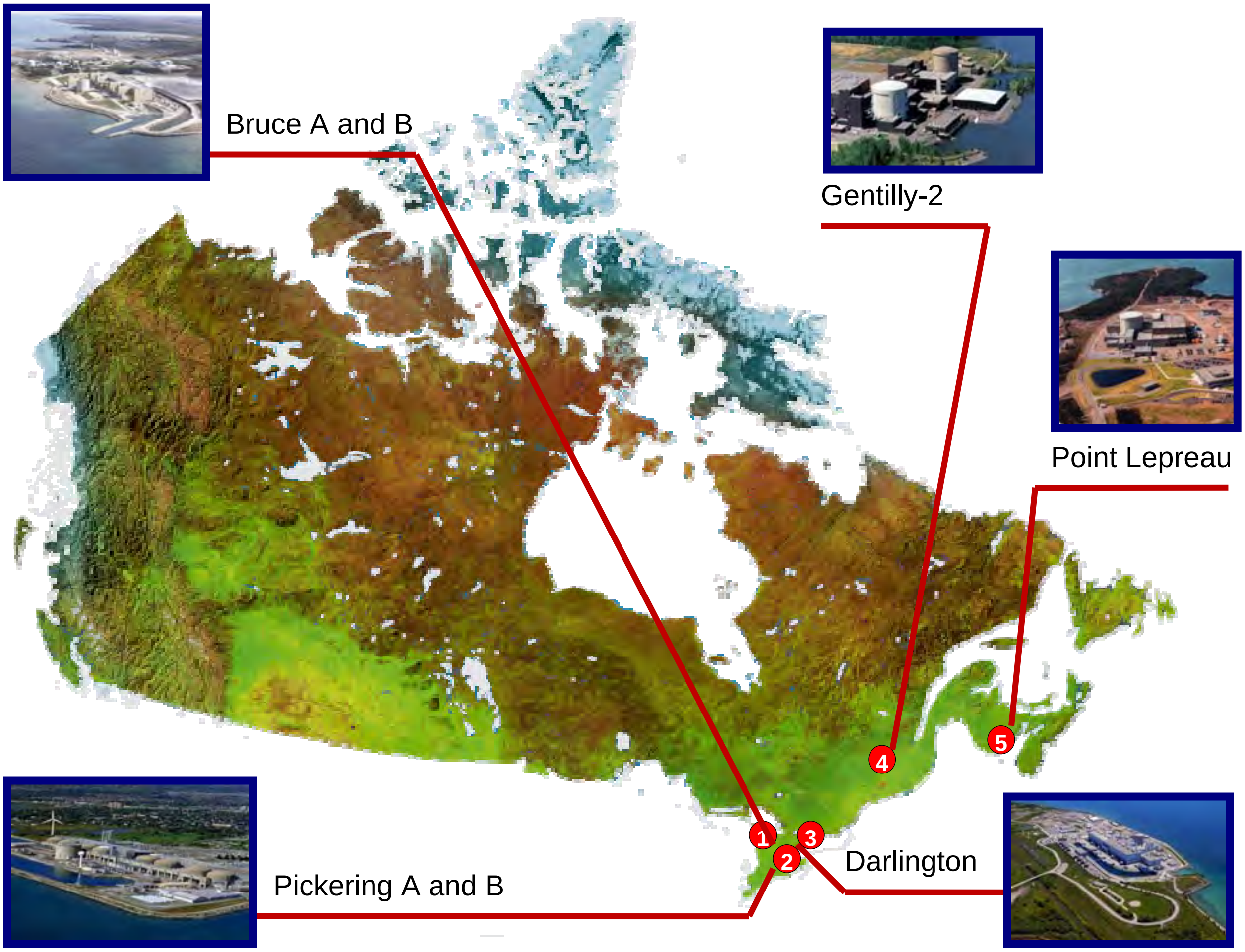
The report also includes six appendices, and concludes with a glossary and a list of references.

Canada's nuclear power plants

There are seven licensed nuclear power plants (NPPs) in Canada, located at five sites in three provinces (as shown in figure 1), and operated by four separate licensees. These NPP sites 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 now owned by 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 site, their initial startup dates, the names of the licensees, and the expiry dates of the operating licences.

Figure 1: Locations and data for Canadian nuclear power plants



NPP	Licensee	Location	State of reactor units	Gross capacity per unit (MWe)	Startup[1]	Licence expiry
Bruce A	Bruce Power Inc.	Tiverton, ON	4 operating	904	1977	Oct. 31, 2014
Bruce B	Bruce Power Inc.	Tiverton, ON	4 operating	915	1984	Oct. 31, 2014
Darlington	Ontario Power Generation Inc	Darlington, ON	4 operating	935	1990	Dec. 31, 2014
Pickering A	Ontario Power Generation Inc	Pickering, ON	2 operating 2 defuelled and in safe storage	542	1971	June 30, 2013[2]
Pickering B	Ontario Power Generation Inc	Pickering, ON	4 operating	540	1982	June 30, 2013[2]
Gentilly-2	Hydro-Québec	Bécancour, QC	1 operating[3]	675	1983	June 30, 2016
Point Lepreau	New Brunswick Power Nuclear Corp.	Lepreau, NB	1 operating	705[4]	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 on December 28, 2012 and is transitioning to safe storage
[4] This value is post-2012 refurbishment; prior to refurbishment, the value was 680 MWe

In 2012:

- seven NPPs were operating at five sites in three provinces
- the year opened with 17 operational reactor units
- Bruce A Units 1 and 2 restarted after undergoing refurbishment
- Point Lepreau was relicensed, and restarted after undergoing refurbishment
- Gentilly-2 was operational throughout 2012, and was shut down and ended commercial operation in December
- Pickering A Units 2 and 3 remained in safe storage, consistent with previous years after they were defuelled in 2008
- the year ended with 19 operational reactor units

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 229 CNSC staff, plus support from other members of the organization. This total effort includes 37 CNSC employees who are located onsite at the seven stations, performing inspections, monitoring safety performance and providing 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.

In 2012, CNSC staff conducted a review of the specific areas. The revised SCA framework was released to CNSC staff in late 2012. To accommodate logistical constraints, the revised framework will be introduced to the annual NPP report over two years – some, this year; the remainder, next year. For a complete list of the SCAs and specific areas used in this report, see appendix A.

Reporting requirements

The CNSC's reporting requirements are documented in the associated regulations, in S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1], and in other specific licence conditions. CNSC staff review the reports to detect potential compliance issues and to verify the quality and completeness of the reports.

Compliance verification program

CNSC staff use the compliance verification program to determine whether licensees are complying with the regulatory requirements specified in the NSCA, the associated regulations, and the operating licences issued by the CNSC. Compliance with these requirements ensures that the risk to the health and security of Canadians remains acceptably low.

The compliance verification program includes all of the compliance activities conducted by CNSC staff. The program is risk-informed, performance-based and aligned with the 14 SCAs. Compliance activities include surveillance, inspections and desktop reviews.

- Surveillance is carried out by onsite CNSC inspectors to monitor station operation and to continually verify that the licensee is operating the station safely according to CNSC requirements and expectations. Surveillance includes daily reviews of operational activities, observation of licensee meetings, and observations noted during field visits.

- Inspections involve reviewing objective evidence and systematic, fully documented compliance activities to determine if a licensee's program, process or practice complies with the CNSC's regulatory requirements. These inspections may be planned or reactive; announced or unannounced; or conducted by one inspector or a team. CNSC staff conducted a total of 167 inspections at NPPs during 2012 (an increase of six inspections from 2011, and representing 90% of all planned inspections).

- Desktop reviews are the review of documents and reports submitted by licensees. Documents include quarterly technical reports, scheduled compliance reports and unscheduled reports such as event reports and corrective action reports.

Safety performance assessment

The 2012 NPP Report presents safety performance ratings for each SCA at each NPP. The ratings are based on the compliance verification program activities. In generating the performance ratings, CNSC staff considered over 1,600 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 finding had a positive, insignificant or small negative impact on the assessment of the specific area. Each remaining finding 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 NPP Report includes an integrated plant rating (IPR) for each NPP. The IPR is a general measure of the overall safety performance of each NPP, and is determined by combining the ratings of the 14 individual SCAs.

Aboriginal consultation

CNSC staff consulted with a number of Aboriginal communities in relation to the environmental assessment and licensing reviews for Darlington, to ensure that the CNSC met the duty to consult. For the Pickering licence renewal, CNSC staff commenced Aboriginal consultation activities in 2012 and continued to consult with Aboriginal communities into 2013, prior to the public hearing. For both processes, consultation activities included letters, meetings, and the public hearings. Aboriginal groups that expressed interest in being kept apprised of activities at the individual nuclear sites were provided copies of the draft 2012 NPP Report and notified of the opportunity to observe the Commission meeting regarding the draft report. Because this report is for informational purposes only, the duty to consult is not triggered.

2. Industry Safety Performance Trends

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 Canadians 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 and event reviews 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

In addition to the 14 SCAs, this section includes an overview of the public information and disclosure programs required by all licensees.

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* [1]. 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 two years.

Overall, based on the information assessed, CNSC staff concluded that the implementation of 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		A	B			
Management system	SA	SA	SA	SA	SA	SA	SA	SA

Management system encompasses the following specific areas:

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

Management system

To ensure safe operation, all NPP licensees are required to implement a management system that complies with N286-05, *Management system requirements for nuclear power plants* [2]. For 2012, the oversight activities carried out by CNSC staff identified some opportunities for improvement but did not identify any compliance issues with this standard. Overall, the licensees' management systems are effective.

Organization

All licensees are required to document the organizational structure under which they conduct their licensed activity. The documentation includes descriptions of all positions with responsibilities for the management and control of the licensed activity. Licensees report organizational changes to the CNSC. In 2012, no compliance issues were identified.

Ontario Power Generation (OPG) made changes at both the corporate level and the nuclear level for Darlington, Pickering A, and Pickering B. The corporation is implementing a centre-led matrix organization, and OPG Nuclear is implementing a centre-led functional area management model. CNSC staff are monitoring the changes and no compliance issues have been identified to date.

In 2012, New Brunswick Power (NB Power) completed the refurbishment of the Point Lepreau station, resulting in a transition from a refurbishment organizational structure to an operational structure. No compliance issues were encountered during the transition.

Configuration management

The baseline program for configuration management has been implemented at all sites. However, each site has some weaknesses in sustaining activities that require continued support in other ongoing processes (such as engineering change control, performance monitoring, maintenance, aging management and corrective actions). No significant compliance issues have been identified.

Business continuity
All licensees were adequately prepared to invoke their contingency plans for events involving labour actions, to ensure that minimum shift complements were not affected.

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 two years.

Overall, based on the information assessed, CNSC staff concluded that the implementation of 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		A	B			
Human performance management	SA	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
- procedures and job aids (no significant observations to report)
- fitness for duty (no significant observations to report)

Human performance program
All licensees have taken steps to strengthen their response to various conditions that extend beyond the original design basis of their plants.

For example, one licensee has participated in an extensive proof-of-concept exercise (the "Huron Challenge – Trillium Resolve"). Because this exercise involved a large number of personnel and outside organizations, it tested the licensee's human performance program (in addition to emergency management) by verifying how its response addresses severe threats to the plant.

Personnel training
All licensees employ systematic approach to training (SAT)-based training systems. Implementation of these systems for the many training programs at each facility generally meets the regulatory requirements. Identified weaknesses are being addressed by the licensees in accordance with their approved corrective action plans and do not represent a risk to nuclear safety.

Personnel certification

The CNSC issued a total of 76 certifications in 2012. The industry continued to maintain a sufficient contingent of certified personnel, including reactor operators (ROs), unit 0 operators (U0Os), shift supervisors (SSs) and senior health physicists (SHPs). Details can be seen in table 2.

Key safety-related positions at nuclear facilities must have personnel, including reactor operators, who have been certified by the CNSC as being qualified, trained and capable of performing their duties.

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

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

NPP		RO	U0O	SS	Subtotal (less SHPs)	SHP	Total (Actual)
Bruce A	Minimum	30	10	10	50	3	84
	Actual	40	21	20	81		
Bruce B	Minimum	30	10	10	50	2	90
	Actual	53	16	19	88		
Darlington	Minimum	30	10	10	50	2	89
	Actual	51	17	19	87		
Pickering A	Minimum	20		10	30	3	64
	Actual	45		16	61		
Pickering B	Minimum	30		10	40	3	71
	Actual	52		16	68		
Gentilly-2	Minimum	6		6	12	4	28
	Actual	12		12	24		
Point Lepreau	Minimum	6		6	12	2	21
	Actual	12		7	19		

Notes:

i. There are no U0O positions at Pickering A, Pickering B, Gentilly-2 and Point Lepreau stations – the corresponding cells are therefore left empty and shaded in dark grey.

ii. The SHP position is not subject to a minimum shift complement requirement – the corresponding column was therefore not assigned a minimum quantity.

Initial certification examinations and requalification tests
Licensees conducted 19 written and oral knowledge-based initial certification examinations, 30 simulator performance-based initial certification examinations, and 134 requalification tests. All tests were administered by the licensees. The candidate pass rates were 94% for both the initial certification examinations and the requalification tests. In addition, the CNSC administered six initial certification examinations and requalification tests to SHP candidates, who achieved an overall pass rate of 83%.

Work organization and job design

Minimum shift complement
All licensees are required to have a minimum shift complement (MSC). The number and qualifications of staff are specific to each site's MSC, and are determined by a systematic analysis and demonstrated by an integrated validation exercise, as described in G-323, *Ensuring the Presence of Sufficient Qualified Staff at Class I Nuclear Facilities – Minimum Staff Complement* [3]. In 2012, all licensees were either conducting the systematic analysis of the MSC requirements or were demonstrating the adequacy of the MSC through validation exercises.

Hours of work
NPPs are staffed continuously, and most workers filling key positions work 12-hour shifts. With a goal of limiting fatigue, the CNSC has expectations for limits on hours of work and mandatory rest periods between blocks of 12-hour shifts. Most of these expectations have been implemented by licensees, with some exceptions (such as application to casual construction trade workers and contractors, or outages).

2.3 Operating performance

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

Overall, CNSC staff concluded that NPP licensees operated their facilities safely and in compliance with the NSCA, regulations, conditions of the licence and the licence conditions handbooks, and in accordance with the licensing basis.

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

Operating performance encompasses the following specific areas:

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

At the start of 2012, 17 reactors were operating in Canada. During the year, refurbishment and reactor restart activities were completed at three reactors (Bruce A Units 1 and 2, and Point Lepreau), giving a total of 20 operating reactors. Near the end of 2012, the reactor at Gentilly-2 was shut down and ended its commercial operation. The year ended with 19 operating reactors.

Conduct of licensed activity

For all licensees, their operational activities are governed by their operating policies and principles (OP&Ps) documents, as referenced in their operating licences. These documents govern how each station operates, maintains and modifies systems at the station to maximize nuclear safety and to keep the risk to the public acceptably low.

There were no serious process failures at Canadian NPPs during 2012. CNSC staff conducted numerous inspections, including field and control room inspections. No significant operations-related compliance issues were identified. Licensees had very good compliance with CNSC requirements and licensees' governing procedures and documents.

"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. Unexpected power reductions may indicate problems within the plant and place unnecessary strain on systems. Unplanned transients include stepbacks, setbacks, and reactor trips where the trip resulted in a reactor shutdown.

Table 3 shows the number of power reductions from actuation of the shutdown, stepback or setback systems. All transients were controlled properly and power reduction was automatically initiated by the reactor control systems. The majority of the unplanned transients experienced by industry NPPs were setbacks, which are gradual power changes and pose little increased risk to plant operations. Two stations experienced unplanned reactor trips during commissioning testing, but as these were prior to return to commercial operation for the units, the trips are not included in table 3.

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**
			Unplanned reactor trips*	Step-backs	Setbacks	Total	
Bruce A	4	18,937	2	3	9	14	0.7
Bruce B	4	33,829	0	0	0	0	0
Darlington	4	34,937	1	0	2	3	0.2
Pickering A	2	13,813	1	0	0	1	0.5
Pickering B	4	30,311	1	0	4	5	0.2
Gentilly-2	1	7,239	1	1	6	8	1.0
Point Lepreau	1	2,208	0	0	1	1	0
Industry total	20	141,274	6	4	22	32	0.3

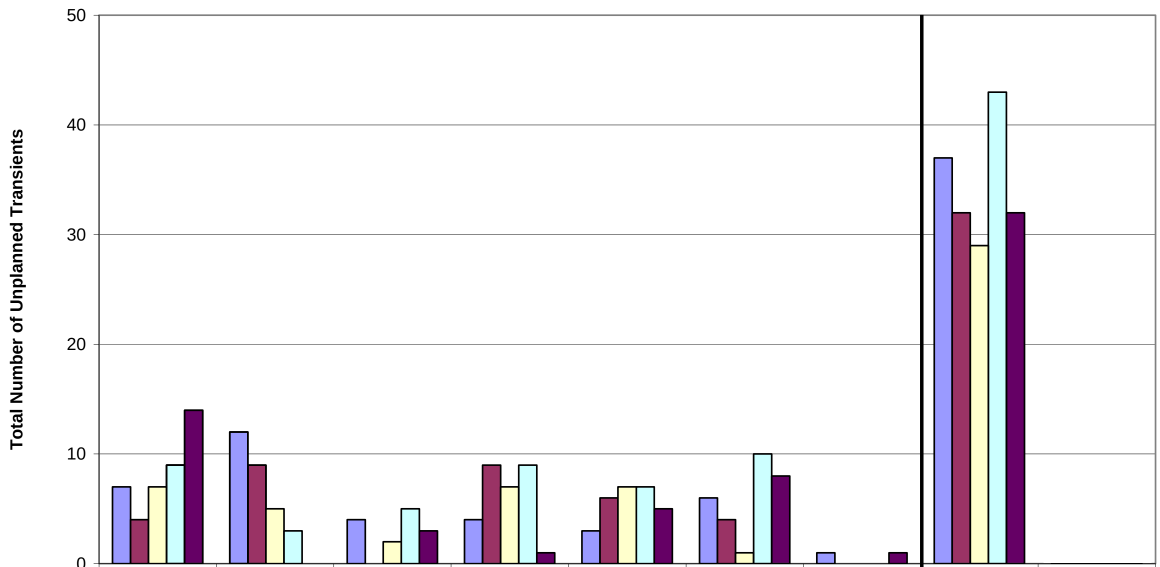
* Automatic reactor trips only; does not include manual reactor trips or trips during commissioning testing.

** 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 2008 to 2012. For five stations and the industry total, the number of unplanned transients decreased. Moreover, the number of reactor trips per 7,000 operating hours decreased for the industry.

The industry average was one unplanned reactor trip per 23,550 hours. The nuclear power industry performance target is less than 0.5 reactor trips per 7,000 hours of operation. It follows that Canadian NPPs performed better than the performance target by more than 65% of the average time between reactor trips.

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



	Bruce A	Bruce B	Darlington	Pickering A	Pickering B	Gentilly-2	Point Lepreau	Industry Total	Industry Trips per 7,000 Hours
2008	7	12	4	4	3	6	1	37	0.4
2009	4	9	0	9	6	4	n/a	32	0.5
2010	7	5	2	7	7	1	n/a	29	0.5
2011	9	3	5	9	7	10	n/a	43	0.5
2012	14	0	3	1	5	8	1	32	0.3

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 decreased in 2012 by more than 40% and it was also 40% lower than the industry performance target level of less than 0.5 reactor trips per 7,000 hours. Figure 3 also shows that the trip rate for the Canadian nuclear power industry was about 35% below the WANO value.

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

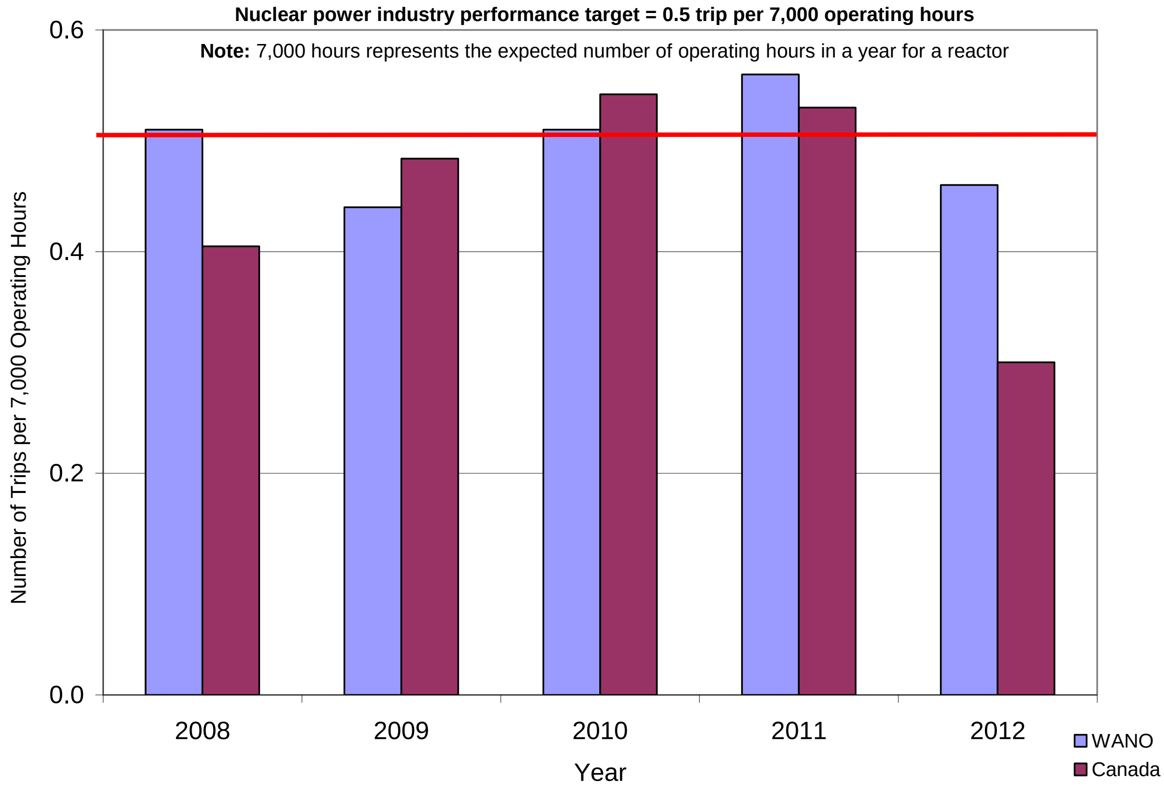
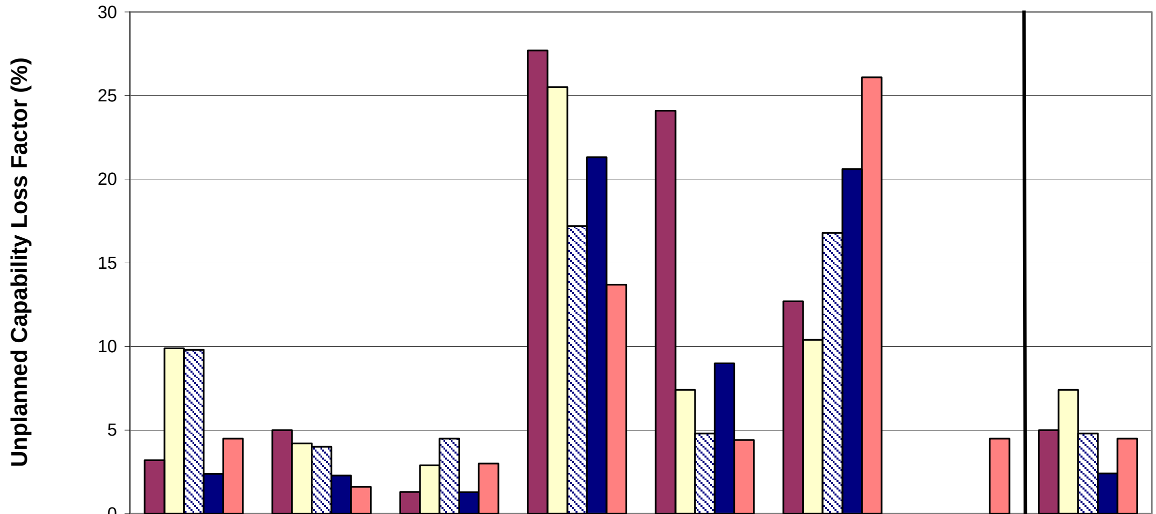


Figure 4 shows the "unplanned capability loss factor" (UCLF) from 2008 to 2012 for Canadian NPP licensees and the industry, and presents the median value for the industry (consistent with WANO methodology). The UCLF is the percentage of the reference electrical output for the station not produced during 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 2.4% to 4.5%, is primarily due to the relatively high values for Gentilly-2 and Pickering A
- three NPP licensees decreased their UCLF value during 2012 and the industry median value continues to be relatively low at 4.5%; however, it increased from 2.4% in 2011
- the UCLF for Gentilly-2 exceeded the UCLF of other NPPs
- 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)
- Point Lepreau was restarted during 2012, and therefore its UCLF value cannot be compared to that of the previous year

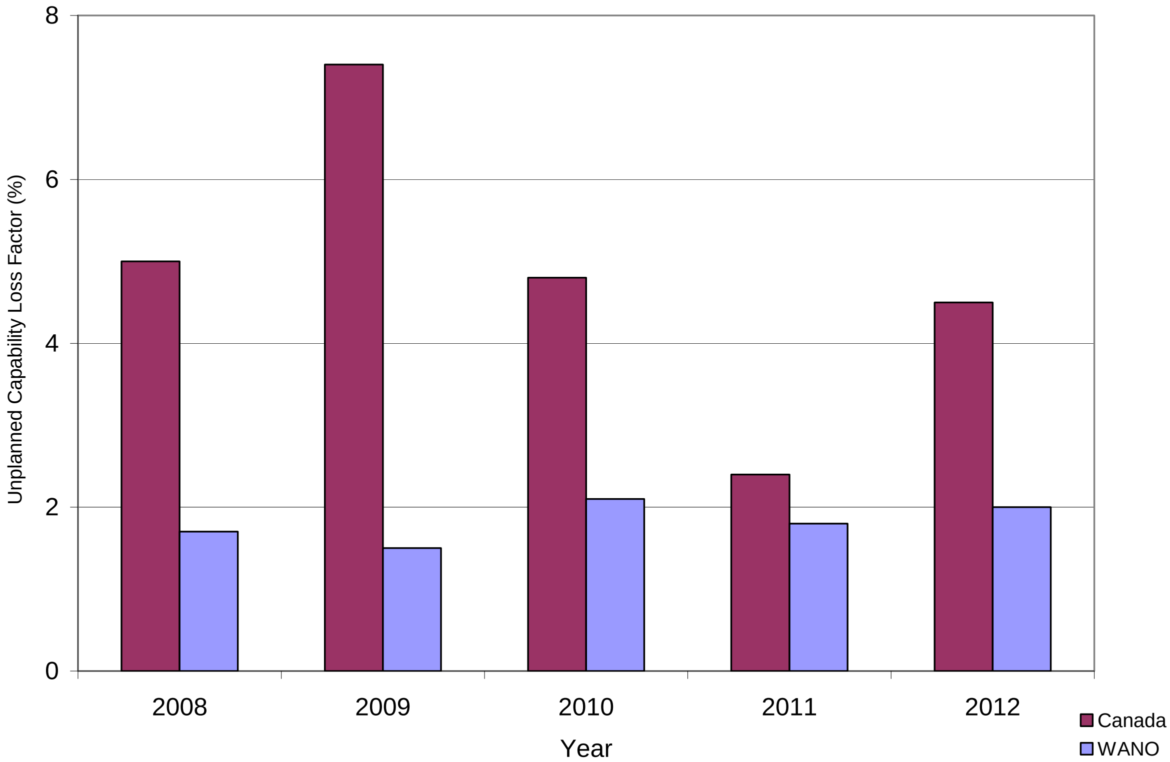
Figure 4: Trend details for unplanned capability loss factor for stations and industry



	Bruce A	Bruce B	Darlington	Pickering A	Pickering B	Gentilly-2	Point Lepreau	Industry Median
2008	3.2	5.0	1.3	27.7	24.1	12.7	0.0	5.0
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

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 refurbished reactors being returned to service and could also be due to differences in reactor technologies, the number of reactors in each group (20 for Canada versus more than 370 reporting units for the WANO values), outage management, station equipment maintenance and reliability – all of which have an effect on the number of forced shutdowns or outage extensions. 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



Operating experience

The operating experience (OPEX) programs for all licensees met regulatory requirements.

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* [1]. NPP licensees complied with the submission of reports as per S-99, and CNSC staff did not identify any significant regulatory issues from those reports.

Outage management performance

All licensees met CNSC expectations for outage executions, outage safety and work management. This evaluation includes the refurbishment and reactor restart activities at Bruce A Units 1 and 2, and Point Lepreau.

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* [4]. CNSC staff conduct Type I inspections to assess each licensee's SOE program against this standard. In 2012, inspections were done at Bruce B and Pickering A. No major compliance issues were identified.

Bruce Power has completed the development of its SOE program, and the remaining work to implement the program is underway. OPG and NB Power completed the development and the baseline implementation of their SOEs. Bruce Power, OPG and NB Power will soon be transitioning to the maintenance mode of their SOEs.

Hydro-Québec started the development of its SOE program in February 2011. However, following the decision to end commercial operation for Gentilly-2, Hydro-Québec has ceased activity in this area.

CNSC staff will continue to monitor the progress of the SOE programs towards final implementation in the licensing basis of each operating NPP.

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. The industry average for safety analysis was “satisfactory”, unchanged from the previous two years.

Overall, based on the information assessed, CNSC staff concluded that the implementation of 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		A	B			
Safety analysis	SA	SA	SA	SA	SA	SA	SA	SA

Safety analysis encompasses the following specific areas:

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

Deterministic safety analysis

CNSC staff reviewed a number of topics, listed below, 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* [5] has made significant progress. The industry has adopted a three-phase approach:

- phase 1: preparation and development of framework for transition to compliance with RD-310
- phase 2: identification of generic gaps against RD-310 and development of principles and guidelines (P&G) 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

Progress included:

- the generic RD-310 gap assessments
- generally agreed-upon rules documentation for safety analyses of anticipated operational occurrences (AOOs) and beyond-design-basis accidents (BDBAs)
- a methodology for limiting the operating envelope, currently used in licence-supporting safety analyses
- improved structure for safety report format and content

Next steps will include a shift in focus from generic issues to station- and accident-specific gaps and analyses (the beginning of phase 3). OPG has already submitted the Darlington gap assessment reports and the RD-310 implementation plan and schedule. The other station-specific gap assessments and RD-310 implementation plans will be submitted by the end of December 2013, which will meet the closure criterion of Fukushima action item (FAI) 2.2.1.

The implementation of RD-310 for operating reactors is a large undertaking. Completion of the first two phases has established the basis for analysis of compliance with RD-310, but updating all sections of the safety reports is expected to take several years.

Neutron overpower protection

The new neutron overpower protection (NOP) methodology is being used by Bruce Power and OPG to manage the effects of aging on reactor protection. CNSC staff made significant progress towards completion of its review of the new NOP methodology, presenting the fourth progress review report to the Commission in August 2012. Review activities identified a number of technical issues that require further discussion and resolution. These issues may require additional compensatory measures; however, the current authorization (for interim use of methodology results) remains sufficient to ensure safe reactor operation.

Notwithstanding the significant progress towards completion of its review of the new NOP methodology, the completion date for the CNSC staff review has been revised. The formulation of a regulatory technical position has been deferred from the first quarter of 2012 to the second quarter of 2013.

Probabilistic safety analysis

All NPP licensees must conduct probabilistic safety assessments according to S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [6]. Licensees are required to develop, periodically review and update their PSAs. The PSAs, their methodologies and their updates are reviewed by CNSC staff using well-accepted international guidance to ensure compliance with S-294.

Licensees made considerable progress in their compliance with the requirements of S-294. The subsequent PSA activities are at various stages of implementation or are under review by CNSC staff. During the reporting period, CNSC staff did not identify any compliance issues in this area.

As part of S-294 compliance, licensees must submit internal and external hazards screening reports, which will be considered for the closure of the Fukushima action item (FAI) 2.1.1.

Criticality safety

Bruce Power is the only NPP licensee required to have a criticality safety program as it has slightly enriched uranium on site. CNSC staff noted that there were no criticality events at this site during the reporting period and that they are satisfied with the provisions implemented by the licensee.

Severe accident analysis

To mitigate consequences of a severe accident, G-306, *Severe Accident Management Programs for Nuclear Reactors* [7] describes CNSC's expectations that 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

A plan was developed for CNSC desktop reviews of severe accident management guidelines (SAMGs) for Point Lepreau. The objective is to develop an approach to conduct an efficient and effective evaluation of SAMG implementation. Subsequently, a review will be conducted at each Canadian NPP. The review will be aligned with international best practices and will be coordinated with the CNSC Fukushima action items (FAIs).

Environmental risk assessment

All licensees continued to maintain an effective environmental risk assessment and management program. Environmental risk assessments done at all sites have predicted acceptably low risk and adequate provision for the protection of the environment and public as verified by ongoing monitoring. These environmental monitoring programs are under review as part of the ongoing implementation of N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [8], with a 2013 target for identification of changes needed to comply for each site.

At all sites, programs to verify adequate provision for fish protection and acceptably low risk from thermal discharge and intake water withdrawal effects of condenser cooling water systems are being developed and implemented by the licensees. CNSC is providing direction, with advice from fisheries regulatory agencies such as Fisheries and Oceans Canada and Environment Canada.

Management of safety issues (including R&D programs)

In 2007, the CNSC initiated a project to systematically reassess the status of outstanding design and analysis safety issues for CANDU reactors and to categorize them in order of risk importance to complement the ongoing work on GAIs.

By the end of 2012, from the original 21 CANDU safety issues (CSIs), 12 remained to be reassessed in the highest risk category. Four of those CSIs were related to large loss of coolant accidents (LLOCA), and eight 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.

CNSC staff are satisfied with the industry's progress with respect to LLOCA and non-LLOCA CSIs. See appendix C for more information on CSIs.

Generic action items

All generic action items (GAIs) were closed in 2012.

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 given new information arising over time and considering changes in the external environment. The industry average rating for physical design was “satisfactory”, unchanged from the previous two years.

Overall, based on the information assessed, CNSC staff concluded that the implementation of 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**		**A**	**B**			
Physical design	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**

Physical design encompasses the following specific areas:

- component design (no significant observations to report)
- equipment qualification
- system design and classification
- human factors in design (no significant observations to report)
- robustness design
- engineering change control (no significant observations to report)
- site characterization (no significant observations to report)

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 their safety-related function when subjected to environmentally harsh conditions resulting from design-basis accidents.

The industry, overall, continued to perform well in this area, and all stations are rated “satisfactory”. The EQ programs compliant with N290.13-05, *Environmental qualification of equipment for CANDU nuclear power plants* [9] have been fully implemented at all NPPs except Gentilly-2. Gentilly-2 ended commercial operation in December 2012 and therefore any outstanding compliance issues related to EQ will not be resolved by Hydro-Québec.

Although all licensees have a mature EQ program, there are still opportunities for improvement, notably in regards to EQ sustainability (steam barriers, cable condition monitoring, and documentation). Licensees are addressing these areas.

System design and classification

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

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

The licensees have continued to maintain and improve the reliability of instrumentation and control (I&C) systems through replacement projects and maintenance strategies. Overall, all stations performed well in the area of I&C.

Service water, including emergency service water systems

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

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

During 2012, the service water systems functioned well at each station. No significant compliance issues were observed by CNSC staff.

Electrical power systems

The electrical power systems are important for cooling, controlling, containing and monitoring the reactor and auxiliary systems.

To address the various electrical requirements within a nuclear power plant, electrical power systems are subdivided according to groups (I and II), classes (I, II, III and IV) and divisions (odd and even). The systems are designed, operated and maintained to supply power to safety-related loads to meet the nuclear safety requirements of the plant. During 2012, the overall performance of the electrical power systems was satisfactory across all stations, and no significant compliance issues were observed by CNSC staff. However, there is some area for improvement with regards to battery and standby generator performances at some stations. Licensees have taken appropriate mitigating actions, and CNSC staff are monitoring the ongoing compliance.

A portable backup electrical generator.

All stations have backup electrical provisions that are designed to be available when Group I electrical power systems may not be available (for example, during seismic events). In all sites except Bruce A and Pickering A, an independent emergency power supply system is located in seismically qualified buildings, sufficiently remote from other electrical systems to ensure that common mode effects are eliminated. Bruce A has a qualified power supply system. The design for Pickering A includes several features such as the Class III interstation transfer bus (ISTB), environmentally qualified rooms to house important Class I and Class II electrical equipment, and seismic qualification of standby generators.

Fire protection design

The implementation of the fire protection programs has generally been effective, although some events were reported at Point Lepreau.

Each licensee is implementing modifications to address recommendations from the CNSC staff's review of their updated fire safety assessment (code compliance review, revision to the facility's fire hazard assessment, and fire safe shutdown analysis) in accordance with N293-07, *Fire Protection for CANDU Nuclear Power Plants* [10]. The issues related to these recommendations are not considered to be risk significant. The proposed modifications will increase the safety margin of each facility's fire protection.

Cyber security
As in the 2011 NPP report, CNSC staff observed that 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.

Seismic qualification
CNSC staff have found that all licensees have established seismic qualification 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.

No significant safety compliance issues related to seismic qualification were found at any sites.

Robustness design
Robustness design covers the physical design of nuclear facilities for sufficient robustness against anticipated threats, such as protection against a malevolent aircraft crash. The assessment and ratings for this specific area are based on licensee performance in meeting the commitments 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.

CNSC staff have fully addressed concerns regarding defence in depth and the regulatory oversight of nuclear power plants in Canada with respect to high-risk malevolent acts that are characterized as beyond-design-basis threats. The operating licenses and licence conditions handbooks are being updated to reflect expectations and compliance verification criteria related to robustness design.

CNSC staff requested licensees to carry out reassessments to resolve residual compliance issues identified at their sites using CNSC staff-developed aircraft impact loading functions for large commercial aircraft crash impact. Licensees responded with additional analysis and their submissions are under review by CNSC staff as part of the Fukushima action items (scheduled to be completed by December 2013). The focus of the review is on mitigation of potential consequences of these accidents.

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 its intended design function when called upon to do so. The industry average rating for fitness for service was "satisfactory", unchanged from the previous two years.

Overall, based on the information assessed, CNSC staff concluded that the implementation of 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		A	B			
Fitness for service	SA	SA	FS	SA	SA	SA	SA	SA

Fitness for service encompasses the following specific areas:

- equipment fitness for service and performance (no significant observations to report)
- maintenance
- monitoring of SSCs (no significant observations to report)
- reliability of systems important to safety
- structural integrity
- aging management / lifecycle management
- periodic inspection and testing
- in-service inspections for balance-of-plant

Maintenance

Maintenance inspections carried out in 2012 did not identify any major compliance issues. CNSC staff routinely monitor several maintenance performance indicators, including preventive maintenance completion ratio (PMCR) and maintenance backlogs.

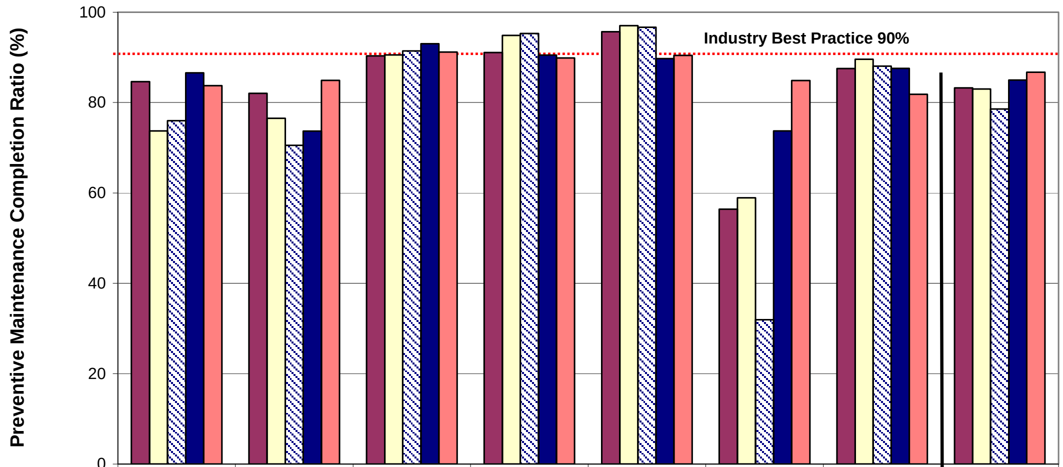
The PMCR performance indicator (PI) is the ratio of preventive maintenance work orders completed on safety-related equipment divided by the total maintenance work orders (preventive maintenance plus corrective maintenance work orders) completed on safety-related equipment. The PMCR monitors the effectiveness of the preventive maintenance program in minimizing the need for corrective maintenance activities. As shown in figure 6, the 2012 PMCR values for Canadian NPPs increased from 85% to nearly 87% in 2012. This average is approaching the industry best practice value of 90%. The OPG stations continue to meet this target, while Bruce A and Point Lepreau experienced decreases in their PMCR values of more than 2%; however, their values remained within 9% of the industry best practice target.


Preventive maintenance at an NPP.

The maintenance backlogs, monitored by CNSC staff, are an indicator of maintenance effectiveness. In particular, the corrective maintenance backlog and the elective maintenance backlog (also referred to as “deficient maintenance backlog” in INPO AP-928 rev 3, *Work Management Process Description* [11]) are reviewed. These maintenance backlogs give an indication of the plant’s material condition. There will always be a certain level of backlog, due to normal work management process and equipment aging. Both corrective and elective (or deficient) maintenance backlog levels at most sites improved over the 2012 operating year, but this will remain a focus area for CNSC staff until all stations meet best industry practice levels.

For maintenance, to date, regulatory standard S-210, *Maintenance Programs for Nuclear Power Plants* had been incorporated into the licence of all nuclear power plants. In December 2012, a new regulatory document, RD/GD-210, *Maintenance Programs for Nuclear Power Plants* [12], was published. RD/GD-210 retains the same requirements as S-210 but includes additional guidance; therefore, no plan is needed by the licensees to transition to RD/GD-210. Current references to S-210 in existing licences will be treated as a reference to the equivalent RD/GD-210, which will be phased in as licences are renewed.

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



	Bruce A	Bruce B	Darlington	Pickering A	Pickering B	Gentilly-2	Point Lepreau	Industry
2008	84.6	82.0	90.3	91.1	95.7	56.4	87.5	83.3
2009	73.7	76.5	90.5	94.8	97.0	58.9	89.6	83.0
2010	76.0	70.5	91.4	95.3	96.7	31.9	88.1	78.6
2011	86.6	73.7	93.0	90.5	89.7	73.7	87.6	85.0
2012	83.7	84.9	91.2	89.9	90.4	84.9	81.8	86.7

Reliability of systems important to safety

As determined through inspections of systems important to safety and reviews of station reports, all licensees were in compliance with the regulatory requirements given by S-98, *Reliability Programs for Nuclear Power Plants* [13].

Overall, the special safety systems performed well in terms of reliability. The impairments that occurred were not safety-significant, and the licensees took appropriate actions to address the impairments and completed corrective actions to prevent reoccurrences.

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.

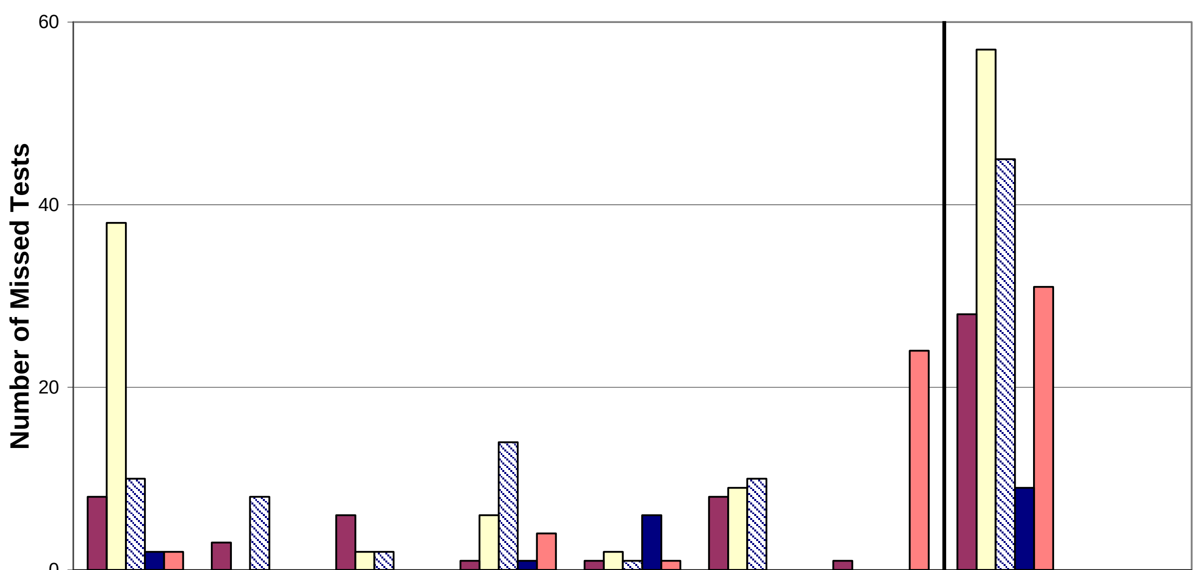
Although the number of missed mandatory safety system tests increased from 9 in 2011 to 31 in 2012, the overall industry percentage of missed tests remained very low at 0.03%. The number of missed tests represents negligible risk since the tests will be performed in the next outage or shortly after the required time. Also, the safety systems involved in the tests have sufficiently high redundancy to ensure continuous safety system availability. In 2012, three stations (Bruce B, Darlington and Gentilly-2) had no missed safety system tests for the second year in a row. The relatively high number of missed safety system tests at Point Lepreau is associated with the return-to-service activities, and did not affect safety.

Table 4: Missed mandatory safety system tests for 2012

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	28,208*	0	2	0	2	0.01
Bruce B	29,297*	0	0	0	0	0
Darlington	14,400	0	0	0	0	0
Pickering A	5,288	1	1	2	4	0.08
Pickering B	10,983	0	0	1	1	0.01
Gentilly-2	4,837	0	0	0	0	0
Point Lepreau	4,590	12	12	0	24	0.52
Industry total	97,603	13	15	3	31	0.03

* The relatively high number of total tests at Bruce A and B is due to the inclusion of panel check safety system tests (SSTs).

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



	Bruce A	Bruce B	Darlington	Pickering A	Pickering B	Gentilly-2	Point Lepreau	Industry Total	Industry % Missed Tests
2008	8	3	6	1	1	8	1	28	0.03%
2009	38	0	2	6	2	9	n/a	57	0.06%
2010	10	8	2	14	1	10	n/a	45	0.05%
2011	2	0	0	1	6	0	n/a	9	0.01%
2012	2	0	0	4	1	0	24	31	0.03%

Structural integrity

Pressure boundary components monitoring

All licensees have inspection programs in place to provide ongoing monitoring of the structural integrity of the passive components (piping, pressure vessels, etc.) at the nuclear pressure boundaries, as well as supplementary programs for pressure tubes, feeders and steam generators. All licensees inspect these pressure retaining components in accordance with the station's periodic inspection programs (PIPs) and applicable standards published by the CSA Group ("CSA standards") as required by the station operating licence. CNSC staff's PIP compliance monitoring activities include the review of governing program documents, review of outage inspection reports, and review of dispositions.

Overall, several inspections were performed by the licensees on the primary heat transport system, steam generators, fuel channels and auxiliary systems covered under the scope of N285.4, *Periodic inspection of CANDU nuclear power plant components* [14]. CNSC staff reviewed the results of the inspections and did not identify any component degradation that would affect nuclear safety.

At the end of 2012, industry submitted to CNSC for acceptance the updated *Fitness-for-Service Guidelines for Steam Generators and Preheater Tubes* (COG-07-4089-R1), used as an industry-wide governing document. CNSC staff are reviewing the updated guidelines.

Testing the Pickering vacuum building.

Concrete containment structures monitoring

All operating NPPs have inspection and testing programs in place to ensure the concrete containment structures are fit for service. Those licensees inspect and perform leakage rate tests of the concrete containment structures in accordance with the station's PIPs and the 2008 version of N287.7, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants* [15]. An updated inspection program is expected to be submitted by Hydro-Québec in 2013 for the safe storage and future decommissioning of Gentilly-2.

During the reporting period, CNSC staff did not identify significant compliance issues affecting safety in this area.

Containment components monitoring

To ensure fitness for service of the metallic and plastic components that form extensions to the containment boundary, all licensees are required to satisfy the periodic inspection provisions of N285.5, *Periodic inspection of CANDU nuclear power plant containment components* [16]. Results of these inspections are filed for review by CNSC staff after every inspection campaign as mandated by S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1].

During the reporting period, CNSC staff did not identify significant compliance issues affecting safety in this area. Overall, all licensees performed satisfactorily and reported on results of periodic inspections for containment components.

Aging management / lifecycle management

All licensees are in the process or have completed gap assessments between the utility's existing programs and RD-334, *Aging Management for Nuclear Power Plants* [17]. Successful completion will result in integrated aging management programs (AMPs) to ensure that SSC aging is understood and managed effectively for the station as a whole.

All operating Canadian NPPs have established component-specific AMPs (also known as lifecycle management programs, or LCMPs) for the major life-limiting components of their CANDU reactors (feeders, pressure tubes, steam generators and containment structures). In the fall of 2012, OPG submitted updated LCMPs for pressure tubes, feeders and steam generators. CNSC staff reviewed the updated LCMPs and found them acceptable. Updated AMPs are expected to be submitted by Hydro-Québec in 2013 for the safe storage and future decommissioning of Gentilly-2.

To develop the engineering methodologies to assess the fitness for service of pressure tubes operating beyond their assumed design life of 210,000 effective full-power hours (EFPH), OPG, Bruce Power and AECL have developed a fuel channel life management project 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 reviewed most of them. The progress of this project is being closely monitored by CNSC staff.

Periodic inspection and testing

Inspections, testing and monitoring of CANDU NPP SSCs, such as pressure boundary components, containment structure and components, and significant balance-of-plant SSCs, are mandatory requirements through standards published by the CSA Group ("CSA standards") that are referenced in all operating licences. These CSA standards define the requirements for the inspection, testing and monitoring programs for CANDU NPPs. The standards are continually revised to reflect important operating experience, and licensees are typically requested to transition to the newer standards at licence renewal.

During the reporting period, CNSC staff did not identify significant compliance issues affecting safety in these areas.

In-service inspections for balance-of-plant

All licensees are required to carry out inspections to monitor the integrity of safety-significant balance-of-plant (BOP) pressure retaining systems and components and safety-related structures. The licensing requirement for the implementation of a BOP inspection program was added to all NPP licences and the licensees are expected to develop, implement and maintain inspection programs for BOP safety-related SSCs. The progress of this project is being closely monitored by CNSC staff.

CNSC staff monitor quarterly pressure boundary reports, operations reports and specific event reports submitted in accordance with S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1] for evidence of safety significant degradation of BOP pressure boundary components. During the reporting period, CNSC staff did not identify significant compliance issues affecting safety in this area. CNSC staff continued to provide regulatory oversight in this area to ensure each licensee's implementation of the inspection of BOP SSCs meets the regulatory requirements.

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 contamination and radiation doses received are monitored and controlled. The industry average rating for the radiation protection SCA was "satisfactory", unchanged from the previous two years.

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

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

Radiation protection encompasses the following specific areas:

- application of ALARA (as low as reasonably achievable)
- worker dose control
- personnel dosimetry
- contamination control
- estimated dose to the public

The overall objective of the radiation protection program is to ensure that radiation exposures to workers and members of the public are kept ALARA, social and economic factors taken into account.

Application of ALARA

All licensees continued to apply measures to keep doses received by workers ALARA. CNSC staff conducted compliance inspections focused on the application of ALARA at some NPPs. Areas for improvement were identified and licensees have developed corrective action plans that have been revised and accepted by CNSC staff.

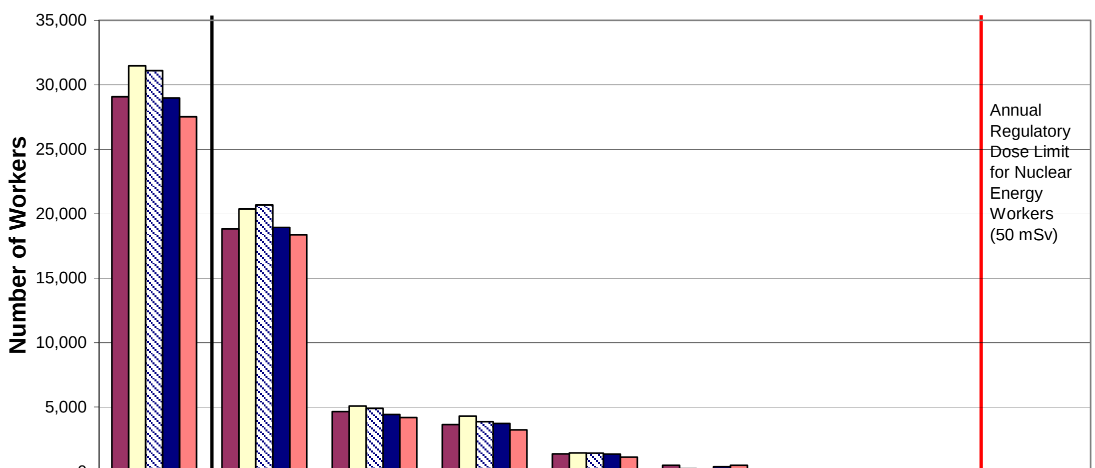
Worker dose control

All licensees had a system in place to control radiation doses to workers. Through inspections and document reviews, CNSC staff monitored the effectiveness of the licensees' radiation protection programs, including the implementation of long-term improvements related to alpha monitoring and control.

The effective dose limits for nuclear energy workers (NEWs), as specified in the *Radiation Protection Regulations*, are 50 millisievert (mSv) per year and 100 mSv over a five-year fixed dosimetry period. In addition to these regulatory dose limits, all NPPs have established action levels and administrative dose limits for workers that are set at a fraction of the regulatory dose limits.

Figure 8 provides the distribution of annual effective doses to workers at all Canadian NPPs from 2008 to 2012. Figure 8 shows that there were no radiation exposures reported at any NPP that exceeded the annual regulatory dose limits, and that approximately 80 percent of the workers at Canadian NPPs received an annual effective dose below 1 mSv (public dose limit). Furthermore, 35 workers received an annual effective dose greater than 20 mSv. These workers were involved in planned outage activities at the Bruce Power site that involved work in areas with high radiation dose rates.

Figure 8: Distribution of annual effective doses to workers in the Canadian nuclear power industry, 2008 to 2012



	Number of Workers Monitored	0	0.01 - 1	1.01- 5	5.01 - 10	10.01 - 15	15.01 - 20	20.01 - 50	> 50
2008	29,071	18,822	4,644	3,652	1,367	481	100	5	0
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

Dose Range (mSv)

Figure 9 shows the arithmetic average effective dose for workers based on non-zero (positive) results and the maximum effective dose to workers at Canadian NPPs for 2012. Figure 9 shows that the average effective worker doses, considering non-zero results only, ranged from 0.70 to 4.30 mSv. Furthermore, the highest annual effective dose received by a worker was 29 mSv, which represents 58% of the regulatory dose limit for nuclear energy workers (this individual is a contractor at the Bruce Power site who worked on the Bruce A Unit 3 and Unit 4 planned outages).

The term "based on the non-zero dose results" in the figure 9 note indicates that the average doses are calculated by only including non-zero (positive) results in the calculation. The minimum reporting level is 0.01 mSv.

The annual collective effective dose to workers at each NPP is presented in appendix D.

Figure 9: Average and maximum effective doses to workers in Canadian nuclear power plants for 2012

	Bruce A & B	Darlington	Pickering A & B	Gentilly-2	Point Lepreau
Average	4.30	1.24	2.92	0.71	0.70
Maximum	29.00	11.70	19.60	3.60	5.10

Dose (mSv)

Note: Arithmetic average dose values are based on the non-zero dose results only

Personnel dosimetry

All licensees continued to operate a CNSC-licensed dosimetry service to monitor, assess, record and report doses received by workers, including contractors and visitors.

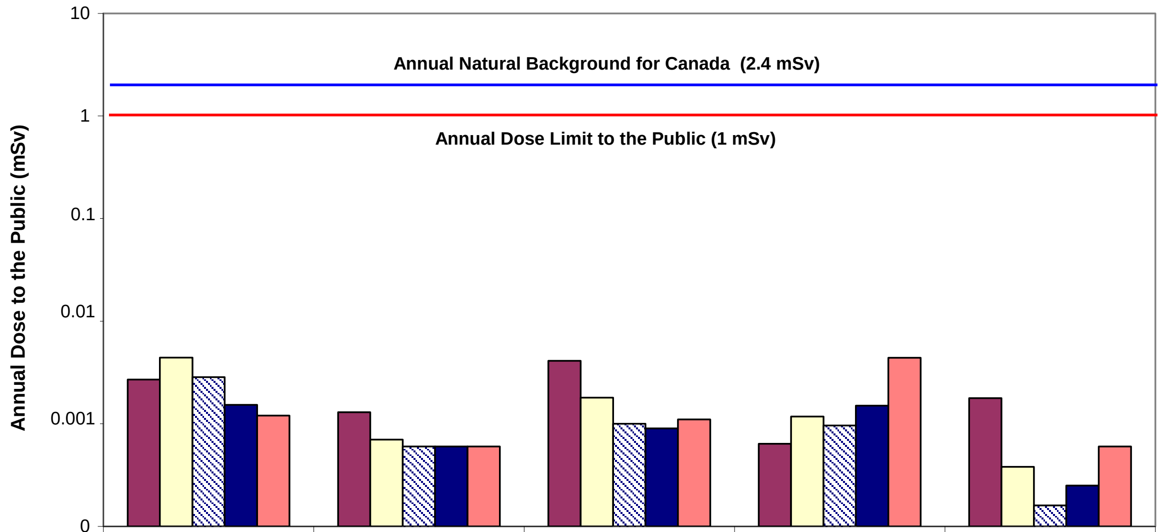
Contamination control

All licensees continued to apply measures to control radioactive contamination in their facilities. Examples of these measures include the use of a radiological zoning system and contamination control areas to contain and control contamination. All licensees also continued to apply a workplace monitoring program to demonstrate that the levels of contamination are controlled.

Estimated dose to public

The dose to the public for both airborne emissions and liquid releases from 2008 to 2012 is provided in figure 10 (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 and negligible in comparison to the amount of radiation dose Canadians receive from natural background radiation sources (on average, 2.4 mSv). The comparison shows that the 2012 doses to the public for Canadian NPPs are within the general range of the 2008 to 2011 values for most stations.

Figure 10: Comparison of estimated dose to public from Canadian nuclear power plants, 2008 to 2012*



	Bruce site	Darlington	Pickering A & B	Gentilly-2	Point Lepreau
2008	0.0027	0.0013	0.0041	0.0006	0.0018
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

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", an improvement from the "satisfactory" ratings in the previous two years.

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

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

Conventional health and safety encompasses the following specific areas:

- compliance with labour code
- housekeeping/management of hazards
- accident severity and frequency

Compliance with labour code

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.

Housekeeping / management of hazards

In general, most NPP licensees met CNSC performance objectives and requirements for housekeeping and management of hazards in accordance with their operating licences and licence conditions handbooks. In 2011, CNSC staff had identified deficiencies at Pickering A and B associated with asbestos hazards; however, throughout 2012, OPG carried out corrective actions focusing on asbestos management. CNSC will continue to monitor the improvements.

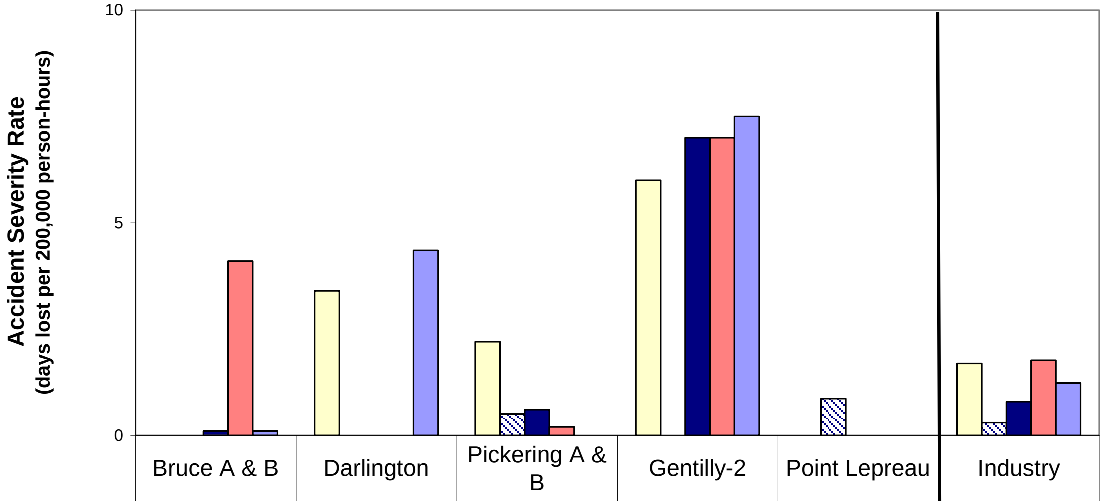
Accident severity and frequency

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. ASR measures the total number of days lost due to injury for every 200,000 person-hours worked at a site. 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 (approximately 100 person-years) worked at a site.

The ASR and AF values for the stations and the industry average are presented in figures 11 and 12, respectively. These figures show that:

- The ASR values for the industry as a whole decreased from 1.8 in 2011 to 1.2 in 2012, an indication that the nature of the injuries sustained were less severe. Point Lepreau achieved the lowest ASR rate, a value of 0. The ASR for Gentilly-2 increased due to an increase in injuries due to lifting or moving objects.
- The AF value for the industry as a whole increased slightly from 0.3 in 2011 to 0.6 in 2012. Specifically, the AF increased for all licensees except Pickering A and B, which remained unchanged at 0.3.

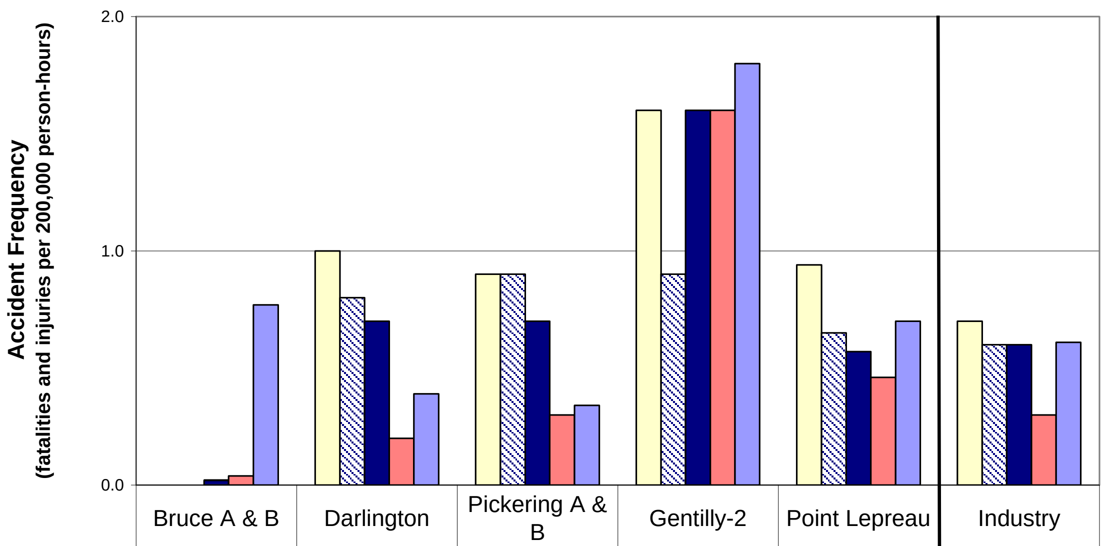
Figure 11: Trend details of accident severity rate for stations and industry



	Bruce A & B	Darlington	Pickering A & B	Gentilly-2	Point Lepreau	Industry
2008	0.0	3.4	2.2	6.0	0.0	1.7
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

* Value revised from previous annual NPP reports based on updated information from the licensee.

Figure 12: Trend details of accident frequency for stations and industry



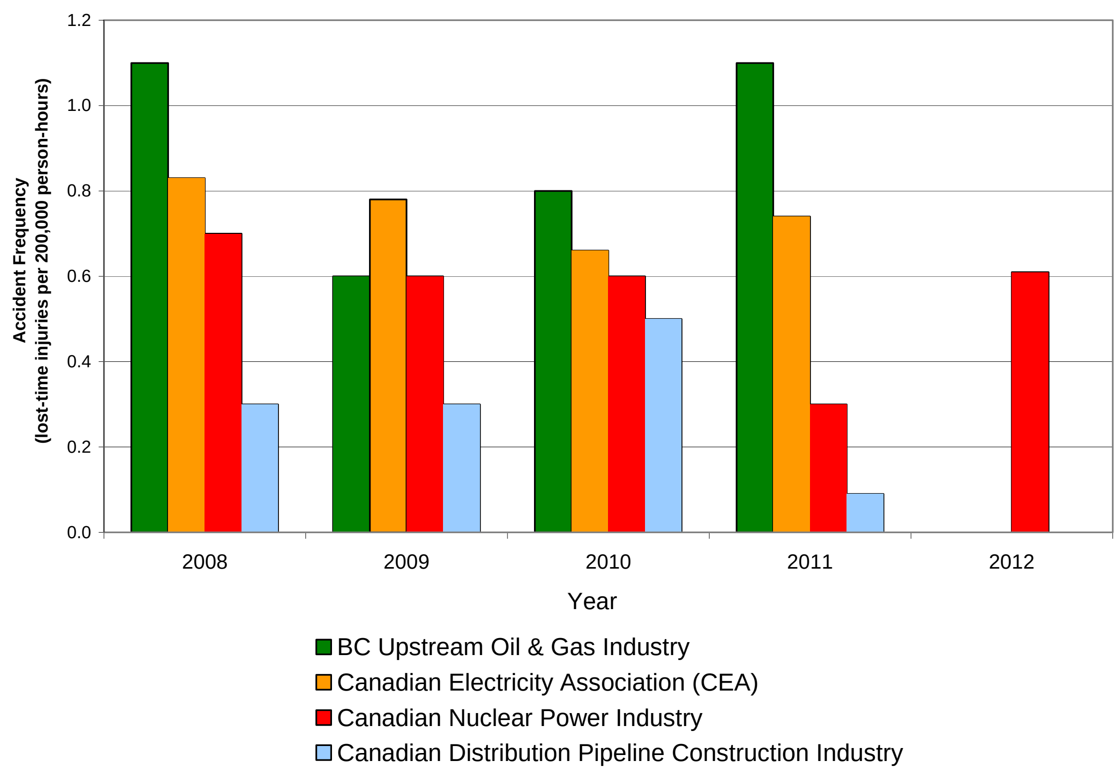
	Bruce A & B	Darlington	Pickering A & B	Gentilly-2	Point Lepreau	Industry
2008	0.0	1.0	0.9	1.6	0.9	0.7
2009	0.0	0.8	0.9	0.9	0.7	0.6
2010	0.02 *	0.7	0.7	1.6	0.6	0.6
2011	0.04 *	0.2	0.3	1.6	0.5	0.3
2012	0.8	0.4	0.3	1.8	0.7	0.6

* Value revised from previous annual NPP reports based on updated information from the licensee.

Figure 13 shows the AF values for the Canadian nuclear power industry from 2008 to 2012 in comparison with values from selected energy-related Canadian industries. The Canadian industries shown in the figure include members of the Canadian Electricity Association (CEA), the BC upstream oil and gas industry, and the Canadian distribution pipeline construction industry.

As shown in figure 13, the AF value for the Canadian nuclear power industry compares very well relative to the selected Canadian industries. It has generally been lower than that of the BC upstream oil and gas industry and of the CEA. For the scope of the comparison, only the Canadian distribution pipeline construction industry's AF values have been lower than the AF values for the Canadian nuclear power industry. Note that only the AF values for the Canadian nuclear power industry include fatalities and medically treated injuries, whereas the AF values for the other energy industries include only the lost-time injuries, which results in an overestimation of the nuclear power industry's values in comparison to the other industries.

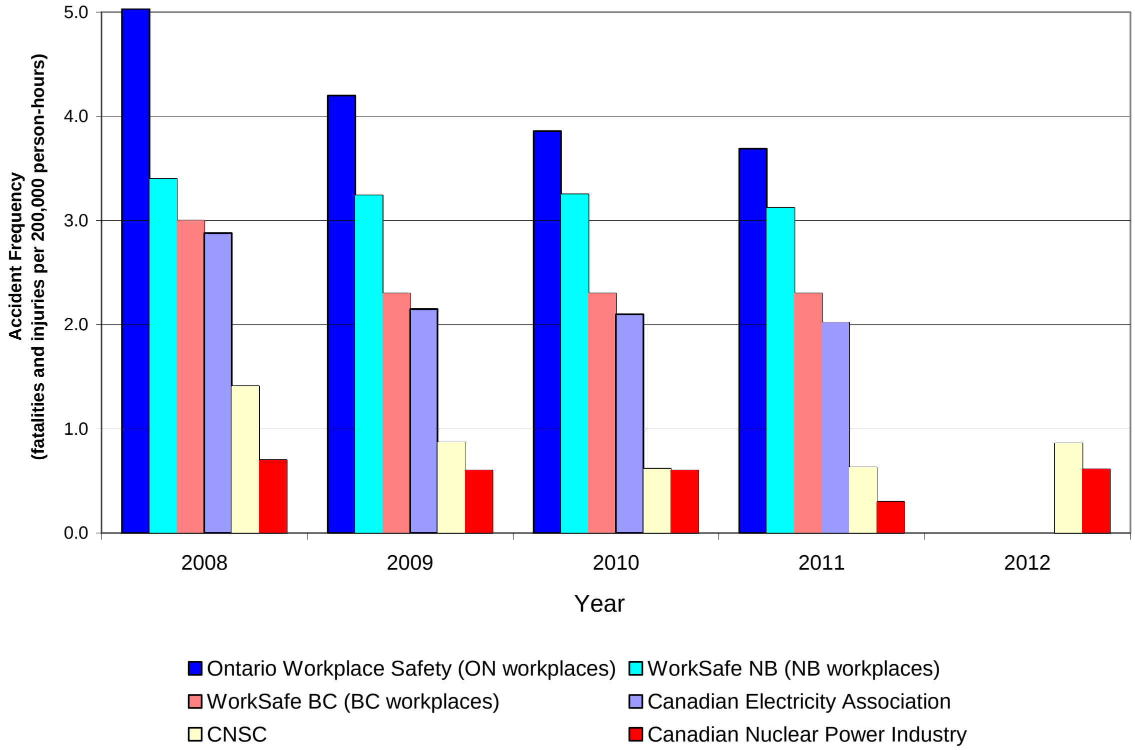
Figure 13: Trend details of accident frequency (based on lost-time injuries) within the Canadian energy industry*



* The AF values for the Canadian nuclear power industry include fatalities and medically treated injuries.

In addition to the information provided in figure 13, figure 14 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 14, the Canadian nuclear power industry's AF is lower than that of other Canadian workplaces. The direct comparison with figure 13 may be affected by small differences in reporting of lost-time injuries and medically treated injuries; however, it demonstrates the effectiveness of the safety programs at the Canadian NPPs in maintaining a relatively low number of injuries.

Figure 14: Trend details of accident frequency (based on lost-time injuries, medically treated injuries and fatalities) for Canadian workplaces



CNSC staff observed that, for the overall nuclear power industry, the industry ASR and AF remained very low during the year despite increased construction work and operational activities associated with refurbishment work at two of the sites.

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 two years.

Overall, based on the information assessed, CNSC staff concluded that the implementation of 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**		**A**	**B**			
Environmental protection	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**

Environmental protection encompasses the following specific areas:

- effluent and emissions control (releases)
- environmental management system
- environmental monitoring

Effluent and emissions control (releases)

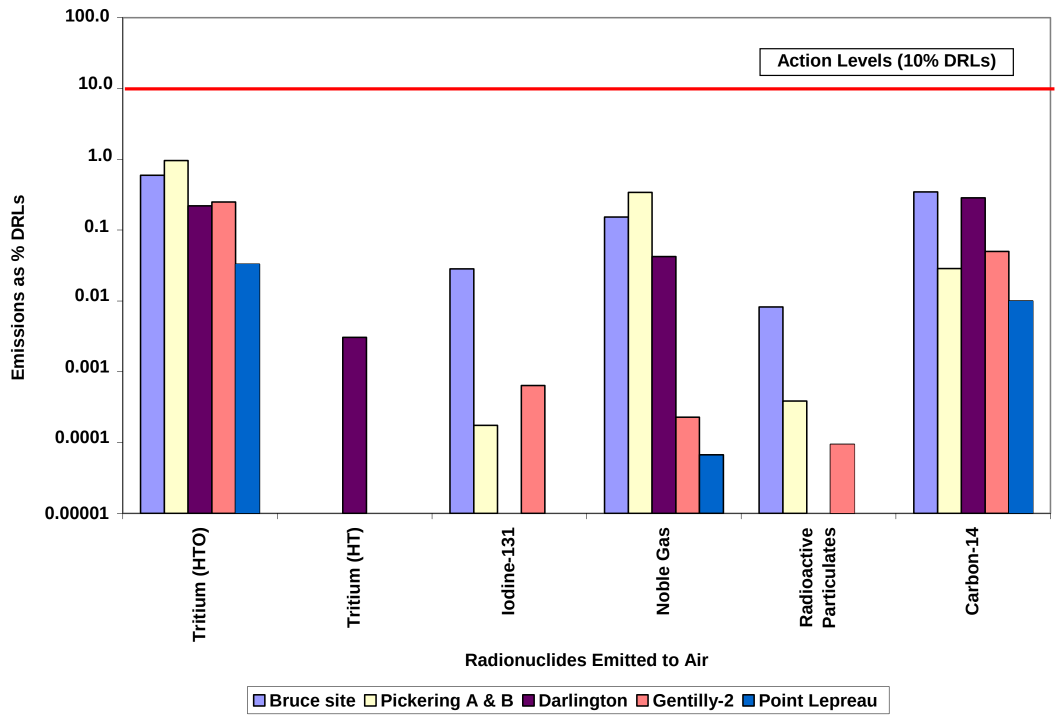
Airborne emissions and liquid releases for 2012 are shown in figures 15 and 16. Note that a logarithmic scale is used for the purpose of direct comparison of the radionuclides. Licensees establish action levels that are set at 10 percent of the derived release limits (DRLs). The DRLs are stated in each operating licence and are given in appendix E, "Derived Release Limits (DRLs) for Canadian NPPs". These 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 the reporting period, all releases were well below action levels and almost negligible in comparison with the regulatory limits.

Environmental monitoring

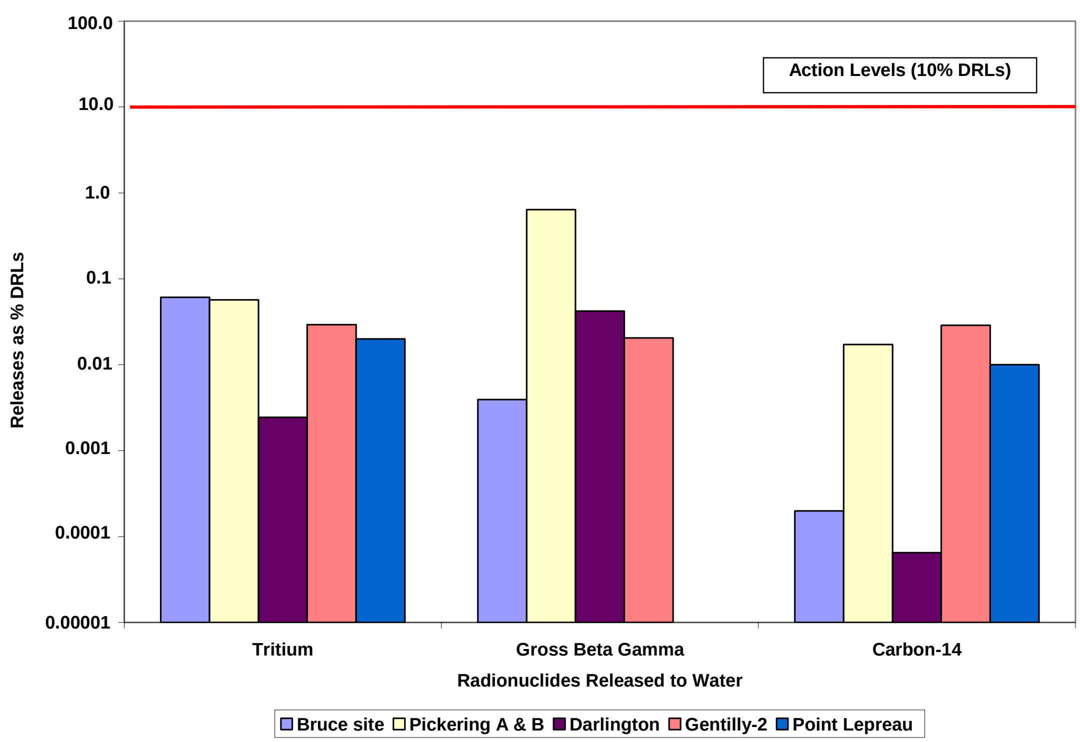
Licensees are working towards the implementation of N288.4-10, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [8]. CNSC staff are satisfied with the progress made in the implementation of this standard.

Figure 15: Radionuclides emitted to air by Canadian nuclear power plants in 2012*



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

Figure 16: Radionuclides released to water by Canadian nuclear power plants in 2012*



* 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 two years.

Overall, CNSC staff concluded that NPP licensees continued to maintain comprehensive and well-documented emergency management programs at their facilities that met all applicable regulatory requirements.

Safety and control area	Rating							
	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau	Industry average
	A	B		A	B			
Emergency management and fire protection	SA	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 operating licenses and licence conditions handbooks. The programs were maintained through training programs, drills and exercise programs.

A fire response crew completes a drill at Point Lepreau.

Nuclear emergency preparedness and response

All licensees continued to maintain and improve their nuclear emergency preparedness and response capabilities at their respective facilities.

Fire emergency preparedness and response

CNSC staff have closely monitored the effectiveness of any corrective actions as part of their return-to-service 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 2012 was "satisfactory", unchanged from the previous two years.

Overall, based on the information assessed, CNSC staff concluded that the implementation of 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		A	B			
Waste management	SA	SA	SA	SA	SA	SA	SA	SA

Waste management encompasses the following specific areas:

- waste minimization, segregation and characterization
- waste storage and processing
- decommissioning plans

Waste minimization, segregation and characterization

All licensees have waste management programs in place that document requirements for the minimization, segregation and characterization of radioactive waste.

Waste storage and processing

All licensees have waste management programs in place for the handling, monitoring, storing and processing of radioactive waste. Based on assessments, all radioactive waste is disposed of appropriately in accordance with regulations and internal procedures.

OPG is proposing to construct and operate a deep geologic repository for the long-term management of low and intermediate level radioactive waste at the Bruce Power site (OPG is the owner of the facility, which is operated by Bruce Power under a lease agreement). The project will hold waste currently in interim storage at OPG's Western Waste Management Facility, as well as the wastes that continue to be produced by the operation of Bruce A and B, Darlington, and Pickering A and B. Low level waste consists of industrial items that have become contaminated with low levels of radioactivity during routine cleanup and maintenance activities at the sites. Intermediate level radioactive waste consists primarily of used nuclear reactor components, ion-exchange resins, and filters used to purify reactor systems. Used nuclear fuel will not be stored or managed in the deep geologic repository. In 2012, a Joint Review Panel was established to review the proposed project, to conduct an examination of the environmental effects, and to obtain the information necessary for the consideration of the licence application under the NSCA. The panel's work is ongoing.

Dry storage modules for used nuclear fuel at Gentilly-2.

Decommissioning plans

The decommissioning plans for six of the seven Canadian NPPs remain current. CNSC staff are satisfied that these plans meet the requirements of G-219, *Decommissioning Planning for Licensed Activities* [18] and N294-09, *Decommissioning of facilities containing nuclear substances* [19]. The decommissioning plans were revised within the last five-year period, as required.

The exception is the plan for Gentilly-2. Due to the early shutdown of this station, Hydro-Québec is required to submit a revised decommissioning plan and associated financial guarantee.

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 "satisfactory", unchanged from the previous two years.

Overall, based on the information assessed, CNSC staff concluded that the security program at every site met the regulatory requirements of the *Nuclear Security Regulations* and associated regulatory documents.

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

Security encompasses the following specific areas:

- facilities and equipment (no significant observations to report)
- access control (no significant observations to report)
- training, exercises and drills (no significant observations to report)
- nuclear response force (no significant observations to report)

All licensees continued to maintain and implement effective security programs in accordance with CNSC requirements. The performance testing program continues to test and validate each licensee's physical protection systems (detection, delay and response) to ensure that they are adequate and in compliance with performance and regulatory requirements. The Canadian Adversary Testing Team continues to be an effective evaluation tool for these performance testing exercises.

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* [20]. The industry average rating for safeguards and non-proliferation was "satisfactory", unchanged from the previous two years.

Overall, based on the information assessed, CNSC staff concluded that the implementation of 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**		**A**	**B**			
Safeguards and non-proliferation	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**	**SA**

The CNSC's evaluation of the licensees' overall performance takes into consideration the IAEA's annual conclusion for Canada as a whole, which is presented to the IAEA Board of Governors each June in the Safeguards Implementation Report. The IAEA has not yet finalized its 2012 evaluation; however, a positive overall assessment is expected by CNSC staff.

RD-336, *Accounting and Reporting of Nuclear Material* [21] became effective January 1, 2011. Licensees were granted a transition period until July 1, 2012 to update their nuclear material accountancy system. CNSC has reviewed submissions from each licensee and has concluded that the transition has been completed and all sites are compliant with RD-336. Although some minor issues have been identified, CNSC staff noted the strong performance of all sites in the timely submission of their nuclear material accountancy reports and the substantial effort required for the implementation of RD-336.

All sites granted access and assistance to the IAEA, both for inspection activities and for the maintenance and monitoring of the IAEA's equipment.

All sites submitted the required annual operational programs with quarterly updates, as well as the annual update, in a timely manner, to the *Protocol Additional to the Agreement between Canada and the International Atomic Energy Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons* [22].

No major IAEA equipment installation occurred in 2012; however, the sites were cooperative in supporting the maintenance of IAEA equipment including the updating of the core discharge monitors at Bruce A, the replacement of spent fuel seals at Darlington, and the reinstallation of equipment following the refurbishment of Point Lepreau.

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. This tracking and reporting assists the CNSC in the implementation of Canada's bilateral Nuclear Cooperation Agreements with other countries. Within this limited scope, no compliance issues were identified. The import and export of controlled nuclear substances, equipment and information require separate authorization from the CNSC and are not included within the scope of this SCA with respect to NPPs.

2.14 Packaging and transport

The packaging and transport SCA pertains to programs that cover the safe packaging and transport of nuclear substances and radiation devices to and from the licensed facility. The industry average rating for this SCA was determined to be "satisfactory", unchanged from the previous two years.

Overall, based on the information assessed, CNSC staff concluded that the implementation of 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		A	B			
Packaging and transport	SA	SA	SA	SA	SA	SA	SA	SA

All licensees have a packaging and transport program that ensures compliance with the *Packaging and Transport of Nuclear Substances Regulations* and the *Transportation of Dangerous Goods Regulations* [23]. The programs are effectively implemented and the transport of nuclear substances to and from each facility is performed in a safe manner.

Licensees reported some minor transport events. There were no safety consequences as a result of the incidents, and CNSC staff found the corrective actions to be acceptable.

Transportation of used fuel at an OPG facility.

2.15 Public information and disclosure programs

In accordance with their licensing basis, all licensees in Canada are required to have robust public information and disclosure programs. Throughout 2012, licensees progressed towards meeting the deadline of December 2013 to ensure their programs would become compliant with the regulatory requirements contained in RD/GD-99.3, *Public Information and Disclosure* [24], which was published in 2012. These new regulatory requirements build on previously established guidance that was first introduced in 2004.

The regulatory requirements include provisions for:

- the identification of clear, measurable objectives and target audiences
- the tracking of public views, opinion and concerns related to the licensed activities
- the development of strategies and communications products that provide for open and easily accessible means to obtain information
- the establishment and implementation of a robust public disclosure protocol
- the maintenance of documentation and records to demonstrate adequate implementation
- program evaluation and improvement

A fundamental element introduced through RD/GD-99.3 [24] is the obligation for licensees to establish public disclosure protocols. Bruce Power, OPG and NB Power have posted their respective disclosure protocols on their Web sites. They have also begun sharing information on events according to the disclosure criteria in these protocols. Hydro-Québec is currently working on its draft protocol. As protocols are shared and stakeholders at large are consulted, licensees will gather comments and integrate them when possible.

NB Power's Public Affairs Manager talks with Bay of Fundy commercial fishermen who have representatives on the licensee's community liaison group.

Licensees made progress in incorporating the program's activities into their corporate management systems. CNSC staff concluded that the licensees are making adequate efforts to meet program requirements.

3. Nuclear Power Plant Safety Performance Ratings

This section is organized by station, with performance ratings provided for each SCA. The ratings reflect CNSC staff's evaluation of how well licensees' programs met regulatory requirements and expectations to protect the overall health, safety and security of Canadians 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 Type I and Type II inspections, reportable events, 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 (OPG).

The Bruce A station consists of four 904 MWe (megawatts electrical) CANDU reactors that came into service between 1977 and 1979. In 1998, all four units were defuelled and placed in a "guaranteed safe shutdown" state. Units 3 and 4 were refurbished, and Unit 4 restarted in 2003 while Unit 3 restarted in 2004.

In 2012, Units 3 and 4 were fully operational throughout the year. The refurbishment of Units 1 and 2 was completed in the second half of 2012, and both units became operational. Unit 1 has one outstanding commissioning issue that is being regulated by a holdpoint imposed by the CNSC.

The Bruce B station consists of four 915 MWe CANDU reactors that came into service between 1984 and 1987. Throughout 2012, all four units were fully operational.

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 different implementation of some programs at the two stations.

The 2012 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 two years 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	SA
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

The management system SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the management system SCA at Bruce A and B met all applicable regulatory requirements.

Management system

Bruce Power's management system was in compliance with N286-05, *Management system requirements for nuclear power plants* [2]. Based on the results of onsite inspections and desktop reviews, CNSC staff found that Bruce Power's management system is adequate and that management performance conformed to the requirements in N286-05. Bruce Power has developed, or is in the process of implementing, appropriate corrective actions for the minor issues identified by CNSC staff.

Management performance

Bruce Power continued to make improvements to its management performance as required by the management system program. CNSC staff conducted an inspection to assess the implementation of the management system effectiveness review. All organizational issues have been properly addressed by Bruce Power throughout the reporting period.

3.1.2 Human performance management

The human performance management SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the human performance management SCA at Bruce A and B met all applicable regulatory requirements.

Personnel certification

Bruce A and B had sufficient numbers of personnel for all certified positions. The personnel certification processes and procedures were found to be adequate. CNSC staff are confident that, in 2012, the certified staff at Bruce Power were competent to perform the duties of their positions safely and adequately. Bruce Power continued to meet the regulatory requirements for personnel certification.

Initial certification examinations and requalification tests

The initial certification examinations and requalification tests programs met the requirements for the initial certification of workers and the renewal of certifications. No significant safety compliance issues were identified at either station. Bruce Power continued to meet the CNSC requirements for initial certification examinations and requalification tests.

The personnel certification processes and procedures were found to be adequate. Bruce Power’s overall pass rate for requalification tests was 93% and for initial certification examinations was 89%. CNSC staff finds these results acceptable.

The inspection and desktop review of the Unit 0 certification examinations, conducted by CNSC staff, identified a number of strengths in the implementation of Bruce Power’s certification examinations program. The inspection and review also identified some areas for improvement, such as inadequate documentation and unclear examination questions, and these are being addressed.

Work organization and job design

Both Bruce A and B had an effective process to ensure that qualified staff are scheduled to meet the minimum shift complement [3]. A process is in place to ensure that qualifications are up to date for those holding minimum shift complement positions for all workgroups and emergency roles. Bruce Power’s staff adhere to their internal process to monitor and control minimum shift complement. However, Bruce A incurred a number of violations of hours-of-work limits in order to maintain the minimum shift complement. The majority were related to the authorized nuclear operator (ANO) positions. Bruce Power was requested to investigate these hours-of-work violations and verify whether any corrective actions can be implemented to prevent reoccurrence. CNSC staff are monitoring progress and will take further regulatory actions as required.

3.1.3 Operating performance

The operating performance SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a “satisfactory” rating, unchanged from the previous two years.

CNSC staff concluded that Bruce Power operated Bruce A and B safely and in compliance with the licensing basis.

Conduct of licensed activity

Both stations operated safely. Bruce A and B met regulatory requirements and operating performance expectations. Bruce Power adhered to the licence conditions concerning reactor power at both stations.

Bruce A Units 1 and 2 refurbishment activities and the restart were successfully completed. Unit 1 has one outstanding commissioning issue that is being regulated by a holdpoint imposed by the CNSC. The licensee is addressing the issue, and CNSC staff are monitoring the progress.

With four reactors each:

- Bruce A experienced two unplanned reactor trips during operation, two unplanned reactor trips during commissioning testing, three stepbacks and nine setbacks (mostly due to return-to-service of Units 1 and 2)
- Bruce B experienced no unplanned reactor trips, no stepbacks, and no setbacks

CNSC staff verified that, for all transient events, Bruce Power staff followed approved procedures, investigated or evaluated the root cause of the event, and took appropriate corrective actions.

Bruce A experienced three forced outages and Bruce B experienced one. In terms of safety and work management, the implementation of the outages met requirements for both stations.

Outage management performance

Three planned outages occurred at Bruce A for Units 3 and 4, and one planned outage at Bruce B for Unit 8. Bruce Power completed all outages successfully and met the requirements for verification of reactor shutdown guarantees (RSGs). CNSC staff verified and confirmed that the RSGs were applied correctly and met the requirements for reactor safety.

Safe operating envelope

A Type I inspection of the safe operating envelope showed an adequate level of implementation.

3.1.4 Safety analysis

The safety analysis SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the safety analysis SCA at Bruce A and B met all applicable regulatory requirements.

Deterministic safety analysis

CNSC staff conducted a desktop review of Bruce Power's deterministic safety analysis program. 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, and the use of analysis results. The review indicated that Bruce Power had an effective, well-managed program for performing safety analysis.

CNSC staff continued reviewing the updated analysis sections of the Bruce B Safety Report. These updates have addressed the gap of the Loss of Coolant Accident plus Loss of Emergency Coolant Injection analysis. The updated Bruce A Safety Report and Bruce B Safety Report were submitted to CNSC and are currently under review.

Probabilistic safety analysis

Bruce Power continued to make progress with respect to compliance with the requirements of S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [6]. Bruce Power's submissions on probabilistic safety analysis methodologies are currently under review by CNSC staff for verification of compliance with S-294. Once the methodologies and the results are accepted, Bruce Power will transition to this regulatory standard.

Criticality safety

Bruce Power is the only licensee required to have a criticality safety program. CNSC staff noted that there were no criticality events at Bruce A and B, and they are satisfied with the provisions implemented by the licensee.

Severe accident analysis

Bruce Power continues its progress in completing the work associated with the Fukushima action items (FAIs). Bruce Power's activities and submissions are aimed at closing the remaining FAIs in accordance with the established schedule.

Environmental risk assessment

Bruce Power's environmental risk assessment program includes mitigation of the risks discussed below:

- ***Fish:*** 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. Risk assessment continues to be informed by monitoring results from the Bruce A environmental assessment follow-up program.
- ***Flooding:*** As part of the efforts to address FAI 2.1.1, Bruce Power has conducted a screening assessment of external hazards including floods (phase 1). Bruce Power is currently conducting the phase 2 assessment.

A flood barrier – one example of efforts to address FAI 2.1.1.

- ***Groundwater:*** The groundwater monitoring program in place at Bruce A and B has indicated no adverse effect on the groundwater flow system.
- ***Hydrazine:*** Unplanned discharges are now controlled through new control and mitigating measures (a result of formal commitments made by Bruce Power).

3.1.5 Physical design

The physical design SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the physical design SCA at Bruce A and B met all applicable regulatory requirements.

Component design

Bruce Power is transitioning to N285.0-08, *General requirements for pressure-retaining systems and components in CANDU nuclear power plants* [25]. CNSC staff monitored this transition and is satisfied with the progress. Bruce A and B confirmed that SSCs important to nuclear safety and security continued to meet their design basis in all operational states.

Equipment qualification

The environmental qualification (EQ) program is fully implemented at all Bruce A and B operating units. The goal of the EQ program is to ensure that all required systems, equipment, components and barriers are properly qualified to perform their safety functions during a design-basis accident (DBA). Implementation of the EQ program at Bruce A Units 1 and 2 was completed prior to restart of both units. An EQ inspection was conducted before the restart to ensure full implementation of the EQ program. Bruce Power demonstrated compliance in having a strong EQ program; however, the qualification status of the Bruce A standby generator 2 for the qualified power supply system is still being resolved by Bruce Power. CNSC staff are monitoring the issue and receiving semi-annual updates from Bruce Power.

System design and classification

In the sub-area of fire protection design, Bruce Power continued its activities to improve fire protection at all the facilities through the implementation of procedural and physical upgrades as recommended by CNSC staff within the code compliance review of the facilities against N293-07, *Fire protection for CANDU nuclear power plants* [10] and the revised fire hazard assessments and fire safe shutdown analysis. These recommendations are not considered to be risk significant, and the proposed modifications will increase the safety margin of the facility with respect to fire protection. CNSC staff continued to monitor progress on addressing the recommendations.

Human factors in design

CNSC staff’s inspection indicated that Bruce Power used the approved process for taking human factors into account in its design process. For the sample of modifications, the human factors aspect of the design was found to reflect good design practices, and the appropriate design guides were specified. However, areas for improvement – such as assessment criteria, process observance and conformance to licensee documents – were identified and communicated to Bruce Power.

3.1.6 Fitness for service

The fitness for service SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the fitness for service SCA at Bruce A and B met all applicable regulatory requirements.

Equipment fitness for service / equipment performance

On the basis of onsite inspections and compliance verifications, CNSC staff are satisfied with the overall equipment performance at Bruce A and B. However, several compliance issues of low significance related to emergency power systems, such as processes for preventive maintenance and record management for testing, require improvements and are being addressed by Bruce Power.

Maintenance

The maintenance program performance at both Bruce A and B remained at a satisfactory level with improvements observed for Bruce B. The preventive maintenance completion ratio (PMCR) improved to 84%, approaching the industry best practice value of 90%. Bruce Power reduced its corrective maintenance backlogs at both Bruce A and B, reaching the best industry practices ratio at Bruce B. The elective maintenance backlogs were also reduced although they remain high at both stations.

Maintenance inspections did not identify any significant compliance issues. CNSC staff noted the implementation of Bruce Power's maintenance activities according to the requirements of RD/GD-210, *Maintenance Programs for Nuclear Power Plants* [12]. Work completion continued to show areas for improvement, particularly for elective maintenance activities. CNSC staff will continue to focus on this area and monitor the corrective actions that have been implemented by Bruce Power to lower the overall maintenance backlogs and the number of work requests, in order to perform maintenance in a timely manner.

Reliability of systems important to safety

Bruce Power's reliability program was in compliance with S-98, *Reliability Programs for Nuclear Power Plants* [13]. However, some improvements are required for the performance objectives to be met in the case of systems important to safety. These improvements are mainly concerned with the reliability modelling and are not related to the performance of the systems important to safety themselves. Bruce Power is addressing the improvements.

For Bruce A, all of the special safety systems met their unavailability targets with the exception of the emergency cooling injection system and shutdown system 2 (SDS2). Neither of the impairments affected safety, because the licensee took appropriate compensatory actions and carried out corrective measures.

For Bruce B, all of the special safety systems met their unavailability targets.

Structural integrity

CNSC staff confirmed that Bruce Power had periodic inspection programs (PIPs) in place for both Bruce A and B that provide ongoing assurance of the structural integrities of major pressure boundary components including pressure tubes, feeders, steam generators and containment systems. Bruce Power conducted inspections in accordance with the site's PIPs and with N285.4, *Periodic inspection of CANDU nuclear power plant components* [14], as required by the Bruce A and B licences. CNSC staff are satisfied with the results of the inspections.

Bruce A and B have fitness-for-service guidelines, which were reviewed and accepted by the CNSC, to assess inspection findings that do not satisfy the acceptance criteria provided in applicable CSA standards. No safety significant compliance issues with pressure boundary degradation were identified, and CNSC staff concluded that the structural integrities of major pressure boundary components at Bruce A and B met regulatory requirements.

Aging management / lifecycle management

Bruce Power continues to implement its equipment reliability program, which defines the activities 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. For Units 1 and 2, Bruce Power performed an assessment of this program and associated process against RD-334, *Aging Management for Nuclear Power Plants* [17] and identified some areas for improvement, which are being addressed.

Bruce Power continued the updates of its lifecycle management programs (LCMPs) for the major pressure boundary components and the concrete containment structures, to provide long-term management plans for the SSCs that experience aging degradation. CNSC staff reviewed these LCMPs and confirmed they met the requirements specified in RD-334.

Periodic inspection and testing

Periodic inspections were conducted according to Bruce Power's PIPs, N285.4, *Periodic inspection of CANDU nuclear power plant components* [14], 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* [15].

Subsequently, Bruce Power updated its PIPs to meet the requirements of new versions of N285.4, N285.5 and N287.7. CNSC staff are reviewing the updated PIPs for acceptance and are monitoring inspection results from the use of these programs. No compliance issues were identified.

In-service inspections for balance-of-plant

Bruce Power is 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 the Bruce A and B pressure boundary and operation quarterly reports and found no evidence of safety-significant degradation of balance-of-plant components.

3.1.7 Radiation protection

The radiation protection SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous year and an improvement from 2010.

Based on the information assessed, CNSC staff concluded that the implementation of the radiation protection SCA at Bruce A and B met all applicable regulatory requirements.

Application of ALARA

At Bruce B, no compliance issues related to ALARA (as low as reasonably achievable) were reported. At Bruce A, a number of areas for improvement were identified, relating to consistent implementation of the ALARA program and procedural requirements. CNSC staff are satisfied that Bruce Power is taking appropriate corrective actions.

Worker dose control

CNSC staff are satisfied that Bruce Power has implemented enhancements in the area of alpha monitoring and control. CNSC staff continue to verify effective implementation of these program enhancements through the baseline compliance plan.

No radiation exposures were reported that resulted in worker doses exceeding regulatory limits or action levels. Three events occurred at Bruce A where the potential existed to exceed an action level. Bruce Power has taken appropriate actions to mitigate reoccurrence of these events. The dose information for Bruce A and B is provided in section 2.7 and appendix D.

The refurbishment activities at Bruce A Units 1 and 2 were completed within the projected dose target.

Contamination control

Three contamination events occurred at Bruce B that resulted in surface contamination action level exceedances. There were no unplanned doses as a result of this event. Following these events, Bruce Power developed corrective action plans that meet CNSC staff's expectations. CNSC staff will continue to monitor performance in this area.

Estimated dose to public

The reported dose to the public from the Bruce site (which includes Bruce A, Bruce B, the central maintenance and laundry facility, the Western waste management facility, and the decommissioned Douglas Point reactor) was 0.0012 mSv, which is well below the public dose regulatory limit of 1 mSv.

3.1.8 Conventional health and safety

The conventional health and safety SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a "fully satisfactory" rating, unchanged from last year and an improvement from 2010.

Based on the information assessed, CNSC staff concluded that the implementation of the conventional health and safety SCA at Bruce A and B exceeded applicable regulatory requirements.

Compliance with labour code; housekeeping / management of hazards

Bruce A and B were compliant with the relevant provisions of the *Occupational Health and Safety Act of Ontario* and the *Labour Relations Act*.

Accident severity and frequency

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

- the accident severity rate was 0.1, a decrease from 4.1 in 2011; even though Bruce Power had only two lost-time injuries in 2012 (the same as in 2011), the accident severity rate decreased because the number of days lost due to injuries decreased
- the accident frequency was 0.8, an increase from 0.04 in 2011, primarily due to including the number of medically treated injuries

Overall, Bruce Power achieved about 7 million hours without a lost-time accident to the end of 2012.

3.1.9 Environmental protection

The environmental protection SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the environmental protection SCA at Bruce A and B met all applicable regulatory requirements.

Effluent and emissions control (releases)
Throughout the reporting period, gaseous and aqueous releases of nuclear substances remained below environmental action levels and derived release limits (DRLs). Some minor issues occurred, related to a standby generator fuel leak and release of building heating steam condensate containing hydrazine. Bruce Power took appropriate measures to address these issues. CNSC staff are reviewing an update of the Bruce DRLs.

Environmental monitoring
CNSC staff conducted a Type II inspection on effluent monitoring at Bruce B and concluded that the effluent monitoring program meets regulatory requirements.

3.1.10 Emergency management and fire protection

The emergency management and fire protection SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that Bruce Power maintains an effective, comprehensive and well-documented emergency management and fire protection program at Bruce A and B that met all applicable regulatory requirements.

Some members of Bruce Power's emergency services team.

Bruce Power is compliant with CNSC regulatory expectations, including RD-353, *Testing the Implementation of Emergency Measures* [26].

Nuclear emergency preparedness and response

No emergency preparedness compliance issues were identified. The minimum shift complement was adequate for full implementation of the Emergency Response Organization (ERO) tasks and proper emergency response.

Bruce Power established a centralized command post, referred to as the Emergency Management Centre (EMC). The EMC is scheduled to replace the existing Site Management Centre and the Corporate Emergency Support Centre, and will support the ERO under radiological emergencies and any other event that would need the support of the ERO. The functionality of the EMC was tested during the "Huron Challenge – Trillium Resolve" exercise in October. CNSC staff concluded that Bruce Power's "proof of concept" by operating the EMC and using the new procedures was successfully achieved.

Based on the outcome of the "Huron Challenge – Trillium Resolve" report, Bruce Power will develop user requirements and technical specifications for alternate command post facilities. Bruce Power will provide an update to the CNSC on the facility improvement plan.

Fire emergency preparedness and response

Bruce Power continued its activities to improve upon fire protection compliance issues. At Bruce A, there were several minor findings of non-compliance with N293-07, *Fire protection for CANDU nuclear power plants* [10]. Bruce Power took appropriate corrective actions.

One reportable fire event occurred at Bruce A, on the non-nuclear side. When a transformer was turned on for the first time, an electrical fault caused a small electrical fire. Fire alarms were sounded, in accordance with the fire emergency preparedness program. Bruce Power response staff took immediate action in a manner consistent with their training. CNSC staff are satisfied with Bruce Power's response to this event.

3.1.11 Waste management

The waste management SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the waste management SCA at Bruce A and B met all applicable regulatory requirements.

Decommissioning plans

OPG maintains decommissioning plans and an associated consolidated financial guarantee for all of its Ontario facilities, which includes the Bruce facility (OPG is the owner of the facility, which is operated by Bruce Power under a lease agreement). The decommissioning plan for Bruce A and B is revised on a five-year cycle, and an update was submitted to the CNSC in 2012. The plan has been reviewed by CNSC staff and found to meet the requirements and expectations in N294, *Decommissioning of facilities containing nuclear substances* [19] and G-219, *Decommissioning Planning for Licensed Activities* [18]. The plan remains valid and current.

The associated decommissioning plan, consolidated financial guarantee and cost estimates for both the Bruce A and B facilities were accepted at the Commission meeting in October 2012 and will be reviewed again in 2017.

3.1.12 Security

The security SCA at Bruce A and B exceeded applicable CNSC performance objectives and requirements. Each station received a "fully satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the security SCA at Bruce A and B continues to exceed all applicable regulatory requirements.

Facilities and equipment
Bruce Power demonstrated the effective maintenance of facilities and equipment, and met regulatory requirements. However, this specific area is experiencing delays in implementing enhancements. Aging-related compliance issues for some of the security equipment will require future investments in the near term. The maintenance program, which includes detailed lifecycle support for the security systems and devices, remains in place to effectively manage equipment.

Investment in exterior delay and assessment devices has been evident at Bruce A and B, and their effectiveness was demonstrated in performance tests conducted by CNSC staff.

Training, exercises and drills
Bruce Power conducted a force-on-force exercise in June, demonstrating effective intervention capabilities against a credible threat. The physical protection systems were realistically tested and assessed. The security organization is supported by a highly effective training team that ensures qualifications are maintained and that skills are reinforced and tested.

The security team was actively engaged in the "Huron Challenge – Trillium Resolve" exercise where it demonstrated the ability to effectively communicate and contribute to the overall site emergency plan. Bruce Power has been notably supportive of the Performance Testing Program by providing Canadian Adversary Testing Team members and essential support staff for the program.

3.1.13 Safeguards and non-proliferation

The safeguards and non-proliferation SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the safeguards and non-proliferation SCA at Bruce A and B met all applicable regulatory requirements.

Bruce Power continued to implement and maintain programs at the Bruce A and B sites to ensure the effective implementation of safeguards measures and Canada's nuclear non-proliferation obligations.

The IAEA conducted a physical inventory verification (PIV) at Bruce B to verify the non-diversion of nuclear material and to confirm the declarations provided by the state authorities and facility operators. The IAEA did not select Bruce A for a PIV in 2012; instead, the CNSC conducted a physical inventory evaluation, to provide assurance to the IAEA that the facility was properly prepared for a PIV if it had been selected. Bruce Power submitted the required operational and design information in a timely manner.

3.1.14 Packaging and transport

The packaging and transport SCA at Bruce A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the packaging and transport SCA at Bruce A and B met all applicable regulatory requirements.

> CNSC staff performed an inspection of transportation of dangerous good (Class 7) radioactive material to verify Bruce Power's compliance with regulatory requirements in the *Packaging and Transportation of Nuclear Substances Regulations* and the *Transportation of Dangerous Goods Regulations* [23]. CNSC staff did not identify any compliance issues regarding packaging and transport.

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 km outside the town of Bowmanville, and about 10 km southeast of Oshawa. The facility is owned by Ontario Power Generation Incorporated (OPG), a Canadian corporation with head office located in Toronto.

Construction of the facility started in 1981 and first criticality of a reactor unit was 1989. The nuclear facility consists of four CANDU reactors, with each reactor rated at 935 MWe (megawatts electrical), and a tritium removal facility.

The 2012 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 two years 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	FS	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	SA	SA
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

The management system SCA at Darlington met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

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

Management system
OPG's operating licences require compliance with N286-05, *Management system requirements for nuclear power plants* [2]. CNSC staff verified Darlington's compliance with this standard through a focus on implementation. CNSC staff reviewed the revisions made in 2012 to the management system documents. All identified compliance issues will be addressed in the next revision of the documents which is conducted on a three-year review cycle.

Organization
OPG informed CNSC staff that they will be moving to a centre-led organization that will consolidate the current reporting relationships and conduct of business at Darlington, Pickering A and Pickering B. OPG's presentations to CNSC staff indicate that this organizational change is in compliance with its change management process.

CNSC staff's verification shows that OPG has a satisfactory process for managing organizational changes. CNSC staff will continue to monitor implementation of this process.

Management performance
CNSC staff conducted two Type II inspections in the specific area of management performance. CNSC staff found that the licensee was in compliance. Only minor deficiencies were identified, such as inconsistencies in document and record control and storage, and in procedural conformity.

Safety culture
OPG staff and CNSC staff regularly engage in discussions aimed at improving the licensee's capability to foster a healthy safety culture. Darlington regularly conducts safety culture self-assessments. CNSC staff are reviewing Darlington's 2012 self-assessments and continue to monitor this specific area for continual improvement.

3.2.2 Human performance management

The human performance management SCA at Darlington met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

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

Personnel certification
Darlington had sufficient numbers of personnel for all certified positions. CNSC staff are confident that, in 2012, the certified staff at Darlington were competent to perform the duties of their positions safely and adequately. The licensee continued to meet the personnel certification requirements.

Initial certification examinations and requalification tests

The initial certification examinations and requalification tests program met the regulatory requirements for initial certification of workers and renewal of certifications. The processes and procedures were found to be adequate. Darlington's overall pass rate was 100% for initial certification examinations and 95% for requalification tests. The licensee continued to meet the requirements for initial certification examinations and requalification tests.

3.2.3 Operating performance

The operating performance SCA at Darlington exceeded applicable CNSC performance objectives and requirements. The station received a "fully satisfactory" rating, unchanged from the previous two years.

CNSC staff concluded that OPG operated Darlington safely and in compliance with the licensing basis, and exceeded applicable regulatory requirements for this SCA.

Conduct of licensed activity

Throughout 2012, Darlington operated within its OP&Ps, and the reactor units operated within the reactor power limits prescribed by Darlington's operating licence.

A CNSC inspector verifying a control panel.

With four reactors, Darlington experienced four forced outages, one unplanned reactor trip, no stepbacks and two setbacks.

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

Outage management performance

Darlington experienced three planned outages. All outages were conducted safely.

Tritium removal facility

Darlington is the only NPP in Canada that operates a tritium removal facility. Tritium builds up gradually 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

The safety analysis SCA at Darlington met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the safety analysis SCA at Darlington met all applicable regulatory requirements.

Deterministic safety analysis
As planned, Darlington submitted its report identifying gaps against compliance with RD-310, *Safety Analysis for Nuclear Power Plants* [5], along with its implementation plan and schedule to update the safety report. CNSC staff are reviewing the report.

Example of an emergency power generator.

Probabilistic safety analysis
Previously, OPG submitted the required methodology guides in compliance with S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [6]. CNSC staff accepted these guides and are reviewing the required PSA reports.

Severe accident analysis
OPG continued its progress in completing the work associated with the Fukushima action items (FAIs) and submissions aimed at closing the FAIs.

Environmental risk assessment
Darlington’s environmental risk assessment program includes mitigation of the risks discussed below:

- ***Fish:*** OPG maintained an effective program for the protection of fish at Darlington that met CNSC requirements. OPG continued to collect information from baseline monitoring and reporting from the Darlington refurbishment/life extension environmental analysis.
- ***Flooding:*** Following the Fukushima Daiichi accident, OPG conducted a flood risk assessment of the site and completed modifications to improve resistance to severe flooding (beyond-design-basis) for equipment that delivers fuel to the emergency power generators.
- ***Groundwater:*** The groundwater monitoring program in place at Darlington has indicated no adverse effect on the groundwater flow system.

3.2.5 Physical design

The physical design SCA at Darlington met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

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

Component design

Darlington confirmed that SSCs important to safety continued to meet their design basis in all operational states.

Equipment qualification

CNSC staff conducted a Type II environmental qualification inspection at Darlington. All compliance issues raised during the inspection have been addressed and closed.

System design and classification

Darlington plans to complete the replacement of obsolete technology of the PDP11/70 digital control computer with the PDP11/70 emulator in 2013. CNSC staff are satisfied with the work completed to date in this project and will continue to monitor its progress.

A Type II electrical power system inspection was carried out at Darlington in late 2011. CNSC staff identified a number of compliance issues. All issues raised during the inspection have been addressed and closed.

OPG continued its activities to improve fire protection at Darlington through the implementation of procedural and physical upgrades as recommended by CNSC staff within the code compliance review of the facilities against N293-07, *Fire protection for CANDU nuclear power plants* [10]. These recommendations are not considered to be risk significant, and the proposed modifications will increase the safety margin of the facility with respect to fire protection. The fire protection program at Darlington continued to meet applicable CNSC performance objectives and requirements. The revised fire hazard assessment and fire safe shutdown analysis continue to be assessed by CNSC staff.

3.2.6 Fitness for service

The fitness for service SCA at Darlington exceeded applicable CNSC performance objectives and requirements. The station received a “fully satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the fitness for service SCA at Darlington exceeded applicable regulatory requirements.

Equipment fitness for service / equipment performance

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

Maintenance

Darlington’s performance in the maintenance program remained highly effective and consistent. The preventive maintenance completion ratio (PMCR) was the best of Canadian NPPs over the past five years, and was 91% in 2012, above the industry best practice value of 90%. The corrective maintenance backlog was in the average range of the industry and is improving. The deficient maintenance backlog remained on the top quartile of the industry. CNSC staff’s assessment of the maintenance-related inspections and reportable events in 2012 demonstrated that Darlington is adhering to the maintenance activities required by all applicable standards and had the best maintenance performance amongst all Canadian NPPs.

Reliability of systems important to safety

The reliability program at Darlington continued to meet regulatory requirements as given in S-98, *Reliability Programs for Nuclear Power Plants* [13].

All of the special safety systems met their unavailability targets, with the exception of shutdown system 2 (SDS2). Although the SDS2 impairments occurred during normal operations, they were not safety-significant. The licensee took appropriate actions to address the impairments, and completed corrective actions to prevent reoccurrence.

Structural integrity

CNSC staff confirmed that OPG had appropriate periodic inspection programs in place to provide ongoing assurance of the structural integrity of major pressure boundary components, such as pressure tubes, feeders, steam generators, concrete containment structures and containment components. OPG conducted inspections in accordance with the station's periodic inspection programs (PIPs) and the applicable CSA standards as required by the operating licence. CNSC staff are satisfied with the results of the inspections.

OPG has fitness-for-service guidelines, which have been reviewed and accepted by CNSC staff. These guidelines are used to assess inspection results that do not satisfy the acceptance criteria provided in the applicable CSA standards. CNSC staff concluded that the implementation of the PIPs at Darlington met regulatory requirements and confirmed that no safety-significant pressure boundary degradation compliance issues were identified.

OPG's exemption, dating from 2010, for the volumetric inspection of feeder dissimilar metal welds has been accepted, conditional on CNSC staff acceptance of a leak-before-break assessment of the welds. OPG provided the preliminary assessment and has committed to further laboratory studies and additional analytical assessments to improve the methods and validate the results. An action item has been opened to track these activities to completion. CNSC staff will continue with regulatory oversight activities in this area.

Aging management / lifecycle management

OPG has implemented an integrated aging management program to ensure that the condition of SSCs important to safety is understood and that required activities are in place to assure the health of these SSCs while the plant ages. OPG reviewed this program to ensure that it is aligned with RD-334, *Aging Management for Nuclear Power Plants* [17]. In addition, OPG conducted SSC condition assessments and aging management program reviews as part of the integrated safety review for the Darlington life extension project. CNSC staff are analyzing the reviews.

CNSC staff reviewed Darlington's updated lifecycle management programs (LCMPs) for pressure tubes, feeders and steam generators, and the aging management program (AMP) for concrete containment structures. The LCMPs have been updated on a regular basis to provide long-term management plans for the SSCs that experience aging degradation mechanisms. The LCMPs and AMP met all regulatory requirements specified in RD-334 [17]. CNSC staff are currently reviewing the updated LCMP for reactor components and structures.

In-service inspections for balance-of-plant

Darlington conducted inspections to ensure the structural integrity of safety-significant balance-of-plant pressure retaining systems and components and safety-related structures. CNSC staff monitored quarterly reports from the licensee and found no evidence of safety-significant degradation of balance-of-plant components.

3.2.7 Radiation protection

The radiation protection SCA at Darlington exceeded applicable CNSC performance objectives and requirements. The station received a “fully satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the radiation protection SCA at Darlington exceeded applicable regulatory requirements.

Application of ALARA

Darlington has an ALARA program in place that integrates the principle of ALARA into planning, scheduling and work control, and exceeds the regulatory requirements.

Worker dose control

No worker received a radiation dose in excess of regulatory action levels or dose limits. The dose information for Darlington is provided in section 2.7 and appendix D.

Inspections identified several findings in the area of worker dose control, the majority of which were positive (that is, they displayed evidence that the program is effective). However, four of the findings were related to contraventions of regulations; specifically, two were related to failure to calibrate fixed/portable gamma radiation monitors according to the required frequency, and two were related to frivolous posting of radiation warning signs. These findings did not have any effect on the health and safety of workers, nor were they indicative of a decline in the effectiveness of the overall radiation protection program. OPG provided a corrective action plan that met the CNSC staff’s expectations. CNSC staff will monitor the implementation of the corrective action plan.

Darlington finalized the implementation of the enhancements to alpha monitoring and control. CNSC staff are satisfied with the implementation.

Personnel dosimetry

Darlington continued to comply with the regulatory requirements to measure and record doses received by workers.

Contamination control

No surface contamination action levels were exceeded at Darlington. However, CNSC staff identified an increased number of areas for improvement in contamination control compared with 2011. Although this increase suggests that OPG’s performance has declined slightly, all findings were considered to have an insignificant or small effect on the safety and control measures and did not result in a decline in the overall effectiveness of the radiation protection program. OPG provided a corrective action plan that met the CNSC staff’s expectations. CNSC staff will monitor the implementation of the corrective action plan.

Estimated dose to public

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

3.2.8 Conventional health and safety

The conventional health and safety SCA at Darlington exceeded applicable CNSC performance objectives and requirements. The station received a "fully satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the conventional health and safety SCA at Darlington exceeded applicable regulatory requirements.

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

Housekeeping / management of hazards
Darlington's work practices and conditions achieved a high degree of personnel safety.

CNSC staff identified a number of minor issues with respect to storage of ladders and scaffolding and to non-radioactive leaks in the station. CNSC staff will monitor OPG's resolution of these issues.

Accident severity and frequency
As reported by the licensee, Darlington's accident severity rate increased from 0 in 2011 to 4.4 in 2012, and the accident frequency increased from 0.2 in 2011 to 0.4 in 2012. The increase in the accident severity rate was attributed to one lost-time accident due to a worker trip and fall.

3.2.9 Environmental protection

The environmental protection SCA at Darlington met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

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

Effluent and emissions control (releases)
Throughout the reporting period, gaseous and aqueous releases of nuclear substances remained below environmental action levels and derived release limits.

Environmental monitoring
CNSC staff conducted a Type II inspection on hazardous waste management. The inspection identified five positive findings (that is, they displayed evidence that the program is effective) and some areas for improvement. OPG addressed the issues and CNSC staff are satisfied with the licensee's response.

3.2.10 Emergency management and fire protection

The emergency management and fire protection SCA at Darlington met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the emergency management and fire protection SCA at Darlington met all applicable regulatory requirements.

Nuclear emergency preparedness and response
Darlington had sufficient provisions for emergency preparedness and response capability to mitigate the effects of an accidental release of nuclear or hazardous substances. No Type I or Type II inspections were conducted at Darlington in 2012, based on CNSC management’s considerations of past good performance of the Darlington emergency response organizations. CNSC continued to monitor the licensee’s performance via S-99 reporting [1], quarterly operations reports, and site inspector surveillance.

OPG conducted emergency exercises as part of its initiative to reduce the minimum shift complement in conjunction with the change to days-based maintenance. These exercises were in addition to the annual exercise program; they allowed additional training of Darlington’s emergency preparedness response staff and provided CNSC staff with another opportunity to observe the station’s performance in this area. CNSC staff evaluated these exercises and did not identify any safety-significant compliance issues.

Fire emergency preparedness and response
Darlington has implemented a comprehensive fire response capability that includes effective procedures, training and maintenance of proficiency.

3.2.11 Waste management

The waste management SCA at Darlington met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the waste management SCA at Darlington met all applicable regulatory requirements.

Waste minimization, segregation and characterization
Darlington has a mature nuclear waste management program to minimize, control and properly dispose of radioactive waste. Nuclear wastes are controlled and monitored, and releases are recorded.

Waste storage and processing
Darlington has appropriately developed, implemented and audited its waste management program to control and minimize the volume of nuclear waste. OPG has also included waste management as a key component of Darlington’s corporate and safety culture.

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 estimates were reviewed and accepted by the Commission in 2012 and will be reviewed again in 2017.

3.2.12 Security

The security SCA at Darlington met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

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

OPG improved its security program, and some of the elements of its training program are rated "fully satisfactory". Notably, OPG shares practices with other high-security nuclear sites in the development of their security programs.

Training, exercises and drills

OPG has been notably supportive of the Performance Testing Program by providing Canadian Adversary Testing Team members and essential support staff for the program.

Nuclear response force

The success of OPG's transition to an in-house onsite response force is evident in its recent results at the Ontario Tactical Advisory Board Special Weapons and Tactics (SWAT) Round-Up competition, where OPG claimed first place against police tactical units from across the provinces of Ontario and Québec, as well as other nuclear security response forces from Canadian NPPs.

OPG also captured the gold medal in the Superstars event of the Toronto Police Games, competing against 10 other police services and military teams. OPG has won this particular event in two of the last three years.

In the overall context of the performance objectives for this SCA, CNSC staff have determined that OPG's response force is sufficiently effective.

3.2.13 Safeguards and non-proliferation

The safeguards and non-proliferation SCA at Darlington met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

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

OPG continued to implement and maintain programs at Darlington to ensure the effective implementation of safeguards measures and Canada's nuclear non-proliferation obligations.

The IAEA did not select Darlington for a physical inventory verification (PIV) in 2012. Instead, CNSC staff conducted a physical inventory-taking evaluation, to provide assurance to the IAEA that the facility was properly prepared for a PIV if it had been selected. OPG submitted the required operational and design information in a timely manner.

3.2.14 Packaging and transport

The packaging and transport SCA at Darlington met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

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

CNSC staff inspected the transportation of dangerous goods (Class 7) radioactive material and are satisfied that Darlington complies with the regulatory requirements. OPG reported one minor transport-related incident, with no safety consequences. The licensee has taken the necessary measures to ensure the incident will not be repeated. CNSC staff did not identify any other compliance issues regarding packaging and transport.

3.3 Pickering A and Pickering B

Pickering A and B are 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 km northeast of Toronto and 21 km southwest of Oshawa. The facility is owned by Ontario Power Generation Incorporated (OPG), a Canadian corporation with 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 stations.

Each operating reactor has a gross electrical output of 542 MWe (megawatts electrical) for Pickering A (Units 1 and 4) and 540 MWe for Pickering B (Units 5 to 8).

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

This report groups the Pickering A and Pickering B stations together because OPG uses common programs at both stations. However, the performance of each station is assessed separately.

The 2012 safety performance ratings for Pickering A and B are shown in table 7. Based on the observations and assessments of the SCAs, CNSC staff concluded that Pickering A and B operated safely. The integrated plant ratings were both “satisfactory”, unchanged from the previous two years under the current SCA framework.

Table 7: Performance ratings for Pickering A and B

Safety and control area	Rating		Industry average
	Pickering A	Pickering 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	SA	SA	FS
Environmental protection	SA	SA	SA
Emergency management and fire protection	SA	SA	SA
Waste management	SA	SA	SA
Security	SA	SA	SA
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)

3.3.1 Management system

The management system SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the management system SCA at Pickering A and B met all applicable regulatory requirements.

Management system
OPG’s operating licences require compliance with N286-05, *Management system requirements for nuclear power plants* [2]. CNSC staff verified Pickering A and B’s compliance with this standard through a focus on implementation. CNSC staff reviewed the revisions made in 2012 to the management system documents. All identified compliance issues will be addressed in the next revision of the documents, which is conducted on a three-year review cycle.

Organization
OPG informed CNSC staff that they will be moving to a centre-led organization that will affect the current reporting relationships and conduct of business at Darlington, Pickering A and Pickering B. OPG’s presentations to CNSC staff indicate that this organizational change has appropriate attention from OPG senior management and is in compliance with its change management process.

Two other substantial organizational changes are being implemented at Pickering: amalgamation of Pickering A and B, and the transition to days-based maintenance. Updates on these changes are provided in section 4.3.

Change management
CNSC will continue to monitor OPG’s progress to ensure the organizational changes will not affect regulatory requirements or the safety of OPG’s nuclear facilities. OPG has a satisfactory process for managing organizational changes and CNSC staff will continue to verify implementation of this process.

Management performance
All licensees are required to submit quarterly reports on operations and performance indicators as described in S-99, *Reporting Requirements for Operating Nuclear Power Plants* [1]. CNSC staff did not identify any significant regulatory issues from the S-99 reports.

Safety culture
OPG staff and CNSC staff regularly engage in discussions aimed at improving the licensee’s capability to foster a healthy safety culture, in particular by conducting safety culture self-assessments. CNSC staff are reviewing Pickering’s 2012 self-assessment and continue to monitor this specific area for continual improvement.

3.3.2 Human performance management

The human performance management SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the human performance management SCA at Pickering A and B met all applicable regulatory requirements.

Human performance program
Pickering’s human performance program addresses the criteria needed to achieve a comprehensive approach to human performance and to help OPG staff carry out their work safely and without errors. This program has been adequately implemented at Pickering A and B.

Personnel certification
Pickering A and B had sufficient numbers of personnel for all certified positions. CNSC staff are confident that, in 2012, the certified staff at Pickering were competent to perform the duties of their positions safely and adequately. OPG continued to meet the personnel certification requirements.

Initial certification examinations and requalification tests
The initial certification examinations and requalification tests program for reactor operators at Pickering A and B, and the program for shift supervisors at Pickering A, met the regulatory requirements. Pickering’s overall pass rate was 95% for initial examinations and 94% for requalification tests. The licensee continued to meet the requirements for initial certification examinations and requalification tests.

In previous years, at Pickering B, the success rate for shift supervisor candidates on initial certification examinations was below industry average. OPG performed two root cause investigations and implemented corrective actions. CNSC staff continues to monitor OPG’s progress and expects OPG to submit an update in 2013.

A 2011 CNSC inspection identified significant deficiencies in the initial simulator-based certification examinations program for Pickering B shift supervisor candidates. OPG implemented a corrective action plan, and CNSC staff continues to monitor the progress. These deficiencies do not affect safety, because they apply only to those OPG personnel who are undergoing training to become certified workers and do not apply to workers who are already certified.

Work organization and job design
OPG implemented hours-of-work limits for employees at the Pickering site, which met CNSC expectations.

3.3.3 Operating performance

The operating performance SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a “satisfactory” rating, unchanged from the previous two years.

CNSC staff concluded that OPG operated Pickering A and B safely and in compliance with the licensing basis.

Conduct of licensed activity

Throughout 2012, Pickering continued to operate within its OP&Ps, and all reactor units operated within the reactor power limits prescribed by Pickering’s operating licences.

- With two reactors, Pickering A experienced four forced outages, one unplanned reactor trip, and no setbacks (Pickering A does not have stepbacks)
- With four reactors, Pickering B experienced three forced outages, one unplanned reactor trip, four setbacks, and no stepbacks

The forced outages were used to repair equipment that is required for safe operation of the plant, or that could not be repaired safely while the plant was operating.

Pickering A and B continue to have significant reliability issues with fuelling machines, resulting in numerous forced deratings due to fuelling deficits. This issue is primarily related to production; however, unplanned and forced reactor power changes are undesirable because they represent operation in off-normal conditions.

Deposits of iron oxide have been observed on discharged fuel bundles from Unit 1 and, to a much lesser extent, other units. One fuel bundle discharged in 2012 had deposits that were significantly larger and widespread than previously observed. It is believed that the deposits are a result of poor chemistry control during outages. OPG has implemented corrective actions, but these actions may take several months to be effective.

Because the deposits may affect fuel heat transfer, CNSC staff required that, until the cause and effect are better understood, Unit 1 remain at or below 97% of full power to ensure a sufficient margin of safety.


A passive autocatalytic hydrogen recombiner.

Procedures

As part of its analysis of the minimum shift complement, OPG conducted an integrated validation in 2010 for all procedures required to respond to a seismic event. These activities resulted in significant improvements to the efficiency and technical accuracy of the procedures in 2012.

Outage management performance

Pickering A had one planned outage, while Pickering B had two planned outages. The outages were conducted safely.

Accident management and recovery

To resolve hydrogen behaviour in containment, Pickering is installing passive autocatalytic hydrogen recombiners (PARs) in all reactors. The PARs have been installed in Units 1, 4 and 7, and installation for Units 5, 6 and 8 is scheduled.

3.3.4 Safety analysis

The safety analysis SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the safety analysis SCA at Pickering A and B met all applicable regulatory requirements.

Deterministic safety analysis

Pickering continued to progress on the transition to compliance with RD-310, *Safety Analysis for Nuclear Power Plants* [5]. The transition includes identifying gaps against RD-310, developing principles and guidelines for the safety analysis and the execution of plans to update the safety report.

A diver prepares to examine the fish nets at Pickering – part of the environmental risk assessment program (photo courtesy of the *Ajax/Pickering News Advertiser*).

Probabilistic safety analysis

For Pickering A, OPG submitted some specific probabilistic safety assessment methodologies and CNSC staff are currently reviewing them. OPG is required under its licence to comply with S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [6] by December 31, 2013 (extended to December 2014 for three elements: internal fires, internal floods, and Level 1 internal events at shutdown state).

For Pickering B, OPG submitted the required methodology guides in compliance with S-294 [6]. CNSC staff accepted these guides and are reviewing the required PSA reports.

Severe accident analysis

OPG continued its progress in completing the work associated with the Fukushima action items (FAIs) and submissions aimed at closing the FAIs.

Environmental risk assessment

Pickering's environmental risk assessment program includes mitigation of the risks discussed below:

- ***Fish:*** OPG maintained an effective program for the protection of fish at Pickering A and B that met CNSC requirements. Risk-informed recommendations from completed assessment studies and monitoring triggered a risk management program for reducing thermal and intake fish mortality. The licensee is addressing open action items in a manner that is acceptable to CNSC staff. Additional details on the status of the fish mortality migration are provided in subsection 4.3.3.
- ***Flooding:*** Following the Fukushima Daiichi accident, OPG is taking additional actions to increase the flood protection capacity; for example, installing additional flood barriers around the Pickering A standby generator fuel forwarding pump house.
- ***Groundwater:*** At Pickering A and B, the tritium concentrations across the site are generally stable or declining (that is, improving). The groundwater monitoring program is functioning as designed – foundation drains collect the groundwater, and extensive monitoring wells are in place. There are no public health concerns.

3.3.5 Physical design

The physical design SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the physical design SCA at Pickering A and B met all applicable regulatory requirements.

Component design

Pickering A and B confirmed that SSCs important to safety continued to meet their design basis in all operational states.

Equipment qualification

CNSC staff conducted a Type II environmental qualification inspection at Pickering B. No significant compliance issues were identified.

System design and classification

A Type II electrical power system inspection was carried out at Pickering A, with the main focus on standby generators and Class I and II power. CNSC staff identified a number of positive findings (evidence that the licensee's actions are effective) as well as some areas for improvement. These areas are all of low safety significance, and OPG is addressing the issues. CNSC staff will continue to monitor OPG's progress on the corrective actions.

CNSC staff conducted a Type II inspection on Pickering A and B's software maintenance, with the main focus on the digital control computer, fuel handling machines, and standby generators. The inspection resulted in a number of positive findings as well as some areas for improvement. All improvements were completed by OPG by November 2012.

At Pickering A, on several occasions the cooling water supply for the emergency service water pump's bearing was not available due to silt blocking the supply lines. OPG has dredged the intake forebay to reduce buildup of silt in the water supply.

In fire protection design, no significant compliance issues were identified. OPG is implementing modifications at Pickering A and B to address the recommendations identified in its updated fire safety assessment in accordance with N293-07, *Fire protection for CANDU nuclear power plants* [10] and according to the schedule outlined in the licence conditions handbooks. These recommendations involve modifications that will increase the safety margin of the facility with respect to fire protection.

Human factors in design

During the Pickering B integrated safety review, some compliance issues were identified in the area of human factors in design relating to engineering change control. OPG will address all of the outstanding issues as part of the Pickering end-of-life project.

3.3.6 Fitness for service

The fitness for service SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the fitness for service SCA at Pickering A and B met all applicable regulatory requirements.

Equipment fitness for service / equipment performance

On the basis of onsite inspections and compliance verifications, CNSC staff are satisfied with the overall equipment performance at Pickering A and B.

Maintenance

Pickering A and B’s performance in maintenance showed improvement. CNSC staff assessments and inspections did not identify any significant maintenance-related compliance issues. The maintenance backlogs have been reduced since 2008. The corrective maintenance backlog was in the average range of the industry, and improving. The deficient maintenance backlog improved to the top quartile of the industry. A longstanding action item related to maintenance backlogs was closed. The preventive maintenance completion ratio has remained satisfactory at Pickering A and B over the past five years, and in 2012 remained at 90% (which is industry best practice).

Reliability of systems important to safety

The reliability program at Pickering A and B continued to meet regulatory requirements as given in S-98, *Reliability Programs for Nuclear Power Plants* [13].

During an inspection, CNSC staff found several station condition reports regarding the degradation and health of Pickering A standby generators. In spite of the degradation, the overall reliability of the Class III power system (which includes the standby generators) met the reliability target. OPG is addressing the upgrade tasks, and CNSC staff are monitoring its progress.

An example of a standby power generator.

All of the special safety systems met their unavailability targets, although the negative pressure containment (NPC) system experienced three impairments. None of the impairments were safety-significant.

Structural integrity

CNSC staff confirmed that OPG had periodic inspection programs (PIPs) in place that provide ongoing assurance of the structural integrities of major pressure boundary components such as pressure tubes, feeders, steam generators, concrete containment structures and containment components. OPG conducted inspections in accordance with its PIPs and the applicable CSA standards. CNSC staff are satisfied with the results of the inspections.

OPG has fitness for service guidelines, which were reviewed and accepted by the CNSC, to assess inspection findings that do not satisfy the acceptance criteria provided in applicable CSA standards. CNSC staff concluded that the implementation of Pickering’s PIPs met regulatory requirements and no safety-significant compliance issues were identified during the inspections of pressure boundary components and containments structures.

During the attempted restart at Pickering A Unit 4, OPG reported leakage from the boiler feedwater (BFW) piping. The leakage was attributed to cracking due to poor piping fit-up following repairs to the steam generator BFW nozzle thermal sleeves in 2006. Sections of the BFW piping were replaced for all 12 steam generators. OPG shut down Unit 1, subsequently detected cracking of the BFW piping for that unit, and replaced piping sections. The replaced piping has been aligned and supported properly to ensure these events will not re-occur. OPG will initiate an inspection program for future monitoring. CNSC staff are currently reviewing the information supplied by the licensee to support its conclusion.

Aging management / lifecycle management

OPG has implemented an integrated aging management program to ensure the condition of SSCs important to safety is understood, and that required activities are in place to assure the health of these SSCs while the plant ages. OPG reviewed this program to ensure that it is aligned with RD-334, *Aging Management for Nuclear Power Plants* [17]. In addition, OPG conducted SSC condition assessments and aging management program reviews for continued operation of Pickering B. CNSC staff raised several comments and requests for additional information which are being addressed by OPG's continued operations plan.

CNSC staff reviewed Pickering's updated lifecycle management programs (LCMPs) for pressure tubes, feeders, and steam generators, and the aging management program (AMP) for concrete containment structures. The LCMPs have been updated on a regular basis to provide long-term management plans for the SSCs that experience aging degradation mechanisms. The LCMPs and AMP met all regulatory requirements specified in RD-334 [17]. CNSC staff are currently reviewing the updated LCMP for reactor components and structures.

Periodic inspection and testing

OPG inspected the concrete containment structures for Units 1, 7 and 8. CNSC staff concluded that the containment structures continue to meet their design intent. OPG also performed a leakage rate test for the reactor building for Unit 7, and CNSC staff are reviewing the results. OPG performs semi-annual on-power leakage rate tests on the vacuum building to confirm its continued performance in accordance with N287.7, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants* [15]. To date, these tests have shown good performance of the vacuum building.

3.3.7 Radiation protection

The radiation protection SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the radiation protection SCA at Pickering A and B met all applicable regulatory requirements.

Application of ALARA

CNSC staff conducted a Type II inspection on the application of the ALARA principle at Pickering A and B. The inspection demonstrated that Pickering has a mature ALARA program in place to plan and control work activities.

Worker dose control

No worker received a radiation dose in excess of regulatory dose limits. The dose information for Pickering A and B is provided in section 2.7 and appendix D.

At Pickering A Unit 1, a worker experienced an unplanned uptake of tritium that exceeded the action level of 2 mSv. OPG performed a root cause investigation and implemented corrective actions. The investigation did not indicate any loss of control of the radiation protection program at Pickering A. No action levels were reached at Pickering B.

Pickering A and B placed a substantial focus on reducing lower-level precursor exposures to both external and internal radiation hazards, resulting in noticeable improvements in the number of precursor-level acute tritium uptakes and dosimeter alarms.

Pickering A and B finalized the implementation of the enhancements to alpha monitoring and control. CNSC staff are satisfied with the implementation.

Personnel dosimetry
Pickering A and B continued to comply with the regulatory requirements to measure and record doses received by workers, contractors and visitors.

Contamination control
No surface contamination action levels were exceeded at Pickering A or B. Pickering A and B continued to apply measures to control radioactive contamination in their facilities.

Estimated dose to public
The reported dose to the public from Pickering A and B (combined) was 0.0011 mSv, which is well below the public dose limit of 1 mSv.

3.3.8 Conventional health and safety

The conventional health and safety SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the conventional health and safety SCA at Pickering A and B met all applicable regulatory requirements.

Compliance with labour code
Pickering A and B were compliant with the relevant provisions of the *Occupational Health and Safety Act of Ontario* and the *Labour Relations Act*.

Housekeeping / management of hazards
OPG generally met CNSC requirements at Pickering A and B, although asbestos hazards (identified as a compliance issue in 2011) continued to be a problem. The Ministry of Labour issued an order for OPG to remediate damaged and deteriorating materials that contain asbestos, and to ensure that workers are trained on the hazards of asbestos exposure and the locations of asbestos-containing material. The Ministry of Labour and CNSC continue to monitor OPG’s corrective actions.

Accident severity and frequency
As reported by the licensee, the combined accident severity rate for Pickering A and B decreased from 0.2 in 2011 to zero in 2012, and the accident frequency remained unchanged at 0.3. These two parameters are lower than the industry average, and the accident frequency is the lowest among the Canadian NPPs.

3.3.9 Environmental protection

The environmental protection SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the environmental protection SCA at Pickering A and B met all applicable regulatory requirements.

Effluent and emissions control (releases)
Gaseous and aqueous releases of nuclear substances remained below environmental action levels and derived release limits. OPG updated its derived release limits 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* [27]. CNSC staff accepted the revised derived release limits.

Environmental monitoring
CNSC staff conducted a Type II inspection of Pickering's environmental monitoring program and are currently reviewing the results.

OPG developed and implemented programs to verify adequate provision for the protection of fish, with direction from CNSC and advice from other regulatory agencies such as Fisheries and Oceans Canada and Environment Canada. CNSC staff are satisfied that the licensee's actions to date, including assessing the effectiveness of the barrier net as a fish intake mitigation measure, demonstrate adequate provision for protection of the environment.

3.3.10 Emergency management and fire protection

The emergency management and fire protection SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the emergency management and fire protection SCA at Pickering A and B met all applicable regulatory requirements.

Nuclear emergency preparedness and response
CNSC staff evaluated the nuclear emergency preparedness and response exercise held at Pickering. While some compliance issues were identified, OPG demonstrated its preparedness and competence to assemble, account for, and evacuate station personnel. None of the issues were of high safety significance, and OPG has responded to all of the issues.

Fire emergency preparedness and response
CNSC staff conducted an inspection during an emergency exercise with a specific focus on fire response. Although some compliance issues were identified, all of them were of low safety significance. OPG has responded adequately to all of the issues.

3.3.11 Waste management

The waste management SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the waste management SCA at Pickering A and B met all applicable regulatory requirements.

Waste minimization, segregation and characterization
OPG has mature nuclear waste management programs at Pickering A and B to minimize, control and properly dispose of radioactive waste. Nuclear wastes are controlled and monitored, and releases are recorded.

Waste storage and processing
OPG has a mature waste management program for both radioactive and hazardous substances wastes. Waste minimization, segregation, characterization, storage and processing at Pickering A and B align with the corporate waste management program.

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 estimates were reviewed and accepted by the Commission in 2012 and will be reviewed again in 2017. Section 4.3.2 provides an update on the management of the facility’s end of life.

3.3.12 Security

The security SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the security SCA at Pickering A and B met all applicable regulatory requirements.

OPG improved its security program, and some of the elements of its training program are rated “fully satisfactory”. Notably, OPG shares practices with other high-security nuclear sites in the development of their security programs.

Training, exercises and drills
OPG has been notably supportive of the Performance Testing Program by providing Canadian Adversary Testing Team members and essential support staff for the program.

Nuclear response force
The success of OPG’s transition to an in-house onsite response force is evident in its recent results at the Ontario Tactical Advisory Board Special Weapons and Tactics (SWAT) Round-Up competition, where OPG claimed first place against police tactical units from across the provinces of Ontario and Québec, as well as other nuclear security response forces from Canadian NPPs.

OPG also captured the gold medal in the Superstars event of the Toronto Police Games, competing against 10 other police services and military teams. OPG has won this particular event in two of the last three years.

In the overall context of the performance objectives for this SCA, CNSC staff have determined that OPG's response force is sufficiently effective.

3.3.13 Safeguards and non-proliferation

The safeguards and non-proliferation SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the safeguards and non-proliferation SCA at Pickering A and B met all applicable regulatory requirements.

OPG continued to implement and maintain programs at Pickering A and B to ensure the effective implementation of safeguards measures and Canada's nuclear non-proliferation obligations.

The IAEA conducted a physical inventory verification at Pickering A and B to verify the non-diversion of nuclear material and to confirm the declarations provided by the state authorities and facility operators. OPG submitted the required operational and design information in a timely manner.

3.3.14 Packaging and transport

The packaging and transport SCA at Pickering A and B met applicable CNSC performance objectives and requirements. Each station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the packaging and transport SCA at Pickering A and B met all applicable regulatory requirements.

Based on site surveillance activities and S-99 reporting [1], CNSC staff did not identify any compliance issues within this area. OPG reported one minor transport-related incident, with no safety consequences. The licensee has taken the necessary measures to ensure the incident will not be repeated.

3.4 Gentilly-2

Gentilly-2, operated by Hydro-Québec, is located on the south shore of the Saint-Laurent river, in the Bécancour municipality, about 15 km west of Trois-Rivières.

The CANDU reactor has a nominal capacity of 675 MWe (megawatts electrical). It went into commercial operation in 1983.

On December 28, 2012, the reactor was removed from the electrical grid. Hydro-Québec is in the process of putting the reactor into a guaranteed shutdown state (GSS).

The 2012 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 operated safely. The integrated plant rating was "satisfactory", unchanged from the previous two years 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	SA
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

The management system SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the management system SCA at Gentilly-2 met all applicable regulatory requirements.

Management system
Hydro-Québec's operating licence requires compliance with N286-05, *Management system requirements for nuclear power plants* [2]. CNSC staff verified Hydro-Québec's compliance with this standard, focusing on the implementation of an adequate quality assurance program.

Activities surrounding the end-of-life planning have been adequately managed by Hydro-Québec, and all necessary actions have been taken to address regulatory requirements.

Organization
The operating organization at Gentilly-2 is being transitioned towards one capable of carrying out the defueling and preparation for safe storage and future decommissioning of the station. Regulatory activities are being planned for the required oversight on the proposed changes to the organizational structure and to roles of key personnel.

Safety culture
Hydro-Québec completed a safety culture self-assessment in 2012. The CNSC is reviewing the results of the self-assessment and will exercise further oversight as the station transitions from operating status to safe storage and future decommissioning.

Business continuity
Hydro-Québec maintains a business continuity plan for Gentilly-2 for cases of possible disruptions due to a variety of predefined issues. The plan would be implemented to ensure continued plant safety and minimum staff complement in the event of a disruption.

3.4.2 Human performance management

The human performance management SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the human performance management SCA at Gentilly-2 met all applicable regulatory requirements.

Personnel training
Gentilly-2 continued to progress towards implementing its systematic approach to training (SAT)-based training program. Due to the announcement that the plant would end its commercial operation, Hydro-Québec will update or develop plans to ensure that the training programs reflect the conditions of the safe shutdown state.

Personnel certification
Hydro-Québec had sufficient numbers of personnel for all certified positions. CNSC staff are confident that the certified staff at Gentilly-2 are competent to perform the duties of their positions safely. The licensee continues to meet the CNSC personnel certification requirements.

Initial certification examinations and requalification tests
During the reporting period, no initial certification examinations and requalification tests were administered by the licensee. Hence, CNSC staff did not conduct any inspection of the licensee's initial certification examinations and requalification tests programs. However, CNSC staff conducted an examination for three senior health physicist candidates. All candidates passed and were certified by the CNSC.

Work organization and job design
Hydro-Québec provided CNSC staff with the results of an analysis that shows an increase to the minimum shift complement was required while in a guaranteed shutdown state. Hydro-Québec also submitted the associated procedural change. CNSC staff are reviewing the information.

3.4.3 Operating performance

The operating performance SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

CNSC staff concluded that Hydro-Québec operated Gentilly-2 safely and in compliance with the licensing basis.

Conduct of licensed activity
A single-reactor station, Gentilly-2 experienced one forced outage, one unplanned reactor trip, one stepback and six setbacks. Gentilly-2's outage management conformed to the conditions prescribed by its operating licence. All outages were conducted safely.

Procedures
CNSC staff verified that, for all events, Gentilly-2 staff followed approved procedures, investigated the reasons for any plant transients, and took appropriate corrective actions.

Outage management performance
Gentilly-2 had one planned outage. The outage was completed safely.

3.4.4 Safety analysis

The safety analysis SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the safety analysis SCA at Gentilly-2 met all applicable regulatory requirements.

Probabilistic safety analysis
Based on the information assessed, CNSC staff concluded that the implementation of the probabilistic safety analysis program at Gentilly-2 met the requirements given in S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [6].

Environmental risk assessment

Hydro-Québec's environmental risk assessment program includes mitigation of the risks discussed below:

- ***Fish:*** The licensee had undertaken risk assessment and management to reduce adverse effects on fish populations from cooling water intake and thermal discharge, in consultation with CNSC staff and with other federal agencies including Fisheries and Oceans Canada and Environment Canada. Hydro-Québec's decision to shut down Gentilly-2 means this work is no longer needed.
- ***Flooding:*** Because Gentilly-2 ended commercial operation and is in transition to safe storage, Hydro-Québec is focusing its activity on ensuring the site has flood protection commensurate with the level of risk.
- ***Groundwater:*** The groundwater monitoring program in place has not indicated any adverse effect on the groundwater flow system.

3.4.5 Physical design

The physical design SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the physical design SCA at Gentilly-2 met all applicable regulatory requirements.

Equipment qualification

Hydro-Québec maintained an acceptable environmental qualification program, but had not yet fully implemented N290.13-05, *Environmental qualification of equipment for CANDU nuclear power plants* [9]. Because of the decision to end commercial operation and transition to a safe shutdown state, any outstanding compliance issues in this area will not be resolved for Gentilly-2. CNSC staff are satisfied that the outstanding issues do not affect safety while the reactor is shut down.

System design and classification

Hydro-Québec is in the process of implementing N293-07, *Fire protection for CANDU nuclear power plants* [10]. The implementation of procedures and physical upgrades will take into consideration the transition from an operating state to a safe shutdown state.

Human factors in design

A documented process exists for considering human factors in design. However, a Type II inspection showed that the application of the process is not always effective. CNSC staff identified several compliance issues and are following up on those issues.

3.4.6 Fitness for service

The fitness for service SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the fitness for service SCA at Gentilly-2 met all applicable regulatory requirements. The identified compliance issues are not safety-significant for a reactor is a safe shutdown state.

Equipment fitness for service / equipment performance
On the basis of onsite inspections and compliance verifications, CNSC staff are satisfied with the overall equipment performance at Gentilly-2.

Maintenance
The maintenance program remained satisfactory. The preventive maintenance completion ratio (PMCR) improved to about 85%, which is close to the industry best practice value of 90%. The corrective maintenance backlog remained low. However, the elective maintenance backlog remained high and the licensee took several measures to lower the backlog. CNSC staff assessments and inspections did not identify any safety-significant issues related to maintenance.

Reliability of systems important to safety
Hydro-Québec’s reliability program for Gentilly-2 continued to meet regulatory requirements as given in S-98, *Reliability Programs for Nuclear Power Plants* [13].

All of the special safety systems met their unavailability targets.

Inspectors viewing a licensee’s irradiated fuel bay.

Structural integrity; periodic inspection and testing
In accordance with Gentilly-2's periodic inspection program (PIP) and applicable CSA standards, Hydro-Québec inspects and tests pressure retaining SSCs. No evidence of safety significant degradation of the nuclear pressure boundary components was identified in 2012.

Hydro-Québec submitted a partial PIP for the concrete containment structure. This program was prepared in order to meet the requirements of N287.7-08, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants* [15]. CNSC staff reviewed the document and provided comments. Because of the decision to end commercial operation and transition to a safe shutdown state, Hydro-Québec has made little progress in finalizing this document.

Although there were no immediate safety concerns, Hydro-Québec's performance did not meet the requirements of its licence or expectations of CNSC staff in the following areas:

- management of its quality assurance program, which has caused significant and recurring delays in the testing, maintenance and replacement of overpressure protection devices
- implementation of an accepted inspection program meeting the requirements of N285.4-05, *Periodic inspection of CANDU nuclear power plant components* [28], N285.5-08, *Periodic inspection of CANDU nuclear power plant containment components* [16], and N287.7-08 [15] (in 2012, Hydro-Québec was in the process of transitioning to these standards, but this process was halted because of the decision to end commercial operation and transition to a safe shutdown state)
- execution of a required concrete containment structure pressure test (because of the decision to end commercial operation and transition to a safe shutdown state, CNSC staff accepted Hydro-Québec's request to not perform the test)
- implementation of an accepted concrete containment structure aging management program

Aging management / lifecycle management
The lifecycle management programs for pressure tubes, feeders and steam generators were all satisfactory at Gentilly-2.

Hydro-Québec submitted a partial aging management program for the concrete containment structure. This program was prepared in order to meet the requirements of RD-334, *Aging Management for Nuclear Power Plants* [17]. CNSC staff reviewed the document and provided comments. Because of the decision to end commercial operation and transition to a safe shutdown state, Hydro-Québec has made little progress in finalizing this document.

3.4.7 Radiation protection

The radiation protection SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the radiation protection SCA at Gentilly-2 met all applicable regulatory requirements.

Application of ALARA
Hydro-Québec has an ALARA program in place that integrates the ALARA principle into planning, scheduling and work control, and meets the regulatory requirements.

Worker dose control
During the reporting period, no worker 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 appendix D.

CNSC staff conducted a Type II inspection on the implementation of the radiation program enhancements related to alpha monitoring and control. The inspection identified a number of areas for improvement, particularly in the areas of characterization, workplace surveillance and work planning. Hydro-Québec developed a corrective action plan to address the deficiencies, and CNSC staff will monitor the implementation of the corrective action plan in 2013.

Personnel dosimetry
Hydro-Québec continued to comply with the requirements to ascertain and record doses received by workers.

Contamination control
Hydro-Québec continued to apply measures to control radioactive contamination in its facility. No events occurred that resulted in an exceedance of the action level for surface contamination.

Estimated dose to public
The reported dose to the public from Gentilly-2 was 0.0044 mSv, which is well below the public dose limit of 1 mSv.

3.4.8 Conventional health and safety

The conventional health and safety SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the conventional health and safety SCA at Gentilly-2 met all applicable regulatory requirements.

Compliance with labour code
At Gentilly-2, Hydro-Québec complied with the relevant provisions of the Québec provincial laws, *An Act respecting occupational health and safety*, and relevant regulations.

Housekeeping / management of hazards
Gentilly-2 met CNSC requirements in housekeeping and hazard management. During field inspections, CNSC staff observed minor non-compliances that, in all cases, were corrected immediately after the licensee was informed.

Accident severity and frequency
As reported by the licensee, the accident severity rate increased from 7.0 in 2011 to 7.5 in 2012, and the accident frequency increased from 1.6 in 2011 to 1.8 in 2012. All the lost-time injuries occurred during the first half of the reporting period; improvement has been noted in this area during the second half. Many of the injuries observed at Gentilly-2 resulted from lifting or moving objects.

3.4.9 Environmental protection

The environmental protection SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the environmental protection SCA at Gentilly-2 met all applicable regulatory requirements.

Effluent and emissions control (releases)
Gaseous and aqueous releases of nuclear substances remained below environmental action levels and derived release limits.

Environmental management system
CNSC staff conducted an inspection of Hydro-Québec’s environmental management system and are currently reviewing the results.

3.4.10 Emergency management and fire protection

The emergency management and fire protection SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the emergency management and fire protection SCA at Gentilly-2 met all applicable regulatory requirements.

Nuclear emergency preparedness and response
As a result of the annual DERAD (Défense Radiologique) emergency management exercise in 2010, CNSC staff issued a directive to Hydro-Québec to correct the notification and activation processes to ensure effective and rapid responses. During the exercise in 2012, CNSC staff observed that Hydro-Québec has adequately addressed this compliance issue.

Fire emergency preparedness and response
As a result of an inspection of the emergency response team in 2011, CNSC staff issued a directive to Hydro-Québec to provide training on the correct use of communication equipment. CNSC staff observed that Hydro-Québec has adequately addressed this compliance issue.

Because of the decision to end commercial operation and transition to a safe shutdown state and the subsequent cancellation of emergency exercises, CNSC staff did not conduct any inspections of fire emergency preparedness and response. CNSC staff monitored Gentilly-2’s fire emergency preparedness and response activities through S-99 reporting [1], quarterly operations reports and site inspector surveillance.

3.4.11 Waste management

The waste management SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the waste management SCA at Gentilly-2 met all applicable regulatory requirements.

Waste storage and processing

Gentilly-2's nuclear waste facility, which includes the radioactive waste storage area, the solid radioactive waste management facility (phase 1) and the irradiated fuel dry storage area, is inspected regularly. In December 2011, although there were no immediate safety concerns, CNSC staff identified the need for some improvements to the maintenance of the facility. In October 2012, CNSC staff assessed the work done by Hydro-Québec and noted that the maintenance of the facility was satisfactory.

Decommissioning plans

The Québec government announced the pre-scheduled shutdown of Hydro-Québec's Gentilly-2 site in December 2012. Because the shutdown is earlier than expected, Hydro-Québec's 2010 decommissioning plan, the associated cost estimate and the financial guarantee are no longer current. Hydro-Québec is expected to submit a revised decommissioning plan and associated financial guarantee.

3.4.12 Security

The security SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years but trending downwards.

Based on the information assessed, CNSC staff concluded that the implementation of the security SCA at Gentilly-2 met all applicable regulatory requirements.

Facilities and equipment

Gentilly-2 completed its vital area enhancement project. The licensee's performance in the specific area of facilities and equipment was effective in 2012; however, some compliance issues were discovered during a security inspection. These issues were related to inconsistent testing procedures for security equipment and inadequate preventive maintenance of protected area barriers and their associated devices, and have been addressed to the satisfaction of CNSC staff.

Access control

The licensee had satisfactory processes and procedures in place to support access control, and maintained a site access clearance program that met regulatory requirements.

Training, exercises and drills

Hydro-Québec maintained a satisfactory training program that met applicable requirements of the *Nuclear Security Regulations* and associated regulatory documents. The security team maintained a training calendar to ensure that requisite subjects were covered. The program included the collective and integrated training of the nuclear response force and the nuclear security officers.

Hydro-Québec continues to support the Performance Testing Program by providing Canadian Adversary Testing Team members and essential support staff for the program.

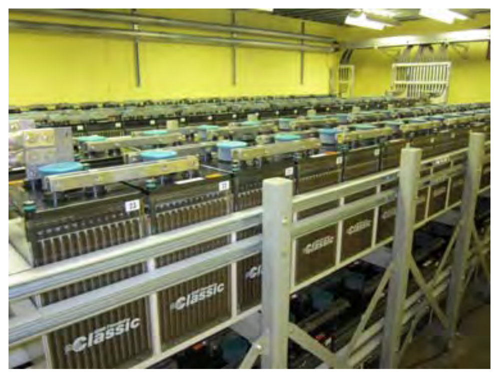
3.4.13 Safeguards and non-proliferation

The safeguards and non-proliferation SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the safeguards and non-proliferation SCA at Gentilly-2 met all applicable regulatory requirements.

Hydro-Québec continued to implement and maintain programs to ensure the effective implementation of safeguards measures and Canada’s nuclear non-proliferation obligations.

The IAEA did not select Gentilly-2 for a physical inventory verification (PIV) in 2012. Instead, CNSC staff conducted a physical inventory-taking evaluation, to provide assurance to the IAEA that the facility was properly prepared for a PIV if it had been selected. Hydro-Québec submitted the required operational and design information in a timely manner.



Emergency batteries at a licensee’s site can provide power during an extreme accident scenario.

3.4.14 Packaging and transport

The packaging and transport SCA at Gentilly-2 met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the packaging and transport SCA at Gentilly-2 met all applicable regulatory requirements.

Based on site surveillance activities and S-99 reporting [1], CNSC staff did not identify any compliance issues within this area.

3.5 Point Lepreau

Point Lepreau is located on the Lepreau Peninsula, 40 km 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, post-2012 refurbishment).

The 2012 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 two years 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**	**SA**
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

The management system SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

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

Management system

NB Power's operating licence was renewed in 2012, and the management manual and related documentation were revised to address the requirements of N286-05, *Management system requirements for nuclear power plants* [2]. CNSC staff verified that the revised manual and documentation met the requirements.

During 2012, the Point Lepreau problem identification and corrective action (PICA) program improved considerably, and management's involvement in daily PICA screenings and weekly meetings reduced the backlog of overdue corrective actions.

Management performance

The positive involvement of management in daily PICA screenings, weekly meetings and monthly management review meetings contributed to a marked improvement in the corrective action and self-assessment programs.

3.5.2 Human performance management

The human performance management SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

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

Human performance program

Point Lepreau has a comprehensive human performance program and implements practices that contribute to excellence in worker safety.

Licensee personnel are certified through examinations. CNSC staff review their qualifications and hours of work.

Personnel certification

Point Lepreau has sufficient numbers of personnel for all certified positions. CNSC staff are confident that, in 2012, the certified staff at Point Lepreau were competent to perform the duties of their positions safely and adequately. The licensee continued to meet the certification training and examination requirements. The personnel certification processes and procedures were adequate.

Initial certification examinations and requalification tests

During the reporting period, NB Power did not administer any initial certification examinations. NB Power conducted requalification tests on a group of shift supervisors; the group's overall pass rate was 100%. The remaining requalification tests, originally scheduled for 2012, were postponed until early 2013 due to refurbishment activities.

Work organization and job design

Point Lepreau continued to maintain effective oversight of its hours of work and minimum shift complement programs. Refurbishment led to a higher demand in the number of hours worked by staff; however, additional monitoring and reporting tools were established to assess and capture worker fatigue.

3.5.3 Operating performance

The operating performance SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

CNSC staff concluded that NB Power operated Point Lepreau safely and in compliance with the licensing basis.

Conduct of licensed activity
In 2012, NB Power continued its refurbishment activities, with most of the work being completed by the summer. Reactor commissioning and restart activities followed. The reactor returned to commercial operation on November 23, 2012. At this point, CNSC staff resumed routine regulatory oversight of operational activities.

A single-reactor station, Point Lepreau experienced no forced outages, one unplanned reactor trip during commissioning testing, no stepbacks and one setback. These transient events were associated with return-to-service activities. CNSC staff verified that, for all transient events, NB Power staff followed approved procedures, investigated or evaluated the root cause of the event, and took appropriate corrective actions.

NB Power’s personnel carried out refurbishment work at the Point Lepreau reactor.

CNSC staff inspections determined that control of combustible transient material did not meet requirements. Following CNSC enforcement actions, NB Power completed a root cause analysis, revised station procedures, and formed a team to address the control deficiencies. Subsequent CNSC inspections determined that compliance with requirements was acceptable and that NB Power had met the requirements of the compensatory measures. CNSC staff continue to monitor NB Power’s performance in implementing the required compensatory measures.

Severe accident management and recovery
CNSC staff developed a plan to review NB Power’s severe accident management guidelines (SAMGs). The review will be in line with best international practices and will be coordinated with the Fukushima action items (FAIs).

3.5.4 Safety analysis

The safety analysis SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the safety analysis SCA at Point Lepreau met all applicable regulatory requirements.

Deterministic safety analysis

NB Power continued to progress on the transition to compliance with RD-310, *Safety Analysis for Nuclear Power Plants* [5]. The transition includes identifying gaps against RD-310, developing principles and guidelines for the safety analysis and the execution of plans to update the safety report.

Probabilistic safety analysis

NB Power continued to comply with S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [6]. With the renewal of NB Power's licence, the probabilistic safety assessment program was included as a licence condition. NB Power is required to update its PSA every three years.

Environmental risk assessment

NB Power's environmental risk assessment program includes mitigation of the risks discussed below:

- ***Fish:*** NB Power continued to maintain and implement an effective environmental risk assessment and management program for the protection of fish at Point Lepreau in accordance with CNSC requirements. It should be noted that NB Power has committed to update its environmental risk assessment by December 31, 2013, including a review of the operation and effectiveness of the cooling water intake system according to the CSA N288 series of standards.
- ***Flooding:*** Licensees are required (by S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* [6]) to complete a Level 2 PSA for internal and external events, and to consider normal operation and shutdown conditions. NB Power completed Level 1 and Level 2 PSAs for these events, as well as for at-power and shutdown states. These assessments addressed potential flooding events.
- ***Groundwater:*** The groundwater monitoring program in place has not indicated any adverse effect on the groundwater flow system.

3.5.5 Physical design

The physical design SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

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

Equipment qualification

CNSC staff reviewed NB Power's update on its environmental qualification program plant life extension. NB Power has made progress, but there are still a few areas for improvement. These areas are all of low safety significance. NB Power is addressing the minor issues and CNSC staff are monitoring the issues.

System design and classification

In 2011, CNSC staff inspected Point Lepreau's electrical power system. This inspection resulted in four action notices that were addressed by NB Power in 2012. Two action items have been resolved; however, the other two are still pending and NB Power will provide CNSC with updates in 2013.

NB Power has replaced the digital control computer (DCC) components according to its DCC maintenance plan.

The licensee reported events related to the management of combustible materials inside the station, and legacy issues with a portion of the fire protection system that affected its availability. NB Power has implemented compensatory measures for the management of combustible materials that ensure an acceptable level of risk is maintained until permanent solutions are implemented. CNSC staff are continuing to monitor the licensee's progress in implementing N293-07, *Fire protection for CANDU nuclear power plants* [10]. The required implementation date is December 2014.

Human factors in design

NB Power continues to demonstrate progress with human factors in design. Work is ongoing to verify further improvements to its process.

3.5.6 Fitness for service

The fitness for service SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

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

Equipment fitness for service / equipment performance

Because Point Lepreau spent much of 2012 in refurbishment mode, little opportunity arose to assess equipment fitness for service or equipment performance for the operational reactor. No compliance issues were reported. CNSC staff continue to monitor these areas.

Maintenance

CNSC staff review and inspections did not identify any safety-significant maintenance issues. Point Lepreau's preventive maintenance completion ratio (PMCR) remained close to the industry average over the last five years and was 82% in 2012 (slightly below the industry best practice value of 90%). The corrective maintenance backlog remained low and was approaching industry best practice. The elective maintenance backlog was high when the reactor returned to operation, but CNSC staff are continuing to monitor the licensee's measures to reduce the backlog through routine maintenance-related desktop reviews and inspections.

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

Systems, structures and components monitoring

NB Power reported that three foam water fire suppression systems and a manual foam hose line providing protection for the standby generator and oil tank farm did not meet design specifications. NB Power had not performed inspections, tests, or maintenance on these systems. Compensatory measures have been introduced to address the availability of certain fire suppression systems. CNSC staff continue to monitor NB Power’s compliance in this area.

Reliability of systems important to safety

Point Lepreau’s reliability program continued to meet the regulatory requirements in S-98, *Reliability Programs for Nuclear Power Plants* [13].

All of the special safety systems met their unavailability targets, with the exception of the emergency core cooling and negative pressure containment. The impairments were not safety-significant. NB Power took appropriate actions to address the impairments, and completed corrective actions to prevent reoccurrence.

Structural integrity

Throughout the 2008-2012 refurbishment outage, NB Power conducted inspections in accordance with the station’s periodic inspection programs (PIPs) and the applicable CSA standards as required by its operating licence. CNSC staff are satisfied with the results of the inspections. NB Power has submitted updated PIPs to provide ongoing assurance of the structural integrities of major pressure boundary components including pressure tubes, feeders, steam generators, concrete containment structures and containment components. These programs are currently being reviewed by CNSC staff for acceptance.

CNSC staff concluded that the implementation of the PIPs at Point Lepreau met regulatory requirements and that no safety-significant pressure boundary degradation findings were identified in 2012.

NB Power carried out the required inspections and repairs for the containment structures and subsequently performed a reactor building leaking rate test (LRT) before restarting the reactor. Based on the preliminary results, the LRT was successful.

Aging management / lifecycle management

NB Power submitted a revised aging management and periodic inspection program for the concrete containment structure at Point Lepreau. CNSC staff have reviewed the document and provided feedback to NB Power. The lifecycle aging management programs for pressure tubes, feeders and steam generators were all satisfactory. CNSC staff continue to provide regulatory oversight in this area.

In-service inspections for balance-of-plant

NB Power is required to carry out inspections to ensure the structural integrity of safety-significant balance-of-plant pressure retaining systems and components and safety-related structures. CNSC staff monitored the pressure boundary and operation quarterly reports, and found no evidence of safety-significant degradation of balance-of-plant components in 2012.

3.5.7 Radiation protection

The radiation protection SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the radiation protection SCA at Point Lepreau met all applicable regulatory requirements.

Application of ALARA

CNSC staff conducted a Type II radiation protection inspection at Point Lepreau. No non-compliances with regulatory requirements were identified. The CNSC noted that NB Power has systematically identified activities to manage tritium in the moderator and primary heat transport systems. The identified activities are based on a comprehensive self-assessment and were approved by the Point Lepreau ALARA committee. CNSC staff continue to monitor the implementation of these improvement initiatives.

Worker dose control

The refurbishment activities at Point Lepreau were completed in 2012 and the total project dose was approximately 12.3 person-sieverts (p-Sv), which was within the project dose estimate of 12.7 p-Sv.

Point Lepreau's radiation protection program continued to ensure that requirements are in place to control doses received by workers. During the reporting period, there were no radiation exposures that resulted in a worker dose exceeding the regulatory dose limits or the action levels. The dose information for Point Lepreau is provided in section 2.7 and appendix D.

In 2012, NB Power reported that they had finalized the implementation of the enhancements to the radiation protection program in the area of alpha monitoring and control. CNSC staff plan to review the program in 2013.

Personnel dosimetry

NB Power continued to comply with the requirements to ascertain and record worker doses, including those for contractors and visitors.

Contamination control

NB Power continued to apply measures to control radioactive contamination. No contamination events occurred that resulted in a surface contamination action level exceedance.

Estimated dose to public

The reported dose to the public from NB Power's licensed activities was 0.0006 mSv, which is well below the public dose regulatory limit of 1 mSv.

3.5.8 Conventional health and safety

The conventional health and safety SCA at Point Lepreau exceeded applicable CNSC performance objectives and requirements. The station received a "fully satisfactory" rating, an improvement from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the conventional health and safety SCA at Point Lepreau exceeded applicable regulatory requirements.

Compliance with labour code
Point Lepreau complied with the relevant provisions of New Brunswick's *Occupational Health and Safety Act*, *Workers' Compensation Act* and *Workplace Health, Safety and Compensation Commission Act*.

Housekeeping / management of hazards
Due to refurbishment activities, more material than usual was stored and disposed of. However, inspections found no significant safety compliance issues with housekeeping. Workers wore personal protective equipment as required.

Accident severity and frequency
As reported by the licensee, the accident severity rate remained unchanged at 0, and the accident frequency increased slightly from 0.5 in 2011 to 0.7 in 2012. This is the lowest accident severity rate for the Canadian nuclear power industry.

3.5.9 Environmental protection

The environmental protection SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

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

Gaseous and aqueous releases of nuclear substances were considerably below the environmental action levels.

3.5.10 Emergency management and fire protection

The emergency management and fire protection SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous year and an improvement from 2010.

Based on the information assessed, CNSC staff concluded that the implementation of the emergency management and fire protection SCA at Point Lepreau met all applicable regulatory requirements.

Nuclear emergency preparedness and response
Upon Point Lepreau's return to service, NB Power upgraded its nuclear emergency program to full, normal operating requirements. Training and drills have been conducted for implementing the new incident command system for emergency response. A full-scale emergency exercise with the Province of New Brunswick was successfully demonstrated in March 2012. Point Lepreau activated both the onsite and offsite response organizations during the exercise. Public alerting was tested and inter-operability with the province was demonstrated.

Fire emergency preparedness and response
No fire response inspection was conducted in 2012 due to the ongoing refurbishment project. Oversight of Point Lepreau's fire response activities continued to be monitored via S-99 reporting [1] and CNSC site inspector surveillance.

3.5.11 Waste management

The waste management SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a “satisfactory” rating, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the waste management SCA at Point Lepreau met all applicable regulatory requirements.

Waste minimization, segregation and characterization
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 storage and processing
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 on a private road, and CNSC staff provide 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 has demonstrated consistent and compliant management and control of waste storage throughout its operations.

Decommissioning plans
The decommissioning plan for Point Lepreau remains valid and current. The plan was revised in 2011, and adequately addressed the regulatory requirements.

3.5.12 Security

The security SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a rating of “satisfactory”, unchanged from the previous two years.

Based on the information assessed, CNSC staff concluded that the implementation of the security SCA at Point Lepreau met all applicable regulatory requirements.

There were no significant compliance issues. In the specific area of training, exercises and drills, NB Power continues to support the Performance Testing Program by providing Canadian Adversary Testing Team members and essential support staff for the program.

Point Lepreau’s security system met CNSC performance objectives and requirements.

3.5.13 Safeguards and non-proliferation

The safeguards and non-proliferation SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

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

NB Power continues to implement and maintain programs to ensure the effective implementation of safeguards measures and Canada's nuclear non-proliferation obligations.

NB Power submitted the required operational and design information in a timely manner. However, the completeness and accuracy of Point Lepreau's accounting reports were deficient for a number of months. CNSC advised NB Power of these concerns and will continue to closely monitor the content of the reports.

The IAEA conducted a physical inventory verification (PIV) at Point Lepreau to verify the non-diversion of nuclear material and to confirm the declarations provided by the state authorities and facility operators.

3.5.14 Packaging and transport

The packaging and transport SCA at Point Lepreau met applicable CNSC performance objectives and requirements. The station received a "satisfactory" rating, unchanged from the previous two years.

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

CNSC staff inspected the transportation of dangerous goods (Class 7) radioactive material and is satisfied that Point Lepreau complies with the regulatory requirements. The licensee reported any occurrences in a timely manner. No significant events were reported. CNSC staff did not identify any compliance issues regarding packaging and transport.

4. Regulatory Developments and Issues

This section provides detailed information on various regulatory developments and issues for each site, including licensing, major projects and descriptions of reportable events. 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 16 months (January 2012 through April 2013).

Licensing

Between January 2012 and April 2013, two power reactor operating licences (PROLs) were renewed: Point Lepreau in 2012 and Darlington in early 2013. The Pickering A and B licences are being considered for renewal in June 2013.

With the renewal of the Pickering licences, all NPP licensees will have an operating licence with a licence conditions handbook (LCH). The process of issuing licences with the revised format and accompanying LCH, which began in 2009 with the renewal of the Bruce A and B licences, will be complete.

Update on Fukushima Daiichi

Following the Fukushima Daiichi accident in 2011, the CNSC issued a regulatory directive 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. In 2012, the CNSC produced the *CNSC Action Plan* [29], which identifies specific action items to be completed by licensees by the end of 2015. Updates on these action items are available in this section, under “Updates on significant regulatory issues” for each site.

Appendix F includes the status of the Fukushima action items (FAIs) as of April 30, 2013. A separate, comprehensive status update on the Fukushima responses is planned for presentation to the Commission in August 2013.

All 18 short-term FAIs were closed or were being reviewed for closure by CNSC staff. This status is consistent with the deadlines established in the *CNSC Action Plan* with the exception of Gentilly-2 where the majority of the short-term FAIs were suspended due to the end of commercial operation.

Event initial reports

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

Previously, an event was reported through an early notification report (ENR). ENRs have been replaced with event initial reports (EIRs) that are submitted to the Commission through a *Status Report on Power Reactors*. Note that the number of EIRs in a given year is not indicative of the safety of Canada’s NPPs. For example, the events reported during 2012 and early 2013 were, in general, of low safety significance. Due to the overlapping nature of the reporting period for regulatory developments and issues, the EIRs that occur in the first part of the calendar year will be reported in two successive annual NPP reports. In each site’s section, the EIRs that were reported in last year’s report have been identified with an asterisk (*).

Overall, 15 EIRs were submitted during the reporting period of January 2012 to April 2013. Summary details of the EIRs are provided in each site’s section.

4.1 Bruce A and B

4.1.1 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. The applications for Bruce A and B licence renewals are expected in late 2013.

Licence amendments

No amendments were made to the Bruce A or B licences during the reporting period.

Revisions to the licence conditions handbooks

Between January 2012 and April 2013, four revisions were made to the Bruce A licence conditions handbook (LCH), and two revisions to the Bruce B LCH. The more significant changes are shown in table 10.

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

Table 10: Changes to LCHs for Bruce A and Bruce B

Section	Description of Change	Revision Type	LCH
2.1	CNSC document, *CNSC Staff Objectives and Criteria for Licensee Hours of Work Limits*, has been added.	Technical	Bruce A and B
4.3	CSA N287.7 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
5.1	Bruce B 2012/13 Safety Report, Parts 1 and 2 have been added.	Administrative	Bruce B
7.1 *	In the compliance verification criteria (CVC) of section 7.1, the CNSC regulatory guide G-217, *Licensee Public Information Programs*, has been added.	Administrative	Bruce A and B
7.1	In the CVC of section 7.1, CNSC guidance document G-217, *Licensee Public Information Programs,* has been replaced with RD/GD-99.3, *Public Information and Disclosure* [24].	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)"* [30].	Technical	Bruce A and B
10.	CNSC security requirements and expectations have been added.	Technical	Bruce A and B
11.1	RD-336, *Accounting and Reporting of Nuclear Material* [21] has been added.	Technical	Bruce A and B
13.3	Added pre-requisite to increase above 50% power (acceptable resolution of the annulus gas system issue for Unit 1 only)	Technical	Bruce A
13.3	Changed 50% power hold point for Unit 1 to 90% to allow for additional commissioning of the annulus gas system	Technical	Bruce A

* This change was previously reported in the 2011 NPP Report as the revision was made on February 3, 2012 (within the reporting periods for both the 2011 NPP Report and the 2012 NPP Report).

Progress made on licensing commitments

Bruce A environmental assessment follow-up program

Bruce Power continued to implement activities concerning the *Canadian Environmental Assessment Act* (1992) follow-up program. As part of the program, and in collaboration with Aboriginal groups and other stakeholders, a long-term whitefish monitoring program was carried out.

At Bruce A, Bruce Power continued to implement the environmental assessment (EA) follow-up monitoring program. The fifth-year report (for 2011) was submitted to the CNSC and was reviewed in 2012. CNSC staff continue to work with Environment Canada, Aboriginal groups and other stakeholders on environmental issues that have arisen through the EA follow-up monitoring program, such as any effects on smallmouth bass and round whitefish. CNSC comments were addressed by Bruce Power and will be included in the 2012 EA program.

Bruce Power has completed all baseline studies that are required before the refurbishment EA programs and operations phase studies can start in 2013. Studies include monitoring the impingement or entrainment of fish species, and monitoring for thermal effects with the four units back in operation at Bruce A.

Aboriginal consultation

For the Bruce A environmental assessment program (EAP), Bruce Power and the Saugeen Ojibway Nations (SON) continued to cooperate in the development of a research program to address the SON's concerns related to the whitefish studies. CNSC staff continue to work with both Bruce Power and the SON.

4.1.2 Updates on major projects and initiatives

Bruce A Units 1 and 2 life extension

Bruce Power completed the return to service of both Units 1 and 2 in 2012, despite various technical difficulties with the refurbishment project. The refurbishment of Units 1 and 2 required significant efforts from Bruce Power and CNSC staff.

Bruce Power's turbine generator at Unit 1.

During commissioning for Unit 1, Bruce Power discovered a flow blockage on a limited number of channels in the annulus gas system (AGS). The AGS provides early detection of leaks by monitoring the dewpoint of the gas outside the tubes in a channel. If dewpoint monitoring cannot be conducted on the affected channels, safety is not compromised because other liquid leak detection methods provide sufficient early detection. CNSC staff approved limited reactor operation with the AGS flow blockages on the basis that the pressure tubes are new and other leak detection is available. In May 2013, CNSC staff accepted a modification to the AGS. Because all items in the integrated implementation plan related to releasing reactor shutdown guarantees had been confirmed as completed, CNSC removed the final hold point for increasing to above 50% reactor power in Bruce A Unit 1.

For Unit 2, in early May 2012, while preparing to synchronize to the electric grid for the first time, a manufacturing defect in the new generator caused the turbine to trip. Significant damage occurred to the generator and it had to be replaced. All safety systems worked as designed, and the reactor was never at risk; however, the refurbishment project was delayed by several months. After the generator was replaced, Unit 2 returned to service with all commissioning completed. CNSC staff have released all hold points, and this unit is now under routine regulatory oversight.

Fuel channel life management project

In 2009, Bruce Power, OPG and AECL jointly initiated a comprehensive R&D project to investigate the feasibility of operating the pressure tubes beyond their current permitted life. OPG seeks to ensure operational flexibility for its Darlington units – through compiling critical data on aging-related issues that might otherwise limit the life of their fuel channels. During the reporting period, 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 deuterium in the pressure tube and the effect on material properties such as fracture toughness with increasing hours of operation

CNSC staff continued to review documentation submitted by the licensee addressing these high-priority areas in accordance with a protocol that provides governing roles and responsibilities between the licensees and CNSC staff.

Modified 37-element fuel bundle

The modified 37-element (37M) fuel bundle design is a minor modification of the fuel design currently in use. The central element (pin) of the 37M bundle has a reduced diameter, allowing more coolant to flow through the centre of the bundle and increasing the overall margins for the critical channel power. This modification was designed to improve thermalhydraulic performance, in order to offset the effects of aging in the heat transport system and to restore system design safety margins by improving the fuel dry-out power of the current design.

Bruce Power intends to use this fuel in both the Bruce A and B reactors. Fuelling of Bruce A Units 3 and 4 is planned for 2013, with further fuelling of Bruce A Units 1 and 2. Bruce Power has provided the supporting safety case submissions to CNSC, and CNSC staff have reviewed all safety aspects for core loading.

In January 2013, Bruce Power received CNSC's consent to use the 37M fuel bundles in the Bruce A units. Later in 2013, CNSC expects Bruce Power to submit its request for consent to use the 37M fuel in the Bruce B units.

4.1.3 Updates on significant regulatory issues

Alpha monitoring program

Since the alpha contamination event in 2009, Bruce Power has improved its alpha monitoring program and has demonstrated a commitment to implementing enhancements to monitor and control alpha hazards. CNSC staff are satisfied that Bruce Power has implemented enhancements in the area of alpha monitoring and control. CNSC staff continue to verify effective implementation of these program enhancements through the baseline compliance plan. The regulatory action for this event is now closed.

Large loss of coolant accident margin restoration

Given the relatively long timeline associated with completion of large loss of coolant accident (LLOCA) safety issues, CNSC has released an interim regulatory position in cases where a research, analytical or plant operation issue may have an effect on LLOCA safety margins. The interim position will remain in effect until the recommendations of the CANDU Owners Group (COG) LLOCA working group are accepted by the CNSC and are fully implemented by the industry.

Neutron overpower protection

Bruce Power continued to use a new methodology for neutron overpower analysis in order to assess the most safety-significant aging conditions. The neutron overpower protection (NOP) system is composed of in-core detectors that provide prompt measurements of neutron flux throughout the core. If an uncontrolled transient in reactor power occurs, inducing a neutron flux increase, then once the NOP trip setpoint is reached, the reactor is shut down to prevent any threat to fuel integrity.

All required NOP reports have been submitted to the CNSC and were reviewed by CNSC staff in 2012. CNSC staff presented the NOP review to the Commission in August 2012, and CNSC's progress report was sent to Bruce Power in 2013. Bruce Power has affirmed that the current NOP trip setpoints are adequate for safe operation of its stations, based on its review of activities completed to date. CNSC staff requested additional information from Bruce Power in April 2013 and extended their acceptance of the current practice for setpoints. This extension for the setpoints will be valid until CNSC staff have reviewed and accepted the additional information, but for no longer than 12 months.

Response to the Fukushima Daiichi accident

In response to the *CNSC Action Plan* [29], CNSC staff established a project to oversee the implementation of 36 site-specific Fukushima action items (FAIs). In addition, CNSC staff have initiated a periodic safety review (PSR) working group to address the recommendation from the Fukushima Task Force to enhance regulatory oversight through the implementation of a PSR process.

Bruce Power continued submitting its updates on lessons learned from the Fukushima Daiichi accident, including the safety reviews of Bruce A and B and its schedule for Fukushima-related enhancements. CNSC staff accepted Bruce Power's plan and schedule for installing passive autocatalytic recombiners (PARs). Bruce Power has implemented key elements of the severe accident management guidelines (SAMGs) for single-unit events. CNSC staff noted that Bruce Power is prepared to deal with potential emergencies.

Of the 36 FAIs, 35 applied to Bruce A and 35 applied to Bruce B. By the end of 2012, all short-term FAIs were closed for both Bruce A and B. Significant progress has been made in key areas related to:

- ***Enhancing emergency response:*** Bruce Power completed construction of the emergency management centre and is investigating backup locations for this facility. Bruce Power plans to develop an enhanced drill/exercise program based on lessons learned from the "Huron Challenge – Trillium Resolve" exercise. Considerable work is underway in the development of an offsite remote monitoring system, including preliminary plans to test monitor types. See appendix F, FAI 4.1.1 to 5.3.1.
- ***Procurement and deployment of emergency mitigating equipment:*** The equipment, consisting of portable diesel pumps and generators to supplement the existing emergency and backup equipment, has been procured and deployed. Operational procedures and guidelines for deployment of this equipment have been issued. These guidelines also provide validation procedures for training. See appendix F, FAI 1.11.1.

An example of a portable pump.

- ***Severe accident management guidelines (SAMGs)***: Several activities have been completed or are ongoing. Activities are underway to update the technical basis and generic documentation in the SAMGs to include multi-unit events and instrument survivability. See appendix F, FAI 3.1.2.
- ***Design upgrades:*** Upgrades related to the evaluation of alternate coolant make-up to the reactor included the installation of external make-up lines and provision of additional relief capacity to the calandria vault. For example, Bruce Power reported that water connections to the steam generators in all Bruce A and B units are complete. An assessment of the practicality for installing overpressure protection to the shield tank is underway at Bruce A and B. See appendix F, FAIs 1.2.3 and 1.7.1.

4.1.4 Event initial reports

Six EIRs were submitted for Bruce A and B from January 2012 to April 2013, as shown in table 11. The EIR events had low safety significance.

Table 11: **Event initial reports for Bruce A and B**

Subject	Brief Description
Bruce A incident declared due to tritium alarm in the Auxiliary Services Building *	On January 23, 2012, a heavy water operator informed the Bruce A control room that a tanker truck carrying heavy water from Bruce B, to be stored in the Bruce A Auxiliary Services Building (ASB), alarmed the detectors in the Bruce A ASB (its final destination). These tankers are never used on public roads and are dedicated exclusively to heavy water transport on the NPP site, which is considered a controlled area from a safety perspective. The origin, destination and travel path were all within the controlled Bruce site. Personnel in the Bruce A ASB were evacuated immediately upon the sounding of the tritium alarms. Surveys were performed and an exclusion boundary was established to prevent unplanned exposures. This event was reported to the Commission through CMD 12-M8 on February 6, 2012. CMD 12-M8 completed CNSC staff notification to the Commission on this event.
Bruce A - Partial loss of Class III and Class IV power to Unit 0 *	On February 8, 2012, an electrical trip occurred during a scheduled test. Since the automatic backup had been isolated as part of the test, backup power was not available. This resulted in a loss of power in the common areas of Bruce A. Operators quickly took action to connect an alternate power supply. At no time did the main control room lose power or the ability to communicate outside the station. The operating units were not affected. Bruce Power determined that this was a reportable event in accordance with the Provincial Nuclear Emergency Plan and Bruce Power procedures. Notifications to the Provincial Emergency Operations Centre and the CNSC were completed as required. This event was reported to the Commission through CMD 12-M10 on February 6, 2012. CMD 12-M10 completed CNSC staff notification to the Commission on this event
Bruce B - Low tritium levels detected in Emergency Water System (EWS) outfall	During the execution of a safety system test on April 26, 2012, samples were collected from the Emergency Water System (EWS) outfall and tested for levels of hydrazine, as per a commitment to Environment Canada to verify that the hydrazine released was within the Certificate of Approval (CoA) limits. Since the hydrazine releases were higher than expected, yet within the CoA limit, several additional analyses were completed, one of which was for tritium. On May 2, 2012, the tritium results were received indicating the EWS outfall samples contained tritium levels between 9.6×10^4 Bq/L and 1.5×10^5 Bq/L. These values, although low, are higher than the limit set in the Provincial Water Quality Objectives of 7.0×10^3 Bq/L. The original sample was re-analyzed and confirmed the elevated levels for tritium. A followup sample was taken on May 2, 2012 at the EWS outfall. The results showed that the release was not ongoing and that tritium was below the Minimum Detection Limit (MDL). The licensee took appropriate measures to prevent any further discharges. No adverse effects on the environment were observed as a result of the event. This event was reported to the Commission through CMD 12-M34 on June 21, 2012. CMD 12-M34 completed CNSC staff notification to the Commission on this event.

Subject	Brief Description
Bruce A, Unit 1 - Excitation transformer trip	On August 24, 2012, during first energization of a transformer on the non-nuclear side of the plant, an electrical fault was encountered which led to a small transformer fire. Staff monitoring the testing identified smoke coming from a piece of electrical equipment and promptly notified the appropriate station management. Fire alarms were sounded as per design. During the event, the electrical bus was cleared by protective relaying, which resulted in the loss of power to primary heat transport pump 4. The heat transport system stabilized at 7.3 MPa, 150 C on 3-pump operation as per design. Two workers were conservatively sent to hospital for smoke inhalation and it was confirmed they had no injuries. They were released during the same shift and returned to normal duties. This event was reported to the Commission through CMD 12-M50 on Sept. 12, 2012. CMD 12-M50 completed CNSC staff notification to the Commission on this event.
Bruce B – Standby generator fuel leak	On December 16, 2012, Bruce Power reported the discovery of a leak of diesel fuel involving an underground pipe between a standby generator and a fuel tank. The leak was contained and there are no safety or environmental implications. This was immediately reported to the Ministry of the Environment (MOE). The Technical Standards and Safety Authority (TSSA) and the MOE district officers came onsite to inspect the spill location. Bruce Power monitors the shoreline with the support of external contractors with expertise in this area and took all action necessary to address any environmental impacts from this release of conventional diesel fuel. This event was reported to the Commission through CMD 13-M4 on January 16, 2013 and has been disclosed on the licensee and CNSC Web sites. CNSC staff continue to review the incident and will present a final update to the Commission in the Fall of 2013.
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 [1] and has been disclosed on the licensee's and CNSC's Web sites. 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 2011 NPP Report.

4.2 Darlington

4.2.1 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).

Licence amendments

The former Darlington licence was amended three times between January 1, 2012 and February 28, 2013. The current Darlington licence has not been amended since the beginning of its licence period, March 1, 2013. Table 12 shows details of the amendments.

Table 12: Amendments to Darlington power reactor operating licence

Power reactor operating licence # - Effective date	Amendment requests
13.17/2013 – February 7, 2012	Replaced Revision 5 of the *Organizational Change Control* document with Revision 6
	Replaced Revision 0 of the *Derived Release Limits and Environmental Action Levels for Darlington Nuclear Generating Station* with Revision 1
13.18/2013 – April 24, 2012	Replaced Revision 9 of the *Station Shift Complement* document to Revision 10
	Replaced Revision 5 of the *Darlington Site Security Report* with Revision 6 and an addendum letter to revise the Security Minimum Shift Complement
	Replaced Revision 24 of the *Darlington Nuclear Operating Policies and Principles* with Revision 25
	Made administrative corrections to the Licence Conditions associated with the amendments approved in PROL 13.17/2013
13.19/2013 – December 19, 2012	Updated Ontario Power Generation's Consolidated Financial Guarantee

Revisions to the licence conditions handbook

Darlington's LCH was issued on March 1, 2013. No revisions were made to the Darlington LCH during the reporting period.

4.2.2 Updates on major projects and initiatives

Modified 37-element fuel bundle

The modified 37-element (37M) fuel bundle design is a minor modification of the fuel design currently in use. The central element (pin) of the 37M bundle has a reduced diameter, allowing more coolant to flow through the centre of the bundle and increasing the overall margins for the critical channel power. This modification was designed to improve thermalhydraulic performance, in order to offset the effects of aging in the heat transport system and to restore system design safety margins by improving the fuel dry-out power of the current design.

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

As of the end of March 2013, approximately 74% of the Unit 1 core and 76% of the Unit 2 core have been fuelled with 37M fuel bundles. A small number of 37M fuel bundles have also been loaded in the Unit 3 core and the Unit 4 core. No anomalies have been observed related to the use of 37M fuel bundles, and CNSC staff remain satisfied that the modified bundle is as acceptable as the original 37R fuel bundle design.

OPG recently submitted additional analyses to support its claims of safety improvements for these 37M fuel bundles. CNSC staff are continuing to evaluate the information.

Refurbishment / life extension

In October 2011, OPG submitted to the CNSC its integrated safety review (ISR) in support of plant life extension at Darlington in accordance with RD-360, *Life Extension of Nuclear Power Plants* [31]. CNSC staff are finalizing their review of the ISR and will be issuing their assessment in July 2013 in accordance with the protocol between OPG and the CNSC for the ISR and for the integrated implementation plan for Darlington's refurbishment. Additional gaps with modern codes and standards have been identified by CNSC staff and accepted by OPG. These gaps will be dispositioned in accordance with the accepted process and will be further discussed as part of OPG's global assessment report (to be submitted in December 2013).

In December 2012, a Commission hearing was held on the environmental assessment screening report. The Commission accepted the screening report and issued the record of decision in March 2013. Following this decision, Greenpeace Canada submitted an application for judicial review to the Federal Court on April 12, 2013.

Fuel channel life management project

In 2009 Bruce Power, OPG and AECL jointly initiated a comprehensive R&D project to investigate the feasibility of operating the pressure tubes beyond their current permitted life. OPG seeks 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. During the reporting period, 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 deuterium in the pressure tube and the effect on material properties such as fracture toughness with increasing hours of operation

CNSC staff continued to review documentation submitted by the licensee addressing these high-priority areas in accordance with a protocol that provides governing roles and responsibilities between the licensees and CNSC staff.

Days-based maintenance

OPG has initiated "days-based maintenance" at all three sites (Darlington, Pickering A and Pickering B) to remove non-essential maintenance personnel and activities from a shift configuration. Sufficient maintenance staff will remain on shift to address emerging operational issues and emergency response.

Validations were performed by OPG, analyzed in an independent review by AMEC-NSS Ltd. and observed by CNSC staff in advance of requests to amend the current minimum shift complement at Darlington. In April 2012, the volunteer emergency response team was replaced by additional emergency response team members and nuclear security officers in an escorting capacity. In June 2012, CNSC staff observed validation of the Emergency Response Organization (ERO). In January 2013, a coordinated four-unit event was validated to assess the capability of operations staff to respond to a design-basis earthquake. The ERO, maintenance and operations portions of the minimum shift complement are under analysis by CNSC staff and the project is expected to be completed in 2013, pending resolution of any issues, concerns and approvals by CNSC staff.

4.2.3 Updates on significant regulatory issues

Alpha monitoring program

Darlington finalized the implementation of the enhancements to alpha monitoring and control in 2012. CNSC staff are satisfied with the enhancements implemented by OPG. CNSC staff continue to verify effective implementation of these program enhancements through the baseline compliance plan.

Response to the Fukushima Daiichi accident

In response to the *CNSC Action Plan* [29], 36 Fukushima action items (FAIs) were derived, and are described in appendix F. OPG continues to address and finalize the implementation of these FAIs by the deadline of December 2015.

Of the 36 FAIs, 34 applied to Darlington. By the end of 2012, all short-term FAIs were closed. Significant progress has been made in key areas related to:

- ***Enhancing emergency response:*** All related short-term FAIs were accepted by CNSC staff and were subsequently closed. These FAIs were identified by the CNSC Task Force to further improve emergency response through streamlining emergency preparedness between onsite and offsite authorities, and strengthening interaction with provincial and federal emergency planning authorities. See appendix F, FAIs 4.1.1 to 5.3.1.
- ***Procurement and deployment of emergency mitigating equipment:*** Work included the development of instructions and training, completion of storage buildings, and deployment of field runs. The equipment includes portable pumps, portable generators, hoses and connections, and personnel communication equipment stored onsite as well as additional equipment and resources stored offsite. A station emergency drill for Pickering A and B was completed in February 2013, with deployment of emergency mitigation equipment, and a report on the drill was issued to validate instructions and timing. See appendix F, FAI 1.11.1.
- ***Hydrogen recombiners***: The installation of recombiners for hydrogen mitigation is either completed, or continuing according to the accelerated schedule. Installation is in progress during unit outages. See appendix F, FAI 1.4.1.
- ***Severe accident management guidelines (SAMGs)***: OPG has implemented SAMGs such as completion of tabletop exercises and training of emergency response organizations and technical support roles. See appendix F, FAIs 3.1.1 to 3.1.4.

4.2.4 Event initial reports

Three EIRs were submitted for Darlington from January 2012 to April 2013, as shown in table 13. The EIR events had low safety significance.

Table 13: Event initial reports for Darlington

Subject	Brief Description
Workplace fatality *	On April 18, 2012, an OPG control technician lost consciousness and collapsed to the floor while performing work on the Unit 3 reactivity deck. A co-worker called 911 and the Darlington Nuclear Emergency Response Team responded. The person was transported to hospital via ambulance, seen by a physician and pronounced dead upon arrival. At the time of the incident Unit 3 was shut down for planned maintenance. OPG made reports to the CNSC, the Ontario Ministry of Labour and the Durham Regional Police. The town mayor was informed by OPG's public affairs staff. OPG management suspended all work at the station for the morning and addressed all site staff directly. A bereavement notice was posted on OPG's intranet and external Web site. The Durham Regional Police conducted an investigation and concluded that the cause of death was not work-related. This event was reported to the Commission through CMD 12-M28 on May 3, 2012. CMD 12-M28 completed CNSC staff notification to the Commission on this event.
Shutdown of heat transport feed pump after detection of unusual operation	On September 5, 2012, Unit 1 was safely shut down after operators detected the unusual operation of a heat transport feed pump. Subsequent investigation identified the cause to be a failed air supply valve. OPG concluded that the failure of a single valve led to this transient. The primary contributing factor was the failure to meet the design intent of the station by not providing failsafe isolation of the instrument air system from the purification system for the pressure and inventory control system. This design/operational flaw has been addressed for all four units in the short term and a permanent solution is being implemented by OPG. Despite this avoidable single valve failure, detailed information from OPG has confirmed that the reactor was safely shut down; no damage occurred to either fuel or fuel channels and special safety systems were not challenged. CNSC staff are conducting an assessment of the corrective actions. This event was reported to the Commission through CMD 12-M54 on October 24, 2012. CNSC staff will provide a further update to the Commission in the Fall of 2013.
Overheated exhaust fan causing smoke	On February 2, 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 Web sites. This event was reported to the Commission through CMD 13-M23 on May 15, 2013. CMD 13-M23 completed CNSC staff notification to the Commission on this event.

* This event was previously reported in the 2011 NPP Report.

4.3 Pickering A and B

4.3.1 Licensing

The licence for Pickering A was renewed in June 2010 for a three-year period (effective until June 30, 2013). Since renewal, the Pickering A licence has had seven amendments, four of which were made during this reporting period.

The licence for Pickering B was renewed in February 2008 for a five-year period (effective until June 30, 2013). Since renewal, the Pickering B licence has had 22 amendments, seven of which were made during this reporting period.

The licences for both Pickering A and B will expire on June 30, 2013. OPG plans to operate Pickering until 2020 and then shut down the facility and end its commercial operation. On February 20, 2013, a presentation was made to the CNSC Commission members to request a five-year, combined Pickering A and B licence. Under the new combined Pickering licence, Pickering A and B will be referred to as Pickering 1, 4 and 5-8.

In preparation for this request, in addition to the licensee programs, CNSC staff reviewed aspects of importance to aging facilities and an approach to the end of commercial operation. In the proposed operating licence, CNSC staff included a regulatory hold point for the re-assessment of the safety case to justify operation of the current facilities beyond the nominal design life of fuel channels. The life of fuel channels, which are life-limiting components in CANDU reactors, is currently estimated at 30 years of operation at 80% capacity (210,000 hours of effective full power operation).

Licence amendments

The Pickering A licence was amended four times between January 2012 and April 2013. Table 14 shows details of the amendments.

Table 14: Amendments to Pickering A power reactor operating licence

Power reactor operating licence # - Effective date	Amendment requests
04.04/2013 – April 24, 2012	An update to the *Pickering Minimum Shift Complement* document to remove the Volunteer Emergency Response Team and to increase the number of Emergency Response Maintainers required
	An update to reference the channel and bundle power limits outlined in the *Pickering A Operating Policies and Principles*
04.05/2013 – June 22, 2012	An update to include the revised Minimum Shift Complement
04.06/2013 – December 19, 2012	An update to include the revised financial guarantee
04.07/2013 – December 28, 2012	An update to include the revised Derived Release Limits
	An update to include the revised Minimum Shift Complement
	Updates to correct the titles of some referenced documents

The Pickering B licence was amended seven times between January 2012 and April 2013. Table 15 shows details of the amendments.

Table 15: Amendments to Pickering B power reactor operating licence

Power reactor operating licence # - Effective date	Amendment requests
08.16/2013 – February 7, 2012	An update to the document entitled *Building Development Site Plan*
	An update to the document entitled *Organizational Change Control*
08.17/2013 – February 24, 2012	An update to licence condition 2.2 to change the requirements for the annual organizational chart submission
08.18/2013 – March 29, 2012	An update to allow the use of rod-based guaranteed shutdown state
08.19/2012 – April 24, 2012	An update to the document entitled *Pickering Minimum Shift Complement.*
	An update to the document entitled *Pickering Nuclear Generating Station Security Report*
	An update to reference the document entitled *Request for Licence Amendments: Revised NSO Minimum Complement Addendum to Pickering Site Security Report, R07 and Darlington Site Security Report, R06*
	An update to reference the fuel bundle power limits outlined in the *Pickering B Operating Policies and Principles*
08.20/2012 – June 22, 2012	An update to adopt the new licence format that had previously been issued for Pickering A
08.21/2012 – December 19, 2012	An update to include the revised financial guarantee
08.22/2012 – December 28, 2012	An update to include the revised Derived Release Limits
	An update to include the revised Minimum Shift Complement

Revisions to the licence conditions handbooks

Between January 2012 and April 2013, Pickering A's LCH was revised six times, and Pickering B's LCH was issued and revised three times. The more significant changes are shown in table 16.

These revisions were approved by the Director General, Directorate of Power Reactor Regulation.

Table 16: Changes to the LCHs for Pickering A and Pickering B

Section	Description of Change	Revision Type	LCH
3.1.1	Updated text to show current status of end-of-life commitments	Administrative	Pickering A
3.1.1, 3.12.2 3.16.2 (Pickering B) 3.16.3, 3.16.4 (Pickering A) A.1.2, A.1.3	Updated text on OPG's financial guarantee	Technical	Pickering A and B
3.1.1, 3.13.1, A.1.3	Updated the text on minimum shift complement	Technical	Pickering A and B
3.1.1, A.1.3	Updated the list of licence amendments	Technical	Pickering A and B
3.1.1, A.1.3	Added PROL amendment requests	Administrative	Pickering A

Section	Description of Change	Revision Type	LCH
3.2.2	Updated the text on Responsible Health Physicists	Technical	Pickering A and B
3.3.1	Updated the text on action item AI 2009OPG-02	Administrative	Pickering A
3.3.2, A.1.3	Updated the text on minimum shift complement	Technical	Pickering A and B
3.3.3	Updated the text on control room staffing	Technical	Pickering A
3.3.4, A.1.3	Updated the documents listed on training	Technical	Pickering A and B
3.3.5	Updated the text on requalification testing	Technical	Pickering A and B
3.4.5, A.1.3	Add reference to OP&Ps	Administrative	Pickering A
3.5.2	Extend the completion date for certain Pickering A PSA from Dec. 31, 2013 to Dec. 31, 2014	Technical	Pickering A
3.6.1	Updated discussion regarding temporary changes	Administrative	Pickering A
3.7.2	Removed text on past outages	Administrative	Pickering A
3.7.3, A.1.3	Updated text on N287.7	Administrative	Pickering A
3.7.3, A.1.3, D.1	Updated the text on CSA N285.5-05	Administrative	Pickering A and B
3.7.3, A.1.3, D.2	Updated the text on CSA N285.4-05	Administrative	Pickering A
3.7.3	Updated the text on CSA N285.5-08	Technical	Pickering A and B
3.7.5	Updated the text on safety-related systems	Technical	Pickering A and B
3.10.1	Updated the text on fish mortality	Administrative	Pickering A and B
3.10.2, A.1.3	Updated the text on derived release limits	Technical	Pickering A and B
3.10.4, A.1.4	Updated the text on environmental action levels	Technical	Pickering A and B
3.10.4	Updated status on derived release limits	Administrative	Pickering A
3.11.1	Added text on RD/GD/99.3 [24]	Administrative	Pickering A and B
3.11.1	Updated text on sirens for outdoor alerting	Technical	Pickering A
3.11.1, A.2.2	Added a paragraph on public information programs	Administrative	Pickering A
3.12.1, D.2	Updated the text on waste diverted to the Lambton Landfill facility	Technical	Pickering A and B
3.13.1, A.1.3	Removed out-of-date footnotes	Administrative	Pickering A
3.14.1	Updated the text on RD-336 [21]	Technical	Pickering A and B
3.14.1	Updated text on safeguards	Technical	Pickering A
3.14.2	Updated the delegation of approval list to reflect the new CNSC organizational structure	Administrative	Pickering A
D.2	Added a letter accepting the use of the Canadian Electrical Association definition of "lost time injury" in place of the S-99 definition [1]	Technical	Pickering A and B
D.2	Added a letter clarifying requirements for reporting nuclear material inventory listing to the CNSC	Administrative	Pickering A and B
D.2	Updated the list of consents given by a person authorized by the Commission	Administrative	Pickering A and B

4.3.2 Updates on major projects and initiatives

Management of end of life

In 2010, OPG announced that it would not pursue refurbishment of the Pickering B units but would operate Pickering A and B until 2020. The key issues for ensuring the continued safe operation of Pickering A and B are:

- fitness for service of SSCs important to safety, including fuel channel lifecycle management, the potential continued use of the containment boundary if continued operation extends past 2020, and maintaining the reliability requirements of the SSCs to end of life
- maintaining the validity of the safety case to end of life, including the effects of aging on the safety case and the use of lessons learned from operating experience and evaluating the need and the timing for implementing corrective actions that require engineering changes
- sustaining effective organizational and administrative provisions, including the continued nurturing of a healthy safety culture, maintaining appropriate organizational structure, assessing continued personnel effectiveness, and the committed adherence to the ALARA principle for radiation protection of persons and the environment
- inclusion of results of improvement projects, including activities resulting from lessons learned from events such as the Fukushima Daiichi accident, environmental effects such as thermal plume, fish impingement and entrainment, and activities resulting from continued upgrades of processes or programs such as emergency preparedness and severe accident management guidelines (SAMGs)

All actions from the *Pickering B Continued Operations Plan* and the *Pickering A and B Sustainable Operations Plan* have been consolidated into an “end-of-life consolidated actions log”. This consolidated actions log will be a “living document”, subject to a monitoring and change control process and executed by OPG through its operation programs. The current COP includes 87 actions, all of which OPG plans to complete by December 2015.

OPG has committed to develop the following:

- by 2015, a stabilization activity plan for beyond-commercial operation from 2020 to 2023
- by 2019, a storage and surveillance plan to cover the period from 2023 to 2050
- by 2045, a dismantling and disposal plan to cover the period from 2050 to 2060
- by 2055, a restoration plan to cover the period from 2060 to 2065

To date, CNSC staff are satisfied with the safety and control measures in place and are confident that the end of life for Pickering will be done safely.

Fuel channel life management project

In 2009, Bruce Power, OPG and AECL jointly initiated a comprehensive R&D project to investigate the feasibility of operating the pressure tubes beyond their current permitted life. OPG seeks to ensure operational flexibility for its Darlington units – through compiling critical data on aging-related issues that might otherwise limit the life of their fuel channels. During the reporting period, 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 deuterium in the pressure tube and the effect on material properties such as fracture toughness with increasing hours of operation

CNSC staff continued to review documentation submitted by the licensee addressing these high-priority areas in accordance with a protocol that provides governing roles and responsibilities between the licensees and CNSC staff.

Days-based maintenance

OPG has initiated "days-based maintenance" at all three sites (Darlington, Pickering A and Pickering B) to remove non-essential maintenance personnel and activities from a shift configuration. Sufficient maintenance staff will remain on shift to address emerging operational issues and emergency response.

Validations were performed by OPG, analyzed in an independent review by AMEC-NSS Ltd. and observed by CNSC staff in advance of requests to amend the current minimum shift complement at Pickering A and B. In April 2012, the volunteer emergency response team was replaced by additional emergency response team members and nuclear security officers in an escorting capacity. In June 2012, CNSC staff observed validation of maintenance staff and the Emergency Response Organization (ERO). CNSC staff reviewed the analysis and validation reports for the ERO and maintenance portions of the minimum shift complement. A revised minimum shift complement was approved by the Commission through a licence amendment in December 2012.

Amalgamation of Pickering A and B

In March 2011, OPG informed the CNSC of an amalgamation initiative with the objective of amalgamating the site organization under one senior leadership team reporting to a single senior vice-president. Plans were submitted to the CNSC showing the implementation of the change in phases over the course of the licensing period. Discussions were held between OPG and the CNSC to keep the CNSC apprised of the status of the transition. CNSC remains engaged with OPG to review plans and track progress.

CNSC expects that this amalgamation will have no negative effect on the safety performance of Pickering A and B.

Pickering A and B are amalgamating the site organization. Also, under a new combined licence, they will be referred to as Pickering 1, 4 and 5-8.

4.3.3 Updates on significant regulatory issues

Alpha monitoring program

Pickering A and B finalized the implementation of the enhancements to alpha monitoring and control in 2012. CNSC staff are satisfied with the enhancements implemented by OPG. CNSC staff continue to verify effective implementation of these program enhancements through the baseline compliance plan.

Fish mortality due to impingement and entrainment

In the 2008 NPP Report, fish mortality due to impingement and entrainment was raised as a major issue. OPG was required to reduce annual impingement mortality by 80% by 2012. OPG installs a barrier net in front of the water intake each year from spring to fall, inclusive.

Test results from the first year, 2010, were reported in July 2011. Performance was close to the annual target of 80%, but was not clearly above it because of episodes in which the net was not properly held in place. These episodes were due to algae influx and unusually strong lake currents. Design improvements to the barrier net were implemented by July 2011. Test results from 2011 show the improvements were effective.

Northern pike, a species of concern, became impinged on intake screens primarily during the winter. OPG has funded the restoration of northern pike spawning habitat in the nearby Duffins Creek Marsh.

Viewing the fish nets (outlined by the line of yellow floats) at the Pickering site (photo courtesy of the *Ajax/Pickering News Advertiser*).

The use of technology to reduce entrainment mortality is not reasonably practicable due to site constraints, long installation timelines and high costs of the few proven options relative to the short period of remaining operating life. This approach is consistent with a recent US Environmental Protection Agency mitigation technology review. OPG's habitat restoration will offset the remaining entrainment mortality.

Fish mortality due to thermal plume

In the 2008 NPP Report, fish mortality due to the effects of the thermal plume on round whitefish spawning was raised as a major issue. OPG has undertaken studies to assess the effects of the thermal plume on round whitefish spawning. The studies concluded that the thermal plume from Pickering B presents a potential but small risk to round whitefish.

In early 2012, OPG completed a review of 14 potential mitigation options. There were no direct mitigation measures that were cost-effective and feasible given the existing facility design, the high costs and short period of remaining operating life.

As an indirect measure, OPG has stopped collecting round whitefish from Lake Ontario as part of the OPG radiological environmental monitoring program. CNSC staff have proposed a fish tagging and/or marking program to investigate if the round whitefish spawning at Pickering involves an isolated population or if there is a linkage to other existing north shore populations. If such a linkage exists, the level of risk would be lowered because a smaller population fraction is exposed at Pickering. Fish of the same genetic stock would be able to migrate from less-affected areas to reverse any local losses that may have occurred during operations.

Response to the Fukushima Daiichi accident

In response to the *CNSC Action Plan* [29], 36 Fukushima action items (FAIs) were derived and are described in appendix F. OPG continues to address and finalize the implementation of these FAIs by the deadline of December 2015.

Of the 36 FAIs, 32 applied to Pickering A and 35 applied to Pickering B. By the end of 2012, all short-term FAIs were closed for both Pickering A and B. Significant progress has been made in key areas related to:

- ***Enhancing emergency response:*** All related short-term FAIs were accepted by CNSC staff and were subsequently closed. These FAIs were identified by the CNSC Task Force to further improve emergency response through streamlining emergency preparedness between onsite and offsite authorities, and strengthening interaction with provincial and federal emergency planning authorities. See appendix F, FAIs 4.1.1 to 5.3.1.
- ***Procurement and deployment of emergency mitigating equipment onsite:*** Work included the development of instructions and training, completion of storage buildings, and deployment of field runs. The equipment includes portable pumps, portable generators, hoses and connections, and personnel communication equipment stored onsite, as well as additional equipment and resources stored offsite. A station emergency drill for Pickering A and B was completed in February 2013, with deployment of emergency mitigation equipment, and a report on the drill was issued to validate instructions and timing. See appendix F, FAI 1.11.1.
- ***Hydrogen recombiners***: The installation of recombiners for hydrogen mitigation is either completed, or continuing according to the accelerated schedule. Installation is in progress during unit outages. See appendix F, FAI 1.4.1.
- ***Severe accident management guidelines (SAMGs)***: OPG has implemented SAMGs such as completion of tabletop exercises and training of emergency response organizations and technical support roles. See appendix F, FAIs 3.1.1 to 3.1.4.

4.3.4 Event initial reports

Four EIRs were submitted for Pickering A and B from January 2012 to April 2013, as shown in table 17. The EIR events had low safety significance.

Table 17: Event initial reports for Pickering A and Pickering B

Subject	Brief Description
Release of oil into Lake Ontario	On August 16 and 17, 2012, a release of up to 150 litres of oil into Lake Ontario occurred from the Pickering site. This minor release occurred overnight from equipment that is part of the non-nuclear systems. The source of the release has been identified and closed. This minor release resulted in no environmental impact and there was no radiological release to the environment. This event was reported to the Commission through CMD 12-M50 on Sept. 12, 2012. CMD 12-M50 completed CNSC staff notification to the Commission on this event.
Spill of heavy water within Pickering A	On October 11, 2012, Pickering A Unit 1 had a spill of approximately 400 litres of heavy water. The spill was entirely contained within the station and there was no release to the environment or harm to any employee. The source of the spill has been identified as a moderator collection drum that was overwhelmed. OPG notified CNSC and the appropriate provincial agencies. This event was reported to the Commission through CMD 12-M54 on October 24, 2-12. CMD 12-M54 completed CNSC staff notification to the Commission on this event.
Steam leak in Pickering B turbine hall	On December 17, 2012, a steam leak developed in the turbine hall. Unit 7 was shut down to repair the leak and returned to service on December 19, 2012. 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.
Fire in Pickering A 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.

4.4 Gentilly-2

4.4.1 Licensing

The licence for Gentilly-2 was renewed in June 2011 for a five-year period (effective to 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

The Gentilly-2 licence was amended once between January 2012 and April 2013. Table 18 shows details of this amendment.

Table 18: Amendments to Gentilly-2 power reactor operating licence

Power reactor operating licence # - Effective date	Amendment requests
10.01/2016 – February 7, 2012	Updated two values in the derived release limits

Note: This table was previously reported in the 2011 NPP Report as the amendment was made on February 7, 2012 (within the reporting periods for both the 2011 NPP Report and the 2012 NPP Report).

Revisions to the licence conditions handbook

Between January 2012 and April 2013, the Gentilly-2 LCH was revised once. The more significant changes are show in table 19. This revision was approved by the Director General, Directorate of Power Reactor Regulation.

Table 19: Changes to licence conditions handbook for Gentilly-2

Section	Description of Change	Revision Type
3.1.3, 3.6.2, 3.11.2, Appendix A.3	Change made to the revision number of MG-22-08 (rev. 1.2)	Administrative
3.3.6, Appendix A.3	Change made to the revision number of the certification examination management manuals GEA-1 and GEA-2 (rev. 1.1)	Administrative
3.4.2, 3.12.2, Appendix A.1	French titles of CSA standards N290.15 and N294 inserted	Administrative
3.5.1, Appendix A.3	CSA change made to the Safety Report revision number (rev. 2011)	Administrative
3.6.5	CSA standard N285.0, revision 1995 added	Administrative
3.7.3	Change made to the implementation date of CSA standards N285.4-2005 and N285.5-2008 (March 31, 2012)	Administrative
Appendix F	Change made to table H15 in appendix F	Administrative
Appendix G	Appendix G: Regulatory Plan was deleted	Administrative
Appendix A.1	CSA standard N292.3 added to appendix A.1	Administrative
3.4.2; 3.4.5, Appendix A.3	Change made to the revision number of the OP&Ps (rev. 7)	Administrative
3.11.1	A paragraph on the public information program was added to the compliance verification criteria	Administrative
All	Grammatical and spelling corrections	Administrative
Flyleaf heading	Change made to the operating licence number	Administrative

Note: This table was previously reported in the 2011 NPP Report as the changes were made on February 8, 2012 (within the reporting periods for both the 2011 NPP Report and the 2012 NPP Report).

4.4.2 Updates on major projects and initiatives

On October 3, 2012, Hydro-Québec announced its intention not to proceed with the refurbishment of the Gentilly-2 facility. In accordance with the licensing conditions, Gentilly-2 operated until December 28, 2012 and was then put in a guaranteed safe shutdown state. Defueling of the reactor core started early in 2013 and is expected to be completed by mid-2013. After the fuel is removed from the core and stored in the irradiated fuel bay, the facility will be put in a safe storage state for a period of about 50 years.

4.4.3 Updates on significant regulatory issues

Alpha monitoring program

The enhancements to Gentilly-2's radiation protection program related to alpha monitoring and control were not fully implemented during 2012. However, interim measures were in place to protect the health and safety of workers. An inspection identified a number of areas for improvement, particularly in the areas of characterization, workplace surveillance and work planning. Hydro-Québec developed a corrective action plan to address the deficiencies. CNSC staff will monitor the implementation of the corrective action plan.

Transition to safe storage and future decommissioning

The Gentilly-2 licence and LCH are currently under review to update them for transition to safe storage and future decommissioning of the site.

Response to the Fukushima Daiichi accident

In response to the *CNSC Action Plan* [29], 36 Fukushima action items (FAIs) were derived and are described in appendix F. Hydro-Québec continues to address and finalize the implementation of these FAIs by the deadline of December 2015.

Of the 36 FAIs, 33 applied to Gentilly-2. By the end of 2012, most of the FAIs were suspended due to the decision to end commercial operation, with the exception of the FAIs related to improving mitigation measures for the irradiated fuel bays (IFBs) and enhancing emergency response. In particular, activities and reviews completed to date or ongoing in response to the Fukushima events are as follows:

- Evaluation of thermal structural integrity of the IFBs at temperature in excess of the design. See appendix F, FAI 1.6.1 and 1.6.2.
- Provisions of water make-up to the IFBs in case of a loss of coolant inventory. See appendix F, FAI 1.7.1.
- Habitability of control facilities, limited to IFB instrumentation and control for measurements of critical parameters (such as water level and temperature). See appendix F, FAI 1.9.1.
- Expanding severe accident management guidelines (SAMGs) to include IFB events. See appendix F, FAI 3.1.3.
- Evaluation and updating of the existing emergency plans and programs following the decision to end commercial operation at Gentilly-2. See appendix F, FAIs 4.1.1, 4.1.2, 4.2.1 and 5.2.1.

In April 2013, Hydro-Québec submitted a Fukushima progress update delineating measures and plans taken to address the FAIs listed above. In that submission, Hydro-Québec indicated that plans are in place to refurbish the IFBs and revise the emergency plans and programs for end of commercial operation, as needed. CNSC staff are reviewing the submission.

4.4.4 Event initial reports

One EIR was submitted for Gentilly-2 from January 2012 to April 2013, as shown in table 20. The EIR event had low safety significance.

Table 20: Event initial reports for Gentilly-2

Subject	Brief Description
Heavy water leak in the reactor building *	On the morning of April 26, 2012, work was under way to change a plug in a fuelling machine. The level of atmospheric tritium measured in the reactor building increased. An area alert was declared, emergency procedure PU-100 was implemented and the reactor building was evacuated. Two operators stopped the leak and evacuated. A team was sent into the reactor building and recovered the heavy water spilled on the floor (10 L) and in a vent line (60 L). The end of the alert was declared at noon. The two operators involved in stopping the leak were exposed to low tritium doses (0.02 and 0.03 mSv) during this event. The release of tritium was estimated to be 1.85×10^{12} Bq, approximately 0.11 percent of the derived release limit. This tritium release was well below regulatory limits. This event was reported to the Commission through CMD 12-M29 on May 3, 2012. CMD 12-M29 completed CNSC staff notification to the Commission on this event.

* This event was previously reported in the 2011 NPP Report.

4.5 Point Lepreau

4.5.1 Licensing

The Point Lepreau licence was renewed in February 2012 for a five-year period (effective until June 30, 2017).

Licence amendments

The Point Lepreau licence was amended once between January 2012 and April 2013. Table 21 shows details of this amendment.

Table 21: Amendments to Point Lepreau power reactor operating licence

Power reactor operating licence # - Effective date	Amendment requests
17.01/2017 – December 20, 2012	Replacement of the Derived Release Limits (DRL) listed in appendix A.3 of PROL 17.00/2017, which was based on the 1998 version of CSA N288.1, with the DRLs based on the 2008 version
	Removal of J.L. Shepherd 142-10 calibrator (Item 11) and RMD Instruments LLC LPA-1 lead paint analyzer (Item 20) from the PROL 17.00/2017. These two items are not in use at Point Lepreau

Revisions to the licence conditions handbook

Point Lepreau's LCH was issued on February 20, 2012. No revisions were made to the Point Lepreau LCH during the reporting period.

4.5.2 Updates on major projects and initiatives

Refurbishment project

NB Power started the reactor refurbishment in 2008. The original deadline for return to full power was 2009, but due to various technical issues the project was extended by several years. Final refurbishment activities, fuel loading, reactor commissioning, restart and return to full commercial operation were completed in 2012.

Throughout the process of restarting, various regulatory hold points were in place. Hold points were removed contingent on NB Power providing confirmation that all related project commitments had been met. CNSC staff reviewed each hold point through desktop reviews and onsite inspections to verify that NB Power was in compliance with the NSCA, regulations, conditions of the licence and the LCH, and in accordance with the licensing basis.

In November 2012, Point Lepreau commenced commercial operation. CNSC staff returned to routine regulatory oversight of operational activities.

Seismic qualification

In their decision for renewing the Point Lepreau licence, the Commission required that NB Power complete a site-specific seismic hazard assessment and share the results through its public information program. NB Power submitted an assessment plan as part of its response to the *CNSC Action Plan* [29].

The site-specific seismic hazard assessment is ongoing. NB Power submitted preliminary results to the CNSC at the end of 2012. These preliminary results are being reviewed by CNSC and Natural Resources Canada staff. A summary version was posted by NB Power on its Web site. The final assessment is expected to be completed by mid-2014.

Environmental monitoring

NB Power continued to maintain and implement an effective environmental risk assessment and program for the protection of fish in accordance with CNSC requirements. In early 2013, NB Power submitted its gap analysis for N288.4, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* [8]. CNSC staff are reviewing the submission.

NB Power has committed to update its environmental risk assessment by December 31, 2013, including a review of the operation and effectiveness of the cooling water intake system. As well, NB Power will conduct fish monitoring activities at Point Lepreau during the summer of 2013 and will submit the information to CNSC staff by October 31, 2013.

CNSC staff will provide an update on fish monitoring at Point Lepreau to the Commission at the public meeting in August 2013.

4.5.3 Updates on significant regulatory issues

Alpha monitoring program

NB Power informed the CNSC that implementation of the radiation protection program enhancements in the area of alpha monitoring and control was completed by December 2012. CNSC has added the monitoring and control of alpha hazards to its baseline compliance program, with the first inspection in this area at NB Power scheduled for March 2013.

Emergency exercises and drills

NB Power completed its emergency exercise “Intrepid” in March 2012. The exercise included offsite activation of the provincial emergency centre and a limited activation of the CNSC emergency operations centre. CNSC staff observed the exercise to verify that the licensee had an effective emergency response organization and that they maintained appropriate coordination, liaison and assistance to the Province of New Brunswick and its emergency management operations.

Overall, NB Power demonstrated its ability to respond to a nuclear emergency. Some minor issues were identified. NB Power committed to resolve all outstanding issues through its emergency preparedness sustainment and improvement plan.

Transient materials

In June 2012, NB Power put controls in place to restrict and control transient materials in nuclear safety-significant areas. This work was done as a compensatory measure to address the issue that a fire-safe shutdown analysis had not yet been fully completed. In November 2012, transient material controls were extended to other areas of the station.

Inspections conducted by CNSC staff in January and February 2013 identified that improvements were required in the implementation of the transient material control process. NB Power has prepared and is implementing a corrective action plan to address the identified deficiencies. Many of the actions have been completed.

CNSC staff held a follow-up inspection that identified that improvements had been made. CNSC staff will continue to track NB Power's progress in addressing deficiencies in this area and will provide an update to the Commission in August 2013.

Response to the Fukushima Daiichi accident

In response to the *CNSC Action Plan* [29], 36 Fukushima action items (FAIs) were derived and are described in appendix F. NB Power continues to address and finalize the implementation of these FAIs by the deadline of December 2015.

Of the 36 FAIs, 21 applied to Point Lepreau. By the end of 2012, all short-term FAIs were closed or were being reviewed for closure by CNSC staff.

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 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:

- ***Enhancing emergency response:*** Enhancements were centered on the evaluation of existing emergency plans and programs, equipment, and results from the full-scale emergency exercise in March 2012. Identified improvements were incorporated into the emergency plan. In collaboration with the New Brunswick Emergency Measures Organization, NB Power developed and issued a five-year exercise program for offsite response. See appendix F, FAIs 4.1.1 to 5.4.1.
- ***Procurement and deployment of emergency mitigating equipment:*** Plans are underway, and detailed engineering is in progress for design changes related to the emergency mitigation equipment. See appendix F, FAI 1.11.1.
- ***Design upgrades:*** NB Power has provided a plan and schedule for the evaluation of alternate coolant make-up to the reactor. Design upgrades include the installation of additional connections to the primary heat transport system, steam generators, and moderator system. The detailed engineering work is in progress, with installation expected during the next planned outage in Spring 2014. See appendix F, FAIs 1.2.3 and 1.7.1.

4.5.4 Event initial reports

One EIR was submitted for Point Lepreau from January 2012 to April 2013, as shown in table 22. The EIR event had low safety significance.

Table 22: Event initial reports for Point Lepreau

Subject	Brief Description
Heavy water spill during heat transport system pressure test	On May 21, 2012, during the activities leading up to performing the hydrostatic pressure test of the primary heat transport system (HTS), one or more of the relief valves on the temporary pressurizing test equipment unexpectedly opened. The primary HTS was approaching the test pressure when the operator adjusted the pressure regulating valve to increase the pressurization rate. The adjustment appears to have led to an unexpected pressure increase, leading to a pressure safety valve lifting. This resulted in approximately 300 litres of heavy water overflowing from the collection system set up for the pressure test. The test was terminated and the heavy water was completely contained, cleaned up and recovered for reuse. There was no requirement to evacuate the reactor building as the spill occurred in a room within the reactor building that was designed to contain and control heavy water and water vapour. NB Power staff involved in this test had the appropriate radiation protection training and were wearing the required protective equipment. Hydrostatic pressure testing of the primary heat transport system was put on hold temporarily until the cause of the event was understood, corrective actions implemented, and the pressurizing test equipment confirmed fit for service. NB Power implemented corrective actions and continued with the test May 31, 2012. CNSC staff inspected the procedure and equipment and monitored the response taken by NB Power as a result of this event. This event was reported to the Commission through CMD 12-M36 on June 21, 2012. CMD 12-M36 completed CNSC staff notification to the Commission on this event.

5. Summary and Conclusions

As part of the assessment of the safety performance of NPP licensees and of the nuclear power industry as a whole, CNSC staff evaluate how well licensees are meeting regulatory requirements and CNSC expectations for the 14 safety and control areas (SCAs) of the regulatory framework. The assessment also reviews generic issues, identifies industry trends and compares Canadian NPP safety performance indicators with those of international NPP operators and other industries.

CNSC staff concluded that the nuclear power industry operated safely in 2012. The review of each licensee's safety performance in the 14 SCAs confirms that the licensees made adequate provisions to protect the health, safety and security of Canadians and the environment from the use of nuclear energy, as well as to ensure that Canada continues to meet its international obligations on the peaceful use of nuclear energy. Licensees complied with the requirements to report events requiring regulatory oversight. Licensees also conducted follow-ups, including root cause analysis, as necessary.

These conclusions are based on the following observations:

- there were no serious process failures at the NPPs
- no member of the public received a radiation dose that exceeded the regulatory 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 was minimal
- no radiological releases from the stations exceeded the regulatory limits
- licensees complied with their licence conditions concerning Canada's international obligations

Furthermore, throughout 2012, licensees progressed towards meeting the December 2013 deadline of ensuring their public information and disclosure programs are updated in accordance with RD/GD-99.3, *Public Information and Disclosure* [24], which was published by the CNSC in 2012. The improved public information and disclosure programs of the licensees ensure that important information is shared with stakeholders in a timely manner.

Table 23 summarizes the 2010–12 ratings for Canada's NPPs. For each station, the SCAs are presented, along with the industry averages and the integrated plant ratings (IPRs) which measure a plant's overall safety performance. Overall, the trend is one of remaining the same or improving. Specifically, in 2012:

- the IPRs were "fully satisfactory" (FS) for Darlington and "satisfactory" (SA) for all other stations
- a total of nine SCAs for the sites were rated as 'fully satisfactory" – the highest number since the SCA framework was introduced in 2010
- in the conventional health and safety SCA, the Canadian nuclear power industry achieved an average rating of "fully satisfactory" – four of the seven stations received ratings of "fully satisfactory" for this SCA
- no SCA received a rating of "below expectations" (BE) or "unacceptable" (UA), a repeat of the final results for 2011

Table 23: **Trends of ratings from 2010 to 2012**

Safety and control area	Year	Bruce		Darlington	Pickering		Gentilly-2	Point Lepreau	Industry average
		A	B		A	B			
Management system	2010	SA	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Human performance management	2010	SA	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Operating performance	2010	SA	SA	FS	SA	SA	SA	SA	SA
	2011	SA	SA	FS	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***FS***	***SA***	***SA***	***SA***	***SA***	***SA***
Safety analysis	2010	SA	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Physical design	2010	SA	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Fitness for service	2010	SA	SA	FS	SA	SA	SA	SA	SA
	2011	SA	SA	FS	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***FS***	***SA***	***SA***	***SA***	***SA***	***SA***
Radiation protection	2010	BE	SA	FS	SA	SA	SA	SA	SA
	2011	SA	SA	FS	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***FS***	***SA***	***SA***	***SA***	***SA***	***SA***
Conventional health and safety	2010	SA	SA	FS	SA	SA	SA	SA	SA
	2011	FS	FS	FS	SA	SA	SA	SA	SA
	2012	***FS***	***FS***	***FS***	***SA***	***SA***	***SA***	***FS***	***FS***
Environmental protection	2010	SA	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Emergency management and fire protection	2010	SA	SA	SA	SA	SA	SA	BE	SA
	2011	SA	SA	SA	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Waste management	2010	SA	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Security	2010	FS	FS	SA	SA	SA	SA	SA	SA
	2011	FS	FS	SA	SA	SA	SA	SA	SA
	2012	***FS***	***FS***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Safeguards and non-proliferation	2010	SA	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Packaging and transport	2010	SA	SA	SA	SA	SA	SA	SA	SA
	2011	SA	SA	SA	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***	***SA***
Integrated plant rating	2010	SA	SA	FS	SA	SA	SA	SA	SA
	2011	SA	SA	FS	SA	SA	SA	SA	SA
	2012	***SA***	***SA***	***FS***	***SA***	***SA***	***SA***	***SA***	***SA***

Furthermore, as shown in table 23, in 2012, within the industry:

- Darlington received four "fully satisfactory" ratings (in operating performance, fitness for service, radiation protection, and conventional health and safety)
- Bruce A and B each received two "fully satisfactory" safety performance ratings (in conventional health and safety, and security)
- Point Lepreau received a "fully satisfactory" safety performance in conventional health and safety
- the "fully satisfactory" ratings for Darlington, and for Bruce A and B, were unchanged from 2011 while the "fully satisfactory" rating in conventional health and safety for Point Lepreau was an improvement from 2011

Licensees continued to implement enhancements in the areas of plant management, facilities and equipment and core control processes through addressing action items that were raised following the Fukushima Daiichi accident. The progress made in 2012 by the NPP licensees is satisfactory with all 18 short-term FAIs closed or being reviewed for closure by CNSC staff. This status is consistent with the deadlines established in the *CNSC Action Plan* with the exception of Gentilly-2, where the majority of the short-term FAIs were suspended due to the end of commercial operation. The licensees' work on the medium- and long-term FAIs is progressing well towards the overall deadline of December 2015.

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 66 specific areas that define the key components of the SCA. In late 2012, CNSC staff reviewed the specific areas and introduced revisions. Due to the revisions being introduced late in the preparation period for the report, CNSC staff are using a transition set of specific areas in the 2012 NPP Report. The revised specific area list will be introduced in the 2013 NPP Report.

The functional areas, SCAs and the transition set of specific areas that are used in the CNSC's safety performance evaluation for 2012 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
		Management performance
		Safety culture
		Configuration management
		Business continuity
	Human performance management	Human performance program
		Personnel training
		Personnel certification
		Initial certification examinations and requalification tests
		Work organization and job design
		Procedures and job aids
		Fitness for duty
	Operating performance	Conduct of licensed activity
		Procedures
		Operating experience
		Reporting and trending
		Outage management performance
		Safe operating envelope
		Accident management and recovery
		Severe 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)

Functional area	Safety and control area (SCA)	Specific area
	Physical design	Component design
		Equipment qualification
		System design and classification
		Human factors in design
		Robustness design
		Engineering change control
		Site characterization
	Fitness for service	Equipment fitness for service / equipment performance
		Maintenance
		Structures, systems and components (SSCs) monitoring
		Reliability of systems important to safety
		Structural integrity
		Aging management / lifecycle management
		Periodic inspection and testing
		In-service inspections for balance-of-plant
Core control processes	Radiation protection	Application of ALARA
		Worker dose control
		Personnel dosimetry
		Contamination control
		Estimated dose to public
	Conventional health and safety	Compliance with labour code
		Housekeeping / management of hazards
		Accident severity and frequency
	Environmental protection	Effluent and emissions control (releases)
		Environmental management system (EMS)
		Environmental monitoring
	Emergency management and fire protection	Conventional emergency preparedness and response
		Nuclear emergency preparedness and response
		Fire emergency preparedness and response
	Waste management	Waste minimization, segregation and characterization
		Waste storage and processing
		Decommissioning plans
	Security	Facilities and equipment
		Access control
		Training, exercises and drills
		Nuclear response force
	Safeguards and non-proliferation	Safeguards and non-proliferation
	Packaging and transport	Packaging and transport

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.

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, given new information arising over time and taking changes in the external environment into account.

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.

Robustness design covers the physical design of nuclear facilities for sufficient robustness against anticipated threats, such as protection against a malevolent aircraft crash. The assessment and ratings for this specific area are based on the licensee's performance in meeting the commitments provided to CNSC staff through an exchange of correspondence, including the submission of detailed aircraft impact assessments. Licensees must demonstrate, 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.

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 reliability of systems important to safety, licensees are expected to maintain reliability programs based on the requirements given by S-98, *Reliability Programs for Nuclear Power Plants* [13] to ensure that systems important to safety can and will meet their defined design and performance specifications at acceptable levels of reliability, throughout the life of the facility.

In the specific area of aging management / lifecycle 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 contamination and radiation doses received are monitored and controlled.

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 as low as reasonably achievable (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 NPP sites 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 safe packaging and transport of nuclear substances and radiation devices 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* [23].

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 determination of the integrated plant rating (IPR) begins with an assessment of the specific areas and determination of the rating for each one.

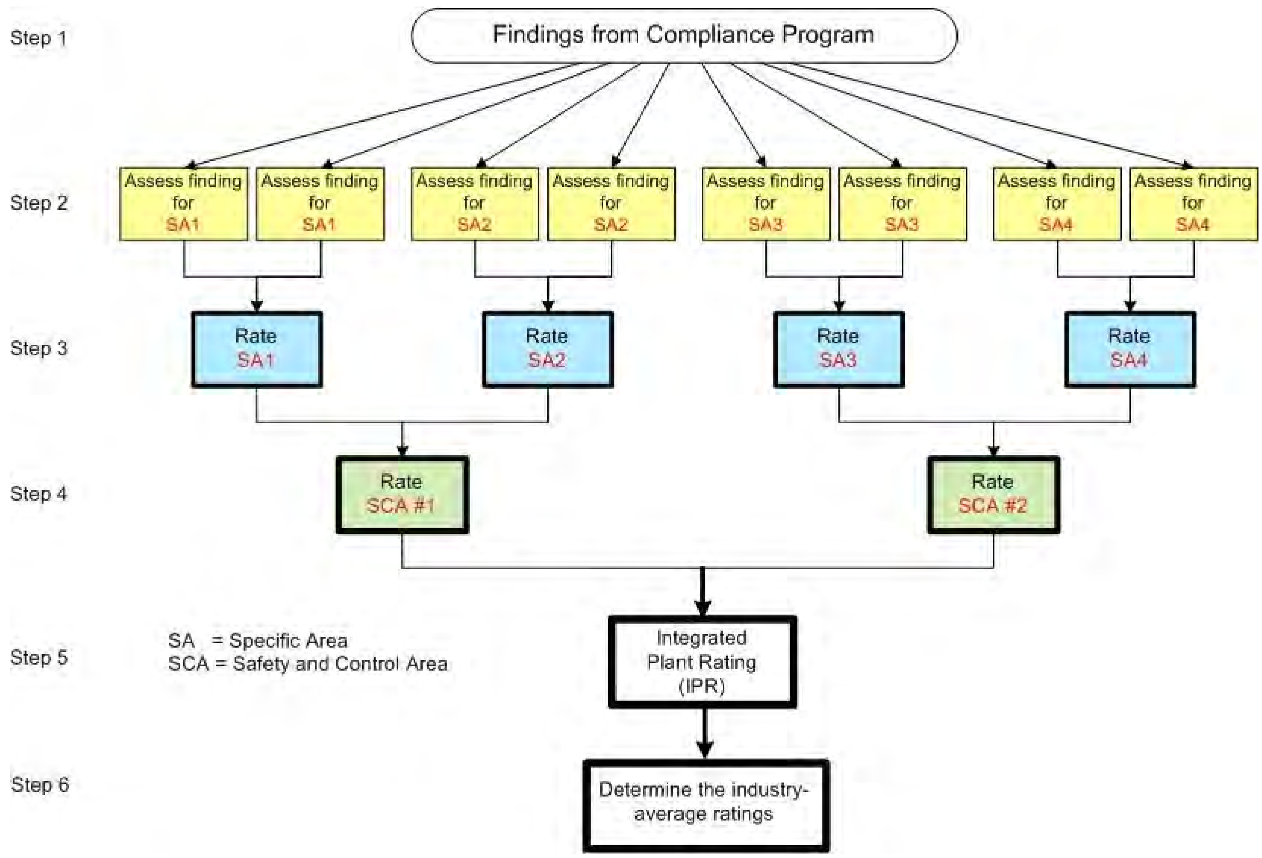
Specific area ratings for each of the stations are based on considerations of individual findings from inspections, event reports and desktop reviews. The rating activity produces performance ratings for each of the specific areas in the 14 SCAs, as given in appendix A.

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 seven 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 station. 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, event reviews 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: Determination of 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: Determination of the industry-average ratings
In addition, the industry-average ratings are determined by averaging the individual SCA and IPR ratings for all seven 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.

The complete results for 2012 are shown in table 1 (in the Executive Summary), and the three-year trend is shown in table 23 (in section 5, 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 four Canadian utilities (Bruce Power, OPG, Hydro-Québec and NB Power), by the Romanian Societatea Nationala NuclearElectrica, and by Atomic Energy of Canada Limited. As specified in COG-10-9205, *Safety and Licensing R&D Program 2010/2011 Operational Plan* [32], 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 various submissions from the industry on the work plans, analysis methodology and results for these ongoing safety analysis programs or topics.

C.2 CNSC R&D activities

Generic action items

All generic action items (GAIs) were closed in 2012.

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.

As shown in table C.1, in 2012 one CSI was recategorized 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 this safety issue. By the end of 2012, 12 CSIs requiring further experimental and/or analytical studies were pending resolution, as shown in tables C.2 and C.3. Four of these are related to large loss of coolant accidents (LLOCAs), while the remaining eight belong to the group of non-LLOCA issues.

For the non-LLOCA issues (table C.3), all CSIs except the fuel bundle / element behaviour under post dry-out conditions (PF 18) have been either recategorized (for specific sites) or information for recategorization is being assessed by CNSC staff. The resolution of most of these CSIs is expected by the end of 2013.

Table C.1: Details of the CANDU safety issue (CSI) recategorized for all licensees

CSI	Title	Brief description	Notes	Recategorization date
SS 5	Hydrogen control measures during accidents	Licensees have committed to installing passive autocatalytic recombiners (PARs) to improve hydrogen control during design-basis accidents.	PARs will be installed at all Canadian NPPs, to provide an additional line of defence to the existing hydrogen mitigation strategies. PARs are installed at Bruce A Units 1, 2 and 4, Darlington Unit 3, Pickering A Unit 4, Gentilly-2 and Point Lepreau. Licensees will provide the planned dates for PARs installation at the remaining units.	October 2012

Table C.2: Details of the LLOCA CANDU safety issues (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– including fuel and voiding transients, and its computer modeling– are subject to some uncertainties.	The CNSC has developed an interim regulatory position, in case that a study, analytical or plant operation finding, with an adverse impact on LLOCA safety margins, emerges during this period. The interim position 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.	December 2013
PF 9	Fuel behaviour in high temperature transients			
PF 10	Fuel behaviour in power pulse transients			
PF 12	Channel voiding during a LLOCA			

Table C.3: Details of the non-LLOCA CANDU safety issues (CSIs)

CSI	Title	Brief description	Notes	Target date
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, in the effectiveness of important safety-related functions.	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 fully systematically implemented.	December 2013
GL 3	Aging of equipment and structures			December 2013
PF 19	Impact of aging on safe plant operation			December 2013

CSI	Title	Brief description	Notes	Target date
PF 20	Analysis methodology for neutron/regional overpower	The neutron/regional overpower trip setpoint function is designed to provide the reactor trip for the 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.	Bruce Power and OPG completed their committed activities for resolution of the recommendations from the independent technical panel (ITP) and from the CNSC staff's previously-reviewed comments by the end of 2011. During 2012, CNSC staff continued their review of Bruce Power and OPG neutron overpower new methodology and benchmarking activities under a CNSC research project. CNSC staff presented their fourth progress review report to the Commission in August 2012.	December 2013
PSA 3	Design of the balance of plant – steam protection	This issue is applicable to the multi-unit stations. In these stations, 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. A high energy line break, such as a steam line break or feed water line break, 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 (HVAC); emergency forced air discharge system; air cooling units).	September 2014
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 (SSCs) and impair defence-in-depth. The issue is primarily related to the fact that there has not been a fully documented systematic review of the consequences of high energy line breaks.	The industry has to provide systematic analysis for protecting SSCs from the effects of postulated pipe rupture.	June 2014

CSI	Title	Brief description	Notes	Target date
AA 3	Computer code and plant model validation	NPP licensees have established specific validation programs for industry standard computer codes, to provide the necessary confidence in the safety analyses being performed.	Existing code validation work does not, in general, comply with the requirements that would allow a full qualification of these codes.	September 2013
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 2008 to 2012) of the annual collective effective 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 represent the doses received by the same group of workers.

For each NPP:

- The first figure provides collective effective doses received during routine operations (day-to-day) versus doses received during outages/refurbishment. The collective effective dose shown for routine operations and outages/refurbishment includes both external and internal doses.
- The second figure provides the collective effective 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 effective 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 2012, approximately 90 percent of the collective effective dose was due to outage activities, and most of the radiation dose received by the workers came from external exposure. Approximately 10 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 effective 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 effective doses at Bruce A and B

In 2012, Bruce A and B were adequate in controlling worker radiological exposures. The annual collective effective dose associated with refurbishment activities was lower than past years due to the types of radiological activities performed. The refurbishment activities at Bruce A Units 1 and 2 were completed in 2012, within the estimated project dose of 28.0 p-Sv (28,000 p-mSv). Unit 1 returned to service on September 19, 2012 and Unit 2 returned to service on October 16, 2012.

Figures D.1 and D.2 reflect the collective effective doses at Bruce A, Units 1 and 2. Unit 1 had one outage in November. The dose associated with this outage, 521 mSv, is included under the Refurbishment / Outages bar of figure D.1.

At Bruce A and Bruce B, variations in the collective effective dose from year to year are due primarily to the number and scope of outages. The collective effective doses at Bruce A, Units 3 and 4, shown in figures D.3 and D.4, remained above the industry average. The large collective dose is due to the large scope of work required for life extension and equipment lifecycle engineering plans at Units 3 and 4. Bruce B had one planned outage in 2012 that had a reduced outage scope in comparison with past years. As shown in figures D.5 and D.6, this resulted in Bruce B achieving the lowest collective effective dose when compared with the previous five years.

The 2012 annual effective doses distribution for workers and the average and maximum effective dose to workers are provided in section 2.7.

Figure D.1: Collective effective dose by operational state for Bruce A – Units 1 and 2

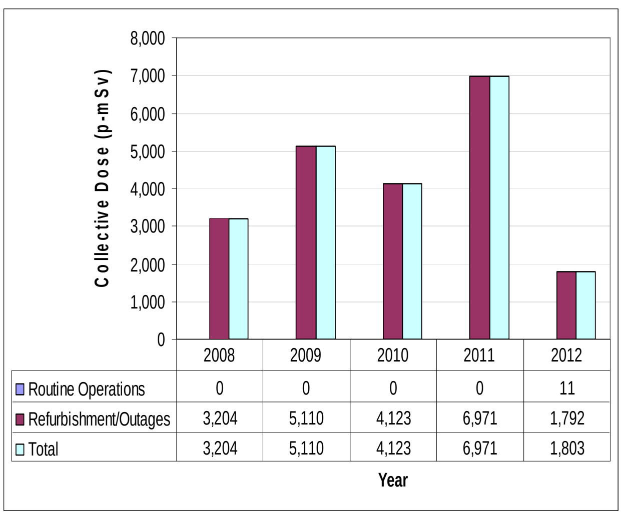


Figure D.2: Collective effective dose from internal and external exposures for Bruce A – Units 1 and 2

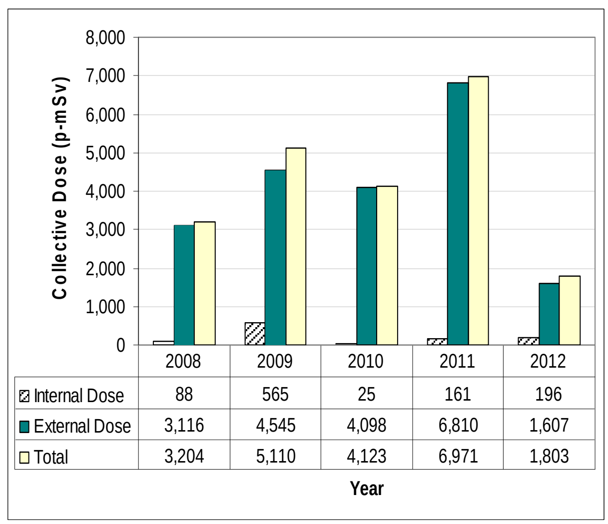
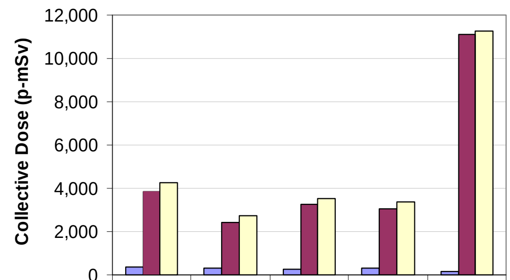


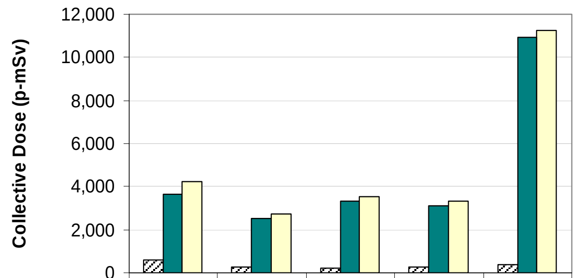
Figure D.3: **Collective effective dose by operational state for Bruce A – Units 3 and 4**



	2008	2009	2010	2011	2012
Routine Operations	387	341	265	310	150
Outages	3,853	2,402	3,277	3,038	11,124
Total	4,240	2,743	3,542	3,348	11,274

Year

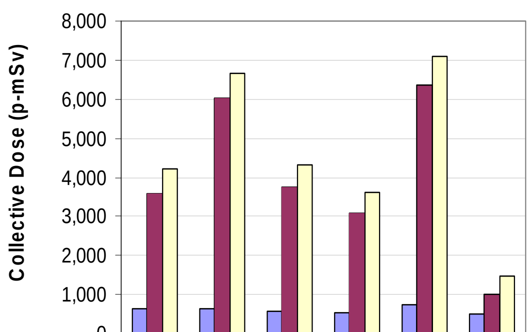
Figure D.4: **Collective effective dose from internal and external exposures for Bruce A – Units 3 and 4**



	2008	2009	2010	2011	2012
Internal Dose	578	244	194	245	367
External Dose	3,662	2,499	3,348	3,103	10,907
Total	4,240	2,743	3,542	3,348	11,274

Year

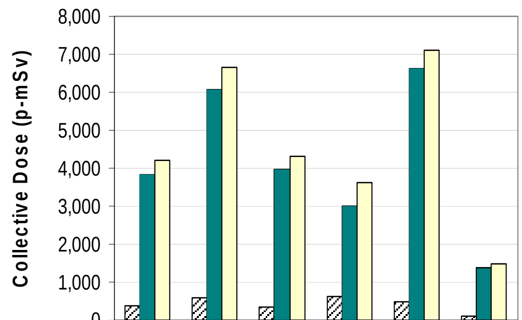
Figure D.5: **Collective effective dose by operational state for Bruce B – Units 5 to 8**



	2007	2008	2009	2010	2011	2012
Routine Operations	640	639	570	534	728	495
Outages	3,572	6,013	3,737	3,079	6,374	994
Total	4,212	6,652	4,307	3,613	7,102	1,489

Year

Figure D.6: **Collective effective dose from internal and external exposures for Bruce B – Units 5 to 8**



	2007	2008	2009	2010	2011	2012
Internal Dose	382	588	333	618	491	120
External Dose	3,830	6,064	3,974	2,995	6,611	1,369
Total	4,212	6,652	4,307	3,613	7,102	1,489

Year

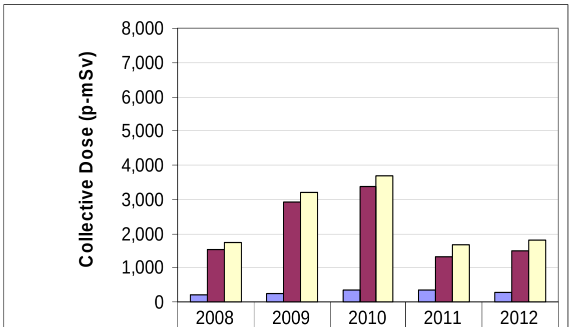
D.2 Annual collective effective doses at Darlington

In 2012, Darlington was effective in controlling worker radiological exposures. As shown in figures D.7 and D.8, OPG performed better than its year-end targets for total collective and external collective doses as a result of effective planning and execution during outages and high hazard work. In 2012, the internal collective dose was higher than 2011 due to higher-than-expected tritium levels experienced during the outage at Unit 3. Mitigation measures were put in place to manage the radiological hazard.

At Darlington, the variations in collective effective dose from year to year are due primarily to the number and scope of outages.

The 2012 annual effective doses distribution for workers and the average and maximum effective dose to workers are provided in section 2.7.

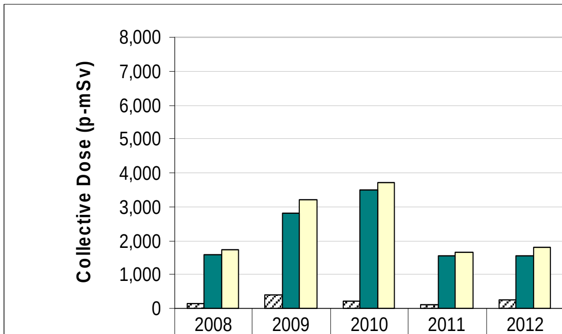
Figure D.7: Collective effective dose by operational state for Darlington – Units 1 and 4



	2008	2009	2010	2011	2012
Routine Operations	220	256	331	333	292
Outages	1,516	2,937	3,373	1,333	1,500
Total	1,736	3,193	3,704	1,666	1,792

Year

Figure D.8: Collective effective dose from internal and external exposures for Darlington – Units 1 and 4



	2008	2009	2010	2011	2012
Internal Dose	139	393	220	110	246
External Dose	1,597	2,800	3,484	1,556	1,546
Total	1,736	3,193	3,704	1,666	1,792

Year

D.3 Annual collective effective doses at Pickering A and B

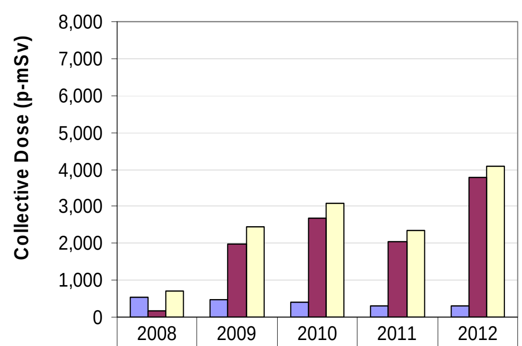
In 2012, Pickering A and B were effective in controlling worker radiological exposures. As shown in figures D.9, D.10, D.13 and D.14, the variations in collective effective dose from year to year were due primarily to the number and scope of outages. The increase in outage collective doses for Pickering A and B is mainly due to the extensive outage programs and modifications executed during planned outages (to improve operations and ensure safe and reliable performance to the end of commercial operation). Some forced outages also contributed to this trend. ALARA initiatives are being implemented to improve future radiation protection performance at Pickering to reduce collective dose.

The dose associated with the radiological activities performed at the units in safe storage is negligible when compared to collective dose of the operational units. Therefore, this dose is not reported separately but instead captured under Pickering A Units 1 and 4 (since 2011).

Figures D.11 and D.12 provide the 2008–2012 data on the collective doses received as a result of the transition to safe storage for Units 2 and 3.

The 2012 annual effective doses distribution for workers and the average and maximum effective dose to workers are provided in section 2.7.

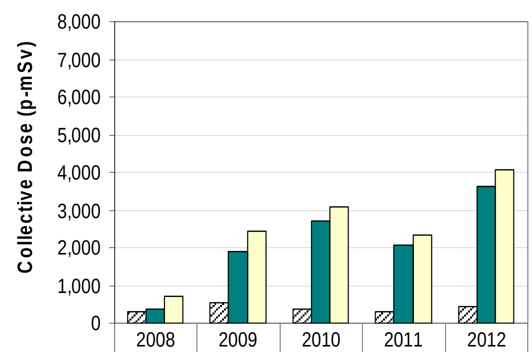
Figure D.9: **Collective effective dose by operational state for Pickering A – Units 1 and 4**



	2008	2009	2010	2011	2012
Routine Operations	536	473	386	295	286
Outages	166	1,970	2,688	2,053	3,784
Total	702	2,443	3,074	2,348	4,070

Year

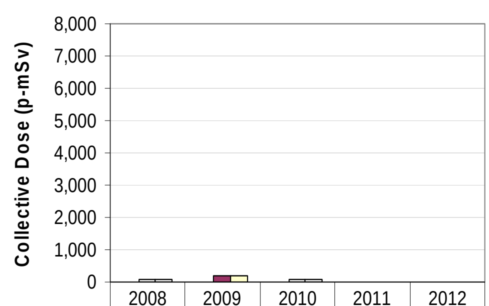
Figure D.10: **Collective effective dose from internal and external exposures for Pickering A – Units 1 and 4**



	2008	2009	2010	2011	2012
Internal Dose	316	551	367	297	432
External Dose	386	1,892	2,707	2,051	3,638
Total	702	2,443	3,074	2,348	4,070

Year

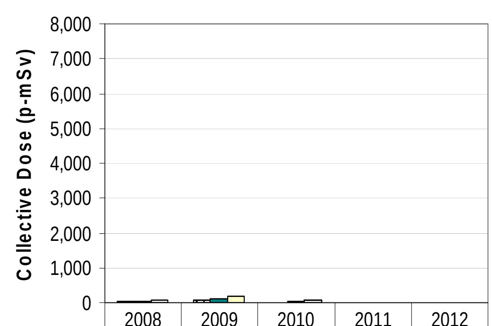
Figure D.11: **Collective effective dose by operational state for Pickering A – Units 2 and 3***



	2008	2009	2010	2011	2012
Routine Operations	0	0	0	0	0
Safe Storage Activities	78	185	65	0	0
Total	78	185	65	0	0

Year

Figure D.12: **Collective effective dose from internal and external exposures for Pickering A – Units 2 and 3***

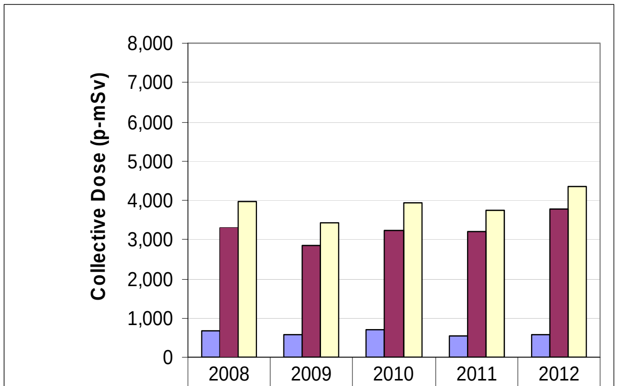


	2008	2009	2010	2011	2012
Internal Dose	33	87	16	0	0
External Dose	45	98	49	0	0
Total	78	185	65	0	0

Year

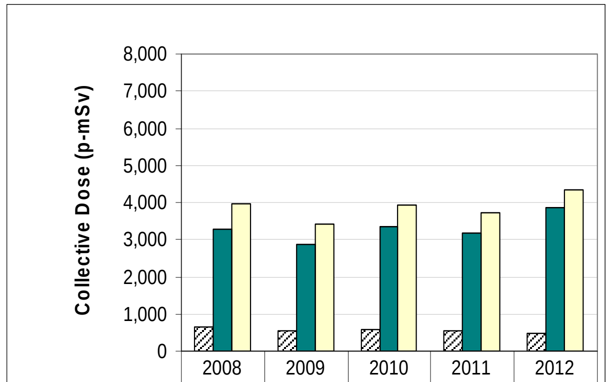
* Transition to safe storage started in 2008.

Figure D.13: Collective effective dose by operational state for Pickering B – Units 5 to 8



Year	2008	2009	2010	2011	2012
Routine Operations	662	573	698	546	571
Outages	3,292	2,836	3,238	3,195	3,781
Total	3,954	3,409	3,936	3,741	4,352

Figure D.14: Collective effective dose from internal and external exposures for Pickering B – Units 5 to 8



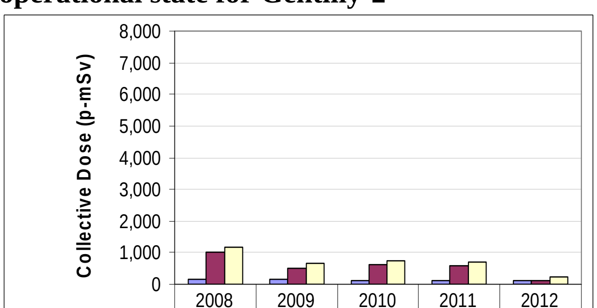
Year	2008	2009	2010	2011	2012
Internal Dose	666	532	584	561	489
External Dose	3,288	2,877	3,352	3,180	3,863
Total	3,954	3,409	3,936	3,741	4,352

D.4 Annual collective effective doses at Gentilly-2

In 2012, Gentilly-2 was effective in controlling worker radiological exposures. The variations in collective effective dose from year to year were due primarily to the number and scope of outages. In 2012, as shown in figures D.15 and D.16, internal and external doses were the lowest in comparison with previous years due to a reduction in the number and scope of radiological activities performed.

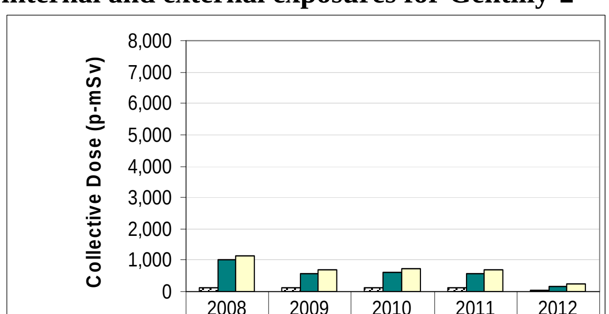
The 2012 annual effective dose distribution for workers and the average and maximum effective dose to workers are provided in section 2.7.

Figure D.15: Collective effective dose by operational state for Gentilly-2



Year	2008	2009	2010	2011	2012
Routine Operations	153	156	105	98	98
Outages	1,001	521	641	604	131
Total	1,154	677	746	702	229

Figure D.16: Collective effective dose from internal and external exposures for Gentilly-2



Year	2008	2009	2010	2011	2012
Internal Dose	140	106	121	119	50
External Dose	1,014	571	625	583	179
Total	1,154	677	746	702	229

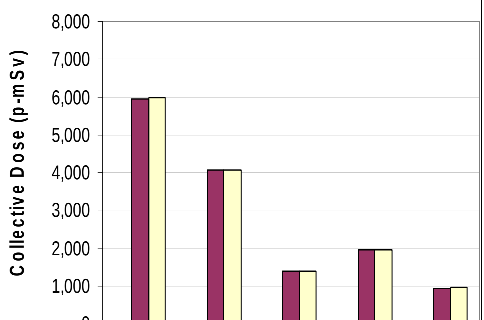
D.5 Annual collective effective doses at Point Lepreau

In 2012, Point Lepreau was effective in controlling worker radiological exposures. In 2012, as shown in figures D.17 and D.18, the collective effective doses to workers were lower than the previous year due to a reduction in the number and type of radiological activities performed. The major work activities associated with the refurbishment project were completed in the spring of 2012 and included lower feeder installation, leak testing, and new fuel load.

The collective doses received from major work activities were in good agreement with dose estimates. The total project dose was approximately 12.3 p-Sv (12,300 p-mSv), which was below the 12.7 p-Sv project dose estimate.

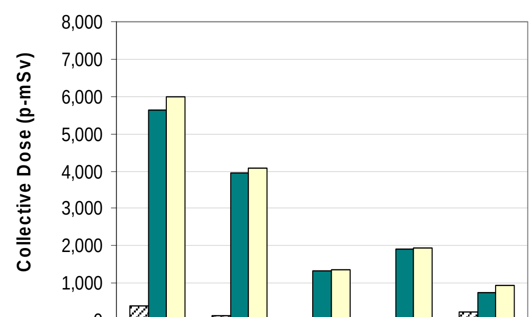
The 2012 annual effective doses distribution for workers and the average and maximum effective dose to workers are provided in section 2.7.

Figure D.17: Collective effective dose by operational state for Point Lepreau*



	2008	2009	2010	2011	2012
Routine Operations	55	0	0	0	8
Outages / Refurbishment	5,943	4,082	1,375	1,953	939
Total	5,998	4,082	1,375	1,953	947

Figure D.18: Collective effective dose from internal and external exposures for Point Lepreau*



	2008	2009	2010	2011	2012
Internal Dose	374	123	50	30	213
External Dose	5,624	3,960	1,325	1,923	734
Total	5,998	4,083	1,375	1,953	947

* Refurbishment began in April 2008. The unit returned to commercial operations on November 23, 2012.

D.6 Average collective effective doses for all Canadian NPPs in operation

For most of 2012, 17 reactor units were operational. Three units returned to service in the fall of 2012 following completion of refurbishment projects: Bruce A Unit 1 returned to service in September 2012; Bruce A Unit 2 returned to service in October 2012; and Point Lepreau returned to service in November 2012.

The routine operations doses following refurbishment for Bruce A (Units 1 and 2) and Point Lepreau were minor. However, Bruce A Unit 1 had an outage in November, and therefore this unit is included in the industry average calculation.

As shown in figures D.19 and D.20, the total collective effective doses and the average collective dose per unit at operating Canadian NPPs increased in comparison with previous years. This result is largely due to the extensive outage programs at Bruce Power and Pickering.

Figure D.19: Collective effective dose by operational state for operating Canadian NPPs, from 2008 to 2012*

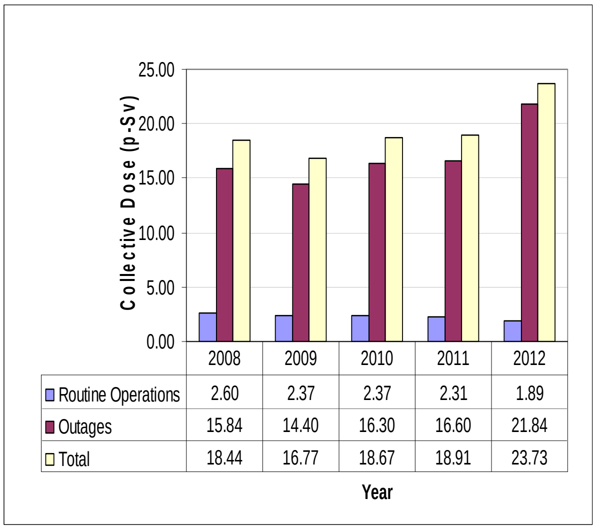
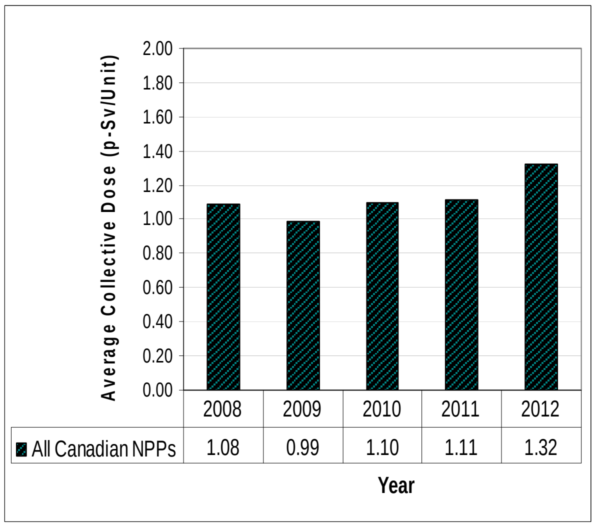


Figure D.20: Average collective effective dose for operating Canadian NPPs, from 2008 to 2012**



* Routine operations and refurbishment collective dose from Bruce A (Units 1 and 2) and Point Lepreau are excluded; the safe storage collective dose from Pickering A Units 2 and 3 is also excluded.

** The average calculated dose for 2012 includes 18 units. Bruce A Unit 2 and Point Lepreau are excluded.

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 [27].

The DRLs for gaseous and liquid effluents from Canadian NPPs can be found in tables E.1 and E.2.

Table E.1: DRLs for gaseous effluents

Nuclear power plant	Tritium* (TBq)	Iodine-131 (TBq)	Noble gases (TBq)	Particulates (TBq)	Carbon-14 (TBq)
Bruce A[a]	1.4×10^5	1.3	4.8×10^4	0.31	1.1×10^3
Bruce B[b]	2.7×10^5	0.98	1.1×10^5	0.74	1.1×10^3
Darlington[c]	5.9×10^4 (HTO) 8.5×10^5 (HT)**	1.4	4.5×10^4	0.67	3.5×10^2
Pickering A[d]	5.5×10^4	9.7	2.9×10^4	2.1	6.3×10^3
Pickering B[e]	5.5×10^4	9.7	2.9×10^4	2.1	6.3×10^3
Gentilly-2[f]	8.6×10^4	0.3	7.7×10^4***	1.2	2.0×10^2
Point Lepreau[g]	4.3×10^5	6.0×10^1	2.9×10^5	5.4	3.3×10^3

* Tritium oxide (HTO)
** For elemental tritium (HT) resulting from operations at the tritium removal facility at the Darlington Nuclear Generating Station
*** TBq-MeV; Terabecquerel-million electron volts

Table E.2: DRLs for liquid effluents

Nuclear power plant	Tritium* (TBq)	Gross beta-gamma activity (TBq)	Carbon-14 (TBq)
Bruce A[a]	2.1×10^6	1.0×10^2	2.6×10^3
Bruce B[b]	2.3×10^6	1.1×10^2	2.8×10^3
Darlington[c]	5.3×10^6	7.1×10^1	9.7×10^2
Pickering A[d]	5.1×10^5	4.7	6.4×10^1
Pickering B[e]	5.1×10^5	4.7	6.4×10^1
Gentilly-2[f]	1.2×10^7	1.8×10^2	2.4×10^3
Point Lepreau[g]	1.6×10^7	1.5×10^1	3.0×10^2

* Tritium oxide (HTO)

a Canadian Nuclear Safety Commission. (November 2009). *Nuclear Power Reactor Operating Licence Bruce Nuclear Generating Station A* (PROL 15.00/2014), Appendix C: Derived Release Limits.

b Canadian Nuclear Safety Commission. (November 2009). *Nuclear Power Reactor Operating Licence Bruce Nuclear Generating Station B* (PROL 16.00/2014), Appendix C: Derived Release Limits.

c 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).

d Canadian Nuclear Safety Commission. (October 2010). *Nuclear Power Reactor Operating Licence Pickering Nuclear Generating Station A* (PROL 04.01/2013), Appendix A.3: Derived Release Limits.

e Ontario Power Generation. (April 2006). *Derived Release Limits for Pickering Nuclear Generating Station B*, NK30-REP-03482-00001-R001 (as referenced in PROL 08.04/2013).

f Hydro-Québec. (2003). *Limites opérationnelles dérivées pour les rejets aériens de Gentilly-2* (used for Section A.3 of PERP 10.01/2016).

g New Brunswick Power Nuclear Corporation. (1996). Point Lepreau Generating Station Reference Document: *Derived Emission Limits for Radionuclides in Airborne and Liquid Effluents*, RD-01364-L1, Revision 2 (as referenced in LCH-PLNGS-R001 for PROL 17.00/2017).

Appendix F: Status of Action Items Applicable to NPPs

Table F.1 provides the status of the action items (AIs) that apply to each station as of April 30, 2013, 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 action items may then be opened to track the performance of further deliverables.

A complete description of these NPP AIs can be found in the *CNSC Action Plan* [29].

Table F.1: Status of Fukushima action items applicable to nuclear power plants (as of April 30, 2013)

	Darlington				Pickering A				Pickering B				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				√				A				A				√				√		
AI 1.2.3						NA				√				A				A				√				√		
AI 1.3.1				√				A				√				√				√				√				S
AI 1.3.2	A			A				A																√				S
AI 1.4.1	√				√				√				√				√				√				√			
AI 1.5.1**		√				A				√	A			A	A			A	A			A				A		
AI 1.6.1		√				A				√				A				A				A				A		
AI 1.6.2		NA				A				√				A				A				A				A		
AI 1.7.1		A												A								A						
AI 1.8.1		A				A				A				A				A				A				S		
AI 1.9.1			A		A				A		A						A		A						A			
AI 1.10.1	√				√				√				√				√				A				S			
AI 1.10.2	√				√	A			√				√	A			√				A	A			S	A		
AI 1.11.1	√				√				√				√				√				√				S			
AI 2.1.1**		√				A				A				A				A				A				S		
AI 2.1.2**		√				A				A				A				A				A				S		
AI 2.2.1		√				A				A				A				A				A				S		
AI 3.1.1		√				√				√				√				√				√				S		
AI 3.1.2		A				A				A				A				A				NA				NA		
AI 3.1.3		√				√				√				A				A				√				A		
AI 3.1.4		A				A				A				A				A				√				S		
AI 3.2.1	√				√				√				√				√				NA				NA			
AI 3.2.2	√				√				√				√				√				NA				NA			
AI 4.1.1	√				√				√				√				√				√				A			
AI 4.1.2	√				√				√				√				√				√				A			
AI 4.2.1	√				√				√				√				√				√				A			
AI 5.1.1	√				√				√				√				√				√				S			
AI 5.1.2	√				√				√				√				√				√				S			
AI 5.2.1	√				√				√				√				√				NA				A			
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				A				S			
Total	18	15	1	2	18	15	1	2	18	15	1	2	18	15	1	2	18	15	1	2	18	15	1	2	18	15	1	2
Closed/NA	18	10	0	1	18	5	0	0	18	8	0	1	18	2	0	1	18	2	0	1	15	7	0	2	4	11	0	2
Active	0	5	1	1	0	10	1	2	0	7	1	1	0	13	1	1	0	13	1	1	3	8	1	0	4	5	1	0

* A description of each Fukushima action item (FAI) follows on the next page   A - Active   S - Suspended for Gentilly-2   NA - Not Applicable

** Extension to 2014/15 under consideration

√ Closed   A Closure Requested/Under Review   Gentilly-2 Active FAIs

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 PHTS, steam generators, moderator, etc.) and putting in place additional coolant make-up 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 1 above is sufficient. If gaps are identified, a corrective plan should be proposed. December

FAI	Fukushima Action Items
	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

AECL	Atomic Energy of Canada Limited
AF	accident frequency
AI	action item
ALARA	as low as reasonably achievable
AMP	aging management program
ASR	accident severity rate
BOP	balance-of-plant
CANDU	Canada Deuterium-Uranium
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
DRL	derived release limit
EA	environmental assessment
EIR	event initial report
EQ	environmental qualification
GAI	generic action item
GSS	guaranteed shutdown state
HTS	heat transport system
I&C	instrumentation and control
IAEA	International Atomic Energy Agency
IFB	irradiated fuel bay
IPR	integrated plant rating
ISR	integrated safety review
IST	industry standard toolset
LCH	licence conditions handbook
LCMP	lifecycle management program
LLOCA	large loss of coolant accident
LOECI	loss of emergency coolant injection
MPCa	maximum permissible concentration for airborne activity
MSC	minimum shift complement
MWe	megawatts electrical (that is, megawatts of electrical power)
NB Power	New Brunswick Power Nuclear Corporation
NGS	nuclear generating station
NOP	neutron overpower protection
NPP	nuclear power plant
NSCA	*Nuclear Safety and Control Act*
OPG	Ontario Power Generation
OP&Ps	operating policies and principles
PARs	passive autocatalytic recombiners
PHTS	primary heat transport system
PI	performance indicator
PIP	periodic inspection program
PIV	physical inventory verification
PMCR	preventive maintenance completion ratio

PROL	power reactor operating licence
PSA	probabilistic safety assessment
PSR	periodic safety review
R&D	research and development
RO	reactor operator
SAMG	severe accident management guideline
SAT	systematic approach to training
SCA	safety and control area
SDS	shutdown system
SHP	senior health physicist
SOE	safe operating envelope
SON	Saugeen Ojibway Nations
SOP	sustainable operations plan
SRWMF	Solid Radioactive Waste Management Facility
SS	shift supervisor
SSCs	structures, systems and components
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 extension conditions
Accident conditions, not considered design-basis accidents, which are taken into account in the design of the facility.

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)
A method for ensuring that a reactor is shut down. The GSS includes adding a substance to the reactor moderator, which absorbs neutrons and removes them from the fission chain reaction, or draining the moderator from the reactor.

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

lost-time injury
An injury or illness resulting in lost days beyond the date of injury as a direct result of an occupational injury or illness incident.

medically treated injury
An injury or illness beyond a first aid injury, where there have been no lost days that are the direct result of an occupational injury or illness incident.

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 Canadian Standards Association 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 of a facility or activity that contribute to protection and safety. 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.

Type I inspection
All verification activities related to onsite audits and evaluations of a licensee’s programs, processes and practices.

Type II inspection
All verification activities related to routine (item by item) checks and rounds. An equipment or system inspection or operating practice assessment carried out by CNSC staff, which includes item-by-item checks and rounds that focus on outputs or performance of licensee programs, processes and practices. Findings play a key role in identifying where a Type I inspection may be required to determine systemic problems in programs, processes or practices.

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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