Acronyms, Abbreviations and Specific Expressions

AECL	Atomic Energy of Canada Limited
CANDU	Canadian Deuterium-Uranium
CMD	Commission member documents are prepared for Commission Tribunal hearings and meetings by CNSC staff, proponents and intervenors (each CMD is assigned a specific identification number)
CIIT	CANDU Industry Integration Team
CNSC	The Canadian Nuclear Safety Commission as an organization
CNSC staff	The staff of the Canadian Nuclear Safety Commission
COG	CANDU Owners Group Inc.
Commission Tribunal	The tribunal component of the Canadian Nuclear Safety Commission
CNS	*Convention on Nuclear Safety*
CSA	Canadian Standards Association
EMO	Emergency Management Ontario
FERP	Federal Emergency Response Plan
FNEP	Federal Nuclear Emergency Plan
IAEA	International Atomic Energy Agency
IFB	Irradiated fuel bay
ICRP	International Commission on Radiological Protection
INES	International Nuclear Event Scale
IRRS	Integrated Regulatory Review Services
ISR	Integrated safety review
LCH	Licence condition handbook
NBEMO	New Brunswick Emergency Measures Organization
NEA	Nuclear Energy Agency (an agency of the Organization for Economic Co-operation and Development)
NPP	Nuclear power plant
NRCan	Natural Resources Canada
NSCA	*Nuclear Safety and Control Act*
OPG	Ontario Power Generation Inc.
PMUNE-G2	Plan des mesures d'urgence nucléaire externe à la centrale Gentilly-2
PAR	Passive autocatalytic hydrogen recombiner
PSA	Probabilistic safety assessment
PSR	Periodic safety review
SAM	Severe accident management
SAMG	Severe accident management guidelines
WANO	World Association of Nuclear Operators

Introduction

Nuclear regulation in Canada

Canada has modern and clear federal legislation, the *Nuclear Safety and Control Act*, at the heart of its nuclear regulatory framework. This Act establishes the Canadian Nuclear Safety Commission (CNSC) as the nuclear regulator in Canada.

The Act empowers the CNSC to establish a comprehensive licensing and compliance system to protect the health and safety of persons, national security, and the environment. It also requires the nuclear industry to protect its workers and the public from unacceptable levels of radiation. The Act is modern, robust, enabling legislation that sets out the legal framework for regulating the Canadian nuclear industry. All persons wishing to carry out nuclear related activities in Canada are required, by law, to have a licence from the Commission Tribunal[1]. The Commission Tribunal has the authority and flexibility to rapidly amend licences to impose additional requirements that are aligned with modern standards, thus contributing to the continuous safety improvement of the nuclear industry. This is regarded as a strength of the Canadian system.

Section 9 of the *Nuclear Safety and Control Act* clearly sets out the objectives of the CNSC as follows:

- 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
- to disseminate objective, scientific, technical and regulatory information to the public concerning the activities of the Commission and the effects, on the environment and on the health and safety of persons, of the development, production, possession and use of nuclear substances, prescribed equipment and prescribed information

The mandate of the CNSC is fulfilled by the work of the Commission Tribunal (up to seven members charged with making the regulatory decisions). The members of the Commission Tribunal are chosen based on their credentials, and are independent of all political, governmental, special-interest group or industry influences. The members are appointed by the Governor in Council (Cabinet) of Canada, for terms not exceeding five years, and may be reappointed. One member of the Commission Tribunal is designated as both the President and the Chief Executive Officer of the CNSC, as an organization.

It is important to note that the promotion of nuclear power is not part of the CNSC's mandate. Furthermore, the CNSC is an independent agency of the federal Government of Canada and is independent of all organizations that promote, or that are directly involved in the production of, nuclear power.

Additional general information on nuclear regulation in Canada is provided in Canada's national report to the Fifth Review Meeting of the CNS. General conclusions regarding the regulatory framework that

[1] Canadian Nuclear Safety Commission, or CNSC, refers to the total organization. The Tribunal component, sometimes referred to as the Commission, is referred to as the Commission Tribunal in this report to distinguish it from the CNSC as a whole.

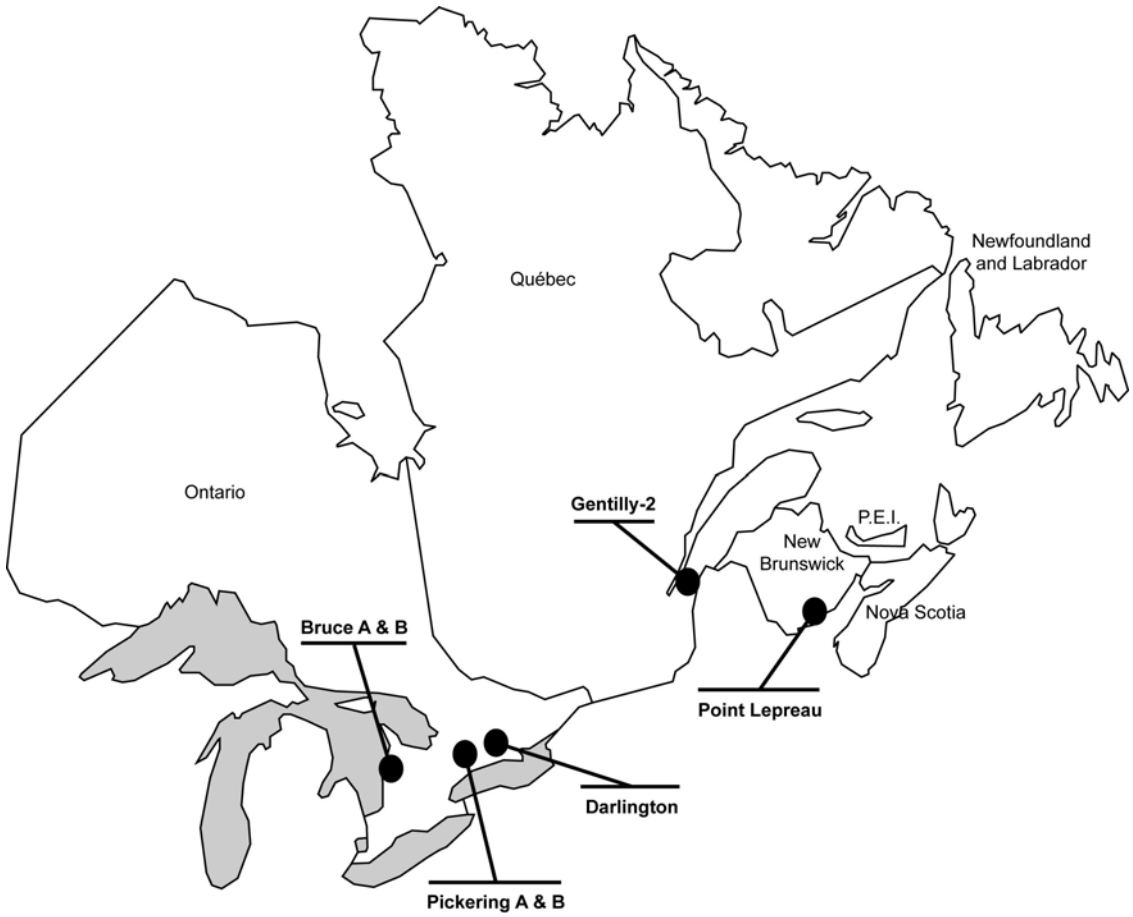
stemmed from the review that followed the Fukushima crisis are described below in the subsection "Observations on the Canadian nuclear regulatory framework".

Nuclear power plants in Canada

Of the 22 nuclear reactor units in Canada, 17 are currently producing power. Their locations within Canada are shown in the map below. Three reactor units are under refurbishment – two at Bruce A and the single unit at Point Lepreau. Two units at Pickering A are in a safe storage state. The operation of these reactors is governed by nuclear power plant (NPP) operating licences for seven distinct sites, which are operated by four licensees as shown in the table on the following page.

The NPPs in Canada use pressurized heavy water reactors of the CANDU design. Important aspects of the design are described in section 2 of this report. A full description of CANDU reactors was provided in the Canadian reports to the first and second review meetings of the CNS.

Locations and basic information on NPP sites in Canada



NPP Site	Province	Licensee	# Reactors	First criticality *
Bruce A	Ontario	Bruce Power	4	1976–1978
Bruce B	Ontario	Bruce Power	4	1984–1987
Darlington	Ontario	OPG	4	1989–1993
Gentilly-2	Quebec	Hydro-Québec	1	1982
Pickering A	Ontario	OPG	4 **	1971–1973
Pickering B	Ontario	OPG	4	1982 - 1985
Point Lepreau	New Brunswick	Énergie NB Power	1	1982

* For the multi-unit NPPs, the date range for first criticality indicates that the construction of the units proceeded over a period of several years.

** Two units at Pickering A are operating and two are defuelled and are in safe storage.

Initial response to Fukushima – the CNSC and other federal organizations

Immediately after the incident, the CNSC:

- activated the CNSC Emergency Operations Centre (EOC) and staffed it 24/7 to monitor the emergency, assess early reports and provide timely, accurate information to Canadians
- performed inspections and walkdowns at nuclear facilities to assess the readiness of mitigating systems
- requested Canadian licensees of Class I nuclear facilities and uranium mines and mills to review the lessons learned
- convened the CNSC Fukushima Task Force to evaluate the operational, technical and regulatory implications of the accident for NPPs

Other federal organizations, including the Department of Foreign Affairs and International Trade (DFAIT), Health Canada/Public Health Agency of Canada, and Public Safety Canada also activated their emergency operations centres to coordinate the federal response to the emergency.

Activation of the CNSC Emergency Operations Centre

Following notification of the Fukushima Daiichi nuclear accident, by midday, March 11, staff from the CNSC's Nuclear Emergency Organization (NEO) assembled in the EOC to assess the situation in Japan and develop the strategy for the Canadian response. For 23 days, CNSC staff worked in the EOC 24/7 to monitor and assess the situation in Japan. CNSC specialists provided expertise in the fields of reactor technology, accident progression and radiation protection.

The CNSC's NEO monitored the situation in Japan in close collaboration with other Government of Canada departments and agencies, and nuclear regulators from the United States, United Kingdom and France, as well as with the International Atomic Energy Agency (IAEA).

Federal government response

Federal organizations including the CNSC's NEO, Health Canada's Radiation Protection Bureau, Public Health Agency of Canada and Environment Canada–Canadian Meteorological Centre supported the Canadian DFAIT Japan Crisis Team on a daily basis by providing timely and accurate information and advice to Canadians in Japan and in particular to the Canadian ambassador and his staff in Japan. Information was posted on the Web sites of the CNSC, DFAIT, Health Canada and Public Health Agency of Canada to provide a consistent, objective and credible source of information for the Canadian public, CNSC staff and other government departments. Coordinated efforts were also undertaken to monitor the Canadian environment and address issues of public concern.

CNSC inspections of Canadian NPPs

Immediately after the Fukushima Daiichi event, CNSC site staff performed walkdowns at Canadian NPPs to verify the licensees' emergency preparedness for external hazards and severe accidents so that the CNSC could reassure the Commission Tribunal and Canadian public that certain aspects that had contributed to the events in Japan had been specifically verified. These aspects included: seismic, fire, backup power availability and condition, hydrogen igniters, and irradiated fuel bays (IFBs).

The readiness of emergency staff and installed equipment was verified and no actions were assigned to the licensees as a result of these inspections.

CNSC staff also verified the licensees' assessment of the capability of:

- provisions to mitigate consequences of external events that may lead to beyond-design-basis accidents
- installed equipment and associated procedures to mitigate conditions that result from beyond-design-basis accidents
- provisions to mitigate station blackout conditions, including robustness of backup power and the emergency power supply systems
- provisions to rapidly reduce reactor power to match the station power demand following a loss of offsite power
- battery backup and fuel supply to emergency generators

CNSC staff also confirmed the licensees' identification of:

- important equipment needed to mitigate consequences of external events
- any potential scenarios that could compromise the equipment's function during seismic events

CNSC staff were satisfied with the short-term actions taken by licensees.

Regulatory request to licensees

Subsection 12(2) of the *General Nuclear Safety and Control Regulations* places an obligation on licensees to respond to a request from the Commission Tribunal, or a person who is authorized by it, to "conduct a test, analysis, inventory or inspection in respect of the licensed activity or to review or to modify a design, to modify equipment, to modify procedures, or to install a new system or new equipment".

In accordance with this provision, the CNSC Executive Vice-President and Chief Regulatory Operations Officer wrote to all Class I nuclear facilities on March 17, 2011, directing the licensees to review initial lessons learned from the earthquake in Japan and re-examine the safety cases of NPPs, in particular the underlying defence-in-depth concept, and report on implementation plans for short-term and long-term measures to address any significant gaps. The focus of the review was:

- external hazards such as seismic, flooding, fire and extreme weather events
- measures for the prevention and mitigation of severe accidents
- emergency preparedness

Letters similar to the 12(2) letters were also sent to the licensees of other facilities and activities.

The CNSC Fukushima Task Force

The CNSC Fukushima Task Force (the Task Force) was set up to evaluate operational, technical and regulatory implications of the Fukushima accident on Canadian NPPs. It was also tasked with reviewing NPP licensees' responses to the "12(2)" letters described above. The Task Force Chair was tasked with reporting the results of the Task Force review to the Executive Vice-President and Chief Regulatory Operations Officer of the CNSC and the Commission Tribunal. While other federal organizations

involved in the emergency response undertook comprehensive lessons-learned reviews, the following focuses on the work of the Task Force.

The mandate of the Task Force was to:

- review submissions from licensees who had been directed under the 12(2) letters to re-examine the safety cases of their respective NPPs; underlying defence in depth against external hazards; severe accidents; and emergency preparedness
- assess available technical and operational information regarding Fukushima and identify a high-level set of lessons learned
- develop recommendations for short-term and long-term measures to address any shortcomings at CANDU reactors, and recommend whether design or operational modifications, including supporting research, are needed
- determine priorities for implementation of corrective actions from lessons learned and the need for further examination
- develop recommendations, as appropriate, for potential changes to CNSC regulatory requirements, inspection programs and policies for existing Canadian NPPs and new builds

The Task Force developed *Nuclear Power Plant Safety Review Criteria* to define measurable expectations for each area of the assessment and aid the systematic identification of findings. The criteria were developed for application to Canadian NPPs and the nuclear regulatory framework but reflected international lessons and observations drawn from Fukushima. The criteria were applicable to the licensees' activities, the CNSC's activities, and the CNSC's regulatory framework and covered the following review elements:

- station design for external hazards
- impacts of beyond-design-basis accidents
- SAM measures for beyond-design-basis accidents, including severe accidents
- emergency planning and response
- regulatory framework and processes

The criteria generally exceeded the applicable requirements and expectations of the current CNSC regulatory framework.

Using the criteria, the Task Force assessed the substantial submissions provided by the licensees and also undertook a preliminary review of the regulatory framework for existing NPPs and potential new builds in Canada. The CNSC reviewed additional plans and concurred that the proposed enhancements have the potential to improve safety at the NPPs.

The Task Force summarized its assessments in the *CNSC Fukushima Task Force Report*. The findings applied to both licensees of operating NPPs and also any new build in Canada. The findings can be categorized into four groups:

- defence in depth
- emergency preparedness
- regulatory framework and processes
- international co-operation

The report was presented to the CNSC Executive Vice-President and Chief Regulatory Operations Officer on September 28, 2011, who accepted the conclusions and recommendations. The ensuing *CNSC Management Response to the CNSC Fukushima Task Force Report* (CNSC Management Response) set out the timeline in which all actions needed to address the recommendations of the Task Force were to be completed. Both of these documents were issued for public comment in October 2011.

Following the comment period, the CNSC developed the *Draft CNSC Staff Action Plan* by translating the key recommendations in the *CNSC Fukushima Task Force Report* into specific actions on licensees and

the CNSC to strengthen defence in depth, enhance emergency response, improve the regulatory framework and enhance international collaboration. In line with the CNSC Management Response, the actions were categorized as either short-term (one-year timeframe), medium-term (two-year timeframe), or long-term (three-year timeframe).

The *Draft CNSC Staff Action Plan* was issued for public comment in December 2011. Following consideration of the comments received from the public and stakeholders, the *Draft CNSC Staff Action Plan* was revised and reissued for public and stakeholder comment in March 2012. Upon completion of this second round of consultation, the draft document was revised to take into consideration all feedback from the public and stakeholders and to incorporate the recommendations of the External Advisory Committee (see below). The revised draft document was renamed the *CNSC Action Plan* and was presented for acceptance on May 3, 2012 at a public meeting of the Commission Tribunal. The meeting was open to the public through the CNSC's public webcast system, and provided opportunities for interested parties and stakeholders to intervene in the discussions. Experts from other government departments (Health Canada, Public Safety Canada and Natural Resources Canada) also participated.

Among other actions, the *CNSC Action Plan* assigned the CNSC to lead the preparation of this report, in conjunction with the licensees and other stakeholders, and participate at the Second Extraordinary Meeting of the CNS (Action 13.1).

Initial response to Fukushima – licensees

Since original construction, the NPP licensees in Canada have made many safety improvements based on CNSC requirements, industry research, national and international operational experience and generally rising public expectations. In particular, licensees of those NPPs that have undergone refurbishment have performed a systematic review against modern standards, as part of the re-licensing process, and have made modifications that reduce the likelihood and consequences of severe core damage and a large release of radioactive materials.

The licensees responded comprehensively to the CNSC's request for information and plans, in response to Fukushima, to improve the safety of NPPs for beyond-design-basis accidents. Guided by the Task Force safety review criteria, the licensees have performed detailed assessments against the lessons learned from the Fukushima accident and have proposed, or are evaluating, a number of further safety enhancements, such as additional coolant injection points, additional hydrogen mitigation, and additional onsite and offsite power supplies and pumps. Some NPPs have implemented modifications to improve defence against extreme natural events (notably flooding), and have accelerated the implementation of passive autocatalytic hydrogen recombiners (PARs) and of severe accident management guidelines (SAMG).

Independent assessments of the CNSC's regulatory response to Fukushima

Integrated Regulatory Review Service mission

At the time of the accident at Fukushima, Canada and the IAEA were already planning an IRRS mission to Canada for late 2011. The purpose was to follow up on the CNSC's progress to address findings from the assessment of Canada's nuclear regulatory framework during the initial IRRS mission to Canada in 2009. The CNSC decided to increase the scope of its follow-up IRRS mission in December 2011 to include the recently developed "Fukushima module", thereby providing a review by international nuclear regulatory experts of the CNSC's response to Fukushima.

The IRRS peer review report for the follow-up mission was provided to the CNSC in January 2012. Among other observations, the IRRS mission concluded that the CNSC's regulatory response to Fukushima was prompt, robust and comprehensive and identified the following good practice that should be used by other regulatory bodies. Its report stated:

> "The CNSC has performed a systematic and thorough review of the implications and the lessons learned from the TEPCO Fukushima Daiichi accident for the safety of the Canadian NPPs, making full use of all the information available, including the review of the actions taken by other international nuclear regulators. The CNSC has set up an Action Plan for addressing all the findings and recommendations arising from the review conducted under the CNSC Fukushima Task Force. The Task Force Report has been made publicly available."

In addition, the mission report identified three other specific findings (two recommendations and one suggestion) that were relevant to the CNSC's response to Fukushima and which were aligned with the recommendations of the Task Force. These IRRS findings are cited in this report under the appropriate topic to help support the conclusions herein.

The CNSC accepted all the findings in the peer review report for the follow-up IRRS mission and provided management responses to all the recommendations, suggestions and good practices. The management responses described clear timelines and deliverables and assigned responsibilities as needed so that each recommendation and suggestion for improvement can be effectively addressed. The CNSC management responses to the IRRS findings are being addressed directly by the *CNSC Action Plan*.

External Advisory Committee

The President of the CNSC established an External Advisory Committee (EAC) in August 2011 to assess the organization's processes and responses in light of the lessons learned from Fukushima. The EAC comprised independent experts in energy, innovation, engineering, governance and safety from outside of the nuclear sector. It performed its assessment independently from the IRRS review and the Task Force review.

The EAC reviewed the CNSC's processes including the immediate response to the Fukushima incident, its connections with the rest of government and international organizations and its interactions with the Canadian nuclear sector and its regulated industries. It also reviewed the CNSC's communications with affected stakeholders, including governments, other nuclear regulators and the public. Finally, the EAC assessed the implications on the CNSC's regulatory approaches from the international response to Fukushima, such as international stress tests and the *IAEA Action Plan*.

In its report to the CNSC in April 2012, the EAC concluded that the CNSC acted promptly and appropriately in the early stages of the Fukushima crisis and followed an appropriate process as it responded over time. The report included nine recommendations that complemented the findings of the Task Force. The CNSC accepted all the findings in the committee's report.

The EAC's recommendations can be sorted into three categories:

- application of Fukushima lessons learned to non-NPP facilities
- recommendations that align with actions already identified in the *CNSC Action Plan*
- communication and public education

Regarding the first category, note that the CNSC, following Fukushima, requested information from the licensees of all major facilities (not just NPPs). Following its review, the CNSC concluded that any lessons learned from Fukushima that are applicable to major facilities other than NPPs will be followed up through routine compliance and licensing activities.

The recommendations in the second category were well aligned with the existing Task Force recommendations and have been addressed by making a few, simple changes to the *CNSC Action Plan*. The EAC's recommendations included several related to emergency preparedness that echo the observations made in section 5 of this report.

Regarding the third category, the EAC recommended that the CNSC develop a comprehensive communication and education strategy that includes tools such as social media and expands partnerships and relationships with various science media organizations that have the ability to inform the public on

nuclear safety. The following briefly describes tools and strategies already used, as well as enhancements that will address this recommendation.

Social media tools have been added or are being added, including a CNSC Facebook page that was launched in February 2012. New Web content will better cover all safety-significant aspects of the operation of nuclear facilities, including measures to deal with nuclear emergencies. The CNSC has already initiated regular updates on current topics of interest to the public and stakeholders, including the *CNSC Action Plan* and emergency preparedness.

Online educational initiatives on the nuclear fuel lifecycle, nuclear safety and other nuclear-related topics include "Educational Resources" and "CNSC On-Line". At "CNSC 101 Information Sessions", held for stakeholders across the country, CNSC staff explain to Canadians how the nuclear industry is regulated.

As a direct result of Fukushima, the CNSC has also expedited development of a "crisis Web site".

More CNSC specialists will be trained in the next year on communicating with stakeholders, with an emphasis on crisis communications. The CNSC worked with the Science Media Centre of Canada during the crisis on the effectiveness of communication of its trained subject matter experts and is considering further partnerships with similar institutions.

CNSC Communications representatives will meet with international peers and make presentations at fora to exchange best practices and lessons learned from Fukushima, such as the Nuclear Energy Agency's "Crisis Communications Workshop" and the IAEA International Experts' Meeting on "Enhancing Transparency and Communication Effectiveness in the Event of a Nuclear or Radiological Emergency, both being held this spring.

Observations on the Canadian nuclear regulatory framework

CNSC regulatory requirements are set out in legislation, regulations, licences and regulatory documents. Guidance on how applicants and licensees can meet regulatory requirements is provided in guidance documents. Info-documents provide more general information on the regulatory regime and processes for the broader public. The Task Force examined all these elements and found that there is no need to revisit the structure of the regulatory framework as a result of the lessons learned from Fukushima.

The Canadian regulatory framework is strong and comprehensive and is effectively applied, even for severe accidents. This finding is consistent with a finding by the initial IRRS mission to Canada in 2009, which stated: "The Canadian legislative and regulatory framework is comprehensive, with an appropriate range of instruments allowing for an effective application of the legal regime."

The Task Force also reviewed the CNSC's key regulatory processes (e.g., relating to licensing, compliance, and maintaining and enhancing the regulatory framework).

Nuclear Safety and Control Act and other legislation

The *Nuclear Safety and Control Act* establishes the CNSC as the clear authority for nuclear safety in Canada. The Act is briefly described earlier in this introduction.

Other areas of jurisdiction in Canada also govern nuclear-related activities. For these, legislation is established to set the relevant requirements. Provisions are in place (e.g., memoranda of understanding, committees) with the other authorities to ensure that all responsibilities are borne by the appropriate body and no ambiguity or overlap exists. Examples of such areas of jurisdiction are emergency preparedness, transportation of dangerous goods, and environmental protection. Some key authorities whose responsibilities interface with those of the CNSC are described in sections 4 and 5 of this report.

The Task Force found that the *Nuclear Safety and Control Act* is sound and does not need revision.

Regulations under the *Nuclear Safety and Control Act*

The *Nuclear Safety and Control Act* authorizes the Commission Tribunal to make regulations. Some of the regulations relevant to this report are the:

- *General Nuclear Safety and Control Regulations*
- *Class I Nuclear Facilities Regulations*
- *Radiation Protection Regulations*

The Task Force reviewed the regulations under the *Nuclear Safety and Control Act* and found that overall the regulations are sound. No changes to the *General Nuclear Safety and Control Regulations* were identified as a result of its review.

Class I nuclear facilities are defined in the *Class I Nuclear Facilities Regulations* and, in addition to NPPs, cover facilities such as small reactors, fuel processing plants and nuclear waste facilities. Paragraph 6(c) of the *Class I Nuclear Facilities Regulations* requires an applicant for a licence to operate an NPP to submit with its application, among other things, a final safety analysis report demonstrating the adequacy of the NPP design. The tools and methodologies used in licensees' safety analysis reports are proven according to national and international experience, and validated against relevant test data and benchmark solutions.

Specific recommendations related to changing regulations are discussed under relevant topics in this report. For example, possible modifications of the *Class I Nuclear Facilities Regulations* related to offsite emergency plans are discussed in section 5 of this report, while those for the *Radiation Protection Regulations* are discussed in section 3. These changes are not needed immediately.

Licensing and the CNSC's licensing process

As mentioned above, the *Nuclear Safety and Control Act* authorizes the Commission Tribunal to establish classes of licences and, therefore, the CNSC has the authority and flexibility to rapidly amend licences. The CNSC has used the licence renewal process (typical licence duration is five years) and amendments to impose additional requirements that are aligned with modern standards, thus contributing to the continuous safety improvement of the NPPs. This is regarded as a strength of the Canadian system. The Fukushima review during the IRRS follow-up mission to Canada also found that the "CNSC has adequately addressed the authorization process in its review of the implications of the lessons learned from the TEPCO Fukushima Daiichi accident."

The NPP operating licences cite various CNSC regulatory documents, as well as some nuclear standards issued by the Canadian Standards Association (CSA). Two of the CNSC regulatory documents cited in the licences that are relevant to the general content of this report are S-99, *Reporting Requirements for Operating Nuclear Power Plants*, and S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*.

To meet the operating licence requirement that cites S-99, a licensee must, within three years of the date of the last submission of the NPP description and final safety analysis report, submit a report that consists of an updated NPP description and an updated final safety analysis. This report must include the following information:

- a description of the changes made to the site, structures, systems and components (SSCs) of the NPP, including any changes to the SCCs' design and design operating conditions
- safety analyses that have been appropriately reviewed and revised, and that take into account the most up-to-date and relevant information and methods, including the experience gained and lessons learned from the situations, events, problems or other information reported pursuant to S-99

All Canadian NPPs are required by their operating licences to have a site-specific Level 2 PSA to meet CNSC regulatory standard S-294.

Other regulatory documents cited in the NPP operating licences are discussed in specific, relevant sections of this report. General comments on the Task Force's review of the CNSC's regulatory documents are provided below.

The CNSC is currently revising the format of the NPP operating licences to more comprehensively cover the safety and control areas that describe how the NPPs are operated safely. The CNSC is also revising the content of those licences to minimize the number of administrative amendments that are sometimes required in the older format of the licence. In parallel with this, each NPP operating licence is to be supported by a licence condition handbook (LCH) that describes the compliance verification criteria that will be used to confirm safe operation. Generic templates for both the NPP operating licence and LCH have been approved for use to optimize consistency among NPP operating licences. As NPP operating licences are renewed, the templates are used to develop the licence and the LCH for that NPP. The Task Force considered the merit of accelerating the conversion of the remaining licences that are still in the old format to the new format. Given that the licensees are already moving to implement the programs needed to meet the new requirements and, given the considerable effort required to prepare or revise the LCH for each licence, the Task Force found instead that the remaining NPP operating licences should be amended to the new format when the licences are next renewed. It is expected that all NPP operating licences will be renewed in the new format with an accompanying LCH, to match the existing templates, by October 2014.

The Task Force found that two new safety requirements should be added to the NPP operating licence template. They are related to accident management (see section 3) and public information programs (see section 5).

The Task Force reviewed the regulatory and guidance documents published by the CNSC that are referenced in the NPP operating licence or LCH. This is a significant number of documents and includes CNSC regulatory standards S-99 and S-294, which are mentioned above. The overall finding was that there is no need to revisit the regulatory framework in order to identify the minimum, necessary and sufficient number of regulatory and guidance documents (RDs and GDs) to support the NPP regulatory program. Should the framework be revisited in the future, the Task Force found, the NPP operating licence and LCH templates should be used as the basis for identifying needs for RDs or GDs. The NPP operating licences and LCHs currently contain some regulatory requirements or expectations that are not found in RDs or GDs; when the framework is revised, the opportunity should be taken to remedy this.

The Task Force also found that certain, specific regulatory documents should be updated on a priority basis (see sections 2 and 5). The Task Force found that other existing regulatory documents should be updated during their next scheduled revision.

Compliance process

The Task Force reviewed the CNSC's programs that verify compliance by licensees with regulatory requirements. The CNSC conducts inspections, reviews, performance assessments and event follow-up to verify compliance. The Task Force found that CNSC staff should review the compliance program for needed improvements once the identified changes to the regulatory framework have been implemented. This review will include updating the baseline compliance program, under which satisfactory performance of all safety and control areas is verified regularly. In particular, enhanced focus is anticipated on:

- licensees' accident management programs and provisions, including NPP accident manuals and procedures
- "operational" aspects of nuclear safety, to maintain regulatory overview of the design capabilities to provide fundamental safety functions such as control of fission reaction, cooling of fuel (including in the IFBs) and confinement of radioactivity
- holistic evaluation of the overall NPP safety case against modern standards and best practices

Integrated safety review and periodic safety review

In recent years, as some of the older reactors approached the end of their design life, licensees have applied for life extension for their NPPs. As a prerequisite, licensees are required by CNSC RD-360, *Life Extension of Nuclear Power Plants*, to conduct an integrated safety review (ISR). As part of the ISR, licensees perform a review of the NPP against modern standards and practices. Identified gaps are reviewed and practicable upgrades are incorporated into the integrated improvement plan. The licensees are expected to fill the gaps as far as reasonably practicable.

As a prerequisite to refurbishment, ISRs have been completed for Point Lepreau, Gentilly-2 and Bruce A, with similar reviews performed for Pickering. The refurbishment of Point Lepreau is particularly interesting because the Fukushima accident occurred during its refurbishment. Several of the potential safety improvements identified by the Task Force had been or were already being implemented by Point Lepreau as part of its refurbishment (which explains why Point Lepreau is further advanced than some of the other NPPs with respect to implementing certain recommendations in the *CNSC Action Plan*). This reinforced the effectiveness of the ISR process as a mechanism for identifying and prioritizing tangible safety improvements.

Given that ISRs provide an opportunity to re-evaluate the entire safety case for an NPP, the Task Force considered that such reviews should be done regularly for all NPPs by means of periodic safety reviews (PSRs). Like the ISR, the PSR would involve a systematic and comprehensive comparison against modern standards and technological developments that assures continued plant safety and viability of the licensing basis. A 10-year frequency, in line with international practice, is judged reasonable and could be integrated into the licensing process. The *CNSC Action Plan* assigned an action to the CNSC to consider the development of a regulatory framework for the implementation of the PSR process (Action 11.1). A Commission member document (CMD), *Implementation of Periodic Safety Reviews for Licensing of Nuclear Power Plants*, is being prepared. That document seeks the Commission Tribunal's approval to incorporate the PSR approach by modifying the regulatory framework and developing the necessary requirements.

About this document

The main body of this report is broken down into six sections – one for each of the six topics suggested by the current General Committee of the CNS:

1. External events
2. Design issues
3. Severe accident management and recovery (onsite)
4. National organizations
5. Emergency preparedness and response and post-accident monitoring (offsite)
6. International co-operation

Wherever applicable, the findings of the Task Force and the IRRS follow-up mission to Canada are cited in this report to corroborate or add insight to the information in this report. Parenthetical references to actions (e.g. Action X.Y) are citations of specific actions in the *CNSC Action Plan*.

Per the request from the General Committee of the CNS, tables are provided in appendix A that summarize the activities taken by the licensees and the CNSC, in response to Fukushima, under each of the six topics.

Topic 1 – External Events

1 External Events

1.1 Overview

The licensees have demonstrated that external hazards are addressed in the NPP safety cases. The hazards considered are specific to each site and include seismic, flood, extreme weather events and events caused by human activities (e.g., explosions). As part of the follow-up to Fukushima, the licensees also examined events more severe than those that have historically been regarded as credible and their impact on the NPPs. The Task Force assessed the magnitudes that had been considered in the design-basis and beyond-design-basis analyses of external hazards. Although the magnitudes were generally based on applicable codes and standards at the time of construction, the rationale for the magnitude selected for beyond-design-basis hazards was not always documented adequately.

Immediately following the accident at Fukushima, the CNSC performed inspections at all NPPs to assess the readiness of systems that mitigate the effects of a severe accident caused by an extreme external event. These inspections covered seismic preparedness, firefighting capability, backup power, hydrogen mitigation and spent fuel cooling. As mentioned in the introduction, the 12(2) letters sent to the licensees requested information specific to external hazards such as seismic, flooding, fire and extreme weather events. The CNSC developed its *Nuclear Power Plant Safety Review Criteria* to help guide the licensees' assessment of capability to respond to external events more severe than have been previously considered.

All licensees provided, in their responses to the 12(2) letters from the CNSC, information on the following:

- hazard analysis and specific hazards of interest
- analysis of design-basis events
- analysis of beyond-design-basis accidents
- probabilistic safety assessment

The Task Force recommended that the licensees should conduct more comprehensive assessments of site-specific external hazards to demonstrate that:

a) considerations of magnitudes of design-basis and beyond-design-basis external hazards are consistent with current best international practices
b) consequences of events triggered by external hazards are within applicable limits

The licensees are conducting or have conducted more comprehensive assessments of site-specific external hazards by using methods that include PSAs. The licensees are also taking actions to improve safety margins for external events.

A table is provided in appendix A that summarizes the actions related to external events that have been taken by the licensees and the CNSC in response to Fukushima.

1.2 Background

The NPPs in Canada are all of CANDU design. They were designed and constructed from the 1960s to the 1980s based on standards available at that time. External hazards are addressed in the reactor safety cases, which are specific to each site – they include seismic, flood, extreme weather events including high winds, and events caused by human activities (e.g., explosions).

Canadian NPPs are located well within the North America tectonic plate, and no NPPs are located near a subduction tectonic plate boundary (as is the case in Japan). The closest tectonic plate boundary is the Mid-Atlantic Ridge. Canadian NPPs are located in areas of much lower seismic risk than Fukushima. The

design bases for Canadian NPPs have typically included design-basis earthquakes with a recurrence interval of 1,000 years.

Analyses of floods for Canadian NPPs have typically included design-basis rainfall or water levels based on a recurrence frequency of 100 years or the highest historical numbers.

All NPP licensees are required, via their operating licences, to update their safety analysis reports every three years (see "Observations on the Canadian nuclear regulatory framework" in the introduction for general information on the safety report). This update includes consideration of any relevant, new techniques or information, which could include new data or insights related to external events.

All Canadian NPPs are required by their operating licences to have a site-specific Level 2 PSA, updated every three years, to meet CNSC regulatory standard S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*. This standard requires consideration of all internal events and external hazards in the PSA. Licensees are explicitly required to perform fire, flood and seismic assessments with a methodology that is acceptable to CNSC staff.

Licensees also have to perform a site-specific external hazards screening to identify other hazards that may require a PSA or a bounding analysis. Further, the licensees must consider combinations of events, including consequential and correlated events. Examples of consequential events include external events (such as a cooling water intake blockage caused by severe weather) and internal events (such as a fire caused by an earthquake); examples of correlated events include heavy rainfall concurrent with a storm surge or high winds caused by a hurricane.

The ISRs conducted before refurbishing reactors involve an assessment against modern standards (see "Observations on the Canadian nuclear regulatory framework"). This assessment includes modern requirements related to consideration of external events.

CNSC regulatory document RD-310, *Safety Analysis for Nuclear Power Plants*, provides a modern, comprehensive treatment of external and internal events and accidents. RD-310 is in the process of being implemented at existing NPPs.

1.3 Activities by the CNSC

The Task Force confirmed the general adequacy of the safety cases of the NPPs for external events.

The Task Force confirmed that the NPPs that were reassessed as part of refurbishment activities were reviewed for external hazards, and their design bases are, to the extent practicable, in line with modern standards and practices.

For NPPs that have not been refurbished, the Task Force concluded that the magnitudes of the external events considered in the designs comply with the standards applicable at the time of original licensing and are generally very conservative. However, the rationale for the magnitudes selected for beyond-design-basis hazards was not always documented adequately. Further, the scope of the assessments and event magnitudes considered were below modern international best practice. Although there are no external events that require immediate action by the CNSC or licensees, the Task Force found that the licensees need to identify the gap between the design basis and modern practice, demonstrate how the gap is being addressed, and confirm that the consequences of these external events are within applicable limits. A specific finding was that the assessment for the design-basis and beyond-design-basis tornado hazard is weak at some NPPs.

The Task Force concluded that the screening of external hazards and bounding analyses are in different states of development for each NPP, such that analysis of all external hazards is not complete at all NPPs. This is to be expected, as it was known that some NPPs will not be in full compliance with S-294, *Probabilistic Safety Assessments (PSA) for Nuclear Power Plants* until 2014. The Task Force reviewed the relevant results and plans submitted by the licensees related to PSA. The Task Force concluded that

the proposed approaches will provide a consistent and up-to-date review of all external hazards for all NPPs. The Task Force determined that the time scale proposed by the licensees to complete the analyses is acceptable.

The *CNSC Action Plan* assigned an action to licensees to complete the review of the basis of each external event to which the plant may be susceptible. The review should be against modern, state-of-the-art practices for evaluating external event magnitudes and corresponding design capacity (Action 2.1). This includes, but is not limited to, earthquakes, floods, tornadoes and fires. The action will cover both the events that were part of the original design basis and those that are identified in subsequent screenings and analyses (e.g., consequential events). The work will involve re-evaluation of event magnitudes, application of PSA, deterministic analyses of representative severe core damage accidents, and assessment of whether the design protection against each event is sufficient.

The *CNSC Action Plan* assigned an action to licensees to continue implementing RD-310, *Safety Analysis for Nuclear Power Plants* (Action 2.2). The CNSC is tracking the progress of the licensees' implementation of RD-310, *Safety Analysis for Nuclear Power Plants*, through the working group discussed in subsection 1.4 below. In March 2012, the CNSC published a companion guidance document, GD-310, *Guidance on Safety Analysis for Nuclear Power Plants.*

1.4 Activities by licensees

The NPP licensees, in their responses to the 12(2) letters from the CNSC, re-confirmed the general adequacy of the safety cases of their NPPs. This included the analysis of design-basis accidents in the safety report. The predicted consequences for design-basis accidents also provide bounding estimates for the consequences of the external hazard accident scenarios within the design basis. The licensees also examined events more severe than those that have historically been regarded as credible and their impact on the NPPs.

The NPP licensees re-confirmed that the risk posed to Canadian NPPs from tsunamis are negligible. All Canadian NPPs except Point Lepreau are located beside lakes and rivers, and the risk of tsunamis has been assessed to be very low. For Point Lepreau, which is located on a bay on Canada's east coast, the licensee studied the threat of tsunamis during plant siting and determined that the storm surge caused by the maximum probable hurricane bounded that of a tsunami. That analysis considered a category-2 hurricane on the Saffir-Simpson Hurricane Scale. Considering Fukushima, and accepting an increased frequency of hurricane occurrence and the potential for stronger storms, the licensee more recently assessed the storm surge level with a high-end category-4 hurricane. The licensee concluded that the site would still not be overtopped by waves. The Task Force accepted this assessment.

Some of the NPPs that have been subject to ISRs for refurbishment projects were reassessed for external hazards, especially for seismic hazards. Seismic margin assessments (SMAs), or seismic PSAs, were conducted to assess the safety margin based on earthquakes with a 10,000-year recurrence interval. Other external hazards, including floods and high winds, were also assessed in ISRs. Where vulnerabilities were identified, modifications were performed where warranted such that refurbished plants exceed or approach modern standards.

The licensees are addressing Action 2.1 by reviewing the bases of external events and completing or updating PSAs. The licensees have performed, or are planning to perform, deterministic analyses for representative severe core damage accidents.

The licensees are expanding the application of PSA to analyze specific hazards. All NPP licensees have submitted to the CNSC their methodologies on external hazards screening and bounding analysis. Pickering A (Canada's oldest operating NPP) and Bruce A completed SMAs, using a review level earthquake with a recurrence interval of 10,000 years. The Pickering A SMA was completed prior to the unit's return to service in 2004. The Bruce A SMA was completed prior to the return to service of units 3

and 4 in 2004 and was completed for units 1 and 2 in 2006 in preparation for return to service. Point Lepreau and Darlington have recently updated their PSAs to conform to the requirements of S-294, *Probabilistic Safety Assessments (PSA) for Nuclear Power Plants*. Seismic and external flooding events are among the events that have been assessed using modern-day methods. The other Canadian NPPs will complete the upgrade of their PSAs by 2014.

Point Lepreau has included seismically induced fires and internal flooding in its Level 2 PSA. Pickering A and B and Darlington are working in concert with the Electric Power Research Institute (EPRI) to develop a PSA methodology to assess seismically induced fires and floods. Pickering and Bruce are developing an assessment methodology for tornadoes as part of their PSA update projects.

Licensees are taking action to improve margins related to external events. For example, Point Lepreau is installing flood protection for its secondary control area tunnel (also discussed in subsection 2.5.6.2) and Darlington and Pickering A have installed and are installing, respectively, additional flood protection for standby and emergency power generators (also discussed in subsection 2.5.2.2). Gentilly-2 is surrounded by a dyke that was built in the mid–1990s for protection against flooding.

The CNSC and industry have co-sponsored a working group to guide the implementation of the new CNSC regulatory document RD-310, *Safety Analysis for Nuclear Power Plants*. A gap assessment between the requirements of RD-310 and the existing safety reports is either underway or planned. The results from this gap assessment will be used to prioritize the update of the NPP safety reports to meet the requirements of RD-310. A pilot project to analyze a design-basis accident according to the requirements of RD-310 was recently completed. The lessons learned are being used to develop further guidance for the implementation of RD-310.

Topic 2 – Design Issues

2 Design Issues

2.1 Overview

The design basis for Canadian NPPs is comprehensive and the NPPs meet the design requirements. The licensees have demonstrated that the consequences of design-basis accidents meet the established acceptance criteria. Also, it has been confirmed that the risk to the Canadian public from beyond-design-basis accidents is very low. This is due, in part, to the fact that CANDUs have separate and diverse means of passive cooling. The steam generators can provide sufficient cooling to prevent fuel damage (i.e., cooling is sufficient to enable returning the fuel to service). In the event the steam generators are unavailable, the large inventory of cool water surrounding the fuel can provide passive cooling to prevent accident progression. These features provide adequate time for long-term mitigation of accidents. Also, CANDUs have two groups of independent, physically separated, and diverse backup power and cooling water systems. In all, there would be adequate time available for long-term mitigation of a beyond-design-basis accident.

Immediately following the accident at Fukushima, the CNSC performed inspections at all NPPs to assess the readiness of systems that mitigate the effects of a severe accident. These inspections covered seismic preparedness, firefighting capability, backup power, hydrogen mitigation and spent fuel cooling. As mentioned in the introduction, the 12(2) letters sent to the licensees requested information on measures for the prevention and mitigation of severe accidents. The CNSC developed its *Nuclear Power Plant Safety Review Criteria* to help guide the licensees' assessment capability of the NPP design to respond to external events more severe than have been previously considered.

All licensees provided, in their responses to the 12(2) letters from the CNSC, information on the following:

- design-basis accidents
- consequential events
- progression of beyond-design-basis accidents
- backup services
- containment venting
- hydrogen management
- coolant make-up
- plant monitoring and instrumentation
- irradiated fuel bays (IFBs)

The licensees have made many design-related safety improvements since original construction and are making more. Some of these improvements have been made during refurbishment projects, as part of the ISR process. Although the risk from beyond-design-basis accidents is very low, other modifications were made in response to lessons learned from Fukushima to reduce the likelihood and consequences of severe core damage and a large release of radioactive materials. The licensees are also performing additional assessments to strengthen existing lines of defence by providing augmented capability to prevent fuel failure, mitigate severe accidents and enhance emergency response.

The Task Force recommended that the licensees should systematically verify the effectiveness of, and supplement where appropriate, the existing plant design capabilities in beyond-design-basis accident and severe accident conditions, including:

a) overpressure protection of the main systems and components
b) containment performance to prevent unfiltered releases of radioactive products
c) control capabilities for hydrogen and other combustible gases

d) make-up capabilities for the steam generators, primary heat transport system and connected systems, moderator, shield tank and IFBs
e) design requirements for the self-sufficiency of a plant site such as availability and survivability of equipment and instrumentation following a sustained loss of power and capacity to remove heat from a reactor
f) control facilities for personnel involved in management of the accident
g) emergency mitigating equipment and resources that could be stored offsite and brought onsite if needed

Ongoing design and modification work by the licensees includes coolant make-up for various systems, passive autocatalytic hydrogen recombiners (PARs), emergency filtered containment venting, and flood protection.

The CNSC continues to review the design assessments and is closely monitoring design improvements as they progress. The CNSC is also revising the design requirements and guidance in its regulatory and guidance documents in light of the lessons learned from Fukushima.

A table is provided in appendix A that summarizes the actions related to design issues that have been taken by the licensees and the CNSC in response to Fukushima.

2.2 Background

CANDU NPPs have large inventories of water that can be used as passive heat sinks in various scenarios, including the loss of electrical power. The water available for passive cooling includes water in the secondary cooling system, the primary cooling system, the moderator and the calandria vault / shield tank. Canadian NPPs also have independent and diverse backup power supplies onsite with enough fuel for many days of emergency power generation.

Existing CANDU reactors in Canada have a design life of 25 to 30 years, but that can be extended another 30 years following refurbishment. Licensees conduct an ISR before refurbishment – this is an assessment against modern standards (including modern design requirements), similar to a one-time application of PSR (see “Observations on the Canadian nuclear regulatory framework” in the introduction). Following the ISR, licensees develop and execute an integrated implementation plan based on the ISR. Upgrades that reduce the likelihood and consequences of severe core damage are performed where reasonably practicable. Examples of such upgrades are cited in subsection 2.5.

At one NPP, where refurbishment is being planned, the licensee is developing the NPP’s integrated implementation plan and has identified a number of safety improvement opportunities that will both strengthen existing barriers and enhance capabilities to prevent and mitigate beyond-design-basis accidents.

The CNSC has published regulatory document RD-360, *Life Extension of Nuclear Power Plants*, which sets requirements for NPP refurbishment projects. It includes requirements related to ISRs and integrated implementation plans. The CNSC has also published regulatory document RD-337, *Design of New Nuclear Power Plants*, which provides design requirements for new NPPs that are aligned with modern practices. Other CNSC regulatory documents that are relevant to NPP design include:

- RD-346, *Site Evaluation for New Nuclear Power Plants*
- S-294, *Probabilistic Safety Assessments (PSA) for Nuclear Power Plants*
- S-296, *Environmental Protection Policies, Programs, and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills*
- RD-310, *Safety Analysis for Nuclear Power Plants* (described in section 1)
- G-306, *Severe Accident Management Programs for Nuclear Reactors*

The Task Force observed that a small number of regulatory and guidance documents lack requirements or guidance related to lessons learned from Fukushima. The Task Force observed that the lessons learned

from Fukushima should be more fully considered in the next revisions of certain documents and in other documents that are being drafted or are only in the planning phase. The *CNSC Action Plan* assigned an action to the CNSC to initiate projects to review and amend, as necessary, regulatory documents to incorporate specific design-related findings of the Task Force for both existing and new NPPs (Action 9.1). Those amendments would update selected design-basis and beyond-design-basis requirements and expectations, including those for:

- external hazards and the associated methodologies for assessment of magnitudes
- probabilistic safety goals
- complementary design features for both severe accident prevention and mitigation
- passive safety features
- fuel transfer and storage
- design features that would facilitate accident management

The CNSC has adjusted its regulatory framework plan based on a re-prioritization, is continuing some existing regulatory document projects with an adjusted focus as described in this report, and has begun some other regulatory projects in response to this action.

Potential changes to RD-337 and G-306 that are related to severe accident mitigation and management are discussed further in subsection 3.3.1.

The Canadian Standards Association (CSA) also sets standards that are related to NPPs and which complement the regulatory documents published by the CNSC. Many of these are related to NPP design issues. The industry and the CNSC contribute to these standards and many of them are cited in the NPP operating licences. The CSA performed an initial review of existing nuclear CSA standards and concluded that they are, in general, robust. The CSA also identified some areas where additional Canadian standards could be beneficial (e.g., in the area of emergency preparedness), based on lessons learned from Fukushima, and will consider these within its Nuclear Strategic Steering Committee. The Task Force observed that the CSA standards applicable to NPPs were not reviewed by CNSC staff following Fukushima. The *CNSC Action Plan* assigned an action to the CNSC to support the review of CSA standards to take into account the lessons from the Fukushima accident through its participation in the CSA Nuclear Strategic Steering Committee (Action 9.4).

CANDU Energy[2] has been involved in the overall industry response to the Fukushima event to reassess the safety of the existing CANDU reactors. CANDU Energy has contributed to the work to determine if changes in design, equipment or processes are needed based on the Fukushima lessons learned.

CANDU Energy is also currently developing a new design, the EC6 reactor, which is a Generation III design that is intended to meet or exceed current regulatory standards such as the CNSC's RD-337, *Design of New Nuclear Power Plants*. CANDU Energy's response to the Fukushima event included a careful review of the EC6 design to ensure that its design takes maximum advantage of the lessons learned from the Fukushima event and the national and international reviews.

2.3 Design-basis accidents

The Task Force confirmed that the safety analysis of each NPP adequately considers design-basis accidents and meets or exceeds the original design intent. The analyses address credible failures in process and safety systems that can result in challenges to fuel cooling in the reactor core and IFBs. The safety report of each NPP shows that the predicted consequences for each design-basis accident (with conservative safety analysis assumptions) meet the CNSC's prescribed acceptance criteria. In addition, PSA studies have provided results that are consistent with those of the safety report for design-basis accidents.

[2] Atomic Energy of Canada Limited (AECL) before October 2011; see subsection 4.2.1 for a description of the recent evolution of CANDU Energy.

The Task Force also confirmed that operating procedures and equipment are in place in all CANDU reactors to ensure that the key safety functions are carried out for extended durations, and to bring the reactor to a safe, stable state following an accident.

Although the licensees' accident management provisions were considered to be adequate, the Task Force identified a need to more explicitly define the CNSC's requirements for accident management. The *CNSC Action Plan* assigned actions to the CNSC to clarify those requirements – see subsection 3.3.1 for details.

2.4 Re-evaluation of consequential events

Consequential events (e.g., external consequential events such as a tsunami caused by an earthquake) are considered in the PSAs. Selected cases are documented in the NPP safety reports. General information on external consequential events is provided in subsection 1.2 above. The CNSC routinely reviews the licensees' assessments of consequential events when it reviews the safety report or when it reviews other PSA-related submissions from the licensees. The Task Force did not re-evaluate those assessments as a direct response to Fukushima.

The Task Force examined internal consequential events also. Events leading to a loss of all heat sinks are of particular significance. Passive make-up to the boilers provides adequate core cooling until supplies of secondary coolant are depleted. However, some loss of heat sink events may include a consequential loss of primary coolant. For these cases, cooling by make-up to the boilers would not be effective in delaying core overheating. However, apart from this difference in timing, the accident consequences would not be significantly changed by the consequential loss of primary coolant.

Given the low likelihood of significant consequential damage to the primary pressure boundary from an event, and its limited additional impact on the end state (other than the timing), the Task Force considered that no additional work is necessary in this area.

Nevertheless, the licensees that are currently working on their PSAs are improving the screening of events, which includes consequential events. Other licensees will address this in future updates of their PSAs.

2.5 Beyond-design-basis accidents

2.5.1 Progression of beyond-design-basis accidents

2.5.1.1 Activities by the CNSC

The Task Force found that the licensees' assessment of the progression of beyond-design-basis accidents was adequate. The assessment, in combination with the detailed analyses described below in subsections 2.5.2 to 2.5.7, helped support the Task Force's conclusion that the risk to the public from beyond-design-basis accidents and events at Canadian NPPs is very low. The Task Force identified the following areas for which additional assessments of margin-to-failure, and potential design changes, should be pursued:

- instrumentation needed for accident management (see subsection 2.5.2.2 and subsection 2.5.6)
- Class I/II batteries (see subsection 2.5.2.2 and subsection 2.5.6)
- degasser condenser pressure relief (see subsection 2.5.5)
- shield tank / calandria vault pressure relief (see subsection 2.5.5)

2.5.1.2 Activities by licensees

The licensees assessed beyond-design-basis accidents in response to the 12(2) letters from the CNSC. The licensees developed a sequence based on a prolonged loss of electrical power leading to a loss of all heat sinks and, inevitably, core disassembly. For the purposes of the review of the accident sequence, it was not necessary to postulate any particular external event. Rather, it was simply assumed that electrical

supplies to power primary and secondary heat sinks were not available, regardless of the probability of occurrence of such an improbable event.

The accident scenario assumed the progressive failure of all mitigating measures. While the resulting scenario has an extremely low probability, it provided a means of identifying possible mitigation strategies at each stage of the accident and the time available to implement them.

The analysis helped demonstrate that significant time for intervention would elapse before core disassembly. The licensees demonstrated that no fuel damage would occur if AC power is restored within one hour (and within a much longer period of time for some NPPs). If simple operator actions to enable gravity feed to the steam generators are executed promptly within this one-hour timeframe, this time can be increased significantly, and a release of radioactive material would not occur for at least 17 hours after the accident. Again, operator actions can significantly extend this period to more than a day using installed equipment and water supplies, even in the absence of normal power supplies. Point Lepreau and Gentilly-2 can also use their dousing tank to extend secondary boil-down in the steam generators to four days. It is worth noting that, in the 1980s, Point Lepreau installed a steam-driven auxiliary feedwater pump that provides up to seven hours of boiler inventory following a loss of AC power to ensure continuous fuel cooling without operator intervention. This would provide ample time for operators to depressurize the boilers to enable gravity feed from the dousing tank, which would simplify accident response.

In summary, assuming that the operator takes very simple actions during the sequence to use the steam generators as a heat sink, at least 17 hours, and up to several days, will elapse before core disassembly. Connection of temporary power and additional water supplies can extend this period indefinitely.

Licensees have conducted various other severe accident progression analyses as part of Level-2 PSA to comply with regulatory standard S-294, *Probabilistic Safety Assessments (PSA) for Nuclear Power Plants*.

Although the risk from beyond-design-basis accidents is very low, the licensees have evaluated, proposed, or in some cases have already begun safety enhancements. Some noteworthy ones are described in the following subsections.

2.5.2 Backup services

The CANDU NPPs in Canada have two independent backup power supplies.

2.5.2.1 Activities by the CNSC

The Task Force confirmed the availability of several days of backup power in the event that the normal source of power is lost for an extended period, thus providing significant time for mitigating action.

See subsection 2.5.6 for discussion of instrumentation and control and the batteries that provide backup power to instrumentation and control.

2.5.2.2 Activities by licensees

After Fukushima, Darlington and Pickering A installed and are installing, respectively, additional flood barriers to provide additional margin for standby and emergency power generators. This was one of several pragmatic safety upgrades that were identified and executed by the licensees to improve defence against severe events.

As part of their submissions to the CNSC, the licensees demonstrated that their backup power supplies are independent, physically separated, and diverse, thus providing high confidence that power can be restored to vital equipment. With many days' supply of fuel for emergency power generators available onsite, adequate time is available to take long-term mitigating action.

Following a loss of all electrical power, batteries support essential services until normal, backup, or emergency AC power is available. CANDU reactors have the guaranteed capability to support all essential electrical equipment for 40 minutes, although the batteries may last significantly longer. This duration is short compared to other essential supply capabilities. Once batteries are exhausted, most control and instrumentation functions are lost. Instrumentation and control is discussed further in subsection 2.5.6.

The issue of backup power for licensees' primary and alternate emergency facilities and equipment, in the event of a loss of external power, is discussed in section 5.

Although the focus of this section is the loss of all electrical power, a much more likely outcome for Canadian NPPs would be that either the normal power backup (standby generators) or the emergency power backup (emergency power supply) work as designed and electrical power is not lost in its entirety for a prolonged period. The licensees demonstrated that there is sufficient fuel, immediately available to these generators, to last several days. For example, each standby generator has enough fuel available to operate at full design power for three to four days.

The licensees are taking further action to procure emergency equipment (e.g., power supplies, pumps) that could be stored onsite or offsite and used to provide backup services during a beyond-design-basis accident (see subsection 3.5.2 for further details). The need for additional protective measures for backup services is being assessed through the licensees' implementation of S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*.

2.5.3 Containment venting

All NPPs have the means to vent the containment to protect containment structural integrity. An emergency containment filtered discharge system is a complementary design feature intended to protect the containment envelope if the internal containment pressure approaches the containment strength limit, and to remove radioactive materials from any gases vented from the containment in a severe accident. The multi-unit NPPs have emergency filtered air discharge systems that can filter the air vented from containment for any design-basis accident. These systems may also be effective for some severe accidents.

Point Lepreau has already installed an emergency containment filtered vent system as part of its refurbishment project to meet its Level 2 PSA limits. It is manually actuated, does not require an external source of power and is used to relieve containment pressure for the conditions that could be present in a severe accident. The system uses a high-efficiency scrubber and filtration unit to filter out the vast majority of fission products so radiation exposure to the public would be limited to acceptable levels in the event of a release. The installation at Point Lepreau maximizes vent availability by locating the controls in an area that would more likely be accessible during an accident.

The Task Force determined that similar venting provisions need to be considered for all other Canadian NPPs. The *CNSC Action Plan* assigned an action to the other licensees to evaluate the means to prevent the failure of the containment systems and, to the extent practicable, unfiltered releases of radioactive products in beyond-design-basis accidents including severe accidents. If unfiltered releases of radioactive products in beyond-design-basis accidents including severe accidents cannot be precluded, then additional mitigation should be provided (Action 1.3).

The options being considered to address Action 1.3 include emergency filtered containment vents. Gentilly-2 has begun engineering work for the addition of an emergency containment filtered vent system during its planned refurbishment.

The licensees' processes to make decisions related to venting containment are described in section 5.

2.5.4 Hydrogen management

Hydrogen can be produced in certain phases of severe accident progression. The Fukushima accident demonstrated the significant threat to the integrity of the containment from hydrogen explosions.

To deal with the hazard of large quantities of hydrogen being produced in a severe accident and causing hydrogen explosions, most CANDU plants are equipped with AC-powered igniters, which are intended to control hydrogen concentrations in the containment atmosphere by initiating limited "burns" before a potentially explosive concentration is reached. Recently, licensees have initiated installation of passive autocatalytic recombiners (PAR). These are devices intended to passively (without the need of external power) remove hydrogen from the containment atmosphere. All Canadian NPPs have either installed PARs (e.g., as part of refurbishment projects or post-Fukushima follow-up) or are in the process of installation.

The *CNSC Action Plan* assigned an action to the licensees to complete the installation of PARs as quickly as possible (Action 1.4). The Task Force expects that all NPP licensees will provide confirmatory assessments demonstrating adequacy of PARs for severe accidents, and assess the need for PARs in the IFB areas.

For those units without PARs, the licensees are either continuing the planning or are continuing to install PARs, and in some cases have accelerated those activities.

2.5.5 Availability and make-up for heat sinks

Availability of multiple heat sinks and make-up provisions (such as dedicated lines intended to replenish water inventory in important plant systems) are important lines of defence against accidents progressing to severe core damage. In CANDUs, the steam generators, calandria, and shield tank / calandria vault are important supplementary heat sinks. Heat removal and make-up are also important for the IFBs. Water can be added to these systems to prevent, slow down or terminate the fuel degradation process. Water is typically provided either by in-containment reserves (such as a dousing tank) or by an external connection to the reactor building or IFB.

2.5.5.1 Activities by the CNSC

The Task Force reviewed the licensees' assessments of relevant details of the CANDU design and confirmed the availability of a large inventory of cool water surrounding the fuel and various options for additional cooling in the event of failures.

The *CNSC Action Plan* assigned an action to licensees to evaluate means to provide coolant make-up to the primary heat transport system, steam generators, moderator, shield tank / calandria vault, IFB and dousing tank, where applicable (Action 1.7). The Task Force also noted the potential for creating a path for unfiltered releases (containment bypass) through a make-up line.

The Task Force examined in detail the licensees' submissions related to the potential boiling and venting of primary coolant. It determined that the capacity of the degasser condenser relief valve (see next subsection) may not be adequate in a beyond-design-basis accident that leads to boiling of primary coolant. Inadequate relief capacity would lead to earlier failure of pressure tubes and shorter available recovery times than would be the case if relief capacity was adequate. The *CNSC Action Plan* assigned an action to licensees to verify the capacity of the degasser (or bleed) condenser relief valves (Action 1.1).

The *CNSC Action Plan* also assigned an action to licensees to investigate if the shield tank is a viable heat sink in severe accidents (see next subsection) and, if it provides significant benefit, to investigate options to ensure that relief capacity is adequate (Action 1.2).

2.5.5.2 Activities by licensees

The licensees systematically assessed all existing and potential means to provide make-up coolant to various reactor systems. Licensees also examined the possibility of a loss of all heat sinks, including the scenario where there is no recovery action by the operator (see subsection 2.5.1.2). In that case, secondary water inventory boils away, leading to heat-up and boiling of the primary coolant. Steam is vented through relief valves into the degasser (or bleed) condenser. The degasser condenser pressurizes and its relief valves open to vent steam into containment.

Further in the accident sequence, after the onset of severe core damage, the core debris falls progressively to the bottom of the calandria vessel. Heat is transferred through the calandria vessel wall into the shield tank (or calandria vault on some designs). The steam generated by boiling in the shield tank would cause the tank to pressurize. The licensees determined that the shield tank relief valves may not have sufficient capacity in this beyond-design-basis accident. The shield tank would fail due to overpressure and, if the rupture is low in the vessel, most or all of the available water would be lost, leading to an earlier failure of the calandria vessel than would be the case if adequate relief was available. This reduces the time available for mitigating action and for offsite emergency measures.

The licensees are evaluating means to provide additional coolant make-up from alternate sources; some modifications are already in progress (Action 1.7). Some NPPs have already procured additional equipment and have implemented procedures for its deployment.

The licensees are performing or have performed appropriate analysis to verify the capacity of the degasser (or bleed) condenser relief valves to respond to a complete loss of heat sinks (Action 1.1).

The licensees are re-examining the capability of the shield tank (or calandria vault) relief to discharge steam and hence maintain that system as a heat sink during severe accidents (Action 1.2). Some assessments are complete and, in one case, modifications have been made to improve performance during accidents.

2.5.6 Plant monitoring and instrumentation

This subsection covers instrumentation and control as well as the functioning of the control rooms.

The batteries that provide backup when AC power is lost are only guaranteed to support all essential electrical equipment for 40 minutes, although the batteries may last significantly longer. Once batteries are exhausted, most control and instrumentation functions are lost.

The monitoring and control instrumentation has been designed and maintained to ensure correct functional performance under the conditions assumed in the NPP design basis. Correct performance of key instrumentation is also essential during beyond-design-basis accidents in diagnosing the plant state and emerging safety challenges, such as containment pressure buildup or hydrogen and fission product accumulation.

2.5.6.1 Activities by the CNSC

The *CNSC Action Plan* assigned an action to licensees to explore options to extend the duration of power supplies, following a loss of all AC power, to key instrumentation and control equipment needed to manage beyond-design-basis accidents, including severe accidents (Action 1.10).

The Task Force evaluated plant monitoring and instrumentation survivability in severe accident conditions and the licensees' plans to address this question. The *CNSC Action Plan* assigned an action to licensees to provide a reasonable level of confidence that the equipment and instrumentation needed to guide accident management will function in the severe accident environment for the duration for which it is needed (Action 1.8). The Task Force found that the licensees should assess equipment survivability

(not full environmental qualification) and/or the need for installing hardened instrumentation, to provide reasonable assurance that adequate information will be available to the operator.

The Task Force also noted that Class I/II batteries are not formally qualified for external hazards (except at Pickering A where Class I batteries are seismically qualified). The Task Force recommended that licensees should determine the minimum design requirements for qualification of Class I/II equipment to mitigate beyond-design-basis accidents involving loss of all AC power and verify that the equipment can survive the accident conditions.

The *CNSC Action Plan* also assigned an action to the licensees to ensure the habitability of control facilities under conditions arising from beyond-design-basis and severe accidents (Action 1.9).

2.5.6.2 Activities by licensees

Licensees have established, or will soon establish, special measures to obtain information on which to base recovery actions for that period when station batteries have become exhausted but portable diesel-powered generators have not yet been installed. Examples of these measures include developing load-shedding procedures to extend battery life up to when portable diesel power generators are installed or using additional battery-powered instrument readout devices.

The licensees are continuing to explore options to extend the duration of power supplies to instrumentation and control equipment. Licensees are installing, or evaluating the installation of, generators to provide backup power for instrumentation, as well as additional battery-powered instrument readout devices, as noted above (Action 1.10).

The licensees are demonstrating that the equipment and instrumentation necessary for SAM and essential to the execution of SAM guidelines will perform their function in the severe accident environment for the duration for which they are needed (Action 1.8). Where additional equipment or design modifications are found to be necessary, the licensees will develop plans and schedules for implementation.

The licensees are evaluating the habitability of control facilities under conditions arising from beyond-design-basis and severe accidents (Action 1.9). Point Lepreau has already provided flood protection for the secondary control area tunnel.

2.5.7 Irradiated fuel bay

The IFBs at most Canadian NPPs are in-ground. Most of the IFBs were not designed to accommodate boiling in the bay. For those NPPs, boiling potentially increases the risk of structural cracking, which could lead to leakage from the IFB and a reduction in the time to fuel uncovering. Further, the lowering of the water level could inhibit manual operations in the IFB area due to elevated radiation fields. The Darlington IFB was designed to accommodate boiling, so this finding does not apply to Darlington.

The licensees' submissions in July 2011 do not generally discuss the need for hydrogen mitigation in the IFB area. The licensees concluded that, as long as water inventory is maintained and the fuel remains submerged, hydrogen generation is not an issue.

2.5.7.1 Activities by the CNSC

The Task Force recommended that licensees develop a strategy to mitigate the concerns of IFB boiling and structural failure. The *CNSC Action Plan* assigned an action to licensees to evaluate the structural integrity of the IFB at temperatures in excess of the design temperature limit (Action 1.6). If structural failure cannot be precluded, the licensees should demonstrate that procedures and equipment are in place to provide make-up water that will compensate for possible leakage (e.g., high-capacity make-up or sprays). The Task Force noted that upgrades to provide an enhanced make-up capability are already being considered. The Task Force noted that these upgrades should consider possible leakage arising from structural failures that may occur when the temperature limits are exceeded. The *CNSC Action Plan* also

assigned an action (also Action 1.6) to licensees to evaluate the consequences of the loss of shielding (e.g., can manual actions be performed in high radiation fields that may arise from a low water level?).

Despite the licensees' conclusion that hydrogen generation in the IFB area is not an issue, the *CNSC Action Plan* assigned an action to the licensees to evaluate the need for hydrogen mitigation in the IFB area, in the event that draining of the IFB following a beyond-design-basis accident cannot be precluded (Action 1.5).

2.5.7.2 Activities by licensees

For those NPPs with IFBs that were not designed for boiling, the licensees demonstrated that a loss of cooling can be tolerated for about 16 hours before the structural design temperature is reached.

The licensees are evaluating, or have already evaluated, the structural response of the IFB to seismic events and elevated temperatures (up to boiling). The licensees are continuing to evaluate potential enhancements to improve make-up capacity to the IFB (Action 1.6). The licensees are using the results of the evaluations to determine if additional hydrogen mitigation is needed for beyond-design-basis accidents involving the IFB (Action 1.5).

The licensees are also assessing options for water and temperature monitoring from a safe location in the case of a loss of inventory.

Topic 3 – Severe Accident Management and Recovery (Onsite)

3 Severe Accident Management and Recovery (Onsite)

3.1 Overview

The *Class I Nuclear Facilities Regulations* under the *Nuclear Safety and Control Act* require NPP licensees to maintain onsite emergency plans and a response capability. Emergency plans and programs, including accident management provisions, are submitted to the CNSC as part of the licence application and are part of the licensing basis. The CNSC also observes emergency drills and exercises to confirm adequate implementation of the licensees' onsite provisions in their emergency response plans.

The CNSC developed its *Nuclear Power Plant Safety Review Criteria* to help guide the licensees' assessment of their capability to mitigate severe accidents.

Severe accident management guidelines (SAMG) have been largely implemented at all plants except one, which is planned for refurbishment shutdown later in 2012. SAMG includes development of procedural guidance for the operating staff and technical support groups, specific training and appropriate drills. All NPP licensees reviewed their procedural guidance and design capabilities of operating NPPs to cope with accidents, including those involving significant core damage. The licensees are pursuing additional enhancements to SAMG, such as increasing the focus on multi-unit events, IFB events, and severe accidents triggered by extreme events.

All licensees provided, in their responses to the 12(2) letters from the CNSC, information on the following:

- status of the implementation of SAMG
- NPP design capabilities for SAM
- assessments of severe accidents
- use of external resources
- IFBs
- multi-unit considerations

The Task Force reviewed the licensees' assessments of severe accidents and their provisions for using existing plant capabilities, complementary design features and emergency mitigating equipment in SAM and recovery. The Task Force confirmed the soundness of the provisions, and several possibilities for further enhancements were identified, most of which are common to all licensees. These review findings identified a need either for additional information on the already ongoing activities, or for licensees to consider further enhancements to the capability of NPPs to cope with severe accidents. The Task Force recommended enhancements of models of beyond-design-basis accidents, including ones developed for multi-unit NPPs.

The Task Force also considered the licensees' plans for the use of external resources, such as equipment, fuel and people, in mitigating severe accidents. Formal plans for inter-utility co-operation in matters such as availability of skilled personnel, provision of technical support and the sharing of equipment are being considered.

The Task Force assessed the CNSC's regulatory framework related to SAM and made three recommendations for the CNSC to pursue:

- Revise the *Radiation Protection Regulations* to introduce additional clarity on emergency dose limits for workers during the phases of an emergency and to establish return-to-work criteria.
- Develop a dedicated regulatory document on accident management.
- Add a condition to the NPP operating licences that explicitly requires the licensees to have an accident management program that includes SAM.

A table is provided in appendix A that summarizes the actions related to SAM that have been taken by the licensees and CNSC in response to Fukushima.

3.2 Background

A severe accident is a beyond-design-basis accident that involves significant core degradation. SAM is one of the components of defence in depth used in the overall safety assurance framework. SAM provides for the management of risks posed by unlikely events leading to severe accidents in an NPP. The CNSC's expectations for SAM are given in CNSC guidance document G-306, *Severe Accident Management Programs for Nuclear Reactors*, published in 2006.

SAM focuses on preventing the progression of a beyond-design-basis accident into a severe accident or mitigating a severe accident when the preventive means have failed. SAM includes the development of guidance and procedures for use by NPP staff. The integration of SAMG into emergency plans offers enhanced technical support to the emergency response organizations, and the additional staff are integrated into the existing structure.

SAM is enabled by explicit assessment of severe accident progression, which is required to develop an understanding of likely challenges to key systems (calandria, containment, etc.), timing of events, required coolant make-up capability, extent of fuel damage and the probable source term.

SAM can be enhanced by bringing in external resources to supplement or replace the onsite resources and may include fuel, water, electric power or equipment such as pumps or generators. Availability of emergency equipment was shown to be crucial during the Fukushima event and could allow avoiding or terminating a severe accident early enough to prevent any radioactive releases to the environment.

IFBs contain significant quantities of irradiated fuel. The long-lived radioactive materials could pose a significant threat if the spent fuel is uncovered and subsequently overheats.

As events at the Fukushima plant have demonstrated, the multi-unit NPPs face unique challenges. Specifically, events affecting more than one unit at a time need to be considered; such events would exacerbate challenges that the plant personnel would face during an accident. The events and consequences of an accident at one unit may affect the accident progression or hamper accident management activities at the neighbouring unit; available resources (personnel, equipment and fuel) would need to be shared among several units.

3.3 Severe accident management and severe accident management guidelines

All Canadian NPPs have a comprehensive set of documentation covering normal plant operation, minor upsets, and accident conditions that are routinely tested in onsite drills. Historically, these drills tested organizational capability to deal with design-basis accidents (drills and exercises are described in more detail in section 5). As part of SAMG development and implementation prior to Fukushima, operating documentation was prepared to explicitly cover severe accidents. The SAMG suite includes a number of procedures and supporting documents, with the fundamental goals of:

- maintaining or restoring fuel cooling
- maintaining the integrity of the containment envelope
- minimizing releases of radioactive products to the environment

SAMG were developed by building both on the existing structure of emergency operating procedures and on international experience and guidance adapted to the CANDU design and expected severe accident progression (the current CANDU SAMG program is based on an adaptation of the Westinghouse Owners Group SAMG). A symptom-based approach was used to allow NPP personnel to identify suitable actions to bring the NPP to a stable and controlled state. As an initial step, the SAMG programs have been geared towards developing guidelines that start at the at-power state. These include:

The consultation process helped ensure that other organizations, as well as Canadian citizens, had an opportunity to provide input into the CNSC's response to Fukushima. More details on these activities are provided in the introduction.

Part of the Task Force's review included an assessment of various national (and other) organizations (including itself) that play significant roles in nuclear safety and nuclear emergency preparedness. In particular, the Task Force focused on the management of a nuclear emergency in Canada, which is a shared responsibility among municipal, provincial and federal jurisdictions. The Task Force reviewed the plans and capabilities of the relevant federal (as well as provincial) authorities to identify any outstanding issues related to coordinated nuclear emergency management. The *CNSC Action Plan* assigned actions to the CNSC (Action 6.1) to address, to the extent possible, some of the issues related to other national organizations involved in emergency preparedness.

At the time of the accident at Fukushima, an IRRS mission to Canada was already being planned in 2011 to follow up on findings from the initial IRRS mission to Canada in 2009. The CNSC decided to increase the scope of its follow-up IRRS mission to include the recently developed "Fukushima module", thereby providing a review by international nuclear regulatory experts of the CNSC's response to Fukushima. More details on the IRRS follow-up mission are provided in the introduction.

The President of the CNSC also formed the External Advisory Committee to provide an independent assessment of the CNSC's overall response to Fukushima. More details on this Committee are provided in the introduction.

4.3.2 Activities by other federal authorities

Health Canada, with input from its federal and provincial coordinating committees for nuclear emergency management, addressed the post-Fukushima situation through the following activities:

- undertaking a lessons-learned review of the response to the Fukushima emergency, focusing on the scientific assessment and timely decision making for offsite emergency response and implications for the update of the FNEP
- revising federal guidance for intervention during a nuclear emergency
- engaging federal, provincial and international partners to address areas of improvement in offsite emergency management

4.3.3 Licensees and CANDU-related organizations

In direct response to the events at Fukushima, the Canadian licensees helped establish the CANDU Industry Integration Team (CIIT) consisting of representatives from domestic and offshore CANDU facility owners. The purpose of the CIIT is to ensure that Fukushima response activities are:

- coordinated and integrated in a manner such that the collective approach is consistent and aligned
- based on a common understanding of regulatory requirements
- bounded in scope and well managed

Within its mandate, the CIIT also initiated specific industry working groups through the auspices of COG to make progress on and resolve industry-wide technical, programmatic, and research and development issues that are raised during Fukushima response activities. These include working groups for:

- emergency preparedness
- design modifications associated with Fukushima
- projects to address several of the SAMG-related findings from the Task Force

CANDU Energy (as well as AECL before October 2011) has been involved in the overall industry response to the Fukushima event. See subsection 2.2 for a brief description of CANDU design activities related to lessons learned from Fukushima.

The CIIT conducts meetings every two weeks for its domestic members and a monthly meeting that includes the international CANDU members.

Topic 5 – Emergency Preparedness and Response and Post-Accident Monitoring (Offsite)

5 Emergency Preparedness and Response and Post-Accident Monitoring (Offsite)

5.1 Overview

In Canada, the provinces have the lead for offsite emergency preparedness within their boundaries and other participants contribute. At the federal level, Public Safety Canada leads the all-hazards Federal Emergency Response Plan (FERP) to address areas of federal jurisdiction and support the provinces and territories. Health Canada administers the comprehensive Federal Nuclear Emergency Plan (FNEP), which is an event-specific plan to support a Canadian province or territory as a consequence of any domestic, trans-boundary, or international nuclear emergency. The CNSC assesses licensees' emergency preparedness programs and inspects their emergency drills and exercises. The CNSC would continue to have regulatory oversight of the licensee during a nuclear emergency.

The Task Force reviewed the plans and capabilities of lead provincial and federal agencies to identify any outstanding issues related to coordinated nuclear emergency management. Overall, coordination between the various organizations is good – all players work together to ensure that safety of the public and environment will be protected during an extreme event. Also, the offsite support components of the licensees' emergency response plans are adequately implemented and tested regularly by drills and exercises. In all, there are no significant gaps in emergency preparedness, i.e., no issues that require immediate action at the NPP, provincial or federal levels.

The Task Force found that communications protocols are well documented. All players work co-operatively through joint emergency operations centres to coordinate protective actions for the public and provide the media with information. Although the provincial and federal nuclear emergency management plans, procedures and arrangements primarily address preparedness and response, there are no guidelines and plans for the recovery phase.

The Task Force noted that the FNEP has not been updated since 2002. Following publication of the FERP in 2009, Health Canada formally launched the process to revise and integrate the FNEP with the FERP as an event-specific annex. The revision process has also addressed lessons learned from the response to the Fukushima emergency. In anticipation of this update, a memorandum of understanding was established in 2007 between Health Canada and Public Safety Canada to describe the interface between the two plans in the event of a nuclear emergency. Additionally, while various organizations and jurisdictions have routinely exercised their plans and capabilities in a range of exercises, the effectiveness of all arrangements has not been tested in a full-scale national exercise since 1999. The Task Force recommended actions to help address identified shortcomings in conjunction with the key stakeholders. Full-scale exercises, including at the national level, are being planned with the involvement of various stakeholders.

The Task Force found that there should be a formal process for national-level oversight of offsite emergency preparedness. It recommended that the CNSC initiate a project to amend the *Class I Nuclear Facilities Regulations* to require submission to the CNSC, as part of the licensing process, of applicable provincial and municipal offsite emergency plans along with evidence to support how the licensees are meeting the requirements of those plans. Health Canada is reviewing the national-level oversight of offsite nuclear emergency plans, programs and performance through the use of its federal and provincial coordinating committees for nuclear emergency management.

The Task Force observed that emergency preparedness at the provincial level is also adequate. The provincial nuclear emergency plans are well integrated with the emergency plans of the NPPs. The provinces and the CNSC are pursuing the resolution of the following issues, which are applicable at the national level also:

- Provincial plans primarily address preparedness and response but there are no guidelines and plans for the recovery phase.
- Full-scale emergency exercises should have a higher priority at the provincial level.

The Task Force made other recommendations to improve offsite emergency preparedness at the NPPs based on lessons learned from Fukushima. The licensees are pursuing the following enhancements:

- formal extension of emergency plans to severe events and/or multi-unit accidents
- enhancement of training and clarification of roles
- improvements to robustness of licensees' primary emergency facilities, alternate facilities, and emergency response equipment
- confirmation of agreements with stakeholders for support and supplies
- post-accident source term estimation
- dose modelling
- field radiation monitoring

Emergency preparedness workshops involving all authorities, licensees and other stakeholders are being held to discuss issues and opportunities for improvement.

Canada is considering an international peer review of emergency preparedness that could address aspects of offsite emergency plans at various levels.

A table is provided in appendix A that summarizes the actions related to emergency preparedness and response that have been taken by the licensees and the CNSC in response to Fukushima.

5.2 Background

Emergency preparedness and response for nuclear-related events, such as an accident at a Canadian NPP, is a shared responsibility between the licensees, the provinces and municipalities in which the NPP is located, and federal departments and agencies. The provinces have the lead.

As mentioned in the introduction, the 12(2) letters sent to the licensees requested information on their provisions for emergency preparedness. The CNSC developed its *Nuclear Power Plant Safety Review Criteria* to help guide the assessment of not only the licensees' emergency preparedness measures but also the measures of other key authorities in emergency preparedness, such as the provinces and various federal departments.

The Task Force's review of international lessons learned from Fukushima identified the following topics related to emergency response:

- enhancement of coordination between federal, provincial and municipal authorities
- international considerations in an emergency

5.2.1 Role of the federal government

In a nuclear emergency, the federal government will manage areas within its jurisdiction and, at the request of a province or territory, will provide support to the province or territory during a nuclear emergency via the resources of multiple federal departments and agencies. These resources are organized according to the FERP and the FNEP.

5.2.1.1 Health Canada and the FNEP

The FNEP is administered by Health Canada. The FNEP integrates with the overarching emergency response arrangements described by the FERP and complements the relevant nuclear emergency plans of other jurisdictions inside or outside Canada. It describes the roles and responsibilities of federal departments and agencies and the measures they should follow to manage and coordinate the federal response to a nuclear emergency based on the scenarios identified in the plan, focusing on the provision of coordinated scientific support to manage radiological consequences. There are 19 federal departments and agencies involved in the latest version of the FNEP, including Health Canada, Public Safety Canada and the CNSC. All departments and agencies are responsible for independently developing, maintaining and implementing their own organization-specific emergency response plans that support the objectives of the FERP and FNEP. The arrangements described in the FNEP can be activated to respond to areas of federal jurisdiction if federal support to a Canadian province or territory is required, as a consequence of any domestic, trans-boundary or international incident as identified in the plan. Annexes to the FNEP describe interfaces between the Government of Canada and the provincial emergency management organizations in the provinces that host NPPs (Quebec, Ontario and New Brunswick).

The occurrence of a radiological or nuclear emergency would lead to a sequence of response actions and technical support functions focused on managing the event, mitigating its effects, and protecting the public and environment against actual or potential radiological impacts. The extent of coordinating arrangements described in the FNEP and of individual departments and agencies would depend on the nature, magnitude and location of the event, responsibilities within federal jurisdiction and the level of assistance requested. The federal government would conduct emergency operations that are within the federal mandate, and would provide, in accordance with prior arrangements, or at the request of the provincial government, national support services and resources coordinated through the National Emergency Response System and provisions of the FNEP or a provincial annex in the FNEP.

Under the FNEP, a technical assessment group would be convened to provide the federal-level technical assessment of the threat and risk associated with the radiological hazard and associated protective action recommendations for mitigating the radiological consequences on health, safety, property and the environment. The technical assessment group might establish task teams or experts within its operations to undertake specific technical assessment functions, such as environmental pathways modelling, radiological assessment or field-based monitoring and surveillance.

The FNEP cites Health Canada's *Canadian Guidelines for Intervention During a Nuclear Emergency*, which address protective measures for the public, including evacuation. The guidelines, developed by Health Canada, recommend evacuation of the population if the projected whole-body dose exceeds 50 mSv in seven days. These guidelines are currently being updated based on the latest guidance from the International Commission on Radiological Protection and IAEA (Basic Safety Standards).

In addition to managing the FNEP, Health Canada's Radiation Protection Bureau is responsible for operating various radiological monitoring networks: the Fixed Point Surveillance Network, the Canadian Radiation Monitoring Network and the radiation monitoring stations within the Canadian portion of the Comprehensive Nuclear Test-Ban Treaty International Monitoring System. See appendix C for details. It also operates radiological sample analysis laboratories (including mobile facilities), contamination monitoring capabilities (including portal monitors), and internal and external dosimetry programs for exposed individuals (including emergency workers). It provides radiation protection guidance and expertise, and organizes emergency exercises within the framework of the FNEP. Health Canada works closely with Environment Canada–Canadian Meteorological Centre to provide a suite of atmospheric modelling capabilities for nuclear emergency management.

5.2.1.2 Public Safety Canada

Under Canada's *Emergency Management Act*, the federal Minister of Public Safety is responsible for coordinating the Government of Canada's response to an emergency. The FERP is an all-hazards plan that outlines the processes and mechanisms to facilitate an integrated Government of Canada response to an emergency and to eliminate the need for federal government institutions to coordinate a wider whole-of-government response. The FERP is designed to harmonize federal emergency response efforts with those of the provinces and territorial governments, non-government organizations and the private sector. A key component of the FERP is the Federal Emergency Response Management System (FERMS), which helps ensure that subject matter experts and liaison officers understand their responsibilities during emergencies.

In addition, the Minister of Public Safety is responsible for promoting and coordinating emergency management plans of federal departments and agencies. All federal ministers are responsible for developing emergency management plans in relation to risks in their areas of accountability. Individual departmental activities and plans that directly or indirectly support the FERP's strategic objectives contribute to the integrated Government of Canada response.

5.2.1.3 Canadian Nuclear Safety Commission

The CNSC continues to have regulatory oversight of the licensee during a nuclear emergency. The CNSC observes emergency exercises to confirm adequate implementation of onsite and offsite provisions in nuclear emergency response plans. The CNSC also participates directly in some exercises to practise discharging its own emergency-related responsibilities.

5.2.1.4 Natural Resources Canada

Natural Resources Canada is responsible for providing emergency radiation mapping and surveying services, providing policy advice and coordinating federal actions in relation to nuclear liability.

5.2.2 Role of the provinces and municipalities

The provincial governments are responsible for overseeing the health, safety and welfare of their inhabitants and the protection of the environment within their jurisdiction. Accordingly, they assume lead responsibility for the arrangements necessary to respond to the offsite effects of a nuclear emergency by enacting legislation, maintaining emergency plans and procedures, and providing direction to the municipalities where the NPPs are located. The provinces maintain emergency operations centres to coordinate protective actions for the public and provide the media with information. In addition, the provincial governments coordinate support from the licensees and from the Government of Canada (described in the next subsection) during the preparedness activities as well as during the response.

The provinces, in co-operation with the local and federal jurisdictions, have established procedures to deal with any significant offsite nuclear impacts, primarily related to providing for urgent protective action. These procedures include:

- limiting access to the affected zone(s)
- providing temporary shelter to the affected population
- evacuating buildings or premises in areas near the NPP
- distribution of potassium-iodide (KI) to the affected population to block thyroid uptake of radiation
- implementing ingestion control measures such as quarantining farm animals, banning the sale of affected foodstuff and restricting the use of affected drinking water
- establishing emergency worker centres and reception centres

Basic details of the nuclear emergency plans for each province in which Canadian NPPs are located are provided in appendix B.

5.2.3 Role of licensees

The NPP licensees are responsible for onsite preparedness and response (described in section 3). The licensees are also required, by the *Class I Nuclear Facilities Regulations* under the *Nuclear Safety and Control Act*, to support the offsite authorities in their planning and response to a nuclear emergency with offsite consequences. Information pertaining to the proposed emergency measures must be included in the licence application to the CNSC. The application should describe the proposed facility, activities, substances and circumstances to which its emergency plans apply. The emergency plans should also be commensurate with the complexity of the associated undertakings, and the probability and potential severity of the emergency scenarios associated with the operation of these facilities. Therefore, the emergency plans must contain a description of the proposed measures to prevent or mitigate the effects of accidental releases of nuclear and/or hazardous substances on the environment, the health and safety of persons, and the maintenance of security, including measures to notify and assist offsite authorities and test the implementation of these measures.

Each licensee's emergency plan is specific to its particular site and organization; however, they all typically cover the following topics:

- documentation of the emergency plan
- basis for emergency planning
- personnel selection and qualification
- emergency preparedness and response organizations
- staffing levels
- emergency training, drills and exercises
- emergency facilities and equipment
- emergency procedures
- assessment of emergency response capability
- assessment of accidents
- activation and termination of emergency responses
- protection of facility personnel and equipment
- interface arrangements with offsite organizations
- arrangements with other agencies or parties for assistance
- recovery program
- public information program
- public education program

The licensees' emergency plans and programs are reviewed by the CNSC. They become binding upon the licensee, as a condition in the operating licences, and are subject to the CNSC's licensing and compliance oversight processes.

The licensees regularly review their emergency plans and revise them to address changes in their operational activities as well as to take into account other relevant factors and circumstances, such as operating experience.

The licensees routinely conduct self-audited emergency drills and, less frequently, full-scale exercises involving offsite provincial and, where applicable, municipal emergency response organizations.

5.3 Findings of the CNSC Fukushima Task Force and follow-up

The Task Force reviewed the plans and capabilities of the licensees and the lead provincial and federal agencies to identify any outstanding issues related to coordinated nuclear emergency management. The

Task Force verified that there are no significant gaps in nuclear emergency planning at these levels. All responsible parties work together to ensure that the safety of the public and environment will be protected in the event of a nuclear emergency.

The Task Force assessed several issues pertaining to the federal level, the provinces and the licensees; these are discussed in subsections 5.3.1, 5.3.2, and 5.3.3, respectively. Issues that are common to more than one of these responsible parties are discussed in subsection 5.3.4.

5.3.1 National level

The Task Force concluded that there are no nuclear emergency response issues that require immediate action at the federal level. The FNEP is both mature and comprehensive.

The FNEP, last updated in 2002, is currently being revised to integrate with the FERP and address lessons learned from the response to the Fukushima emergency. In the interim, a memorandum of understanding was established between Health Canada and Public Safety Canada to describe the interface between the two plans.

The *CNSC Action Plan* assigned an action to the CNSC to initiate and facilitate discussions with provincial and federal nuclear emergency planning authorities to ensure understanding of these findings and pursue recommended solutions (Action 6.1). Health Canada began a process to update the FNEP in 2010 following publication of the FERP. There is ongoing effort and consultation between Health Canada, Public Safety Canada and other federal departments to review and update the FNEP and to align it with Public Safety Canada plans and responsibilities. Preparedness activities within the framework of the FNEP are coordinated through Health Canada's federal and provincial coordinating committees for nuclear emergency management.

5.3.2 Provinces

The Task Force concluded that there are no emergency response issues that require immediate action at the provincial level. Although some opportunities for improvement were identified, overall each province has developed well-documented emergency plans, and these plans and their elements are well integrated in the licensees' onsite emergency plans.

The following are highlights of the findings related to the provincial emergency preparedness plans. For addition background information on those findings, see appendix B.

The Task Force observed that, prior to the recent exercise in New Brunswick, it had been at least five years since the provinces conducted full-scale nuclear emergency exercises. The need for more frequent nuclear emergency exercises is discussed in greater detail in subsection 5.3.4.3.

The Task Force found that the basis for the current nuclear emergency plans and offsite arrangements in the Province of Ontario is a single-unit accident scenario and does not explicitly consider a multi-unit accident scenario. Also, there are ongoing public alerting issues in the 3-km zone around Pickering, and the new 10-km public alerting requirement has not been fully implemented. Furthermore, the Task Force observed that the effectiveness of the approach for KI pills in Ontario (stocking at predetermined locations rather than pre-distribution to all households) has not been validated. The *CNSC Action Plan* assigned an action to the CNSC to meet with Ontario nuclear emergency planning authorities to ensure understanding of these findings and pursue recommended solutions (Action 6.1).

The Task Force noted that there is no automated public alerting system around Gentilly-2. Also, the Province of Quebec has not recently updated its nuclear emergency plan. The *CNSC Action Plan* assigned an action to the CNSC to meet with Quebec's nuclear emergency planning authorities to ensure understanding of these findings and pursue recommended solutions (Action 6.1).

The Task Force noted that the Province of New Brunswick does not have the capability for predicting offsite effects. The *CNSC Action Plan* assigned an action to the CNSC to meet with New Brunswick nuclear emergency planning authorities to ensure understanding of this finding and pursue recommended solutions (Action 6.1).

5.3.3 Licensees

The Task Force reviewed the NPP licensees' submissions against its *Nuclear Power Plant Safety Review Criteria* for emergency response, and:

- the *Nuclear Safety and Control Act*
- subsection 6(k) of the *Class I Nuclear Facilities Regulations*
- applicable site-specific licences
- CNSC guidance document G-225, *Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills* (based on IAEA standard GS-G-2.1, *Arrangements for Preparedness for a Nuclear or Radiological Emergency*)
- CNSC regulatory document RD-353, *Testing the Implementation of Emergency Measures*

In addition, all licensees' nuclear emergency preparedness programs and plans were reviewed against the requirements of their respective provincial offsite emergency response plans.

The Task Force confirmed that offsite support components of the licensees' emergency response plans are comprehensive and adequately documented and implemented. The licensees' programs and plans meet the relevant CNSC requirements and criteria and the requirements of their respective provincial offsite emergency response plans. There are no emergency response issues that require immediate action at the NPP/licensee level.

The licensees' emergency plans exceed the requirements for design-basis accidents (no offsite dose consequences). In addition, the licensees' emergency exercises routinely simulate scenarios with offsite effects that would require the activation of the provincial plans and local area evacuations. The emergency scenarios needed to trigger this degree of response are, in fact, beyond-design-basis accidents. Therefore, they demonstrate that the licensees' emergency response programs are capable of dealing with a beyond-design-basis accident.

The Task Force found that, where SAMG have been implemented, the guidelines are effectively integrated into the emergency plans. Nonetheless, the licensees are enhancing their training and clarifying roles in their emergency response organizations (discussed in subsection 3.3.2).

The Task Force also found some documentation issues in the licensees' emergency plans and procedures. The alternate locations for the emergency centres were not always documented. In some cases, information was lacking about the robustness of licensees' primary facilities. None of the licensees had robustness criteria for their alternate facilities.

The licensees are addressing the adequacy of primary and alternate emergency facilities, regional emergency centres, and emergency communications. The following subsections (5.3.3.1 to 5.3.3.7) describe specific elements of the licensees' emergency programs and provisions that warrant additional attention by the licensees and the Task Force.

5.3.3.1 Emergency response to severe and/or multi-unit events

The Task Force found that the licensees' emergency response organizations are capable of responding to single-unit, beyond-design-basis accidents. Evaluation and revision of emergency plans in regard to multi-unit accidents and severe external events (e.g., conducting exercises based on severe event and/or multi-unit accident conditions), including an assessment of the minimum complement requirements, have not been performed. As a result, it has not been conclusively demonstrated that emergency response organizations would be capable of responding effectively in a severe event and/or multi-unit accident.

The *CNSC Action Plan* assigned an action to the licensees to evaluate and revise their emergency plans in regard to multi-unit accidents and severe external events. This activity should include an assessment of their minimum complement requirements to ensure their emergency response organizations would be capable of responding effectively to multi-unit accidents or to severe natural disaster events (Action 4.1). The licensees are currently performing these assessments and considering the need for changes to their emergency plans.

The *CNSC Action Plan* also assigned an action to the licensees to review their drill and exercise programs to ensure that they are sufficiently challenging to test the performance of the emergency response organization under severe events and/or multi-unit accidents conditions (Action 4.2). This review is also ongoing. Other aspects of emergency exercises are discussed in subsection 5.3.4.3.

5.3.3.2 Capacity for emergency preparedness without external power

Emergency facilities and equipment that are designated as essential for emergency response must always be available, accessible and ready to operate. The Task Force noted that not all licensees' emergency facilities and equipment have backup power available in the event of a loss of external power. In some cases, backup power sources for primary and alternate emergency facilities and emergency response equipment have not been systematically identified. The applicable emergency plans and procedures do not, in all cases, adequately document the requirements and limitations related to the backup power supply. The *CNSC Action Plan* assigned an action to the licensees to review primary and alternate emergency facilities, and all emergency response equipment that requires electrical power to operate (e.g., electronic dosimeters, two-way radios), to make sure that appropriate backup power sources exist. The requirements and limitations should be documented in the applicable emergency plans and procedures (Action 5.1).

Those licensees that do have backup power for emergency facilities and equipment understand their limitations and are investigating their ability to maintain backup power for extended outages and correcting deficiencies as they are identified. Those licensees that do not have backup power for their emergency facilities and/or equipment are aware of this weakness and are working towards correcting this shortcoming by identifying the weaknesses and assessing their needs and options.

The availability of backup power for the CANDU reactor itself is discussed in subsection 2.5.2.

5.3.3.3 External supplies and support

All licensees have agreements in place with their respective stakeholders for support and supplies during emergencies. The Task Force noted, though, that the licensees' arrangements for support and supplies are not consistently formalized or documented, in most cases, in their emergency plans and procedures. The *CNSC Action Plan* assigned an action to licensees to formalize all arrangements and agreements for external support, and to document these in the applicable emergency plans and procedures (Action 5.2).

The licensees are confirming that their arrangements will work in an actual accident. The licensees are working together (through COG, discussed in section 4) to develop and formalize an industry-wide "mutual assistance" agreement and document it in their emergency plans and procedures.

5.3.3.4 Containment venting process

There are two containment venting strategies: nominal containment venting, which keeps containment pressure below its structural limit, and alternate containment venting, which is a coordinated process involving offsite stakeholders to determine the optimal venting strategy to protect the public and the environment.

In all cases, the senior authorized person on shift (e.g., shift manager, shift supervisor, chef de quart) is fully authorized to perform nominal venting. If nominal venting is not required, NPP staff coordinate with offsite authorities before venting. The Task Force confirmed that all licensees have clear guidance in

place that assigns responsibility for decisions regarding containment venting to the NPP operator. The Task Force was satisfied that the containment venting decision process and authority are effective and are appropriately documented by the licensees. Design issues related to containment venting are discussed in subsection 2.5.3.

5.3.3.5 Source term estimation

Post-accident source term estimation is a method that can be used to quantify a potential release of radioactive material before it occurs. Bruce, Pickering A and B, and Darlington use software and in-plant gamma survey measurements to perform post-accident source term estimations; however, these are designed for an accident in only one unit. Gentilly-2 and Point Lepreau do not perform source term estimation in support of offsite emergency response. Source term estimation is a best practice and it would be beneficial if all licensees were able to provide source term information to offsite authorities in emergency situations.

The *CNSC Action Plan* assigned an action to Gentilly-2 and Point Lepreau to develop source term estimation capability (Action 5.4), including dose modelling tools (described in the next subsection). These should be specific to their NPP sites. The licensees for Gentilly-2 and Point Lepreau are currently developing that capacity.

5.3.3.6 Plume dispersion and dose modelling

All licensees have plume modelling capability that can be used to guide field survey teams and to inform offsite authorities about the potential spread of radiation releases in the event of an accident. The approach to dose modelling is different across all licensees. Bruce, Pickering A and B, and Darlington perform dose modelling based on source term estimates, the monitoring of venting radiation, and field surveys. Hydro-Québec performs dose modelling based on the monitoring of venting radiation, fixed radiation surveillance station data and field surveys. Énergie NB Power does not perform dose modelling.

The multi-unit NPPs (Bruce, Pickering A and B, and Darlington) have software that is capable of providing plume modelling for multi-unit events, as plume modelling is independent of the source term. However, dose modelling is directly affected by the source term and, therefore, dose modelling for multi-unit scenarios will need to be reassessed to ensure accuracy.

In regard to dose modelling to support offsite authorities, the Task Force recommended that Gentilly-2 ensure that source term estimates are included in dose modelling, and Point Lepreau develop comprehensive dose modelling. As mentioned above, the *CNSC Action Plan* assigned an action to Gentilly-2 and Point Lepreau to develop source term estimation capability that is specific to their NPP sites, including dose modelling tools (Action 5.4).

The licensees are developing dose modelling tools. OPG and Bruce Power are involved (through the Electric Power Research Institute (EPRI)) with international efforts to assess improvements in plume modelling based on observations during Fukushima.

5.3.3.7 Station boundary and field radiation monitoring

All licensees perform field radiation monitoring by dispatching dedicated monitoring teams to designated locations, both onsite and offsite, to collect measurements using gamma dose rate meters and air samplers as determined by the plume modelling results. Some licensees have arrangements with Health Canada for the operation and sharing of data from fixed point gamma monitors around their facilities. Some licensees have an automated system that provides real-time field monitoring data in addition to the results collected by its field monitoring teams. Some NPPs have implemented automated, solar-powered near-boundary monitoring. In all cases, field radiation monitoring results are relayed to the provincial authorities, as well as the CNSC, to be used by the offsite authorities to assess and to determine which protective actions should be recommended for the public.

The Task Force concluded that all licensees have satisfactory arrangements in place to perform field radiation monitoring. However, for most licensees, the current method depends on the presence of NPP staff in the field to collect samples and take readings. The use of automated real-time field monitoring at an NPP boundary is seen as a best practice that allows critical data to be available sooner to appropriate authorities. The *CNSC Action Plan* assigned an action to licensees to install automated real-time NPP boundary radiation monitoring systems with appropriate backup power and communications systems (Action 5.3). The licensees are evaluating options to align their various boundary radiation monitoring systems with these criteria and some modifications are already underway.

5.3.4 Issues common to multiple stakeholders

5.3.4.1 Clarifying requirements for nuclear emergency preparedness

The Task Force observed that, while each licensee has its own means and methods of meeting the emergency preparedness and response expectations, there is no regulatory requirement or standard to ensure consistency among the licensees. The Task Force noted that the suite of emergency preparedness regulatory documents, currently comprising

- G-225, *Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills*
- RD-353, *Testing the Implementation of Emergency Measures*

are lacking detailed and specific requirements needed to strengthen and standardize emergency preparedness and response in Canada.

Thus, the Task Force recommended that the documents containing guidance or requirements for emergency management should be reviewed and updated. The *CNSC Action Plan* assigned an action to the CNSC to develop a dedicated regulatory document on emergency management that incorporates the information in the two existing CNSC regulatory/guidance documents G-225 and RD-353 (Action 9.3). It is also worth noting that the CSA has also identified the possible need for a new Canadian standard on nuclear emergency management that would complement the regulatory requirements (see subsection 2.2 for additional details on the assessment of CSA standards).

The Task Force noted that there is no established national guidance or standard for offsite nuclear emergency planning. Whereas NPP licensees are provided with CNSC guidance on emergency planning (as noted above), there is no Canadian guidance for offsite nuclear emergency plans. This issue will be addressed through meetings between the CNSC and federal and provincial nuclear emergency planning authorities (Action 6.1).

The Task Force also identified the need to improve the clarity of requirements in the *Radiation Protection Regulations* related to worker dose limits during the phases of an emergency and return-to-work criteria (Action 8.1, as discussed in subsection 3.3.1).

5.3.4.2 Strengthening oversight of nuclear emergency preparedness

As noted in subsection 3.2, the licensees are required by the *Class I Nuclear Facilities Regulations* to submit their onsite emergency plans to the CNSC as part of the licence application and renewal process. NPP licensees' onsite emergency plans, programs and performance are included in the CNSC regulatory oversight process. However, the *Class I Nuclear Facilities Regulations* do not currently require submission of offsite emergency plans with an NPP operating licence application. The *CNSC Action Plan* assigned an action to the CNSC to initiate a project to amend the *Class I Nuclear Facilities Regulations* to require submission of applicable provincial and municipal offsite emergency plans along with evidence to support how the licensees are meeting the requirements of those plans to the CNSC as part of the licence application or licence renewal process (Action 7.1).

There is no formal requirement for the CNSC to review the offsite plans, although the CNSC has always considered the preparedness of the offsite authorities when reviewing a licence application. The Task

Force, recognizing that emergency preparedness is the joint responsibility of the licensees and host municipalities and provinces, noted the need for formal, national-level oversight process for offsite nuclear emergency plans, programs and performance. The Fukushima review during the IRRS follow-up mission to Canada had a similar finding. Recommendation RF7 from the IRRS mission report stated:

> "The Government of Canada should assure that the review and assessment of off-site emergency plans for nuclear power plants include all relevant authorities and are comprehensive, and that the relevant organizations which implement those plans are capable of performing the assigned duties."

The *CNSC Action Plan* assigned an action to the CNSC to initiate and facilitate discussions with provincial and federal nuclear emergency planning authorities to ensure understanding of these findings and pursue recommended solutions (Action 6.1). Health Canada is taking the lead on addressing this finding and is reviewing the national-level oversight of offsite nuclear emergency plans, programs and performance through the use of its federal and provincial coordinating committees for nuclear emergency management.

5.3.4.3 Emergency exercises

The Task Force found that federal and provincial nuclear emergency planning authorities are not making regularly planned, full-scale NPP-focused exercises a priority. There has been a general reduction in the frequency of full-scale NPP-focused exercises at the provincial and federal level. Although all provincial and federal plans reviewed appear to be satisfactory, the implementation, and thus the capability to respond, has generally not been tested in an exercise for several years. For example, prior to the recent exercise in New Brunswick in March 2012, the most recent provincial, full-scale nuclear emergency exercise was in 2007 (see subsection 5.3.1). While various organizations and jurisdictions have routinely exercised their plans and capabilities in a range of exercises, the effectiveness of all arrangements (federal, provincial, municipal, operator) has not been tested in a national, full-scale exercise since 1999. Consequently, the full integration of the FNEP and the FERP, including their linkages with provincial nuclear emergency plans has not been validated in a full-scale, NPP-focused exercise. A series of exercises to test these arrangements, including a full-scale national-level exercise, is being planned as part of the FNEP update with the involvement of various stakeholders.

The Task Force recommended that the effectiveness of the FNEP should be tested in a full-scale, national exercise more frequently. The Fukushima review during the IRRS follow-up mission to Canada made a similar finding. Recommendation RF8 from the IRRS mission report stated:

> "The Government of Canada should assure that full-scale exercises of off-site emergency preparedness plans be held on a periodic basis, including participation of the licensee and the municipal, provincial, and federal organizations."

The *CNSC Action Plan* assigned an action to the CNSC to initiate and facilitate discussions with provincial and federal nuclear emergency planning authorities to ensure understanding of these findings and pursue recommended solutions (Action 6.1).

The March 2012 full-scale emergency exercise held by Point Lepreau and the provincial authority (New Brunswick Emergency Measures Organization) simulated a severe accident and mock evacuation of the surrounding communities. The CNSC's Emergency Management Programs Division, along with selected members of the CNSC Nuclear Emergency Organization and the CNSC site staff at Point Lepreau, also participated. The CNSC's technical assessment and regulatory operations teams used the opportunity to practise their functions through analysis and assessment. This included plume modelling and the evaluation of the protective actions taken by the provincial authorities.

Bruce Power and the Ontario Emergency Measures Organization are staging a series of training sessions leading to a functional exercise in the fall of 2012 that involves a beyond-design-basis accident. This

exercise will test the capabilities currently in place for both the onsite and offsite components of emergency management. In conjunction with this, Bruce Power is relocating its emergency management centre and upgrading emergency response equipment.

Darlington, Gentilly-2, and Pickering are also planning multi-level emergency exercises between now and 2016. Various federal and provincial authorities, as well as the U.S. Nuclear Regulatory Commission, are expected to participate.

5.3.4.4 Recovery phase

The Task Force found that federal and provincial nuclear emergency planning authorities primarily address preparedness and response, but do not fully address recovery phase guidelines and procedures in their emergency plans.

Health Canada has been updating the FNEP (as discussed in subsection 5.3.1). The current draft identifies the following federal activities, or support for the provinces, that are recognized as being part of the recovery phase:

- development of a long-term recovery management plan, including reference levels on residual dose from long-term contamination and strategy for restoration of normal socio-economic activities, including international aspects
- monitoring of long-contaminated areas, assessment of potential doses to public and workers, and assessment of medium- and long-term health hazards
- environmental decontamination and radioactive waste disposal operations
- maintenance of dose registries for emergency workers
- non-radiological recovery operations
- proactive and transparent public information and international communication related to all of the above activities

5.3.4.5 Communications

The Task Force found that communications protocols between the licensees and the offsite response organizations, including provinces, municipalities and the CNSC, are well documented in both the licensees' emergency response plans and procedures, and those of the offsite organizations. During the planning and preparedness phases of emergency management, all licensees work closely with their respective offsite emergency response stakeholders to maintain good working relationships. In addition, the provinces, the Government of Canada and the licensees work co-operatively through joint emergency information centres to provide the public and the media with information about the status of the crisis and other relevant information. Effective coordination of communications between licensees and offsite authorities, related to decision making and public/media affairs, has been observed during coordinated emergency exercises.

The Task Force found that the CNSC should continue to develop requirements for licensees' public information programs and to reflect them in the NPP operating licences. The *CNSC Action Plan* assigned an action to the CNSC to continue to develop and submit to the Commission Tribunal for approval, regulatory and guidance document RD/GD-99.3, *Public Information and Disclosure* (Action 10.2). This document (published in March 2012) would detail the requirements for public information programs and public disclosure as part of that program and supersede G-217, *Licensee Public Information Programs*. The information to be disclosed under these documents would include the impact of natural events such as earthquakes, routine and non-routine releases of radiological and hazardous materials to the environment, and unplanned events, including those exceeding regulatory limits. This, therefore, would cover severe accidents such as Fukushima. The *CNSC Action Plan* assigned an action to the CNSC to add a condition to the operating licences of the NPPs requiring the implementation and maintenance of a public information program that would include a proactive disclosure protocol (Action 10.1).

The information described above was added to RD/GD-99.3 and the Commission Tribunal approved the publication of RD/GD-99.3 in 2012, thus completing Action 10.2. CNSC staff are now planning to add conditions to all NPP operating licences that require public information programs, with a proactive disclosure protocol, per RD/GD-99.3.

At the national level, the Federal Public Communications Coordination Group coordinates the federal government's communications response to the public, the media and affected stakeholders in collaboration with the provinces/territories. Experience from previous nuclear emergency situations has highlighted the primary importance of coordinated, proactive and transparent public communications. As such, the FNEP Federal Spokesperson(s), which would include a senior official from Health Canada and others, as designated by senior decision makers, would present the federal position with respect to the radiological or nuclear emergency, in coordination with the provincial information centres. For emergencies occurring at licensed facilities, the facility operator and the CNSC would provide information on onsite conditions. In addition to the FNEP Federal Spokespersons, other federal public affairs staff would be dispatched to the provincial information centre upon its activation, in accordance with the provincial annexes to the FNEP, to coordinate information to the media and the public.

General activities being undertaken by the CNSC to improve its communications with various stakeholders, including crisis communications, are described in the subsection "External Advisory Committee" in the introduction.

5.3.4.6 Ongoing improvements and assessments

In June and November of 2011, emergency preparedness workshops were held with the attendance of NPP licensees, the military, the CNSC and emergency response organizations at the federal, provincial, and Ontario municipal levels. The purpose of the workshops was to:

- provide emergency response organizations at all levels with an overview of the events at Fukushima and lessons learned
- discuss earthquake and tsunami hazards
- examine the challenges experienced by emergency response organizations at Fukushima
- identify opportunities for improvement to emergency response plans at all jurisdictional levels
- clarify roles and responsibilities during a postulated nuclear accident at a domestic facility

In large part, the workshops were designed to highlight the need for change, where necessary, and to ensure that all levels of government have a common understanding of gaps and the path forward in terms of ensuring a holistic and integrated accident response.

A third workshop is planned.

The Fukushima review during the IRRS follow-up mission to Canada found that Canada would benefit from an international peer review of emergency preparedness. Suggestion SF9 from the IRRS follow-up mission report stated:

> "The Government of Canada should consider inviting an international peer review mission for emergency preparedness and response."

The CNSC will initiate and facilitate discussions with federal and provincial nuclear emergency planning authorities to address this suggestion (Action 6.1).

Topic 6 – International Co-operation

6 International Co-operation

6.1 Overview

The licensees are involved in various international groups with a focus on nuclear safety, including COG and the World Association of Nuclear Operators (WANO). These groups have capitalized on international participation and co-operation to identify and address the lessons learned from Fukushima. Also, when the licensees formed the CANDU Industry Integration Team (CIIT) to help coordinate their response to Fukushima, they included international participation of foreign CANDU facility owners to ensure a comprehensive approach. Finally, the licensees have contributed significantly to Canada's involvement in the activities related to the CNS, including (but not limited to) the preparation of this report.

Canada is a strong supporter of the IAEA, actively participates in its programs, including the IRRS, high-level meetings on nuclear safety, and lessons-learned exercises, and is a signatory to the conventions relevant to NPP safety. Canada has made several proposals, for consideration at the Second Extraordinary Meeting of the CNS, to improve the effectiveness of the review meetings. Canada also actively participates in international emergency management activities through the IAEA, the Nuclear Energy Agency (NEA) and the World Health Organization (WHO), among others.

The CNSC has memoranda of understanding in place with most international stakeholders and also chairs the CANDU Senior Regulators' Meeting. The CNSC is enhancing co-operation with other nuclear regulators in addressing the lessons learned from the Fukushima Daiichi nuclear accident and thus further strengthening the capability to respond efficiently to any nuclear emergency.

Canada has excellent working relationships in place with the United States at both the nuclear regulatory and emergency preparedness levels.

A table is provided in appendix A that summarizes the actions related to international co-operation that have been taken by the licensees and the CNSC in response to Fukushima.

6.2 CANDU Owners Group

As described in subsection 4.2.3, COG is an affiliate of CANDU NPP operators and AECL. Operator membership is restricted to organizations that own or operate a CANDU nuclear reactor. Supplier and engineering organizations involved in the design, construction and operation of CANDU reactors are eligible for participation in specific programs.

The utilities that are members of COG are:

- Bruce Power
- Hydro-Québec
- Korea Hydro and Nuclear Power Company
- Énergie NB Power
- Nuclear Power Corporation of India
- Nucleolectrica Argentina (Embalse NPP)
- Ontario Power Generation
- Pakistan Atomic Energy Commission (Karachi NPP)
- Societatea Nationala Nuclearelectrica (Cernavoda NPP)
- Third Qinshan Nuclear Power Company

One of COG's purposes is to exchange information, including the sharing of operating experience and the provision of support to resolve technical and operating problems for all COG members. COG facilitates inter-station assistance and joint projects, both of which may involve CANDU NPP operators or owners

outside Canada. COG also provides assistance to offshore members to address regulatory issues that are in common with the Canadian regulatory environment.

6.3 World Association of Nuclear Operators

All Canadian licensees are members of the WANO. The licensees are strongly committed to the objectives of WANO and undergo periodic technical support missions and peer reviews. As part of the peer reviews, facilities are subject to review against specific performance objectives and criteria. In response to Fukushima, three WANO significant operating experience reports (SOERs) have been issued to date dealing with key lessons learned from Fukushima, including issues related to emergency preparedness, the extended loss of all AC power, and IFBs. Each Canadian licensee is obligated to examine its vulnerabilities and provide an acceptable response to the WANO SOER recommendations. In the SOERs, it is typically stated that the recommendations will be considered in subsequent peer reviews.

6.4 International involvement of CIIT

The CIIT as described in subsection 4.3.3 consists of representatives from domestic and offshore CANDU facility owners and, as such, is an international entity. With international participation, the Canadian nuclear industry is able to draw upon the insights, lessons learned and improvement actions being taken by its international partners to ensure the CANDU industry response to Fukushima is comprehensive and reasonable. The CIIT conducts a meeting every two weeks for its domestic members and a monthly meeting that includes both domestic and international members.

As a follow-up of the Fukushima accident, the European Union commissioned a “stress test” to be performed on all European NPPs and assess their safety and implementation programs so as to address Fukushima lessons learned. The Cernavoda reactor units 1 and 2 in Romania are CANDU 600 MW units and were subject to this review. The stress test review was performed by NPP licensees and reviewed by teams of senior European regulators. CANDU Energy, as the designer of the Cernavoda units, actively supported the Romanian utility and operator in this review. The review resulted in a positive report for the Romanian CANDU reactors.

6.5 Other international activities of licensees

Collectively and individually, the licensees are involved in other international co-operative undertakings to enhance their responses to Fukushima. For example, all licensees and CANDU Energy contributed significantly to this report and will participate with the CNSC and other stakeholders at the Second Extraordinary Meeting of the CNS (as they have done at previous review meetings). Also, as noted in subsection 5.3.3.6, Darlington and Pickering are involved, through EPRI, with international efforts to improve plume modelling based on observations during Fukushima.

6.6 Canada-U.S.A and bordering states

U.S. states and Canadian provinces that share borders have mechanisms in place to communicate and work together in the event of any emergency affecting the population on both sides of the border. The states have direct links to liaise and communicate with the provinces. In the event of a nuclear emergency, protocols are in place to exchange information between them. Existing bilateral agreements between states and provinces allow for direct communication and provision of mutual aid whereby provincial authorities will ensure that Health Canada and Canada’s Department of Foreign Affairs and International Trade are kept informed of discussions with their U.S. counterparts.

Public Safety Canada has a memorandum of understanding with the U.S. Federal Emergency Management Agency. Furthermore, the Joint Radiological Emergency Response Plan has been established to set the basis for co-operative measures to effectively deal with peacetime radiological

events involving Canada, the United States, or both countries. It is designed to alert the appropriate federal authorities within each country of the existence of a threat from a potential or actual radiological event in order to facilitate co-operation between organizations of the federal government of each country in providing support to states and provinces affected by the radiological event.

6.7 International Atomic Energy Agency

Canada is a strong supporter of the IAEA and participates in various IAEA activities and committees, such as high-level meetings on nuclear safety, lessons-learned exercises, international expert peer reviews and the setting of international standards and guidance for nuclear matters. Canada was one of the first signatories to the CNS and has been actively involved in all review meetings, including the Open Ended Working Groups. In the context of the Second Extraordinary Meeting of the CNS, Canada has made several proposals, for consideration at the meeting, to improve the effectiveness of the review meetings, identify issues, and capitalize on opportunities to tangibly improve safety. Canada supports and follows the practice of making national reports to the CNS publicly available.

Canada is a signatory of the IAEA's *Convention on Early Notification of a Nuclear Accident* (1986), which establishes a notification system for nuclear accidents that have the potential for international trans-boundary release that could be of radiological safety significance for another country. The accident's time, location, radiation releases, and other data essential for assessing the situation must be reported, both directly to the IAEA and to other countries either directly or through the IAEA.

Canada is also a signatory of the IAEA's *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency* (1986), which sets out an international framework for co-operation between countries and with the IAEA to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies. It requires countries to notify the IAEA of their available experts, equipment, or other materials they could offer in assistance. In case of a request for assistance from an affected country, each country decides whether it can offer the requested assistance. The IAEA, in particular the Incident and Emergency Centre, serves as the focal point for such co-operation by channelling information, supporting efforts, and providing its available services.

As National Competent Authorities to the IAEA, the CNSC and Health Canada have protocols and plans in place to ensure close communication with the IAEA for any domestic nuclear emergency.

CNSC Communications representatives will meet with international peers and make presentations at the IAEA International Experts' Meeting on "Enhancing Transparency and Communication Effectiveness in the Event of a Nuclear or Radiological Emergency" in Vienna in June 2012 to exchange best practices and lessons learned from Fukushima, focusing on crisis communications and emergency preparedness.

6.8 Integrated Regulatory Review Service

Canada is a strong supporter of the IAEA's Integrated Regulatory Review Service (IRRS). Canada has frequently contributed experts to participate in IRRS peer reviews in other countries. Canada has also invited two IRRS missions to assess the CNSC – the first in 2009 and a follow-up mission in 2011. Canada strongly encouraged the creation of the "Fukushima module" for IRRS missions and was the first to request the inclusion of such a module in its IRRS mission. The assessment of the Fukushima module during the IRRS follow-up mission to Canada in 2011 was a learning opportunity for both the CNSC and the expert peer reviewers, as well as the IAEA itself.

Canada supports and follows the practice of making IRRS reports publicly available. Canada endeavours to reflect its IRRS mission findings in its national CNS reports as a way to foster ongoing focus on issues, as well as good practices, that have been identified. This report includes cross-references to the relevant findings from the 2011 follow-up IRRS mission to Canada.

6.9 International regulators

6.9.1 United States Nuclear Regulatory Commission

There is a memorandum of understanding between the U.S. Nuclear Regulatory Commission (U.S. NRC) and the CNSC whereby the two organizations agree to exchange information. During the Fukushima nuclear emergency, exchange of information between the U.S. NRC and CNSC was very useful.

6.9.2 CANDU Senior Regulators

A domestic or international emergency involving a CANDU reactor would require the CNSC to communicate with all the international regulators that regulate CANDU reactors. Canada chairs the annual CANDU Senior Regulators' Meeting, which is facilitated by the IAEA and attended by high-ranking regulatory staff in all countries with CANDU reactors. Specific memoranda of understanding are in place with most of these regulatory agencies. The Task Force found that these memoranda of understanding have not been reviewed to identify what support, if any, they would require from the CNSC during a nuclear emergency. The *CNSC Action Plan* assigned an action to the CNSC to initiate discussions with CANDU Senior Regulators to determine areas of interest where mutual support could be offered during a nuclear emergency (Action 12.1). In response to this action, the CNSC led a CANDU Senior Regulators Meeting in April 2012 to specifically discuss the responses to Fukushima of each regulator.

6.10 Nuclear Energy Agency

Canada participates actively in, and is a strong supporter of, the NEA. Health Canada has organized Canadian participation in most of the International Nuclear Exercises (INEX) organized under the auspices of the NEA since the mid-1990s, and most recently the INEX 4 exercises conducted in Canada in early March 2011.

CNSC Communications representatives will meet with international peers and make presentations at the NEA's "Crisis Communications Workshop" in Madrid, Spain, in May 2012 to exchange best practices and lessons learned from Fukushima, focusing on crisis communications and emergency preparedness.

Conclusion

In response to the accident at Fukushima, Canada has performed a comprehensive national review of the safety and safety framework for NPPs. Both the CNSC and licensees formed dedicated groups to coordinate the reviews, establish criteria, and document findings. The work included inspections, detailed reviews of the lessons learned from Fukushima, assessments, modifications, and identification of recommendations and plans for further improvements to address any gaps identified. The overall conclusion of this review is that NPPs in Canada are safe and the risk posed to the health and safety of Canadians or to the environment is very low. This includes the risk due to beyond-design-basis accidents. The CNSC identified a comprehensive set of recommendations and corresponding actions to address findings that apply to both the licensees and the CNSC's regulatory framework. Once completed, these actions will render the NPPs in Canada even safer, reducing the associated risk to as low as reasonably practicable.

Appendix A – Summary Tables of Activities for Each Topic

The activities described in the following tables are aligned, to a great extent, with the actions identified by the CNSC Task Force. The numbering of Actions, and their associated specific "Action Items", is taken from the *CNSC Action Plan*.

Topic 1 table – External events

Activity related to external events	Operator			CNSC		
	Status	**Schedule**	**Results available**	**Status**	**Schedule**	**Conclusion available**
Submission and review of detailed information on external events for each NPP	Complete	Jul. 2011	Yes	Complete	Oct. 2011	Yes
Action 2.1 – Licensees should complete the review of the basis for external events against modern state-of-the-art practices for evaluating external events magnitudes and relevant design capacity for these events, including but not limited to: earthquakes, floods, tornadoes and fires. This assessment should consider elements of human and organizational factors under accident conditions.				Action assigned	Dec. 2011	NA[3]
Through implementation of the current S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* Action Item 2.1.1 – Re-evaluate, using modern calculations and state-of-the-art methods, the site-specific magnitudes of each external event to which the plant may be susceptible. Action Item 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.	Complete for some NPPs Ongoing for others	- Dec. 2013	Yes No			
Action 2.2 – Implementation of RD-310, *Safety Analysis for Nuclear Power Plants*, is already in progress and being tracked by the CNSC/Industry Safety Analysis Improvement Initiative working group.				Action assigned	Dec. 2011	NA
Action Item 2.2.1 – No new requirement since implementation plans already being developed for RD-310.	Ongoing	Dec. 2013	No			

[3] NA – not applicable

Topic 2 table – Design issues

Activity related to design issues	Operator			CNSC		
	Status	**Schedule**	**Results available**	**Status**	**Schedule**	**Conclusion available**
Submission and review of detailed information on design issues for each NPP	Complete	Jul. 2011	Yes	Complete	Oct. 2011	Yes
Identification of safety improvement opportunities that improve defence in depth and prevention/mitigation of beyond-design-basis accidents, as part of planning Darlington refurbishment	Ongoing	2012/13	Partial			
Action 1.1 – Licensees should submit additional evidence (e.g., test results) that provide confidence in the bleed condenser / degasser condenser relief capacity.				Action assigned	Dec. 2011	NA
Action Item 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	Ongoing	Dec. 2012	Results for some NPPs expected Jul 2012			
Action Item 1.1.2 – If required, a plan and schedule either for confirmatory testing of installation or provision for additional relief capacity.	Ongoing	Dec. 2012	No			
Action 1.2 – Licensees should re-examine the capability of the shield tank /calandria vault relief to discharge steam produced in a severe accident. The benefits of sustainability of shield tank heat sink during accident conditions should also be re-examined.				Action assigned	Dec. 2011	NA
Action Item 1.2.1 – An assessment of the capability of shield tank / calandria vault relief. Action Item 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.	Complete for some NPPs Ongoing for others	- Dec. 2013	Yes No			
Action Item 1.2.3 – If additional relief is beneficial and practicable, a plan and schedule for provision of additional relief.	Ongoing	Dec. 2013	No			
Action 1.3 – Licensees should evaluate the means to prevent the failure of the containment systems and, to the extent practicable, unfiltered releases of radioactive products in beyond-design-basis accidents including severe accidents. If unfiltered releases				Action assigned	Dec. 2011	NA

Activity related to design issues	Operator			CNSC		
	Status	Schedule	Results available	Status	Schedule	Conclusion available
of radioactive products in beyond-design-basis accidents including severe accidents cannot be precluded, then additional mitigation should be provided. This assessment should consider elements of human and organizational factors under accident conditions						
Action Item 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.	Complete for some NPPs Ongoing for others	- Dec. 2015	Yes No			
Action Item 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.	Ongoing (not applicable to one NPP)	Dec. 2015	No			
Action 1.4 – Licensees should complete the installation of passive autocatalytic recombiners (PARs) as quickly as possible.				Action assigned	Dec. 2011	NA
Action 1.4.1 – A plan and schedule for the installation of PARs as quickly as possible.	Complete	-	Yes			
Action 1.5 – If draining of the irradiated fuel bay (IFB) following a beyond-design-basis event cannot be precluded, the need for hydrogen mitigation should be evaluated.				Action assigned	Dec. 2011	NA
Action Item 1.5.1 – An evaluation of the potential for hydrogen generation in the IFB area and the need for hydrogen mitigation.	Ongoing	Dec. 2013	No			
Action 1.6 – Licensees should evaluate the structural integrity of the IFB at temperatures in excess of the design temperature limit. If structural failure cannot be precluded, then additional mitigation (e.g., high-capacity make-up or sprays) should be provided. Consequences of the loss of shielding should be evaluated. This assessment should consider elements of human and organizational factors under accident conditions.				Action assigned	Dec. 2011	NA

Activity related to design issues	Operator			CNSC		
	Status	Schedule	Results available	Status	Schedule	Conclusion available
Action Item 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.	Complete for one NPP Ongoing for others	- Dec. 2013	Yes No			
Action Item 1.6.2 – A plan and schedule for deployment of any additional mitigating measures shown to be necessary by the evaluation of structural integrity.	Complete for one NPP Ongoing for others	- Dec. 2013	Yes No			
Action 1.7 – Licensees should evaluate means to provide coolant make-up to the primary heat transport system, steam generators, moderator, shield tank / calandria vault, spent fuel pools and dousing tank where applicable. Means include: a) Coolant make-up to prevent severe core damage. b) If severe core damage cannot be precluded, then the make-up coolant should be used in severe accident management guidelines (SAMG) to mitigate the severe accident. This assessment should consider elements of human and organizational factors under accident conditions.				Action assigned	Dec. 2011	NA
Action Item 1.7.1 – A plan and schedule for optimizing existing provisions and putting in place additional coolant make-up provisions, and supporting analyses.	Ongoing	Dec. 2013	No			
Action 1.8 – Licensees should provide a reasonable level of confidence that the means (e.g., equipment and instrumentation) necessary for severe accident management and essential to the execution of SAMGs will perform its function in the severe accident environment for the duration for which it is needed. This assessment should consider elements of human and organizational factors under accident conditions.				Action assigned	Dec. 2011	NA
Action 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.	Ongoing	Dec. 2013	No			

Activity related to design issues	Operator			CNSC		
	Status	Schedule	Results available	Status	Schedule	Conclusion available
Action 1.9 – Licensees should ensure the habitability of control facilities under conditions arising from beyond-design-basis and severe accidents. This assessment should consider elements of human and organizational factors under accident conditions.				Action assigned	Dec. 2011	NA
Action Item 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.	Ongoing	Dec. 2014	No			
Action 1.10 – Licensees should investigate means of extending the availability of power for key instrumentation and control (I&C) needed in accident management actions following a loss of all AC power. This assessment should consider elements of human and organizational factors under accident conditions.				Action assigned	Dec. 2011	NA
Action Item 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. Action Item 1.10.2 – A plan and schedule for deployment of identified upgrades. A target of eight hours without the need for offsite support should be used.	Ongoing	Dec. 2012	No			
Action 9.1 – The CNSC will initiate projects to amend applicable regulatory documents in order to incorporate the findings of the CNSC Task Force for both existing and new nuclear power plants.				Action assigned	Dec. 2011	NA
Action Item 9.1.1 – The CNSC will adapt the proposed GD-310, *Guidance on Safety Analysis for Nuclear Power Plants*, prior to publishing it, to address the findings of the CNSC Task Force review findings.				Complete	Mar. 2012	Yes
Action 9.1.2 – The CNSC will prepare revisions to RD-337, *Requirements and Guidance for Design of New NPPs* and, following a public consultation period, submit them to the Commission (Tribunal) for approval to publish.				Ongoing	Dec. 2013	No
Action 9.1.3 – The CNSC will prepare targeted amendments to				Ongoing	Dec. 2013	No

Activity related to design issues	Operator			CNSC		
	Status	**Schedule**	**Results available**	**Status**	**Schedule**	**Conclusion available**
specific regulatory documents and, following a public consultation period, submit them to the Commission (Tribunal) for approval to publish. These include: • RD-346, *Site Evaluation for New Nuclear Power Plants* • S-294, *Probabilistic Safety Assessments for Nuclear Power Plants* • S-296, *Environmental Protection Policies, Programs, and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills* • RD-310, *Safety Analysis for Nuclear Power Plants* • G-306, *Severe Accident Management Programs for Nuclear Reactors*						
Action 9.4 – The CNSC will support the review of Canadian Standards Association (CSA) standards to take into account the lessons from the Fukushima Daiichi nuclear accident through its participation in the CSA Nuclear Strategic Steering Committee (NSSC).				Action assigned	Dec. 2011	NA
Action Item 9.4.1 – The CNSC will request the CSA to provide, within the proposed timeline: • identification of the issues that need to be addressed in the next review cycles for its standards • action and work plans to address the identified needs				Ongoing	Dec. 2013	No

Topic 3 table - Severe accident management and recovery (onsite)

Activity related to severe accident management	Operator			CNSC		
	Status	**Schedule**	**Results available**	**Status**	**Schedule**	**Conclusion available**
Submission and review of detailed information on severe accident management for each NPP	Complete	Jul. 2011	Yes	Complete	Oct. 2011	Yes
Action 1.11 – Licensees should procure, as quickly as possible, emergency equipment and other resources that could be stored offsite and brought onsite to mitigate a severe accident. This assessment should consider elements of human and organizational factors under accident conditions.				Action assigned	Dec. 2011	NA
Action Item 1.11.1 – A plan and schedule for procurement.	Complete for some NPPs Ongoing for others	- Dec. 2012	Yes No			
Action 3.1 a) Licensees should develop/finalize and fully implement severe accident management guidelines (SAMGs) at each station. b) Licensees should expand the scope of SAMGs to include multi-unit and IFB events. c) Licensees should demonstrate effectiveness of SAMGs. Licensees should validate and/or refine SAMGs to demonstrate their adequacy in the light of lessons drawn from the Fukushima Daiichi nuclear accident. This assessment should consider elements of human and organizational factors under accident conditions.				Action assigned	Dec. 2011	NA
Action Item 3.1.1 – Where SAMGs have not been developed/finalized or fully implemented, provide plans and schedules for completion.	Complete for most NPPs Ongoing for one NPP	- Dec. 2013	Yes No			
Action Item 3.1.2 – For multi-unit stations, provide plans and schedules for the inclusion of multi-unit events in SAMGs.	Ongoing for multi-	Dec. 2013	No			

Activity related to severe accident management	Operator			CNSC		
	Status	Schedule	Results available	Status	Schedule	Conclusion available
	unit NPPs					
Action Item 3.1.3 – For all stations, provide plans and schedules for the inclusion of IFB events in station operating documentation where appropriate. Action Item 3.1.4 – Demonstrate the effectiveness of SAMGs via table-top exercises and drills.	Complete for one NPP Ongoing for other NPPs	- Dec. 2013	Yes No			
Action 3.2 – Licensees of multi-unit NPPs should develop improved modelling of multi-unit plants in severe accident conditions or demonstrate that the current simple modelling assumptions are adequate. This assessment should consider elements of human and organizational factors under accident conditions.				Action assigned	Dec. 2011	NA
Action Item 3.2.1 – An evaluation of the adequacy of existing modelling of severe accidents in multi-unit stations. The evaluation should provide a functional specification of any necessary improved models. Action Item 3.2.2 – A plan and schedule for the development of improved modelling, including any necessary experimental support.	Ongoing for multi-unit NPPs	Dec. 2012	No			
Action 8.1 – The CNSC will initiate a project to amend the *Radiation Protection Regulations* to introduce additional clarity on emergency dose limits for workers and to establish return-to-work criteria.				Action assigned	Dec. 2011	NA
Action Item 8.1.1 – The CNSC will prepare and consult on a discussion paper on potential amendments to the *Radiation Protection Regulations* which will include proposed amendments to the emergency provisions in the regulations. Action Item 8.1.2 – The CNSC will prepare proposed amendments to the *Radiation Protection Regulations* for consultation in the *Canada Gazette Part I* and submit them to the Commission (Tribunal) for approval to proceed. Action Item 8.1.3 – The CNSC will review results of consultation and prepare final amendments to the *Radiation*				Ongoing	Dec. 2013	No

Activity related to severe accident management	Operator			CNSC		
	Status	Schedule	Results available	Status	Schedule	Conclusion available
Protection Regulations and propose them to the Commission (Tribunal) for enactment.						
Action 9.2 – The CNSC will initiate a project to develop a dedicated regulatory document on accident management.				Action assigned	Dec. 2011	NA
Action Item 9.2.1 – The CNSC will prepare a draft document on accident management and, following a period of public consultation, submit it to the Commission (Tribunal) for approval to publish.				Ongoing	Dec. 2013	No
Action 10.1 – Require licensees to have programs for accident management, severe accident management and public communication.				Action assigned	Dec. 2011	NA
Action Item 10.1.1 – A Commission member document (CMD) will be produced for the February 2012 Commission (Tribunal) meeting, requesting approval of a new PROL template that will include new licence conditions. The following wording is proposed: "The licensee shall develop and implement operational guidance and adequate capabilities to deal with abnormal situations, emergencies, and accidents, including severe accidents and, where applicable, multi-unit events." … Sections will be added to the NPP Licence Condition Handbook (LCH) template to clarify the compliance verification criteria for the new licence conditions. Action Item 10.1.2 – The amendments to the existing PROLs will be added to comply with the updated template.				Ongoing Ongoing	Oct. 2012 Dec. 2014	No No
Also, see **Action 9.1** in the Topic 2 table.						

Topic 4 table – National organizations

Activity related to national organizations	Operator			CNSC		
	Status	**Schedule**	**Results available**	**Status**	**Schedule**	**Conclusion available**
Submission and review of information on national organizations	Complete	Jul. 2011	Yes	Complete	Oct. 2011	Yes
Action 6.1 – CNSC staff will meet with provincial and federal nuclear emergency planning authorities to ensure understanding of recommendations and findings.				Action assigned	Dec. 2011	NA
Action Item 6.1.1 – CNSC staff will participate in activities led by respective provincial and federal authorities and initiate adequate CNSC regulatory framework or oversight measures to address recommendations.				Ongoing	Dec. 2013	No
Also, see **Action 9.4** in the Topic 2 table.						

Topic 5 table - Emergency preparedness and response and post-accident monitoring (offsite)

Activity related to emergency preparedness and response	Operator			CNSC		
	Status	Schedule	Results available	Status	Schedule	Conclusion available
Submission and review of detailed information on emergency preparedness and monitoring for each NPP	Complete	Jul. 2011	Yes	Complete	Oct. 2011	Yes
Licensees developing framework for a regional emergency response support centre as a resource for managing severe accidents and similar events	Ongoing	2012/13	No			
Action 4.1 – Licensees should evaluate and revise their emergency plans in regard to multi-unit accidents and severe external events. This activity should include an assessment of their minimum complement requirements to ensure their emergency response organizations will be capable of responding effectively to multi-unit accidents or to severe natural disasters. This assessment should consider elements of human and organizational factors under accident conditions.				Action assigned	Dec. 2011	NA
Action Item 4.1.1 – An evaluation of the adequacy of existing emergency plans and programs.	Ongoing	Dec. 2012	Results for some NPPs expected Jul 2012			
Action Item 4.1.2 – A plan and schedule to address any gaps identified in the evaluation.	Ongoing	Dec. 2012	No			
Action 4.2 – Licensees should review their drill and exercise programs to ensure that they are sufficiently challenging to test the performance of the emergency response organization under severe events and/or multi-unit accident conditions. This assessment should consider elements of human and organizational factors under accident conditions.				Action assigned	Dec. 2011	NA
Action Item 4.2.1 – A plan and schedule for the development of improved exercise program.	Ongoing	Dec. 2012	No			
Action 5.1 – Licensees should review primary and alternate emergency facilities, and all emergency response equipment that requires electrical power to operate (e.g., electronic dosimeters, two-way radios), to make sure that appropriate backup power				Action assigned	Dec. 2011	NA

Activity related to emergency preparedness and response	Operator			CNSC		
	Status	Schedule	Results available	Status	Schedule	Conclusion available
sources exist. The requirements and limitations should be documented in the applicable emergency plans and procedures. This assessment should consider elements of human and organizational factors under accident conditions.						
Action Item 5.1.1 – An evaluation of the adequacy of backup power for emergency facilities and equipment. Action Item 5.1.2 – A plan and schedule to address any gaps identified.	Ongoing	Dec. 2012	No			
Action 5.2 Licensees should formalize all arrangements and agreements for external support and should document these in the applicable emergency plans and procedures. This assessment should consider elements of human and organizational factors under accident conditions.				Action assigned	Dec. 2011	NA
Action Item 5.2.1 – Identify the external support and resources that may be required during an emergency. Action Item 5.2.2 – Identify the external support and resource agreements that have been formalized and documented. Action Item 5.2.3 – Confirm if any undocumented arrangements can be formalized.	Ongoing (not applicable for one NPP)	Dec. 2012	No			
Action 5.3 – Licensees should install automated real-time station boundary radiation monitoring systems with appropriate backup power and communications systems.				Action assigned	Dec. 2011	NA
Action Item 5.3.1 – Provide a project plan and installation schedule.	Ongoing	Dec. 2012	Results for some NPPs expected Jul 2012			
Action 5.4 – Licensees should develop source term estimation capability including dose modelling tools.				Action assigned	Dec. 2011	NA
Action Item 5.4.1 – Provide source term and dose modelling tools specific to each NPP.	Ongoing (not applicable to multi-unit NPPs)	Dec. 2012	No			
Action 6.1 – CNSC staff will meet with provincial and federal				Action	Dec. 2011	NA

Activity related to emergency preparedness and response	Operator			CNSC		
	Status	Schedule	Results available	Status	Schedule	Conclusion available
nuclear emergency planning authorities to ensure understanding of recommendations and findings.				assigned		
Action Item 6.1.1 – CNSC staff will participate in activities led by respective provincial and federal authorities and initiate adequate CNSC regulatory framework or oversight measures to address recommendations.				Ongoing	Dec. 2013	No
Action 7.1 – The CNSC will initiate a project to amend the *Class I Nuclear Facilities Regulations* to require submission of applicable provincial and municipal offsite emergency plans along with evidence to support how the licensees are meeting the requirements of those plans to the CNSC as part of the licence application or licence renewal process.				Action assigned	Dec. 2011	NA
Action Item 7.1.1 – The CNSC will prepare proposed amendments to the *Class I Nuclear Facilities Regulations* for consultation in *Canada Gazette Part I* and submit to the Commission (Tribunal) for approval to proceed. Action Item 7.1.2 – The CNSC will review results of consultation and prepare final amendments to the *Class I Nuclear Facilities Regulations* and propose to the Commission (Tribunal) for enactment.				Ongoing	Dec. 2013	No
Action 9.3 – The CNSC will initiate a project to develop a dedicated regulatory document on emergency management.				Action assigned	Dec. 2011	NA
Action Item 9.3.1 – The CNSC will prepare a draft regulatory document on emergency management, reviewing and incorporating existing information in G-225, *Emergency Planning at Class I Nuclear Facilities and Uranium Mines and Mills*, and RD-353, *Testing the Implementation of Emergency Measures* and, following a period of public consultation, submit them to the Commission (Tribunal) for approval to publish.				Ongoing	Jun. 2014	No
Action 10.1 – Require licensees to have programs for accident management, severe accident management and public communication.				Action assigned	Dec. 2011	NA

Activity related to emergency preparedness and response	Operator			CNSC		
	Status	Schedule	Results available	Status	Schedule	Conclusion available
Action Item 10.1.1 – …A licence condition will also be proposed, requiring licensees to implement and maintain a public information program that includes a proactive disclosure protocol, once RD-99.3, *Requirements and Guidance for Public Information and Disclosure* (or its replacement), has been approved for publication (refer to Action 10.2 below for details). Sections will be added to the NPP licence condition handbook (LCH) template to clarify the compliance verification criteria for the new licence conditions. Action Item 10.1.2 – The amendments to the existing PROLs[4] will be added to comply with the updated template.				Ongoing Ongoing	Feb. 2012 Dec. 2014	No No
Action 10.2 – The CNSC will continue to develop and submit to the Commission (Tribunal) for approval, RD/GD-99.3, *Public Information and Disclosure*.				Action assigned	Dec. 2011	NA
Action Item 10.2.1 – The CNSC will submit the updated draft RD/GD-99.3 to the Commission (Tribunal) for approval to publish at the February 2012 meeting. Action Item 10.2.2 – The amendments to existing PROLs will be consistent with the implementation timeline set out in Action 10.1.				Complete Ongoing	Feb. 2012 Dec. 2014	Yes No
Also, see **Action 8.1** in the Topic 3 table.						

[4] PROLs – power reactor operating licence

Topic 6 table – International co-operation

Activity related to international co-operation	Operator			CNSC		
	Status	**Schedule**	**Results available**	**Status**	**Schedule**	**Conclusion available**
Action 12.1 – The CNSC is to initiate discussions with CANDU senior regulators to determine areas of interest where mutual support can be offered during a nuclear emergency.				Action assigned	Dec. 2011	NA
Action Item 12.1.1 – The CNSC in collaboration with the IAEA and CANDU senior regulators proposes a meeting in April 2012 in Vienna, Austria, in advance of national report submissions for peer review in May 2012 to establish a common platform for harmonization of future improvements arising from the lessons learned from their independent safety reviews.				Complete	May 2012	Yes
Action 13.1 – Canada, as a signatory to the *Convention on Nuclear Safety*, is required to participate in triennial review meetings of the Convention and any extraordinary meeting that may be agreed to by contracting parties. The CNSC on behalf of Canada is responsible for coordinating the preparation and submission of the national reports for peer review and the participation of Canadian delegates at the review or extraordinary meetings. The CNSC in collaboration with industry and government stakeholders is to prepare a national report for peer review by contracting parties and to participate at the 2nd Extraordinary Meeting of the Convention on Nuclear Safety on the sharing of lessons learned and actions taken by contracting parties in response to the Fukushima Daiichi nuclear accident.				Action assigned	Dec. 2011	NA
Action Item 13.1.1 – A national report on lessons learned from the Fukushima Daiichi nuclear accident consistent with the requirements established by contracting parties at the Fifth Review Meeting in April 2011. The national report is to be submitted to the IAEA Secretariat in May 2012 for peer review by the *Convention on Nuclear Safety* states and discussed at an Extraordinary Meeting of the Convention in Vienna, Austria, August 27–30, 2012.				Ongoing	Aug. 2012	No

Appendix B – Provincial Nuclear Emergency Plans

The Bruce A, Bruce B, Pickering A, Pickering B, and Darlington NPPs are located in the province of Ontario. Gentilly-2 is located in the province of Quebec. Point Lepreau is located in the province of New Brunswick.

B.1 Ontario

B.1.1 Summary

- Ontario has a comprehensive and up-to-date provincial nuclear emergency response plan (PNERP).
- Ontario's PNERP is well integrated with NPP emergency plans.
- Ontario has set the most stringent requirements for public alerting among the provinces with NPPs.
- The requirements for indoor public alerting in Durham region are not being met. In addition, the implementation of the new 10 km public alerting requirement has just recently begun.
- Ontario has a Nuclear Emergency Management Coordinating Committee (NEMCC) comprising all municipal/regional, provincial and federal stakeholders. This forum provides an opportunity to discuss issues pertaining to the nuclear emergency management on a quarterly basis.
- The last full-scale nuclear exercise in Ontario was in 2007.
- Ontario is the only province in which potassium-iodide (KI) pills are not pre-distributed to households in the designated planning zones.
- PNERP planning is based on a single-unit accident and does not explicitly consider multi-unit accidents.

B.1.2 General

The Province of Ontario's *Emergency Management and Civil Protection Act* governs emergency preparedness and response in Ontario. This legislation requires the government to formulate a plan for emergencies arising in connection with NPPs. Emergency Management Ontario (EMO) is the lead organization for coordinating all the aspects of nuclear emergency management.

B.1.3 Plans

Ontario's nuclear emergency plans are structured as the PNERP Master Plan with NPP-specific implementing plans. The PNERP Master Plan is the overarching plan that provides the general principles, concepts and organization for nuclear emergency management. The PNERP implementing plans for Pickering, Darlington and Bruce address site-specific aspects. PNERP planning, however, is based on a single-unit accident and does not explicitly consider multi-unit accidents.

EMO chairs the NEMCC, which comprises members from the NPPs, designated municipalities/regions, ministries and federal departments and agencies such as the CNSC, Health Canada and Public Safety Canada. This committee meets quarterly to discuss issues of mutual interest pertaining to nuclear emergency management in Ontario.

The PNERP Master Plan and the implementing plans for Pickering, Darlington and Bruce NPPs were last updated and approved by the Ontario Cabinet in 2009.

B.1.4 Planning zones

The planning zones used by the Province of Ontario are each generically described as being a certain radial distance from the NPP, but in practice they are defined in a geographically logical manner. For NPPs in Ontario, the following planning zones are used.

- The **contiguous zone** is the offsite area immediately surrounding the nuclear facility where an increased level of preparedness and response is required (nominally 3 km).
- The **primary zone** is the area around the nuclear facility where exposure control measures may be required (nominally 10 km). The approximate population is 7,500 in the Bruce primary zone, 122,000 in the Darlington primary zone and 261,000 in the Pickering primary zone.
- The **secondary zone** is the area where ingestion control measures may be required (50 km).

B.1.5 Event assessment

The NPP licensee is required to communicate the following information to the Provincial Emergency Operations Centre initially, and then on an hourly basis:

- categorization of the accident
- status of safety systems and containment
- repressurization estimates or reactor/vacuum building pressures
- source term estimates
- field monitoring data
- weather data (current and forecast)

The Scientific Section at the Provincial Emergency Operations Centre has the required expertise and the required software to use data provided by the NPP licensee to perform plume modelling and projection of the likely offsite effects. This provides a valuable assessment of an event on an ongoing basis and helps the Provincial Emergency Operations Centre to decide on the appropriate protective measures. Health Canada, the CNSC and the provincial ministries of Labour and the Environment are also represented at the Scientific Section. This enables the section to also incorporate the technical advice and data coming from these organizations.

B.1.6 Public alerting

A 2009 update to the PNERP now requires that the entire primary zone population must be able to receive alerts within 15 minutes. As per the provincial standards defined in the PNERP, the population within the 3 km radius requires a very stringent notification due to proximity to the hazard – the capability to alert practically 100 percent of the population both indoors and outdoors at any time of the day or year. The population within the remainder of the primary zone (3–10 km) must be notified on an area-wide basis – the signal will cover that geographical area, but does not presume notification of practically 100 percent of the population. The new requirements for indoor public alerting in Durham region (where Darlington and Pickering are located) are not yet being met.

B.1.7 Protective measures

The PNERP addresses exposure control measures to protect against external irradiation and inhalation of radioactive material. Measures include evacuation, sheltering, and thyroid blocking with stable iodine in KI pills. The PNERP also addresses ingestion control measures, such as protecting the food chain from radioactive material and preventing the ingestion of contaminated food and water.

In particular, the PNERP requires designated municipalities (Durham Region, City of Toronto and Municipality of Kincardine) to facilitate the availability of KI pills for the primary zone institutions, emergency centres and for any member of the zone population who wishes to possess a supply. However, the mode of distribution is left to the designated municipalities to determine.

In all cases in Ontario, the designated communities have stocked the pills for the general public at central locations (pharmacies in Durham, reception centre in Kincardine) and have pre-distributed the pills to locations such as schools and long-term care facilities. The KI pills are not pre-distributed to households, although the general public can obtain them from pharmacies at any time.

The decision to implement the administration of KI would be taken by the Chief Medical Officer of Health for Ontario. The directive to obtain and ingest would then be issued through the Provincial Emergency Operations Centre's emergency bulletin and emergency information systems.

B.2 Quebec

B.2.1 Summary

- Quebec has a comprehensive nuclear emergency response plan (PMUNE-G2). A revision is expected to be approved later this year.
- The planning basis adopted by Quebec is in-depth and recent.
- Quebec's PMUNE-G2 is well integrated with Gentilly-2's emergency plan.
- There is no provincially set requirement for public alerting in Quebec.
- Currently, the municipality of Bécancour relies on using first responders going door to door and on issuing notifications through the media to alert the public. The municipality is investigating the use of an automated system.
- The last full-scale nuclear exercise in Quebec was in 2005.

B.2.2 General

The Province of Quebec's *Plan national de sécurité civile du Québec*, in accordance with the Quebec provincial *Loi sur la sécurité civile*, provides the terms of reference for all emergencies. The Organisation de la sécurité civile du Québec (OSCQ) is responsible for emergency planning and the government response to all hazards.

The provincial nuclear emergency plan, *Plan des mesures d'urgence nucléaire externe à la centrale nucléaire Gentilly-2* (PMUNE-G2), addresses the specifics of planning and response for a nuclear emergency.

The last full-scale nuclear exercise in Quebec was in 2005.

B.2.3 Plans

The provincial PMUNE-G2 addresses the specifics of planning and response for a nuclear emergency. It is composed of a master plan (plan directeur) and sub-plans (lignes directrices).

The PMUNE-G2 defines the government ministries and agencies that have responsibilities in a nuclear emergency at Gentilly-2. It describes the objectives of minimizing the consequences, protecting the public and providing support to the municipalities. At the regional level, the Direction générale de la sécurité civile et de la sécurité incendie is responsible for preparing and maintaining the PMUNE-G2. The coordination for the health portfolio is carried out by the Agence de la santé et des services sociaux de la Mauricie et du Centre-du-Québec. Its mission is to offer the necessary health services to protect the lives and the health of individuals who are facing the crisis.

Under the PMUNE-G2, the OSCQ would open the government operations centre in Québec City to coordinate the actions of the various government organizations in the province to maintain a link with the federal departments and agencies. A regional response centre located in Trois-Rivières would be opened by the Organisation régionale de sécurité civile (ORSC) to coordinate local responses and provide support to the affected municipalities.

The original PMUNE-G2 master plan was released in 1996. A revision process was started in 2005. A revised plan is under review and expected to be formally approved by the end of 2011.

B.2.4 Planning zones

The planning zones used by the Province of Quebec are each generically described as being a certain radial distance from the NPP, but in practice they are defined in a geographically logical manner. The planning zones defined by PMUNE-G2 are as follows:

- Plume exposure planning zone (Zone de planification d'urgence pour l'exposition au panache: ZPU-P) is an area around the NPP where the emphasis is on exposure control measures (nominally 8 km). The approximate population in the G2 ZPU-P is 10,000.
- Ingestion planning zone (Zone de planification d'urgence pour l'exposition par ingestion: ZPU-I) is an area around the NPP where the emphasis is on the ingestion control measures (nominally 70 km).

B.2.5 Event assessment

The ORSC has the software capability to model plumes and predict the offsite effects. As per the PMUNE-G2, the ORSC recommends the protective actions for the public and the environment.

These calculations and recommendations are done by the ORSC's radiological risk assessment team (Équipe d'evaluation du risque radiologique) in the ORSC headquarters in Trois-Rivières. It uses real-time NPP measurements to predict the offsite effects.

B.2.6 Public alerting

Public alerting is the responsibility of the municipalities. The municipalities alert the public by organizing first responders to go door to door and by issuing media notifications. There is no provincially mandated time requirement, although the PMUNE-G2 indicates it should be done as quickly as possible.

The Municipality of Bécancour, with assistance from Hydro-Québec, is investigating the use of an automated system to alert the residents living in the 8 km zone.

B.2.7 Protective measures

The PMUNE-G2 lists exposure control measures, such as evacuation, sheltering, and thyroid blocking (KI pills), to protect the public against external irradiation and inhalation of radioactive material. The PMUNE-G2 also addresses ingestion control measures, such as protecting the food chain from radioactive material and preventing the ingestion of contaminated food and water. As per the *Loi sur la sécurité civile*, it is the responsibility of the municipalities of Quebec to develop and maintain a plan which contains protective measures to take when faced with an emergency.

In particular, KI pills are pre-distributed to the residents within the plume exposure planning zone (8 km), and a comprehensive public information program for KI and other protective measures is in place. In addition, KI pills are stocked in locations such as daycare centres, schools and provincial and municipal centres. The decision to recommend the use of tablets by the population is made by the Regional Director of public health. The provincial Service Québec department and the municipalities are responsible for retransmitting this directive to the public through first responders (police, firefighters) and the media (radio, television).

B.3 New Brunswick

B.3.1 Summary

- New Brunswick updated its provincial offsite emergency plan in 2011 and validated the plan in a major exercise in March 2012.
- The offsite emergency plan continues to use a single 20 km zone, but recognizes that urgent protective actions may be authorized immediately out to 5 km.

- New Brunswick has an event assessment/modelling capability, which includes Health Canada's ARGOS system, S3Fast and a proprietary system for design-basis incidents called DoseWin.
- The New Brunswick Emergency Measures Organization (NBEMO) requires that all residents within the 20 km zone be alerted by telephone within 15 minutes and has a service agreement that meets that standard.
- An effective automated public alerting system is in place, with backup plans using area wardens. There is as yet no outdoor alerting capability, however digital highway signs and sirens are under consideration for selected areas.
- The last provincial, full-scale nuclear exercise in New Brunswick was held in 2012.

B.3.2 General

The Province of New Brunswick's primary agencies for emergency management and public security are the NBEMO and the New Brunswick Security and Emergencies Directorate (NBSED). NBEMO is the provincial lead agency for emergency management and business continuity, including radiological and nuclear emergencies. The NBSED is the provincial lead agency for security and the protection of critical infrastructure. These two agencies consolidate their efforts under the mandate of the New Brunswick Department of Public Safety.

The last full-scale nuclear exercise in New Brunswick was held in 2012. NBEMO and NBSED hold exercises on components on an annual basis.

B.3.3 Plans

Under the provincial *Emergency Measures Act*, NBEMO has the lead responsibility for developing provincial emergency plans and coordinating all aspects of an emergency. The *New Brunswick Point Lepreau Nuclear Offsite Emergency Plan*, *Volume 1 Policy* and *Volume II Procedures* were updated in 2011–12.

The plan defines specific responsibilities of the Department of Public Safety and the supporting roles of some 20 organizations. Representatives from these organizations make up the Provincial Emergency Action Committee (PEAC), which directs, controls and coordinates emergency operations, as well as assisting and supporting municipalities as required.

B.3.4 Planning zones

The New Brunswick Nuclear Emergency Plan uses a nominal 20 km zone for planning purposes. The approximate population in the zone is 4,000.

Of note, Point Lepreau uses three planning zones. NBEMO has indicated that the provincial plans will incorporate these zones shortly. These zones are described as:

- precautionary protective action zone (4 km, but will be increased to 5 km)
- urgent protective action zone (12 km)
- long-term protective action zone (20 km)

B.3.5 Event assessment

NBEMO has recently acquired a capability to run plume and dose modelling to predict offsite effects. There is a provision for the Province to consider pre-emptive, planned evacuation (before the situation deteriorates) in scenarios of fuel damage, potential fuel damage or NPP instability. However, this provision depends on the qualitative assessment of Énergie NB Power. Following a release, NBEMO would use sensors and a radiation survey data collected by Énergie NB Power to decide on protective measures such as sheltering, evacuation or administration of KI pills.

B.3.6 Public alerting

Since 2000, NBEMO has been able to alert the entire population within 20 km of Point Lepreau in 15 minutes, using a multi-channel mass notification service. This system is tested semi-annually. NBEMO also has some direct-to-broadcast capabilities in development, including cable, satellite and commercial radio channels. Members of the public have the opportunity to profile how they wish to be alerted. The system also notifies all businesses and institutions, such as schools, within the emergency planning zone. A volunteer uniformed service assists in notification and with residents requiring evacuation assistance.

B.3.7 Protective measures

The New Brunswick plan lists exposure control measures to protect against external irradiation and inhalation of radioactive material. Measures include evacuation, sheltering, thyroid blocking (KI pills). The plan also addresses ingestion control measures, such as protecting the food chain from radioactive material and preventing the ingestion of contaminated food and water.

Under the New Brunswick plan, KI pills are pre-distributed to all the residences within the 20 km zone. The pills are also stocked at other locations such as long-term health facilities, hospitals and RCMP posts. The Department of Heath and Wellness, in consultation with the PEAC, makes decisions on recommending administration of the KI pills to the public. Notification to the public is carried out by the NBEMO community notification system and followed by wardens, media or public safety announcements and Web bulletins.

Appendix C – Selected Radiation Monitoring Programs Administered by Health Canada

Health Canada is responsible for operating various radiological monitoring networks: the Fixed Point Surveillance Network, the Canadian Radiation Monitoring Network and the Canadian Comprehensive Test-Ban Treaty (CTBT) Radiation Monitoring Network.

The Fixed Point Surveillance Network is the result of a project to build a real-time radiation detection system across Canada. This network monitors public doses from radioactive materials in the air and makes Canada better prepared in case of nuclear or radiological incidents.

The network consists of radiation detection equipment located at 77 locations across the country and a single data centre that collects, analyzes and stores the data measured at each of these monitoring stations. This data centre is located at Health Canada's Radiation Protection Bureau in Ottawa and communicates with the stations on a daily or as-needed basis. Currently, the network includes monitoring stations installed by Health Canada plus several stations that are owned and operated by industrial partners who share their data with Health Canada. Health Canada maintains about 20 additional detectors that can be deployed across Canada according to need.

The Canadian Radiation Monitoring Network is a national network of monitoring stations that routinely collect air, precipitation, drinking water, atmospheric water vapour, and milk for radioactivity analysis and measure external gamma dose. This network was initiated in 1959 to monitor environmental releases of radioactivity from atmospheric nuclear weapons testing and accidental releases from nuclear facilities.

Samples are analyzed for radionuclides that may adversely impact the health and well-being of Canadians. The techniques employed to identify and quantify radionuclides of interest are gamma spectroscopy, gas proportional counting, liquid scintillation counting, and inductively coupled mass spectrometry. In addition, certain stations in this network also collect water vapour for assessment of tritium content, which is used as a metric to assess reactor leakage. Continuous and comprehensive monitoring provides a current and accurate background for radioactivity in Canada, and enables early detection and rapid response in the event of a national or international incident with radiological consequence. There are 26 environmental monitoring stations, plus additional sites in the vicinity of nuclear reactors.

Since 1998, Health Canada has been contributing to the International Monitoring System, an element of the Verification Regime overseen by the Comprehensive Nuclear Test-Ban Treaty Organization (CTBTO). This compliance treaty seeks a universal ban on all nuclear detonation as an effective means to stop further development of nuclear weapons.

Canada is responsible for the installation and operation of four CTBTO radiation monitoring stations across the country as well as a radionuclide laboratory. Health Canada's Radiation Protection Bureau is responsible for the radionuclide laboratory and monitoring stations at St. John's, NL; Yellowknife, NT; Vancouver, BC; and Resolute, NU. These installations collect and transmit monitoring data to the CTBTO to monitor for evidence of any nuclear explosion. However, the data can also be used for a national response to nuclear emergencies.

In addition to the above cross-Canada environmental monitoring networks, Health Canada also operates programs for internal and external dosimetry of occupationally exposed workers (in routine and emergency situations), and maintains capabilities for contamination monitoring.