THE STANDING SENATE COMMITTEE ON ENERGY,

THE ENVIRONMENT AND NATURAL RESOURCES

CANADA'S NUCLEAR REACTORS: HOW MUCH SAFETY IS ENOUGH?

INTERIM REPORT

The Honourable Nicholas W. Taylor, *Chair*
The Honourable Mira Spivak, *Deputy Chair*

JUNE 2001

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STANDING SENATE COMMITTEE ON ENERGY, THE ENVIRONMENT AND NATURAL RESOURCES

The Honourable Nicholas W. Taylor, *Chair*
The Honourable Mira Spivak, *Deputy Chair*

And the Honourable Senators:

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Isobel Finnerty
James F. Kelleher, P.C.
Colin Kenny
* John Lynch-Staunton (or Noël A. Kinsella)
Nick G. Sibbeston

* *Ex Officio* Members

Other Senators who participated in the work of the Committee:

Thelma Chalifoux, The Very Rev. Lois Wilson , *Sharon Carstairs (or Fernand Robichaud, P.C.) and *John Lynch-Staunton (or Noël A. Kinsella)

* *Ex Officio* Members

ORDER OF REFERENCE

Extract of the *Journals of the Senate* of Thursday, March 1st, 2001:

The Honourable Senator Taylor moved, seconded by the Honourable Senator Cordy:

That the Standing Senate Committee on Energy, the Environment and Natural Resources be authorized to examine such issues as may arise from time to time relating to energy, the environment and natural resources, including the continuation and completion of the study on Nuclear Reactor Safety;

That the papers and evidence received and taken on the subject of Nuclear Reactor Safety during the Second Session of the Thirty-sixth Parliament be referred to the Committee; and

That the Committee report to the Senate no later than December 15, 2002.

The question being put on the motion, it was adopted.

Paul C. Bélisle
Clerk of the Senate

EXECUTIVE SUMMARY AND RECOMMANDATIONS

Although nuclear reactors have been in operation in Canada since the 1970s without a major accident or incident on the scale of Three Mile Island or Chernobyl, the issue of their safety is never far from the public eye. When Ontario Power Generation announced that it planned to restart the four units at Pickering A that have been shutdown since 1997, in part for safety reasons, the issue once again surfaced. The Parliament of Canada has a role to play in ensuring that these concerns are addressed and the Standing Senate Committee on Energy, Environment and Natural Resources was given the mandate of studying the safety of nuclear power generation.

At the outset, the Committee decided to focus on four particular aspects of nuclear safety, namely: technological aspects; the safety culture at nuclear power stations; federal legislation and oversight; and finally, the public role in decision-making regarding safety issues. To fulfil the mandate, Committee members toured the Pickering Nuclear Generating Station, spoke with concerned citizens in the area, heard witnesses in Ottawa, commissioned an independent expert review of the accident risk posed by Pickering A and met with U.S. regulatory officials in Washington and officials of the World Association of Nuclear Operators in Atlanta, Georgia. The Committee intends to further examine the international regulation of nuclear reactor safety at a later date, by consulting with experts from such organizations as the International Atomic Energy Agency and the Nuclear Energy Agency.

The study led the Committee to make a number of recommendations in each of the four subject areas noted above. The recommendations are as follows:

TECHNICAL ASPECTS:

Recommendation 1:
The Committee recommends that the Canadian Nuclear Safety Commission "CNSC" maintain an arm's-length relationship with utilities when dealing with compliance to orders on critical matters of safety.

Recommendation 2:
The Committee recommends that substantive discussions such as those related to the safety system upgrades be documented to the extent possible, that those documents be made publicly available and that the public be consulted before final decisions are made.

Recommendation 3:
The Committee recommends that the CNSC require thorough testing and monitoring of the shutdown system upgrade at Pickering A following its installation and make public all reports of its performance in tests and under operating conditions.

Recommendation 4:

The Committee recommends that prior to the restart of any reactor, CNSC order Ontario Power Generation "OPG" to recalculate the seismic hazard by conducting a thorough seismic risk assessment including full consideration of the risk related to the pressure relief ducts, and that they make any additional safety improvements that may be identified.

Recommendation 5:
The Committee recommends that the CNSC require OPG to conduct a full, third-level probabilistic risk assessment of Pickering A.

SAFETY CULTURE:

Recommendation 6:
The Committee recommends that the necessary steps be taken by the CNSC or other responsible authority to speed up the process of adopting updated International Commission for Radiological Protection "ICRP" standards in Canada.

Recommendation 7:
The Committee recommends that in the interests of public safety, the Government of Ontario and the Federal Government consider amendments to human rights legislation that would permit drug and alcohol testing of workers in areas critical to public safety. In the meantime, the Committee recommends that representatives of union and management at OPG give priority to establishing a program for alcohol and drug testing that does not contravene existing law.

FEDERAL LEGISLATION AND OVERSIGHT:

Recommendation 8:
The Committee recommends that the government take immediate action to amend the Nuclear Liability Act, and increase and maintain the mandatory operator held insurance coverage from the current 75 million dollars at an amount in line with the Paris and Vienna Conventions " over 600 million dollars".[1]

PUBLIC INPUT TO DECISION-MAKING:

Recommendation 9:
The Committee recommends that the Comprehensive Study List Regulations of the CEAA be amended to include the restart of a nuclear power reactor following a prolonged shut down of the reactor or significant modification to the reactor and/or the station.

[1] The Vienna Convention on Civil Liability for Nuclear Damage and the Paris Convention on Third Party Liability in the Field of Nuclear Energy.

Recommendation 10:

The Committee recommends that the CNSC ensure public confidence in the federal environmental assessment process by:

- *retaining for itself the public consultation process, not delegating it to a project proponent;*
- *setting more realistic and fair deadlines on public comment periods taking into account the volume of material to be assessed and the technical expertise required to analyze it;*
- *determining the scope of assessments independently of the project proponent;*
- *improving its maintenance of the public registry required under CEAA; and*
- *developing guidelines to make intervenor funding available to interested parties.*

As governments around the world grapple with the challenge of reducing energy-related emissions of greenhouse gases, nuclear power is being looked at with renewed interest. The Committee believes that implementation of its recommendations will assist in ensuring that nuclear power is generated in a manner that protects the health and safety of employees, the public and the environment. We have requested that the appropriate Ministers give prompt attention to our findings and we will revisit the subject in the future to ascertain what action has been taken to address the issues we have raised.

CANADA'S NUCLEAR REACTORS: HOW MUCH SAFETY IS ENOUGH?

INTERIM REPORT

INTRODUCTION

Nuclear power generation has been a fact of life in Canada since the early 1970s when the commercial CANDU reactors at Pickering, Ontario and Gentilly, Quebec**,** began to produce electricity. Today, some 15 per cent of Canada's supply of electricity is produced by nuclear energy. Ontario residents are particularly dependent on it. Fifty per cent of that province's electrical supply is now powered by 12 nuclear reactors. In New Brunswick, the Point Lepreau Nuclear Power Station furnishes 30 per cent of the province's demand for electricity. [2] In Quebec, the Gentilly-2 station satisfies about three per cent of Quebec's demand.

Utilities that planned and built nuclear power stations three decades ago expected that they would operate safely for 40 years or more. However in 1997, Ontario Hydro, the forerunner to Ontario Power Generation (OPG) [3], shut down its seven oldest reactors at an estimated cost of $5 billion to $8 billion.[4] Simply put, the oldest plants had not been well maintained. They were performing at a minimally acceptable level – a rating that likely would have resulted in comparable stations in the United States being placed on the Nuclear Regulatory Commission's watch list.[5] According to Ontario Hydro's chief executive officer of the day, management had lost its focus on safety and efficiency, and allowed a deterioration of standards. [6]

Moreover, the Atomic Energy Control Board (AECB), the predecessor to the Canadian Nuclear Safety Commission (CNSC) [7], had ordered Ontario Hydro to make a key safety improvement at Pickering Nuclear Generating Station A by the end of 1997. Unable to meet the deadline for an

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[2] *David Torgerson, Vice President, Research and Product Development, Atomic Energy of Canada Ltd.*, Standing Senate Committee on Energy, Environment and Natural Resources, Minutes of Proceedings and Evidence, *Issue # 3, p. 3:8, 22 February 2000.*

[3] *OPG came into existence on 1 April 1999. Before that time Ontario Hydro operated the nuclear reactors in the province. The two names will be used interchangeably depending on the date of the information being referenced.*

[4] Report of the Select Committee on Ontario Hydro Nuclear Affairs, *December 1997*

[5] *Ontario Hydro*, Report to Management, Independent Integrated Performance Appraisal(IIPA)/Safety System Functional Investigation (SSFI) Evaluation Findings and Recommendations, *21 July 1997 (hereafter cited as IIPA)*

[6] "*Meltdown*", Maclean's Magazine, *Special Report*, *25 August 1997*, *p.14*

[7] *The name of the AECB was changed to the Canadian Nuclear Safety Commission (CNSC) on 30 May 2000. References will use the name in use at the time the documents being cited were prepared.*

improved fast shutdown system for the reactors, Ontario Hydro took Pickering A out of service on December 31, 1997. The nuclear fuel was not removed.

Critics of the nuclear industry viewed the shutdowns as the beginning of the end of nuclear power generation in Canada.[8] The shutdowns also reawakened public concern about the safety of nuclear reactors -- concern fuelled since the 1970s by major accidents at nuclear power stations at Three Mile Island, Pennsylvania and at Chernobyl in the Ukraine. The Government of Ontario made an immediate effort to address public unease by establishing the Select Committee on Ontario Hydro Nuclear Affairs. The report of the Select Committee concluded that the nuclear reactors were being operated safely, but made 39 recommendations for improvements -- five of which were directed at the federal regulator or the Government of Canada.[9] [10]

In 1998, the House of Commons Standing Committee on Foreign Affairs issued a report, *Canada and the Nuclear Challenge: Reducing the Political Value of Nuclear Weapons in the Twenty-First Century*. While the report focused on nuclear weapons, it also touched briefly on the civilian use of nuclear power and the export of Canadian nuclear technology. Members of that Committee recognized that they had no mandate to deal with those issues. They recommended that another, more appropriate parliamentary body conduct a separate study. In February 2000, the Standing Senate Committee on Energy, the Environment and Natural Resources took up the task.

At the outset, the Senate Committee decided to focus solely on the safety of CANDU nuclear power reactors, of which there are 25 in Canada. In particular, the Committee decided to concentrate on four principal areas: the technological aspects of safety; the culture of safety at nuclear power stations; federal legislation and oversight; and the concept of social safety which deals with how ordinary Canadians regard nuclear power and their input into decision-making about it.

The committee is cognizant that nuclear power generation raises a host of other issues. Among them are federal government subsidies to the industry; the benefits of nuclear power in the fields of medicine and advanced research; the unresolved issue of nuclear waste disposal; the industry's potential to contribute to reducing emissions of greenhouse gases; and the larger question of alternative sources of power.

Today, Ontario Power Generation is planning to restart its four reactors at Pickering A. The utility has also signed an 18-year agreement with British Energy PLC, of Scotland, for the lease and operation of reactors at Bruce Nuclear Generating Station on Lake Huron.[11] Four of that station's eight reactors are currently shut down. Bruce Power, a wholly owned subsidiary of British Energy,

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[8] "*Nuclear Option is Dead*", Ottawa Citizen, *A1, 14 August 1997*

[9] Report of the Select Committee on Ontario Hydro Nuclear Affairs, *December 1997*

[10] *The Committee notes with interest that in December 2000, the Auditor General reviewed the regulatory activities of the CNSC related to licensing and regulating power reactors. He made a number of recommendations for improving practices of the CNSC in these areas. Details can be found in :* Report of the Auditor General of Canada to the House of Commons, *Chapter 27, Canadian Nuclear Safety Commission – Power Reactor Regulation, December 2000.*

[11] "*British Energy to Run Ontario Power's Bruce Plants*", The Globe and Mail, *B1, 12 July 2000*

has applied to the CNSC for operating licences for reactors at the site.[12] It has also begun a $30 million detailed engineering study that anticipates the restart of two of the four reactors now in shutdown. Acknowledging that millions of Canadians still rely on nuclear power, the pressing concern is not the energy choices made decades ago, but the decisions that are being made today about the aging plants. The Committee chose Pickering A, the oldest nuclear power station, as the logical test case for its investigation.

Officials of the Canadian Nuclear Safety Commission told the committee at the outset that its role is to regulate nuclear power in a manner that does not pose "an unreasonable harm to health, safety, the environment and national security." The federal regulator is on record as not being fully satisfied with the present standard of operation and maintenance at Canadian power reactors. A CNSC official told the Committee:

> *"I will say that the Atomic Energy Control Board is on record as being not fully satisfied with the present standard of operation and maintenance at Canadian power reactors. While we remain satisfied that the provisions for public safety, security, and environment are sufficient to allow operations in the short-term, we are determined that the Canadian safety philosophy of "defence-in-depth" not be eroded."* [13]

He further elaborated on this issue, commenting that: "We are not satisfied that the quality of operation and maintenance is adequate for the longer term -- which would be five to 10 years."[14]

How much safety is enough? It is the question one Committee member posed on the first day of hearings in Ottawa. It remained a key question throughout the Committee's work -- as members toured the Pickering Nuclear Generating Station, spoke with concerned citizens in the area, heard witnesses in Ottawa, commissioned an independent, expert review of the accident risk posed by Pickering A, and met with U.S. regulatory officials in Washington and officials of the World Association of Nuclear Operators in Atlanta, Georgia.

Committee members came as laypeople to the subject matter. They arrived at their conclusions, however, with the assistance of research staff, an independent expert consultant, informed witnesses, written submissions and the voluntary assistance of both nuclear industry critics and industry officials. Our recommendations are made in the hope that federal authorities and provincial utilities charged with ensuring nuclear reactor safety will consider those areas where sober second thought dictates there can, and should be, considerable improvement.

The Committee planned to table its report before Parliament in ample time for the Canadian Nuclear Safety Commission to consider its observations when making decisions about the environmental assessment of Pickering A. However, like other committees of Parliament, the Committee found its work cut short by the dissolution of Parliament in October 2000, and the call of a general election. Unable to report until Parliament was recalled, the Committee nevertheless hopes that Ontario Power Generation, the CNSC and appropriate Ministers will benefit from its

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[12] "*Bruce Power Applies for Operating Licences"*, Nuclear Canada, *Volume 1, No. 11, 1 December 2000, p.1*

[13] *Jim Harvie, Director General, Reactor Regulation, Atomic Energy Control Board*, Standing Senate Committee on Energy, Environment and Natural Resources, Minutes of Proceedings and Evidence, *Issue # 4-, p.4:7, 24 February 2000*

[14] *Ibid, p.4:15*

findings when making decisions about the restart of Pickering A and other nuclear stations, in particular the Bruce Nuclear Generating Station, where a return-to-service has been proposed. Finally, some of the Committee's findings are applicable to safety concerns at all operating reactors.

PICKERING A SHUTDOWN AND REHABILITATION: A BRIEF HISTORY

The Three Mile Island accident in the United States served as a wake-up call for the nuclear industry in that country. In 1979, in response to the accident and the decline in safety and operating performance that led to it, U.S. nuclear plant operators formed the Institute of Nuclear Power Operations (INPO), a self-help group for the industry. In the following decades, with the help of INPO, the performance and safety of U.S. plants improved dramatically.[15] In Canada, however, performance and safety were steadily declining.

In 1994, Pickering A was the site of Canada's worst accident at a commercial nuclear station. On December 10, 1994, a pipe break at Pickering reactor 2 resulted in a major loss of coolant accident and a spill of 185 tonnes of heavy water. The Emergency Core Cooling System was used to prevent a meltdown. About 200 workers were involved in the cleanup. The reactor was restarted 14 months later.

Throughout its operation, Ontario Hydro reported other significant events at the Pickering station to the AECB. Among them were the following:

- On August 1, 1983, Pickering reactor 2 had a loss of coolant accident after a pressure tube suffered a metre-long rupture. The station was shut down and the four reactors at Pickering A were eventually retubed at a cost of about $1 billion.

- On November 22, 1988, an operator error damaged 36 fuel bundles. The cooling system was contaminated by radioactive iodine that was vented into the environment over several weeks following the accident.

- On September 25, 1990, Pickering reactor 2 experienced large power shifts in the reactor core. Staff spent two days trying to stabilize it before shutting it down. The AECB later criticized the utility for not shutting down immediately.

- On August 2, 1992, Pickering reactor 1 had a heavy water leak from a heat exchanger that resulted in a release of 2,300 trillion becquerels of radioactive tritium into Lake Ontario.[16]

- On April 15, 1996, Pickering reactor 4 had a heavy water leak from a heat exchanger that resulted in a release of 50 trillion becquerels of tritium into Lake Ontario.

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[15] *Institute of Nuclear Power Operations,* 1999 Annual Report, *Atlanta, Georgia, p. 14*

[16] *To put this huge number into some context, if this total release were evenly diluted in the total volume of water in Lake Ontario (without suggesting that this is what would happen), it would add roughly 2 becquerels/litre of radiation. The Ontario Drinking Water Standard is currently 7000 becquerels/litre.*

By 1997, the AECB was so concerned about the declining performance of Pickering Generating Stations A and B that it shortened the normal two-year term of the operating licence to six months. Four years earlier, the federal regulatory board had ordered that a second fast shutdown system be added to the Pickering A reactors by the end of December 1997. By November 1996 it was apparent that the deadline would not be met, and that dramatic action was needed to stop and to reverse the downward trend in performance and safety.

The president of Ontario Hydro called in experts from the U.S. to provide what he later described as a "brutally honest" assessment of their nuclear operations and to develop an improvement plan. The Committee heard testimony from Mr. Carl Andognini who headed the review team that prepared the Integrated Independent Performance Assessment (IIPA) and later served as Special Nuclear Advisor to the President of OPG. Mr. Andognini attributed the decline to the retirement of experienced staff, weak leadership, and decentralization of nuclear operations.[17] More importantly, Mr. Andognini noted that "the organization (Ontario Hydro) never really shifted from a fantastic engineering and construction organization, to an operational and maintenance organization."[18]

The IIPA report had concluded that:

> *"Long standing management, process and equipment problems in Ontario Hydro Nuclear plants are well known but have not been aggressively resolved. As a result, the overall performance of OHN is well below the level of performance typically achieved by the best nuclear utilities. Immediate attention is needed to improve performance so that the value of OHN's assets does not depreciate beyond recovery."*[19]

The IIPA rated the Pickering station minimally acceptable – a ranking substantially below industry standards – in its operations, maintenance, training, engineering, radiation protection, chemistry and organizational effectiveness. The minimally acceptable rating signalled that immediate management attention was required. Only in the area of emergency preparedness was the Pickering station given the somewhat higher designation of below standard.[20]

In a detailed look at the station's electrical distribution system, the IIPA team reported that in some cases, the ability of the system to fulfil the functions for which it was designed was not assured. In other cases, the system's ability to function had been reduced to unacceptable levels. The chief cause was a failure to account for the cumulative effect of design and operating changes. Ineffective maintenance was also cited. In response, Ontario Hydro shut down the four Pickering A units and the three Bruce A units so that it could focus resources on the remaining reactors and bring them back to fully acceptable operation.

The Committee heard that the performance of OPG nuclear plants that were not shut down has improved as a result of a wide-ranging Performance Improvement Program in place during the last

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[17] *Carl Andognini*, Standing Senate Committee on Energy, Environment and Natural Resources, Minutes of Proceeding and Evidence, *Issue # 7, p. 7:6-7:7, 13 April 2000*

[18] *Ibid.*

[19] *IIPA (1997), p. 2*

[20] IIPA (1997), p.6

three years. Using standards developed by the World Association of Nuclear Operators (WANO), the overall OPG performance indicator has gone from about 57 per cent in 1997 when the North American average was 81 per cent, to 81 per cent at the end of 1999 when the world average had reached 88 per cent.[21] This improvement, along with economic considerations, encouraged OPG to seek permission from the CNSC to restart the Pickering A units, subject to specific improvements, including a safety system upgrade. The proposal provided the Committee with an excellent case study for its review of nuclear safety.

The above noted use of WANO standards raised the issue of the potential role of international bodies in overseeing the safety of nuclear reactors worldwide. The Committee intends to follow up on this aspect of nuclear reactor safety in Paris and Vienna with representatives of the International Atomic Energy Agency and the Nuclear Energy Agency at a later date.

[21] *Andognini, p. 7:8*

TECHNICAL ASPECTS OF THE PICKERING A RESTART

SAFETY FEATURES OF CANDU REACTORS

The Committee heard repeatedly that the CANDU reactor is a robust technology that is tolerant of human error and mechanical failure.[22] One witness described it as the safest nuclear technology in the world.[23]

No serious injury or death to workers or the public has been recorded in more than 30 years of operation of CANDU reactors in Canada. Officials of Atomic Energy of Canada Ltd., the federal agency which designs and sells the reactors attributes the safety record to the CANDU design that duplicates or triplicates safety features. The Committee was told that separate, independent groups of systems are put in place to control the reactor power and if necessary to shut it down, to remove heat after it is shut down, to contain radioactive emissions within the plant and to monitor the state of the plant.[24]

In comparison to the majority of the world's commercial reactors, which are pressurized, light water reactors (PWR), the CANDU heavy water reactor design has several inherent safety advantages. A CANDU reactor has relatively large inventories of both (heavy) water and of uranium. If cooling of the reactor core is interrupted for whatever reason, their thermal mass will slow the rate of temperature increase in the reactor core. The separation of cooling water and moderator water in the CANDU design is also seen as a safety advantage.[25]

On the other hand, the CANDU design uses a relatively large amount of zirconium alloy in the fuel bundles – almost four times as much as is present in some light water reactors. This large zirconium inventory gives CANDU reactors a safety disadvantage. Zirconium reacts vigorously and exothermically (produces heat) with steam at the high temperatures that would be experienced during a core damage accident. This reaction produces hydrogen gas that can quickly reach explosive concentrations inside a reactor containment building. [26] (Officials from AECL told the Committee that, to address this issue, they have developed a passive recombiner that can destroy the hydrogen

[22] *Victor Snell, Director, Nuclear Safety and Licensing, Atomic Energy of Canada*, Standing Senate Committee on Energy, Environment and Natural Resources, Minutes of Proceeding and Evidence, *Issue #3, p. 3:16,* 22 *February, 2000*

[23] *Andognini, p. 7:5*

[24] *Snell, p.3:13*

[25] *Thompson, p.7*

[26] *Ibid.*

in the containment building. This technology is being designed into new CANDU reactors and could be retrofitted on to existing ones.[27])

Another area of concern is the potential seriousness of a loss of coolant accident. In light water reactors, the power level declines if the cooling water is lost. CANDU reactors, like the RBMK reactor in Chernobyl, however, see power levels increase when coolant is lost. An accident of particular concern for CANDU reactors involves a loss-of-coolant accident together with a failure of the reactor shutdown system. If the fast shutdown fails, the power level can rise dramatically. A violent disruption of the reactor core can occur within four to five seconds and release significant quantities of radioactive material. [28]

PARTICULAR FEATURES OF THE PICKERING A REACTORS

The four reactors at Pickering A were the first commercial CANDU units. As such they lacked some safety features that were incorporated into later CANDU reactors. For example, the units were designed to have one fast-acting shutdown system that could shut down the reactor in two seconds and one slow-acting system which requires more than 10 seconds to be effective. When the Pickering A plant was licenced, its slow-acting system was thought to be an adequate, second shutdown method. However, AECB later revised its findings regarding the need for a redundant fast shutdown system. All subsequent CANDU reactors were built with a second independent, fast shutdown system that can inject a neutron absorbing liquid to halt the nuclear reaction in the core.

In addition, Ontario Hydro employed a design concept atypical of most nuclear generating stations. At the Pickering Nuclear Generating Station, eight reactors share the same safety and support systems. While the sharing of systems occurs at nuclear generating stations elsewhere in the world, generally it exists to a much smaller extent.

All eight reactors at Pickering share the same containment system, which consists of eight individual reactor buildings, one vacuum building and one pressure relief duct which connects them. The system is designed to absorb the stored energy and radioactive decay heat from one reactor for one hour after shutdown. In comparison to light water reactors, the Pickering containment system is large, which offers a safety advantage. However, the advantage is offset by a low design pressure and the shared nature of the system.

Similarly, the emergency coolant injection system is shared by eight reactors. Built during the construction of Pickering B station, the storage tank and pumphouse can provide emergency coolant for one accident at one reactor.

The proposed restart of the Pickering A units raises questions. Never before in Canada have reactors this old (25 years) been returned to service following such a long shutdown. How great an accident risk does the restart of the Pickering A reactors pose? How is risk measured? How effective will safety upgrades proposed by Ontario Power Generation (OPG) prove to be?

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[27] *Torgerson, p. 3:30*

[28] *Ibid.*

The Committee heard testimony from a number of sources, and as is often the case, the answers to the general questions were contradictory. Officials of OPG said that it will be safe to restart the four reactors at Pickering A when safety and equipment upgrades are in place. Others, including representatives of the Pickering East Shore Community Association, view the restart as a potentially dangerous experiment.[29]

The Committee sought independent expert advice to help it understand the accident risk associated with restarting Pickering A. It commissioned Dr. Gordon Thompson[30] of the Institute for Resource and Security Studies (IRSS) to study the issue. The results of his report [31] along with testimony presented to the Committee form the basis of the following technical discussion.

PROPOSED RETURN TO SERVICE

Ontario Power Generation plans to return to service the first of four Pickering A reactors at the end of 2001. The remaining reactors will be brought on-line one at a time at six to eight month intervals. Before returning the reactors to service, OPG says it will spend in the order of $1 billion on improvements related to safety or environmental protection.[32] In the area immediately around the nuclear reactors proposed improvements include:

- Upgrading emergency shutdown systems;
- Replacing pumps and other parts of the heavy water system to avoid potential leaks;
- Further improving air-handling systems to reduce already small releases of radioactivity to the atmosphere;
- Increasing the resistance of key structures and reactor control systems to seismic damage.

OPG is also planning a number of improvements to areas outside the immediate area of the reactors including:

- Replacement of brass condenser tubes with stainless steel tubes to reduce copper and zinc discharges to the lake;

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[29] *Pickering East Shore Community Association, at informal meeting with the Standing Senate Committee on Energy, Environment and Natural Resources, Pickering, 4 April 2000*

[30] *Dr. Gordon Thompson, an engineer and Doctor of Philosophy (DPhil) in applied mathematics, is the Executive Director of the IRSS. He has extensive experience in assessing the hazards associated with nuclear facilities and in identifying alternative designs and modes of operation that can reduce a facility's hazard potential. Dr. Thompson has also worked on a range of other subjects related to energy, environment and international security.*

[31] *G. Thompson,* A Review of the Accident Risk Posed by the Pickering A Nuclear Generating Station*, A Report to the Standing Senate Committee on Energy, the Environment and Natural Resources, August 2000*

[32] *Ontario Power Generation (OPG)*, Pickering A Return to Service: Environmental Assessment, *October 1999, Issue 2, p.1*

- Improved fire detection and suppression systems;
- Better spill protection for chemical and fuel oil storage facilities;
- New management systems to improve environmental performance.[33]

Unfortunately, OPG provided only limited information about the proposed improvements in its April 2000 environmental assessment report on the restart. The report does not set out an integrated package of improvements and does not describe the allocation of funds to types of improvements. Thus, it is unclear how much of the $1 billion will be spent on hardware upgrades, as opposed to such functions as training, documentation and managerial improvements. Nor is it possible to determine the extent to which the proposed improvements will affect the risk posed by the reactors.[34] Additional information is provided in a November 1999 OPG document, however it does not provide a firm commitment to implement all of the listed improvements.

The proposed improvements that generated the most discussion during Committee hearings and site visits are examined in detail in the following sections of this report.

UPGRADE OF FAST SHUTDOWN SYSTEM

The most contentious of the planned improvements is the upgrade to the emergency shutdown system. As noted earlier, the removal from service of the four Pickering A reactors was, at least in part, due to Ontario Hydro's inability to meet a licence condition and deadline imposed by the AECB in 1993. The condition in question was the installation of an enhanced[35] fast shutdown system by the end of December 1997.

The AECB began discussions with Ontario Hydro on upgrading the Pickering A reactors' fast shutdown system following the 1986 Chernobyl accident. The Pickering A units were built with only one fast shutdown system, in which control rods can be dropped into the reactor core to stop the chain reaction in the case of an emergency, within two seconds. A second shutdown system that stops the reaction by dumping the heavy water that moderates it, is also available, but takes more than ten seconds to be fully effective and so is said to be slow acting.

From 1986 until 1993, the AECB and Ontario Hydro were involved a closed-door discussion in which they "negotiated what the upgrade would be." The process was criticized by some observers who saw it as an example of an inappropriately close relationship between the regulator and the industry it regulates.[36]

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[33] *OPG, Pickering A Return to Service: Environmental Assessment, Newsletter, Issue 3, November/December 1999, p. 3.*

[34] *Thompson, p..9*

[35] *J. Harvie, Director General, Reactor Regulation, Atomic Energy Control Board,* Standing Senate Committee on Energy, Environment and Natural Resources, Minutes of Proceedings and Evidence, *Issue # 4, p. 4:28, 24 February 2000*

[36] *Durham Nuclear Awareness*, Comments to the Canadian Nuclear Safety Commission on the Draft Screening Report on the Pickering A Nuclear Station Restart Proposal, *4 July 2000*

Four upgrade options were finally accepted by the AECB. They ranged from installation of a second, fully independent fast shutdown system to the much simpler addition of a small number of control rods to the existing 21 rods, division of the rods into two banks, and the addition of a separate set of sensors and trip mechanisms for each bank. Either bank of rods, operating alone would be able to shut the reactor down.[37] In fact, as few as five control rods inserted into the core are capable of shutting down the reactor.[38] Finally, in 1993, OPG decided on the latter option, and AECB gave its approval.

The Committee heard testimony questioning the rationale for accepting this particular upgrade, which, the AECB admits does not in fact constitute a second independent system.[39] Witnesses from OPG stated that:

> *"There are not, currently, two independent shutdown systems available at Pickering A. However, the equivalent of two independent systems is being installed."*[40]

OPG officials also told the Committee that the fact that the more extensive upgrades would result in greater worker exposure to radiation was also a factor in deciding which option to pursue.[41]

The Committee's consultant summed up the issue, stating:

> *"The agreed set of enhancements is a comparatively cheap option, and will not provide a second, independent fast-acting shutdown system."* [42]

Some witnesses also questioned the equivalency of the upgrade option and whether cost, rather than safety, was the deciding factor in the final decision. The expected cost of the approved enhancement is about $30 million (1995$), while the other options ranged from $127 million to $352 million.

One witness stated:

> *"There is no public access to the debate and the negotiations around what kind of upgrades will be done and whether there are in fact safety trade-offs being made to save money on the whole restart budget."*[43]

In light of the evidence:

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[37] *Atomic Energy Control Board*, Board Management Decision 93-07, *5 January 1993, Appendix A*

[38] *Bob Strickert, Vice-President for Pickering A, meeting with OPG officials at Pickering plant site, 5 April 2000*

[39] *Harvie, p. 4:28*

[40] *Carl Andognini, Special Nuclear Advisor to the President, Ontario Power Generation*, Standing Senate Committee on Energy, Environment and Natural Resources, Minutes of Proceedings and Evidence, *Issue # 7, p. 7:24, 13 April 2000,*

[41] *Strickert, 5 April 2000*

[42] *Thompson, p. 11*

[43] *Kock, p.8:6*

Recommendation 1:
The Committee recommends that the Canadian Nuclear Safety Commission "CNSC" maintain an arm's-length relationship with utilities when dealing with compliance to orders on critical matters of safety.

Recommendation 2:
The Committee recommends that substantive discussions such as those related to the safety system upgrades be documented to the extent possible, that those documents be made publicly available and that the public be consulted before final decisions are made.

Recommendation 3:
The Committee recommends that the CNSC require thorough testing and monitoring of the shutdown system upgrade at Pickering A following its installation and make public all reports of its performance in tests and under operating conditions.

Dr. Gordon Thompson, the Committee's consultant, noted further that none of the safety improvements promised by OPG have yet been subjected to or included in an appropriate risk assessment. As a result, there is no assessment of the impact of these proposals, on the overall risk profile of the Pickering Station.[44] Before approval is given to restart Pickering it would be prudent to fill this knowledge gap.

SEISMIC HAZARD

On May 24, 2000 a mild earthquake shook the Pickering region and neighbouring areas of southern Ontario – the fourth in 18 months. Centred under Lake Ontario just south of Oshawa, the earthquake measured 3.1 on the Richter scale. Seismic monitors on turbine generators at the Pickering station registered a vibration. Workers checked for structural damage but found none. [45] Six months earlier a 3.8 magnitude earthquake arose from the same location in the lake.[46]

During the course of its study, the Committee heard a great deal about the seismic hazard at the Pickering site. The discussions could be separated into two distinct, but closely related aspects of the issue. A number of witnesses addressed the ongoing debate over the magnitude of an earthquake that can reasonably be expected to occur at or near the Pickering site. The second aspect related to the ability of the Pickering A Nuclear Generating Station to withstand the effects of an earthquake and the manner in which that ability has been assessed.

When Pickering A was constructed, buildings at the site were designed to exceed the minimum National Building Code Standards of the day. The Canadian Standards Association had not yet

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[44] *Thompson (2000), p.28*

[45] *Peter Small, "Quake gives eastern GTA a gentle wake-up call",* The Toronto Star, *5 May 25*

[46] *Tom Blackwell, " Toronto shakes, rattles in quake",* The Edmonton Journal, *25 May 2000*

developed the seismic design standard that was applied to many of the later CANDU reactors in Canada.[47] Ontario Hydro increased the requirements beyond the national building code from about 2% to 5% gravity equivalent static load for the nuclear structures.[48] In the early 1970's, 5% was viewed as more than sufficient to protect the plant from damage due to seismic activity. However, the International Atomic Energy Agency, headquartered in Vienna, now suggests a minimum design standard of 10% gravity equivalent static load for nuclear structures.

The anticipated level of seismic activity near the Pickering site was based on a review of the limited historical earthquake data. Data were limited because this mid-continental region had always been regarded as geologically very stable. Consequently, only limited geophysical research had been conducted.

In the mid-1980s, OPG began a series of seismic hazard studies for its nuclear and hydroelectric facilities using newly developed methodology and technology. Over the years, seismological and geophysical research has continued and the hazard assessments have been updated to reflect new findings. The results of these studies have become controversial, with a divergence of professional opinion over the interpretation of some of the findings. The debate over the potential magnitude and frequency of seismic activity in southern Ontario was apparent to the Committee from the conflicting testimony it received.

Dr. Arsalan Mohajer, a seismologist who conducted some of the earliest research for OPG in the Pickering area, told the Committee that his initial research had "…found a break in the earth's crust directly under a nuclear power plant." [49] The plant in question is the Pickering Nuclear Generating Station. The witness described how a further five to six years of study revealed still more evidence of potential seismic risk in the form of an "…indication of young faulting close to the surface… "[50] in the Rouge River Valley, a few kilometres west of Pickering. He stated that one of the fault lines found to be crossing Lake Ontario "…appears to be a reflection of the St. Lawrence fault zone which is proven active…" [51]

Dr. Mohajer also reported a discontinuity or unevenness of the bedrock surface across Ontario, which he had identified using data from wells drilled throughout the province. He concluded that this discontinuity was indicative of faulting due to seismic activity. Further indications of seismic activity, including photographs of large segments of broken rock on the floor of Lake Ontario were also described to the Committee.[52]

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[47] *Atomic Energy Control Board*, AECB workshop on Seismic Hazard Assessment in Southern Ontario – Recorded Proceedings, *Ottawa, Ontario, 19-21 June 1995, p.11*

[48] *Ibid., p. 71*

[49] *Arsalan Mohajer, Associate Professor of Geophysics, Environmental Sciences, Physical Sciences Division, University of Toronto,* Standing Senate Committee on Energy, Environment and Natural Resources Minutes of Proceedings and Evidence, *Issue # 11, p. 11:20, 30 May 2000*

[50] *Ibid.*

[51] *Ibid., p. 11:21*

[52] *Ibid. p. 11:22*

In response to this testimony, OPG submitted a detailed document on seismic hazard and seismic design to the Committee in which it challenged many of the conclusions presented by Dr. Mohajer.[53] It noted that detailed geological mapping completed in 1999 by an expert panel of three scientists, specializing in glacial deformation, structural geology and seismic hazard, had shown that only one of the identified faults, the Rouge River fault, was not clearly of glacial origin. In other words, in the opinion of the expert panel, the faults are the result of the pressure and movement of glacial ice during the last Ice Age. They are not a reflection of deep crustal faulting in the underlying bedrock, which would indicate a seismic hazard.[54]

Deep drilling was conducted to assess the Rouge River fault. The drilling was completed in May 2000 and OPG reported to the Committee that "…preliminary borehole data showed no evidence of faulting of seismic origin."[55] The final *Rouge River Advisory Panel Report* was issued in September 2000. This report provides a more detailed account of the findings, concluding:

> *"The Panel is satisfied that sufficient work has been carried out in the Rouge River Valley to demonstrate that there is no surficial evidence of a continuous earthquake-related fault in the valley. The structural features encountered in the exposures of quaternary sediments and underlying rock are explained by glaciation-related phenomena, and are not relevant to seismic hazard in the region. An important result of this study is the demonstration that it is extremely difficult, and in some cases impossible, to differentiate between structural features of glacial origin and those of tectonic origin, based on surface deformation features alone. This may explain why some previous investigations of the Rouge River features reached the conclusion that the deformation features were likely related to earthquake faulting. In the absence of a clearly-expressed continuous fault of crustal dimensions, the evaluation of minor structures such as those observed at the Rouge River localities requires subsurface information in order to have any bearing on seismic hazard."* [56]

As important as determining the likelihood of seismic activity in the area of the plant is the assessment of the effect that an earthquake would have on the Pickering A Nuclear Generating Station. In 1993 the AECB requested that Ontario Hydro carry out an assessment of how well Pickering A would withstand an earthquake. Five years later, the utility published its findings, which are discussed in the following paragraphs.

The method of assessment selected by Ontario Hydro was developed by the U.S. Electrical Power Research Institute and is known as a seismic margin assessment (SMA).[57] The first step in the assessment is to determine a review level earthquake, or the likely magnitude and frequency of earthquake that could be expected at the site. The station's ability to withstand such a quake without suffering a severe accident is then determined by examining the performance of key, safety-related

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[53] *Ontario Power Generation - Nuclear,* Seismic Hazard and Seismic Design Issues at OPGI Nuclear Power Stations, *July 2000*

[54] *Ibid. p. 14*

[55] *Ibid, p.16*

[56] *R.L. Brown, G.M. Atkinson and A. Dreimanis,* Rouge River Expert Advisory Panel Summary Report, *September, 2000, p.6*

[57] Electric Power Research Institute, NP-6041, *A Methodology for Assessment of Nuclear Power Plant Seismic Margin,* October, 1988

facility components that must function if the plant is to reach a safe shutdown. The key components must withstand the ground motion caused by the earthquake and shut down the reactor, cool the fuel and contain radioactivity.

A SMA is regarded as a simpler and cheaper method of analysis than a seismic probabilistic risk assessment.[58] As a result, it provides less information about a nuclear plant's ability to ride out an earthquake. There is some question of how accurately an SMA can assess risk when compared to the more detailed seismic probability risk assessment (PRA) methodology.

The seismic PRA approach involves three basic steps. First, a set of 'seismic hazard curves' is developed for the site in question, showing the annual probabilities of earthquakes of differing intensities (ground accelerations), at a range of confidence levels. Second, a set of 'fragility curves' is developed, showing the conditional probabilities of specified outcomes (e.g., severe core damage) for earthquakes of differing intensities, at a range of confidence levels. Third, the findings of the first two steps are combined, to show the annual probabilities of the specified outcomes." [59]

From its seismic margin assessment, OPG concluded that:

> *"A large part of the station's key safety-related structures, systems and components that are needed for shutdown, cooling, monitoring and containment functions following a major earthquake were shown by inspection to meet seismic screening criteria."*[60]

The SMA identified some areas that required seismic upgrading, including the anchoring of components to prevent shifting, reinforcement of concrete masonry adjacent to safety-related equipment and the replacement of a number of components. OPG has undertaken to make the improvements before restarting Pickering A.[61]

However, the Committee received disturbing testimony from a number of witnesses about a component that is not on the above list of those being upgraded. Pickering area public interest groups including Durham Nuclear Awareness, Pickering Ajax Citizens Together for the Environment, Liverpool Community Association and Pickering East Shore Community expressed concern about potentially serious problems with the pressure relief duct that is part of the station's system for containing radioactive gases. [62]

The duct is a large, elevated, rectangular, reinforced concrete structure. Approximately half a kilometre in length, it connects the four reactor buildings of Pickering A, as well as the four Pickering B reactor buildings to the vacuum containment structure. In the event of a serious

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[58] Thompson, p. 16

[59] *Ibid.*

[60] *OPG - Nuclear, July 2000, p. 3*

[61] *Ibid., p. 4*

[62] *Kock, Informal meeting in Pickering, 4 April 2000*

accident and the consequent release of radioactive gases, the pressure relief duct was designed to keep excess pressure from building up inside any one of the reactor buildings.

The Committee's consultant also provided details of concerns about the pressure relief duct raised in a 1999 review for the AECB of the Pickering A SMA by Acres International.

> *"The Acres review expressed concern that Ontario Hydro's seismic margin assessment did not adequately examine the behaviour of the pressure relief duct during the review level earthquake. According to the Acres review, surface waves in the duct could lead to forces and displacements larger than those estimated by Ontario Hydro, potentially causing pounding of expansion joints and threatening the integrity of the emergency coolant injection piping where it enters the reactor building."* [63]

In 1995, the AECB had paid for an analysis of the seismic fragility of the pressure relief duct. The analysis predicted collapse of the duct at a peak ground acceleration of 0.22g – a less severe earthquake than the earthquake considered in the SMA.

Pickering area public interest groups pointed to the fact that only 10% of the one-half kilometre length of the duct was modelled in the Ontario Hydro assessment. They told the Committee that:

> *"The (Acres) report concluded that Ontario Hydro's results likely underestimate the impact of an earthquake on the duct because the effect of surface waves along the entire one half kilometre length of the duct was not considered, and recommended further study."*[64]

The Committee also learned of another concern raised in the Acres review of the Pickering SMA. This concern deals with the human response to an event, such as an earthquake, that results in a small loss of coolant from the reactor. For the reactor to be successfully shut down, human intervention would be necessary. In light of the confusion that would surround a serious event, it may be very difficult for operators to perform all of the tasks required, unless they are well prepared. Dr. Thompson noted that:

> *"The Acres review pointed out that achievement of the success path [to safe shutdown and containment] would require the correct implementation of a variety of operator actions. For example, if the earthquake causes a small LOCA [loss of coolant accident], up to 14 operator actions would be required to remain on the success path. Yet, many components and instruments not in the success path could fail as a result of the earthquake, leading to a large number of alarm indications and a stressful work environment. Thus, correct implementation of the necessary operator actions cannot be assured. To accommodate such concerns, a seismic risk assessment should be integrated with an internal-events PRA. This has not been done for Pickering 'A'."*[65]

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[63] *Acres International*, Seismic Assessment of Systems and Components at Pickering A, , *Prepared for Atomic Energy Control Board, 11 January 1999*

[64] *Durham Nuclear Awareness (4 July 2000), p.13*

[65] Thompson (2000), p.21

These findings are cause for serious concern. The Committee concurs with its consultant that there are grounds to doubt that Ontario Hydro's seismic margin assessment correctly assessed the ability of the Pickering 'A' Station to ride out the review level earthquake.[66]

> ***Recommendation 4:***
> *The Committee recommends that prior to the restart of any reactor, CNSC order Ontario Power Generation "OPG" to recalculate the seismic hazard by conducting a thorough seismic risk assessment including full consideration of the risk related to the pressure relief ducts, and that they make any additional safety improvements that may be identified.*

THE SIGNIFICANCE OF FIRES AT PICKERING A

In 1997, the IIPA team paid special attention to fire hazards at the Ontario Hydro stations. A fire protection assessment found a lack of managerial leadership had resulted in poor storage of materials, deficient housekeeping and inadequate controls on flammable materials. It pointed out that there was insufficient understanding of where the plants were vulnerable to fire, how fires in critical locations could affect nuclear safety and where more detection and suppression systems were needed. The team of experts also issued the caution that fire is the dominant contributor to core damage frequency at some stations in the U.S. Core damage resulting from fire at Ontario Hydro units was also a possibility.[67]

The lack of understanding of the risk of fire and the failure to assess its implications are particularly regrettable in light of the design of the OPG stations. In contrast to the typical nuclear plant design using small compartments surrounded by fire barriers, fire detection and suppression systems, the OPG units are characterized by expansive openness intended for easy access for equipment and personnel engaged in manual fire-fighting. Ontario Hydro acknowledged in 1997 that the design concept would not necessarily be repeated in future stations if fire protection was a major consideration.[68]

The Committee's consultant pointed out that analytical techniques have been developed to consider fires as accident-initiating events in probabilistic risk assessments.

> *"It appears, however, that these techniques have not been applied to Ontario Hydro's CANDU stations. Thus, at Pickering A, the contribution of fires to the probability of severe core damage is unknown."*[69]

While OPG has listed improved fire detection and suppression systems among its proposed upgrades, in the absence of details of those systems, the allocation of funds to them and an

[66] *Ibid. p. 18*

[67] *IIPA, p. 34*

[68] *Thompson, p.19*

[69] *Thompson p. 19*

independent assessment of their adequacy it is impossible to know the extent to which the problems will be resolved.

RISK ASSESSMENT: EVALUATING THE ACCIDENT RISK POSED BY PICKERING A

In the early years of the nuclear power industry, safety and risk focused on preventing "design-basis" accidents -- accidents that the nuclear plant was designed to accommodate. Severe accidents such as damage to the reactor core or the release of large quantities of nuclear material to the atmosphere were not considered, as they were thought to be so unlikely that they were "incredible" events. However, during the 1970s studies began to show that such accidents were credible. Since then, the events at Three Mile Island and Chernobyl proved beyond a doubt that severe accidents involving core damage and large releases of radioactive material are indeed credible.[70]

In 1990, the U.S. Nuclear Regulatory Commission published a study that is still considered state of the art for nuclear reactor risk assessment. The methodology is known as probabilistic risk assessment (PRA) and can be performed at three levels. A first level PRA estimates the probabilities of specified states of core damage. At the second level, it estimates the probabilities and characteristics of potential releases of radioactive material. The third level is an assessment of the offsite consequences of those releases.

In some cases, a PRA is performed only for events considered internal to the reactor operation such as equipment failure and human error. In other cases, events that are external to the system -- earthquakes, storms, fires and explosions – are also considered. [71] While PRA methodology can provide a valuable framework for assessing a reactor's potential to experience a severe accident, there is a need for caution in interpreting results.

The findings are typically expressed as a single number that expresses the probability of severe core damage or the magnitude of a release of radioactive material. For example, a probability of severe core damage at the Darlington station is estimated at 1.5 per 100,000 years of reactor operation. While there are always substantial uncertainties, it is common for PRA reports to express findings as a single number without the acknowledgement of those uncertainties. For example, a PRA does not consider the impact of gross errors in design, construction, maintenance, operation or acts of malice or insanity. Additionally, there is no certainty that every possible accident sequence has been identified and accounted for. In the words of Dr. Thompson, "A PRA can be a valuable document, but only in the hands of an informed, sceptical reader." [72]

In 1995, Ontario Hydro completed a PRA for Pickering A, known as the PARA, which examined accidents caused by equipment failure and human error. The study also examined the response of the station's containment system to accidents involving severe core damage and estimated the probability of a large release of radioactive material. It did not, however, estimate the magnitude or

[70] *Ibid., p.13*

[71] *Ibid. p.13*

[72] *Ibid. p.14*

characteristics of large radioactive releases or their impact beyond the nuclear station. Nor did it include such events as fires, earthquakes or explosions.

How useful is this study in determining the risk of serve accident that the restart plans pose? A critical review was carried out by the AECB and the Committee's consultant has provided further comment.

The AECB found that while the PARA was useful for qualitative purposes, confidence in its numerical findings was low. The AECB report concluded as follows:

> *"As stated in several reports and presentations to Ontario Hydro and by the independent external contractors, a rework of PARA is deemed necessary in order to correct PARA deficiencies. This rework should be such that it corrects, as much as possible, conservatism and optimism, and produces a model that can be modified and computed quickly by plant staff. It could so be used in plant operation and for regulatory decisions."* [73]

The Committee's consultant noted that among the important lessons that the AECB learned in reviewing the PARA, three are of particular importance to the proposed restart of Pickering A.

> *"First, safety-related systems at Pickering 'A' have a higher degree of interdependence (cross links) than is characteristic of later CANDU reactors, leading to a comparatively high probability of severe core damage. Second, there are many accident sequences in which, following a design-basis initiating event, a single component failure or human error leads to severe core damage. This situation is contrary to the AECB's single failure principle. Third, in many sequences there is a high degree of reliance on operator actions to prevent severe core damage following a design-basis initiating event."* [74]

OPG was told by the AECB to correct the deficiencies in the PARA and to use the reworked assessment to correct safety related weaknesses in the Pickering A station**.** It has also been noted that, while the methodology exists for consideration of fires as accident-initiating events in a PRA, it has not been applied by Ontario OPG and so the contribution of fires to the probability of severe core damage at Pickering A is unknown.

The 1995 study was done on the basis of a theoretical (design-basis) station and not for the actual Pickering A station. The numerous and significant deficiencies in operations identified in the 1997 Independent Integrated Performance Assessment are not reflected in the PARA as it now stands.

Dr. Thompson was similarly critical of the conclusions in the PARA with regard to the very low probability of large releases of radioactive material to the atmosphere following a severe core damage accident. He said:

> *"PARA estimated the probability of a large (severe) release of radioactive material from Pickering 'A' to the environment to be 6.3 per 1 billion reactor-years. This low probability is not credible. The actual probability*

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[73] *C.B. Parsons (AECB), letter sent to R.J. Strickert (Ontario Hydro), transmitting undated document* AECB Review of Pickering A Risk Assessment: Conclusions From the Review, *(As cited in Thompson (2000), p.18)*

[74] *Thompson (2000), p.18*

of a large release is likely to exceed 1 per 100 thousand years, thereby exceeding OPG's own probability limit. Additional investigations are needed to determine the probability."[75]

The PARA assumes that the containment is robust enough to remain intact during almost any core damage accident. Dr. Thompson points out that a hydrogen explosion could potentially cause a major breach of containment early in an accident sequence. He points to the large inventory of zirconium in the core of a CANDU reactor. During a severe core damage accident the zirconium would react with steam to produce large amounts of hydrogen. The resultant increase in pressure could quickly breach containment at Pickering. He concludes that this potential hazard has a major influence on the risk profile of the Pickering A reactors and requires more rigorous analysis than the 1995 PRA has provided.[76] AECL has more recently developed new technology that will address the issue of hydrogen accumulation, and if it is installed at Pickering A, an analysis of its impact on the risk profile would have to be part of any new PRA.

Another aspect of risk that the existing PARA does not take into account is the potential for multi-reactor accidents. Fire, which has not been included in the study, is one event that could result in a multi-reactor accident. The eight reactors of Pickering A and B share certain safety systems including the pressure relief duct and the vacuum containment building. These structures are designed to accommodate the excess pressure associated with a severe accident in only one reactor at any given time. A multi-reactor accident would "challenge the integrity of the containment." [77]

As already noted the PARA was done with reference to only internal initiating events. Studies in the U.S. have shown that when a third-level, external-event PRA is conducted, fires and earthquakes make a contribution to the probability of severe core damage that is comparable to that attributable to internal-initiating events. This conclusion points to the importance of carrying out a full, third-level PRA of Pickering A, to include both internal and external-initiating events.

Recommendation 5:
The Committee recommends that the CNSC require OPG to conduct a full, third-level probabilistic risk assessment of Pickering A.

PUBLIC HEALTH ISSUES

The public health impacts associated with nuclear safety were a recurring issue during this study. Representatives of the AECB (CNSC) health unit began their presentation to the Committee with the following pertinent question: "Why has there been a focus of concern about cancer near nuclear facilities when evidence, as assessed by major scientific bodies, does not predict these effects?"[78] Indeed, some members of the public frequently express concern about the impact of radiation on their health. The Committee heard that this is not surprising given the fact that ionizing radiation is

[75] *Ibid, p. 32*

[76] *Ibid, p.27*

[77] Ibid.

[78] *Atomic Energy Control Board*, Radiation and Health Effe*cts, presented to the Standing Senate Committee on Energy, Environment and Natural Resources, 24 February 2000.*

a known carcinogen. We know the health effects of relatively high doses of radiation from the experience of Japanese survivors of the atomic bomb. The health effects of very low-levels of ionizing radiation are much less well understood.

The Committee heard that it is important to understand that radiation exists in a variety of forms and comes from a variety of sources not all of which are manmade. Radiation is everywhere. Every day we are exposed to cosmic radiation from space and to terrestrial radiation from rocks and soil. It has been estimated by the AECB that a person living at the boundary of a nuclear generating station 24 hours per day and consuming local water and produce receives about 1% of his or her daily radiation exposure from the nuclear generating station. The other 99% comes from natural background radiation. This would explain why it is so difficult to isolate the health effects of a person's exposure to radiation from a nuclear power station alone.

Why then are people so concerned? Beginning in the 1980's, a number of studies were conducted looking at cancer rates in persons living near nuclear facilities. The reported results of some of these studies fuelled public concern. For example, a 1983 study done in the United Kingdom showed a higher than expected rate of childhood leukemia in those living near the Sellafield nuclear reprocessing plant. Similarly, a study carried out by the AECB in 1991 compared the rate of childhood leukemia in the province of Ontario as a whole with rates in communities near nuclear power stations. The study showed a higher than average rate in Pickering and Ajax. These findings heightened public concern, but epidemiologists with the AECB told the Committee that similar cancer clusters have also been identified in locations where no nuclear facility is present.[79] The AECB concluded that there was "…no statistical evidence that the difference is due to anything but the natural variation in the occurrence of the disease."[80]

In a letter to the Committee, Dr. Philippe Duport, Director, International Centre for Low Dose Radiation Research, University of Ottawa explained that studies on mammals have shown both decreasing and increasing incidence of cancer with low-level ionizing radiation exposure over long periods of time. Studies tracking human exposure also do not provide conclusive results of radiation harm at these levels. He suggested that exposure to low levels of ionizing radiation should be considered together with factors like inherent DNA instability. Dr. Duport stated that there is no simple linear relationship between low-level radiation dose and risk of developing cancer.[81]

Despite these conclusions, the question of health impacts of radiation from nuclear power stations remains an issue of concern to some residents in the Durham Region of Ontario. About 185,000 people in the region live within 10 km of either the Pickering or the Darlington Nuclear Generating Stations. Since 1983, the region has monitored the health effects of the generating stations through a program known as *Radiation and Health in Durham Region.* Using routinely available health data, the region published a compendium of health statistics for the areas immediately next to the nuclear facilities, several nearby communities with no nuclear facilities and the Province of Ontario as a

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[79] *Ibid,* p.3

[80] *Atomic Energy Control Board, as cited in Ontario Power Generation, "Pilot Cancer Study"*, Neighbours – News from Pickering Nuclear, *Volume 6, Number 1, Winter 2000, p.4*

[81] *Dr. Philippe Duport, Director, International Centre for Low Dose Radiation Research, University of Ottawa*, Letter to the Standing Senate Committee on Energy, Environment and Natural Resources, *20 October 2000*.

whole for 1983, 1985 and 1988. A new compendium is expected in 2001. They focused on measured health statistics such as specific types of cancers and birth defects related to ionizing radiation.

Representatives of the Durham Region Health community appeared before the Committee and explained the details of their 1996 publication, *Radiation and Health in Durham Region,* in which they summarized the findings of their compilations and of all available studies on the issue. Their major conclusion was that there is no consistent pattern among the observed health indicators suggesting that radiation from nearby nuclear power generation station is affecting the health of Durham residents.[82] However, they also noted that the study results do raise questions and that incidences of leukemia, thyroid cancer, multiple myeloma, prostate cancer and Down syndrome should be examined further. As noted above, more recent information, from the post-1991 time frame, is now being analysed and the next report is expected to be published sometime in 2001.

Even though previous studies have suggested that the nuclear power stations are not adversely affecting the health of local residents, the CNSC is continuing to study the issue. One of the most recent studies was released in August 2000. The Health Canada study of cancer incidence near Port Hope (the former site of an Eldorado Nuclear fuel plant) was commissioned by the CNSC. It compiled data from the Ontario Cancer Registry and compared the incidence of various types of cancer near Port Hope with the rest of the province. Statistically elevated rates of some forms of cancer are indicated although these differences could be attributed to normal fluctuations expected in occurrences of rare diseases as well as to a variety of carcinogenic substances known to exist in the region but at levels not expected to cause cancer. Overall the rates are comparable to those found across the province. In order to take a proactive approach to these findings the CNSC proposed that a formal health studies panel be formed to represent the community interests and to evaluate study results in partnership with scientists and recommend needed follow-up work.[83]

Representatives of the CNSC also told the Committee that, in conjunction with Health Canada and the Laboratory Centre for Disease Control they would be establishing an on-going cancer surveillance program. They will monitor cancer rates in the general area of all nuclear facilities in Canada, including research reactors, uranium mines, uranium refining and conversion facilities, and nuclear power generation stations. This approach is a precautionary measure to address areas of public concern and to continue monitoring for any contradiction to the current balance of evidence that there does not appear to be a causal relationship between low doses of ionizing radiation from the nuclear facility and the incidence rate of cancer.[84] Irene Kock from Durham Nuclear Awareness stressed the need for this program to be designed in such a way that it can specifically verify whether or not a cause and effect relationship exists between exposure and cancer rates. Ms. Kock further noted that she hoped that there would be some public involvement in the design of the study.[85]

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[82] *Durham Region Health Department, Radiation and Health in Durham Region, November 1996, p. A-7*

[83] *Canadian Nuclear Safety Commission, Port Hope Cancer Incidence Study Released,* Press Release, *22 August 2000*

[84] *Canadian Nuclear Safety Commission, p. 11:15 - 16*

[85] *Kock, p. 8:7*

The pilot project for the new study will, in fact, be carried out in the area near the Pickering station to identify the best approach and the CNSC assured the Committee that the key community stakeholders (Durham Region Health Unit) are being consulted with regard to the design of the study. The anticipated development timeframe of the study is 3-4 years.

Not all scientists are in full agreement with the CNSC conclusion that studies do not indicate a cause and effect relationship between these low levels of ionizing radiation and disease. In papers submitted to the Committee by Durham Nuclear Awareness, Distinguished Professor David G. Hoel, Medical University of South Carolina argues that the AECB childhood leukemia study "…fails to follow appropriate statistical methods for analyzing radiation cancer epidemiology data." He further notes, "…when the data is considered appropriately, the study shows a statistically significant excess leukemia rate …"[86] He also notes that the AECB had obtained two expert opinions on this new analysis. One supported it and the other did not.[87]

Dr Rosalie Bertrell, from the International Institute of Concern for Public Health, told the Committee that low-level radiation effects are an extremely complex phenomenon. She explained that with ionizing radiation there is not a straight-line relationship between increasing dose and increasing damage. A plateau is reached where the damage is still being repaired. Beyond that plateau, but before sufficient damage has occurred to kill the cell, cancer can develop.[88] It is Dr. Bertell's view that researchers are looking at this plateau area when they find that ionizing radiation is not causing cancer.

Dr. Bertell was also critical of the International Commission on Radiological Protection (ICRP) that sets the standards for radiation exposure. She told the Committee that it is a self-constituted, self-perpetuating body of physicists and radiologists that does not make use of the expertise of epidemiologists or oncologists. [89] Dr. Phillipe Duport challenged this contention in his previously cited letter to the Committee.

Dr. Bertell also disagrees with the manner in which the ICRP standards are portrayed. Instead of representing a level below which exposure to radiation is safe, the ICRP standards are a level below which the benefits, such as diagnostic x-rays, outweigh the risks. [90]

With regard to the ICRP, the Committee also heard from the CNSC that Canadian standards for public and occupational exposure to radiation are based on their recommended standards and that

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[86] *Dr. David Hoel,* Affidavit in Federal Court of Canada, Trial Division Between Inverhuron and District Ratepayers Association (Applicant) and The Minister of the Environment, the AECB, the Minister of Fisheries and Oceans and Ontario Power Generation (Respondents), *File # T-906-99, 9 December 1999*

[87] *Ibid.*

[88] *Dr. Rosalie Bertell, Standing Senate Committee on Energy, Environment and Natural Resources,* Minutes of Proceedings and Evidence, *Issue # 22, p.22:5 - 6, 21 September 2000*

[88] *Ibid.*

[89] *Ibid.*

[90] *Ibid.*

the 1992 ICRP standards are now being adopted in Canadian regulations. The nearly decade long delay in adopting the "latest" standards seems unreasonable and prompts the following recommendation:

> ***Recommendation 6:***
> *The Committee recommends that the necessary steps be taken by the CNSC or other responsible authority to speed up the process of adopting updated International Commission for Radiological Protection "ICRP" standards in Canada.*

SAFETY CULTURE

Over the past three years Ontario Hydro (OPG) has attempted to entrench a safety culture in its nuclear operations, in response to criticisms raised in the IIPA report. A safety culture is a mindset -- one in which all workers and management team members make safety their first priority in all of their actions and decisions. Without a strong safety culture, the safe operation of nuclear facilities can be compromised. One witness pointed out that the CNSC has accepted the link between corporate culture and safety. He noted

> *"The regulator figured out in the last few years that culture, the structure of thought in an organization, turns out to be the key to whether reactors are run relatively safely or relatively unsafely."* [91]

The findings of the IIPA of Ontario Hydro nuclear power stations were highly critical of virtually all aspects of management and operational performance, especially those related to the decline of, or lack of, a strong safety culture. Many of the deficiencies that were identified "…represent departures from the "defence-in-depth" concept that forms the cornerstone of the nuclear industry. They result in unacceptable erosions of the margin of safety afforded the public and employees." [92] The IIPA report went on to note that "Management is neither setting high standards for itself nor demanding the best from other departments, and personnel have not incorporated an adequate safety culture into their normal activities." Instead, the IIPA report found that Ontario Hydro had developed a "production-dominated culture."[93]

The IIPA noted that "There are pronounced cultural problems that need to be addressed," and identified some of the behaviours that had been observed that support this harsh assessment.

> *"It's acceptable to cut corners. It is not acceptable to make waves. Those who have made waves have been fired or sidelined. The messenger with bad news will be told to fix the problem. Attention to detail is not as important as getting the job done. Not meeting commitments is the norm. One person can't make a difference."* [94]

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[91] *Norman Rubin, Senior Policy Analyst, Energy Probe*, Standing Senate Committee on Energy, Environment and Natural Resources, Minutes of Proceedings and Evidence, *Issue # 5, p. 5:12, 29 February 2000.*

[92] *IIPA (1997), p.5*

[93] Ibid. p.11

[94] Ibid. p.10

Committee members questioned the OPG nuclear management team about these criticisms and what progress has been made in addressing them. Senior managers from OPG acknowledged the past difficulties and outlined a series of changes to the organizational framework of the company that they hope will address them.

The new approach includes making certain that there are clear responsibilities, accountabilities and authorities and that all activities are guided by equally clear policies, expectations and procedures. Effective management oversight and the encouragement of a self-critical, questioning attitude are also being promoted. OPG further outlined new management and leadership goals such as clear, consistent direction, safety reinforced as an overriding priority, effective two-way communication and fostering a questioning attitude.[95]

In addition, there is a clear message to all staff concerning the importance of developing a safety culture. The message is:

- Nuclear safety is the overriding priority;
- Respect for reactor core;
- All decisions / actions based on nuclear safety;
- Questioning attitude / two-way communications;
- Rigorous and prudent approach;
- Staff trained and qualified to perform tasks;
- Continuous improvements / self critical; and
- Learn from experience.[96]

How can one judge whether OPG's goals are in fact, being implemented?

By measuring the progress that OPG has made since 1997, the World Association of Nuclear Operators (WANO) provides some insight. The Committee visited the WANO headquarters in Atlanta where the organization, funded by utilities, provides a forum for operators to share operating experiences in confidence, including problems that have come up, how they were addressed, which approaches were successful and which were not. WANO also conducts detailed peer reviews and offers recommendations for improvements in plant operation. The organization has also developed a set of performance indicators by which the nuclear operations of all member utilities are rated. Eight of the eleven indicators are safety related.

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[95] *Bob Strickert,* Senate Committee Visit to Pickering Nuclear: Nuclear Basics, Nuclear Safety and Performance Results, *5 April 2000*

[96] *Ibid.*

Regarding WANO's ratings of OPG's operating stations, (which does not include Pickering A) OPG officials told the Committee that:

> *" Every one of these eight safety indicators has shown either a major improvement over the past two years or has remained stable. . . . We are achieving the maximum score in five of those eight safety indicators."* [97]

The President and CEO of Ontario Power Generation also told the Committee:

> *"I will give an indication of our progress. Our overall nuclear performance index, which is the amalgam of those 11 indicators, has moved from a score of 58 per cent or 58 points out of 100, at the end of 1997, to 83 per cent at the end of this year's second quarter. This obviously is good progress, but we still have a way to go. … We compare ourselves to the North American nuclear industry. The bar for that North American industry is constantly rising. The performance index for U.S. nuclear stations now averages just over 90 per cent. We are at 83 per cent; they are at just over 90 per cent.* [98]

An independent assessment of the WANO ratings is impossible, as all of their reports remain confidential. While Ontario's Information and Privacy Commissioner has ruled that OPG must release some past WANO documents to members of the public who asked for them, WANO has challenged the ruling in court. In Atlanta, Committee members were told that without the assurance of complete confidentiality, it would be impossible to get all of the world's nuclear plant operators to join WANO. WANO is now the only international organization that takes part in inspection, assessment and improvement programs with countries such as India and Pakistan. Membership in WANO is their only point of access for safety-related advice and assistance.

Representatives of the Power Workers Union, which represents the majority of employees at the nuclear power plants, also testified to a renewed emphasis on a safety culture. They noted that, since the nuclear improvement program was initiated in 1997-98, they have altered their approach to labour-management issues. They told the Committee that they are looking for ways to "work better and more co-operatively together" [99] with management. The best example of this new spirit of co-operation is the partnership agreement that the union has signed with the Society of Energy Professionals of Ontario and OPG management. The union representatives noted that:

> *"This was a partnership agreement designed to put in writing principles that would establish the new relationship going forward between the Power Workers' Union, the Society of Energy Professionals and the company…. The PWU signed this agreement because it had confidence that all parties felt equally strong about achieving the objectives and wanted to seize the opportunity presented by the restructuring of the electricity industry in Ontario to shape a culture and a new company based on those values. We would not have signed it unless we felt empowered to equitably enforce the intent and spirit of the agreement. We mentioned this*

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[97] *Ron Osborne, President and Chief Executive Officer, Ontario Power Generation,* Standing Senate Committee on Energy, Environment and Natural Resources, Minutes of Proceedings and Evidence, *Issue # 24, p.24:7, 19 October 2000*

[98] *Ibid.*

[99] *John Murphy, Past President, Power Workers Union, Standing Senate Committee on Energy, Environment and Natural Resources,* Minutes of Proceedings and Evidence, *Issue # 8, p.8:19, 2 May 2000*

partnership agreement because it is the key to achieving our dual objective of high safety and operational performance." [100]

It is apparent that OPG has made some progress toward establishing a safety culture at its nuclear power plants, but it is equally clear that efforts must continue if this vitally important goal is to be achieved.

Another aspect of safety culture discussed during the Committee's study was the question of a fitness-for-duty program. It would involve testing to test people working in critical parts of plant for drugs and alcohol to determine whether they are fit to carry out their duties. Evidence of substance use at the Pickering plant became public in 1996 when a citizen's group, using the Ontario *Freedom of Information Act*, obtained reports of five incidents in which empty beer cans, a liquor bottle, drug paraphernalia and marijuana were found inside the plant and reported to the AECB. No mandatory testing program was, or is now, in place at any Canadian nuclear power plant.

Representatives of the Power Workers Union told the committee that:

"…the union is in favour of drug and alcohol testing that conforms with the law in this regard. That is, testing that respects the privacy and human rights that employees (like all citizens) have and is part of a broader treatment program geared to dealing with actual problems in the workplace. It cannot legally support any policy that would violate human rights legislation." [101]

The union made reference to a recent Ontario Court of Appeals ruling in which the court set out the legal prohibitions on drug testing in the workplace resulting from human rights legislation.

" In the case of Entrop v. Imperial Oil, the Court of Appeal ruled that both pre-employment drug testing and random drug testing of employees constitute a violation of the Ontario Human Rights Code, which in this regard is not different from the Canadian Human Rights Act." [102]

The Court held that drug testing did not necessarily measure current impairment, but could represent past use, while alcohol testing might be allowed if the consequences of a failed test did not include automatic dismissal and did include assistance for handicapped persons. It is apparent that, despite the importance of fitness-for-duty testing, current laws put severe limitations on what can be done.

Recommendation 7:
The Committee recommends that in the interests of public safety, the Government of Ontario and the Federal Government consider amendments to human rights legislation that would permit drug and alcohol testing of workers

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[100] *Don MacKinnon, President, Power Workers Union, letter to Clerk of Standing Senate Committee on Energy, Environment and Natural Resources, 8 November 2000*

[101] *Don MacKinnon, President, Power Workers Union, letter to Clerk of Standing Senate Committee on Energy, Environment and Natural Resources, 8 November 2000*

[102] *Ibid.*

in areas critical to public safety. In the meantime, the Committee recommends that representatives of union and management at OPG give priority to establishing a program for alcohol and drug testing that does not contravene existing law.

FEDERAL LEGISLATION: THE NUCLEAR LIABILITY ACT

The Nuclear Liability Act (NLA), which came into force in 1976, places liability for nuclear damage on the operator of the nuclear installation. The required level of coverage under provisions of the Act is $75 million. The Act also provides for the establishment of a Nuclear Damage Claims Commission to deal with claims for compensation in the event that the Federal Government finds that total damages from any one nuclear accident are likely to exceed $75 million.[103] The government is expected to pay for these claims. While utilities have paid premiums for 25 years, no insurer has made a payment for damage.

The Committee heard that the $75 million coverage required under the NLA is woefully inadequate by international standards. Officials from Natural Resources Canada told the committee that today $250 million would be an equivalent amount, accounting for inflation, while the international standard is approximately $650 million Canadian.[104]

Representatives of the Nuclear Insurance Association of Canada reported that in the U.K. and in the U.S. (for specific plants) the limit is about $300 million (Canadian). Under the Paris Convention, to which most European governments are signatory, the recommended limit is $600 million.[105] The committee asked why Canada lags so far behind, despite the fact that, during parliamentary committee debate preceding passage of the Act in 1976, it was recommended that the legislation be reviewed every five years. Twenty-five years later, the Act has yet to be updated.

Officials from Natural Resources Canada described the history of the NLA review.[106] The NLA was passed in 1970 but not proclaimed until 1976, after an agreement was struck with a group now known as the Nuclear Insurance Association of Canada (CNIA) to provide the liability coverage. Six years after enactment, in 1982, an Interdepartmental Working Group (IWG) was appointed by the Atomic Energy Control Board (AECB) to carry out the recommended review. In 1984, the IWG issued a discussion paper seeking public input. In 1990, recommendations were sent to the Minister of Energy, Mines and Resources. However, in 1987, Energy Probe, the City of Toronto, and Dr. Rosalie Bertell challenged the constitutionality of the NLA. The government consequently set aside plans to change the Act. In 1994, the court ruled, in favour of the federal government. The plaintiffs filed an appeal but withdrew it in 1996 due to lack of funds.

In 1995, a new Interdepartmental Review Committee again began to develop proposed changes to the NLA in consultation with the various stakeholders. For four years, officials refined the

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[103] *Government of Canada*, Canadian National Report for the Convention on Nuclear Safety, *September 1998, p. 49*

[104] *R. Cameron, Assistant Deputy Minister, Natural Resources Canada*, Standing Senate Committee on Energy, Environment and Natural Resources, Minutes of Proceedings and Evidence, *Issue # 12, p.12:10, 1 June 2000*

[105] *Dermot Murphy, Manager, Nuclear Insurance Association of Canada*, Standing Senate Committee on Energy, Environment and Natural Resources, Minutes of Proceedings and Evidence, Issue # 10, *p.10:7, 11 May 2000*

[106] *Cameron, p.12:7-8*

proposed changes and once again sent them to stakeholders for comment. The committee was told that the revision process, focusing on improvement of victim compensation, clarification of key provisions, clarification of federal responsibilities and technical improvement, had neared completion. However, witnesses from Natural Resources Canada could not tell the committee when legislation to update the Act might be forthcoming. They said that they "...hope to bring proposals to the Minister's attention by the end of summer 2000."[107] (The recent federal election resulted in a further delay in the process. Following the election, in February 2001, the Minister received the recommendations for changes to the Act. His decision is still awaited.)[108] The committee is appalled at the lack of action.

Recommendation 8:

The Committee recommends that the government take immediate action to amend the Nuclear Liability Act, and increase and maintain the mandatory operator held insurance coverage from the current 75 million dollars at an amount in line with the Paris and Vienna Conventions "over 600 million dollars".[109]

[107] *Ibid., p.12:8*

[108] *Jacques Henault, Natural Ressources Canada, Telephone conversation, 3 April 2001*

[109] The Vienna Convention on Civil Liability for Nuclear Damage and the Paris Convention on Third Party Liability in the Field of Nuclear Energy.

PICKERING A AND THE FEDERAL ENVIRONMENTAL ASSESSMENT PROCESS

The Committee heard strong, often conflicting opinions about the adequacy of the recently completed federal environmental assessment of the restart of Pickering A. While OPG officials held that the review exceeded the legal requirements for a review of a restart, citizens groups, municipal councils and others held that it was seriously deficient.

Chief among the criticisms were that:

- the assessment excluded any consideration of a severe accident at Pickering A or the consequences of such an accident beyond the plant site,
- that alternative ways to meet electricity demands were not considered
- an independent, full-panel review was not ordered and
- the CNSC poorly met its obligations under the *Canadian Environmental Assessment Act*.

As it happened, the environmental assessment of Pickering A was a test of the kind of environmental review that can, or should be, conducted when reactors are shut down for a prolonged period and major modifications are made.

BACKGROUND

The Canadian Nuclear Safety Commission licenses all nuclear reactors in Canada under the *Nuclear Safety Control Act* and like other federal bodies, the Commission must adhere to the *Canadian Environmental Assessment Act (CEAA)* when its licensing authority triggers an environmental assessment. Before considering a licence application, the Commission must decide whether the nuclear facility is likely to cause significant adverse environmental effects and determine an appropriate course of action.

Until recently, no nuclear power generating station has been the subject of a federal environmental assessment. Some aspects of the industry have been assessed and projects at stations have been reviewed. However, no station as a whole has been subjected to the review process. All currently held licences were initially granted prior to1995, the year that *CEAA* came into force. Although the federal Cabinet had established the Environmental Assessment and Review Process (EARP) Guidelines in 1984, before many of Canada's nuclear power reactors first operated, the Cabinet order was not applied to them. It was not considered mandatory until it was later challenged in court**.** Review panels under the EARP Guidelines were completed on the concept of deep geological disposal of nuclear waste, on uranium mining developments in Northern Saskatchewan and on the uranium mine tailings areas of Elliot Lake.

In early 1999, Ontario Power Generation expressed its intent to return the four reactors at Pickering A to service. In July 1999, staff of the CNSC determined that the proposed restart of the reactors

would require an environmental assessment and began a screening level review of the project -- the lowest of the three levels of environmental assessment under *CEAA*. The City of Toronto, the City of Pickering and many public interest groups were not satisfied that a screening of the project was adequate. They called for a full panel review – the most open, comprehensive and lengthy level of environmental assessment.

The CNSC had the authority, at any time during the process, to request that the Minister of the Environment refer the project to a review panel or a mediator. It chose not to do so. On 5 September 2000 CNSC staff officials reported to Commission members that, based on their review of the Screening Report, they had concluded that the return to service was not likely to cause significant adverse environmental effects.[110] They recommended that the Commission proceed to assess Ontario Power Generation's application to restart the reactors under the terms of the *Nuclear Safety Control Act*. On 16 February 2001 Commission members accepted that recommendation.[111]

Federal authority in the process, however, was far from exhausted. The Minister of the Environment could have exercised his authority to refer the project to a mediator or review panel. The CNSC also had yet to determine whether to grant a licence to operate Pickering A. Commission staff viewed the licensing and compliance process as a way to ensure that the requisite follow-up to the environmental assessment is implemented. (Since the Committee concluded its hearings, the CNSC held licensing hearings on January 18 and March 8, 2001. On 30 March they announced their final decision to approve an operating licence for Pickering A, for a period of two years, ending on 31 March 2003.[112])

WHAT KIND OF ASSESSMENT IS APPROPRIATE?

The *Canadian Environmental Assessment Act* came into force in January 1995 after five years of public consultation, including two years of scrutiny by Parliament. The new law, however, failed to anticipate the circumstances that arose at Ontario Hydro nuclear generating stations. The Act identified that certain projects are likely to have significant adverse environmental effects and through regulations named them in a list of projects requiring comprehensive study.[113]

In the nuclear field, it named eight types of projects in uranium mining, power generation, the storage of spent fuel and disposal of irradiated materials. The proposed construction, expansion, decommissioning or abandonment of dozens of facilities in Canada were designated as being subject

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[110] *Canadian Nuclear Safety Commission*, Staff Report to Commission Members on the Pickering NGS-A Environmental Assessment, *Document 26-1-4-15-1, 5 September 2000*

[111] *Canadian Nuclear Safety Commission,* Record of Proceedings, including Reasons for Decisions In the Matter of Environmental Assessment under the Canadian Environmental Assessment Act of the Proposed Return to Service of the Pickering A Nuclear Generating Station, 16 February 2001

[112] *Canadian Nuclear Safety Commission, News Release,* CNSC Announces Decisions on Ontario Power Generation's Pickering Facilities, *30 March 2001*

[113] *Canadian Environmental Assessment Agency,* Canadian Environmental Assessment Agency Comprehensive Study List Regulations – Legal Text, *at www.ceaa.gc.ca/0011/10004/sor94-638.txt*

to a comprehensive study. The comprehensive study list does not include the shut down of a nuclear power reactor with fuel in place, nor does it list the proposed rehabilitation and restart of a nuclear power station such as the $1-billion modification and restart of Pickering A.

Beyond the requirements of an environmental screening, a comprehensive assessment must also consider technically and economically feasible alternatives. In addition, when a comprehensive study is conducted, the Minister of the Environment, rather than the Canadian Nuclear Safety Commission, must decide whether to allow a project to proceed.

In recent years, comprehensive studies have been conducted on projects such as a military parachute training area, a water pipeline, road construction and quarry development.[114] Meanwhile, in the Pickering area, less rigorous screenings have been held on bridge repairs at a golf course, reconstruction of a level crossing and the demolition of barns on various sites. Given the relative importance of the rehabilitation of the Pickering A station and the potential long-term environmental consequences of the use of nuclear power, the Committee can only conclude that the omission of such a project from the comprehensive study list was an unfortunate oversight.

> ***Recommendation 9:***
> *The Committee recommends that the Comprehensive Study List Regulations of the CEAA be amended to include the restart of a nuclear power reactor following a prolonged shut down of the reactor or significant modification to the reactor and/or the station.*

Not only does the comprehensive study list exclude the Pickering A shutdown and restart, but Ontario Power Generation also advanced the position that the project fell under the assessment Act's exclusion list – a list of projects whose environmental effects are insignificant. The utility obtained two legal opinions to that effect. [115] The Atomic Energy Control Board did not agree.

Having determined in July 1999 that the federal environmental assessment process did apply to the restart, staff of the AECB faced a decision on the appropriate type of review. With a comprehensive study ruled out, there were three choices – a simple screening, a screening that had the features of a comprehensive study, or a request to the Minister of the Environment to refer the review to a mediator or a review panel. The Board chose the screening option, determining at the time that neither the predicted environmental effects nor the level of public concern warranted a referral.

The Committee finds the decision surprising, given the information it received about the well-documented history of public concern. In 1994, the region's Member of Parliament, Member of the Provincial Legislature and municipal council had all requested an independent review of the relicencing of the Pickering station under the federal EARP Guidelines which were later replaced by the *CEAA*. The City of Toronto, the City of Oshawa and more than 200 other intervenors also called for a comprehensive federal review which the AECB denied. Three years later during the

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[114] *Canadian Environmental Assessment Agency,* Completed Comprehensive Studies, *at www.ceaa.gc.ca/0009/0003/completed_e.htm*

[115] *Gene Preston, Vice-President-Nuclear, Ontario Power Generation, discussions during Pickering site visit, 5 April 2000.*

1997 municipal elections, more than 17,000 residents – some 87 % of voters – supported a referendum calling for a provincial environmental assessment prior to the restart of Pickering A. The Towns of Ajax and Whitby, the Township of Uxbridge and the Regional Municipality of Durham also requested the review, which was denied by the Ontario Government.

More recently, the AECB's decision to order a screening prompted calls for a full panel review from the City of Pickering, the City of Toronto and Nuclear Awareness Project, a citizen's organization based in the Durham region, which includes Pickering. A team of scientists from the University of Toronto and McMaster University, hired by the City to Pickering and funded by OPG to review the assessment plan, also recommended an upgrade in the review, at a minimum to one that more closely resembled a comprehensive study. [116]

A Nuclear Awareness Project spokesman told the Committee:

> *"We have made a formal request that the Minister of the Environment refer this matter to a panel review. There are important reasons for that, partly because of the process and how it has been handled by the AECB so far, but also because of the narrow scope selected for this review."*[117]

On a positive note the AECB required what Ontario Power Generation has described as an enhanced screening. OPG officials said they committed in July, 1999 to undertake a comprehensive consultation program, to address some 160 issues identified in a previous consultation with the community and to fund an independent peer review of reports.[118] The Board also committed to hold one of two meetings to consider the environmental assessment report in the City of Pickering. The commitments were made in July, but it was not until August 10, 1999 that OPG officially received notification that an assessment was required, according to staff of the federal regulator.[119]

While OPG viewed its efforts as going above and beyond the legal requirements of a screening, critics saw private negotiations between OPG and the regulator as improper and a further reason to call for a referral to an independent review panel. One witness told the Committee:

> *"We have concluded that the AECB really is not managing the EA properly at this stage. We feel the independent panel review route is essential to get credible assessment results."*[120]

The regulator delegated to Ontario Power Generation much of the technical and public consultation aspects of the assessment, as is common practice for environmental assessments. However, the Board retained for itself the determination of the scope of the review. The scope itself became controversial. In many of the 43 submissions to the AECB, there was criticism that the scope was

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[116] *Dr. N. Eyles et al,* Peer Review Team Comments on Pickering A Return to Service Environmental Assessment: Preliminary Draft Report, *Prepared for Corporation of the City of Pickering, December 1999*

[117] *Kock, p.8:5*

[118] *Kurt Johansen, Senior Manager, Environmental Assessments, Ontario Power Generation,* Committee Site Visit,*5 April 2000*

[119] *Canadian Nuclear Safety Commission (5 September 2000)*

[120] *Kock, p.8:6*

too limited geographically and temporally; that consideration of a severe nuclear accident was excluded; and that there would be no review of possible alternatives to the project.[121]

CONDUCT OF THE ASSESSMENT

The Committee also heard criticism that the 30-day period for public comment was too short, given the magnitude of the project and the technical information that had to be reviewed to allow for informed comment. Criticism of the brevity of comment periods resurfaced in May 2000 when the regulator distributed the massive draft Screening Report prepared by OPG and set a 60-day comment period. The Committee heard that the 60-day period placed tremendous pressure on groups and municipalities that chose to comment. [122]

The Committee received documentation of weekly discussions between OPG and AECB officials concerning the scope of the review, including how to respond to items that public interest groups believed should not be excluded.[123] The Committee also received evidence from the AECB, acknowledging problems in the maintenance of the public registry required under the Act, including missing documents and delays in processing requests. [124] Committee members also heard that the AECB granted deadline extensions to some organizations that requested them, but denied them to others.

The Committee also heard criticism from local interest groups during its visit to Pickering that the screening process did not allow for intervenor funding. The groups wanted to hire outside experts in preparing their comments – an option that *CEAA* would allow if a full panel review were conducted.

For its part, OPG told the committee that the environmental assessment process was more than adequate.

> *"We have produced a very comprehensive examination of the potential environmental impacts associated with bringing the units back to service. We have identified the appropriate mitigating actions. …Public involvement has been extensive, and generally it has been greater than is required by law under the process."*[125]

OPG gave the Committee a detailed seven-page description of consultation with its employees, federal and provincial officials and local residents through newsletters, open houses, displays and a

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[121] *Canadian Nuclear Safety Commission (5 September 2000)*

[122] *Kock, p.8:8*

[123] *Irene Kock, Nuclear Awareness Project,* E-mail to Bernard Richard, AECB Program Management and Review Section, *25 February 2000*

[124] *Bernard Richard, AECB Program Management and Review Section,* Letter to Irene Kock, Durham Nuclear Awareness, *13 March 2000*

[125] *Osborne, p. 24:3*

web site. It also described consultations with local health officials and municipal councils, Members of Parliament and Members of the Ontario Legislature and community advisory groups. [126]

OPG's president said:

> *"Under the Neighborhood Walk program, OPG employees have volunteered to go door-to-door in Pickering and Ajax neighborhoods to discuss our plan to return Pickering A to service . . . . Altogether, our employees have knocked on more than 16,000 doors in the communities of Pickering and Ajax. I must say we are very pleased with the positive reception that we have received from the vast majority of homeowners."* [127]

The committee notes that the level of outreach by Ontario Power Generation within the geographic limits prescribed by AECB was extraordinary for an environmental screening. The utility was clearly prepared to make a considerable effort at the local level to explain its view of the project. This effort stands in stark contrast to the and restrictions imposed by the federal regulator on the scope of the review and opportunities for public comment by others elsewhere or by bodies wishing to present expert analysis of both the scope of the assessment the Screening Report.

Within the self-imposed limits of the review, CNSC staff concluded that, taking into account appropriate mitigation measures, the Pickering A restart was not likely to cause significant adverse environmental effects. In addition, it concluded that public concerns expressed prior to September 2000 did not warrant reference of the matter to the Minister of the Environment for a referral to a mediator or review panel.[128]

Committee members found the matter of public concern of particular importance. One member posited that citizens do not want more information by way of newsletters and community forums. Rather they have a dread of the nuclear industry and want to know about the risk of a severe accident. The president of OPG responded:

> *"I do not accept, however, that there is what you refer to as a dread of nuclear in those communities. We have knocked on 16,000 doors over the course of the past five months. Everyone at this table has participated in that role. I just fail to believe that people are so incredibly polite to others and me and not tell us what is on their mind. We ask them what is on their mind. What are your concerns?*
>
> *Yes, there are people who are very concerned. We accept that, but there is not a widespread dread through out the community -- quite the reverse. We are gratified with the results of that."* [129]

In a submission to the CNSC, Durham Nuclear Awareness cited an OPG public attitudes poll which revealed that more than 8,000 families within a 10 kilometre radius of the plant would be likely to move if Pickering A is restarted.

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[126] *R. J. Strickert, Site Vice President, Pickering 'A' Nuclear,* Letter to Senator Mira Spivak, Chairman,Standing Senate Committee on Energy, Environment and Natural Resources, *11 May 2000*

[127] *Osborne, p. 24:4*

[128] *Canadian Nuclear Safety Commission (5 September 2000)*

[129] *Osborne, p. 24:20*

The Committee also asked about the criteria to determine whether the level of public concern warranted referral to a panel. An official replied that the Commission would consider the following items:

- The level and nature of public concern about the project;
- The extent to which the issues of public concern relate to potentially significant environmental effects and to matters under federal jurisdiction;
- Any scientific and technical information relating to the project; and
- The likely ability of a review panel, if appointed, to complete its work and contribute to resolving issues of public concern. [130]

The Committee would have had greater confidence in any determination exclusively by the Commission on the matter if it had:

- considered the demonstrated level of public concern at the outset;
- undertaken the public consultation itself, rather than delegating it to the OPG, the project proponent;
- retained greater arm's length from OPG in determining the scope of the project;
- included matters in the review requested by organizations which commented on the scope;
- better maintained the public registry from which the public might have obtained information, and
- not arbitrarily extended deadlines to some organizations but not to others.

Given the events, the Committee believes that the Minister of the Environment should have given the matter closer attention and considered exercising authority under *CEAA* to refer the matter to a review panel based on demonstrated public concern.

The Committee notes that the federal guide to *CEAA* has two passages germane to this issue:

> *"Responsible Authorities should not necessarily rely on numbers when judging the importance of public concerns. Even a few letters or call may express public concerns, particularly if they are from people who will be most directly affected by the project."*

And:

> *" . . . alternatives to the project are functionally different ways of achieving the same end. For example, 'alternatives to' the nuclear power plant include importing power, building a hydroelectric dam, conserving*

[130] *J.D. Harvie, Director General, Atomic Energy Control Board,* Letter to Senator Mira Spivak, Chairman, Standing Senate Committee on Energy, Environment and Natural Resources, *28 March 2000*

energy, and obtaining energy through renewable sources. Consideration of 'alternatives to' the project is at the discretion of the Responsible Authority in screening, or of the Minister in consultation with the Responsible Authority in a comprehensive study, mediation or panel review." [131]

To avoid the difficulties that arose in the environmental assessment of the Pickering A restart in other, similar situations, the Committee makes the following recommendation:

Recommendation 10:
The Committee recommends that the CNSC ensure public confidence in the federal environmental assessment process by:

- *retaining for itself the public consultation process, not delegating it to a project proponent;*
- *setting more realistic and fair deadlines on public comment periods taking into account the volume of material to be assessed and the technical expertise required to analyze it;*
- *determining the scope of assessments independently of the project proponent;*
- *improving its maintenance of the public registry required under* CEAA; *and*
- *developing guidelines to make intervenor funding available to interested parties.*

[131] *As cited in Irene Kock, Letter to Mayor Arthurs and Councillors, City of Pickering, 13 April 2000*

CONCLUSION

The Committee would like to request that the appropriate Ministers respond to the recommendations made in this report as soon as possible. We feel that their implementation will address a number of important issues in the field of nuclear reactor safety. In one year's time, the Committee will revisit the issue and examine what action has been taken to implement the recommendations. In light of the worldwide scope of nuclear power generation and of the potential international consequences of breaches in safety, the Committee intends to build on this study in the future by looking more deeply into the international regulation of nuclear power reactor safety. This review will include meetings with officials from the International Atomic Energy Agency in Vienna and the Nuclear Energy Agency in Paris.

LIST OF RECOMMENDATIONS

Recommendation 1:
The Committee recommends that the Canadian Nuclear Safety Commission "CNSC" maintain an arm's-length relationship with utilities when dealing with compliance to orders on critical matters of safety.

Recommendation 2:
The Committee recommends that substantive discussions such as those related to the safety system upgrades be documented to the extent possible, that those documents be made publicly available and that the public be consulted before final decisions are made.

Recommendation 3:
The Committee recommends that the CNSC require thorough testing and monitoring of the shutdown system upgrade at Pickering A following its installation and make public all reports of its performance in tests and under operating conditions.

Recommendation 4:
The Committee recommends that prior to the restart of any reactor, CNSC order Ontario Power Generation "OPG" to recalculate the seismic hazard by conducting a thorough seismic risk assessment including full consideration of the risk related to the pressure relief ducts, and that they make any additional safety improvements that may be identified.

Recommendation 5:
The Committee recommends that the CNSC require OPG to conduct a full, third-level probabilistic risk assessment of Pickering A.

Recommendation 6:
The Committee recommends that the necessary steps be taken by the CNSC or other responsible authority to speed up the process of adopting updated International Commission for Radiological Protection "ICRP" standards in Canada.

Recommendation 7:
The Committee recommends that in the interests of public safety, the Government of Ontario and the Federal Government consider amendments to human rights legislation that would permit drug and alcohol testing of workers in areas critical to public safety. In the meantime, the Committee recommends that representatives of union and management at OPG give priority to establishing a program for alcohol and drug testing that does not contravene existing law.

Recommendation 8:
The Committee recommends that the government take immediate action to amend the Nuclear Liability Act, and increase and maintain the mandatory operator held insurance coverage from the current 75 million dollars at an amount in line with the Paris and Vienna Conventions "over 600 million dollars".

Recommendation 9:
The Committee recommends that the Comprehensive Study List Regulations of the CEAA be amended to include the restart of a nuclear power reactor following a prolonged shut down of the reactor or significant modification to the reactor and/or the station.

Recommendation 10:
The Committee recommends that the CNSC ensure public confidence in the federal environmental assessment process by:
retaining for itself the public consultation process, not delegating it to a project proponent;

- *setting more realistic and fair deadlines on public comment periods taking into account the volume of material to be assessed and the technical expertise required to analyze it;*
- *determining the scope of assessments independently of the project proponent;*
- *improving its maintenance of the public registry required under CEAA; and*
- *developing guidelines to make intervenor funding available to interested parties.*

APPENDIX A

WITNESSES

NAME OF ORGANIZATION AND/OR WITNESS	ISSUE NUMBER	DATE OF APPEARANCE
ATOMIC ENERGY CONTROL BOARD (AECB) Cait Maloney, Director, External Relations and Documents Division; Jim Harvie, Director General, Reactor Regulation; Michael Taylor, Deputy Director General, Reactor Regulation; Richard Ferch, Director, Wastes and Decommissioning Division; Rod Utting, Director Radiation and Environmental Protection Division.	4	February 24, 2000
ATOMIC ENERGY OF CANADA LIMITED (AECL) David Torgerson, Vice-President, Research and Product Development; Victor Snell, Nuclear Safety and Licensing.	3	February 22, 2000
ENERGY PROBE Normand Rubin, Director of Nuclear Research, Senior Policy Analyst.	5	February 29, 2000
INTERNATIONAL INSTITUTE OF CONCERN FOR PUBLIC HEALTH Dr. Rosalie Bertell, President	22	September 21, 2000
NATURAL RESOURCES CANADA Ric Cameron, Assistant Deputy Minister, Energy Sector; Peter Brown, Director, Uranium and Radioactive Waste Division, Energy Sector; Dave McCauley, Advisor, Uranium and Radioactive Waste Division, Energy Sector; Jacques Hénault, Analyst, Uranium and Radioactive Waste Division, Energy Sector.	12	June 1st, 2000
NUCLEAR AWARENESS PROJECT Irene Kock, Executive Director	8	May 2nd, 2000

NAME OF ORGANIZATION AND/OR WITNESS	ISSUE NUMBER	DATE OF APPEARANCE
NUCLEAR INSURANCE ASSOCIATION OF CANADA Steve Hammond, Chairman; Dermot Murphy, Manager.	10	May 11, 2000
ONTARIO POWER GENERATION Ron Osborne, President and Chief Executive Officer; Gene Preston, Executive Vice-President and Chief Nuclear Officer; Pierre Charlebois, Senior Vice-President, Technical Services and Chief Nuclear Engineer; Richard Dicerni, Executive Vice-President and Corporate Secretary; Kurt Johansen, Senior Manager of Environmental Assessments.	24	October 19, 2000
ONTARIO POWER GENERATION Carl Andognini, Special Nuclear Advisor to the President; Richard Dicerni, Executive Vice-President and Corporate Secretary.	7	April 13, 2000
POWER WORKERS' UNION John Murphy, President; Terry Pigeau, Vice-President; Peter Falconer, Chair of the PWU Health, Safety and Environment Committee; Jim Beggs, Sector 1 Board Member, Darlington Nuclear Station; Dennis Fry, Sector 1 Board Member, Bruce Nuclear Station; Charlie Gill, Sector 1 Board Member, Pickering Nuclear Station.	8	May 2nd, 2000
REGIONAL MUNICIPALITY OF DURHAM, HEALTH DEPARTMENT Robert Kyle, Medical Officer of Health; Donna Reynolds, Associate Medical Officer of Health; Mary-Anne Pietrusiak, Epidemiologist; Larry O'Connor, Chair, Health and Social Services Committee.	11	May 30, 2000

APPENDIX B

FACT-FINDING MISSION TO WASHINGTON, D.C. AND ATLANTA, GEORGIA (OCTOBER 9 – OCTOBER 14, 2000)

ENVIRONMENTAL PROTECTION AGENCY	John Beale, Principal Deputy Assistant Administrator for Air and Radiation, EPA; Patricia Koshel, Director, Western Hemisphere and Bilateral Affairs Office, EPA;
INSTITUTE OF NUCLEAR POWER OPERATIONS (INPO)	James T. Rhodes, President and Chief Executive President; Sig Birg, INPO Executive Vice-President; Ed Hux, Director, Plant Operations Division.
NUCLEAR REGULATORY COMMISSION	Greta Joy Dicus, Acting Chairman; Jeffrey S. Merrifield, Commissioner; Edward McGaffigan, Commissioner.
UNION OF CONCERNED SCIENTISTS	Dave Lochbaum, Nuclear Safety Engineer.
WORLD ASSOCIATION OF NUCLEAR OPERATORS (WANO)	William R. Kindley, Director; Jim Miller, Legal Counsel.