AECL EACL

Licensing Package

Renewal (2006) of the CRL Site Operating Licence - Information Presented for the Day One CNSC Public Hearing (2006 April 26)

Licensing-Single Point of Contact

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ABSTRACT

This document was prepared in support of the AECL presentation at the CNSC Public Hearing (Day One) for the renewal of the Chalk River Laboratories site licence. The document has been prepared by Licensing-Single Point of Contact following input received from various subject matter specialists across the Chalk River Laboratories site.

NOTICE TO READERS

This document is submitted by Atomic Energy Canada Limited (AECL) for consideration as a Commission Member Document at the Day One Public Hearing being held on 2006 April 26. In parallel with the submission of this document, AECL also provides for consideration as Commission Member Documents, a further five stand-alone documents, all of which are references within this document.

Specifically, the following five documents are available for consideration as Commission Member Documents in parallel with this document at the Day One Public Hearing.

- AECL, *AECL Annual Environmental Performance Report for 2004,* AECL-MISC-387-04, Revision 0, 2005 December.
- AECL, *Comprehensive Preliminary Decommissioning Plan for AECL's Chalk River Laboratories,* CPDP-01600-PDP-002, Revision 1, 2006 February.
- AECL, Framework for a Communications and Public Consultation Plan, *Periodic Updating of the Public on the Comprehensive Preliminary Decommissioning Plan for Chalk River Laboratories,* 3600-07440-PLA-001, Revision 1, 2005 December.
- AECL, *Strategic Initiatives Document, Federal Nuclear Legacy Liabilities Management Plan, Conceptual Long-Term Technical Strategy for the Management of Nuclear Legacy Liabilities at AECL Sites: Five Year Operational Implementation Plan – Chalk River Laboratories*, 3600-01620-067-003, Revision 0, 2006 February.
- Université Laval, *Radiological Environmental Survey Outside the Chalk River Laboratories Site*, LRUL 2006-1, 2006 February.

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APPENDICES

CHAPTER 1 INTRODUCTION

1.1 Scope

This document has been prepared to assist the Canadian Nuclear Safety Commission (CNSC) members in their assessment of the application [1-1 and 1-2] from Atomic Energy of Canada Limited (AECL) to renew the Nuclear Research and Test Establishment Operating Licence (NRTEOL) [1-3] for Chalk River Laboratories (CRL). It has been compiled following recent discussions with CNSC staff, and having taken into consideration the most relevant and recent licensing documentation since the previous renewal in 2003.

1.2 Purpose of this Submission

The purpose of this document is to provide information in support of our application for a 63-month licence period, to describe the improvements that have been implemented at CRL during the current licensing period in response to issues identified by CNSC staff, the Commission, the public and AECL, and to describe the major activities that will be undertaken during the proposed licence period. This submission contains information on performance of the licence-listed facilities at CRL and on the key compliance programs in place to ensure the health and safety of workers and members of the public and to ensure adequate security and protection of the environment.

AECL is submitting this document to the Commission to provide appropriate and sufficient information to enable Commission members to effect an informed judgement of the 63-month application period that is under consideration. The proposed renewal period is longer than previous CRL licence durations, and has been made in accordance with applicable Commission Member Documents [1-4 and 1-5]. Reference [1-4] identifies guidelines for a licence period up to five years or longer, and AECL's view is that these guidelines have been met, as supported by the information contained herein.

1.3 References

[1-1] J.P. Létourneau, Letter to G. Lamarre, *Chalk River Laboratories (CRL) Application for Operating Licence Renewal – 2006*, SPOC-05-175/ 4161-00521-021-000, 2005 November 30.

[1-2] J.P. Létourneau, Letter to G. Lamarre, *Chalk River Laboratories (CRL) Application for Operating Licence Renewal – 2006 (Supplementary Information)*, SPOC-05-133/ 4161-00521-021-000, 2005 December 16.

[1-3] Nuclear Research and Test Establishment Operating Licence, Chalk River Laboratories, NRTEOL-1.04/2006. Expiry Date: 2006 July 31.

[1-4] CNSC, *New Staff Approach to Recommending Licence Periods,* CMD 02-M12, 2002 March.

[1-5] CNSC, *New Staff Approach to Recommending Licence Periods (Supplementary Information)*, CMD 02-M12.A, 2002 March.

CHAPTER 2 GENERAL INFORMATION

2.1 History of the CRL Site

AECL's origins date back to the early 1940's when the Zero Energy Experimental Pile (ZEEP) was designed in the Montreal Laboratory of the National Research Council of Canada. The Chalk River Laboratories have a long and distinguished history dating back to 1944 when the National Research Council (NRC) established a research laboratory on the banks of the Ottawa River near the Village of Chalk River. The NRC-designed ZEEP reactor was built at Chalk River and on 1945 September 05 became the first reactor outside of the United States to sustain a nuclear chain reaction. The National Research Experiment (NRX) Reactor was then built and operated for about four years before AECL was incorporated as a federal Crown corporation in 1952. Construction of the National Research Universal (NRU) Reactor began in 1951 April and the reactor achieved first criticality in 1957 November. Over the next several decades, much pioneering work was performed at Chalk River, developing reactor physics, chemistry, fuels, materials and engineered systems for the CANDU[1] Reactor. The technology was also put to good use in radio-medicine applications and AECL became (and still is) the world's leading producer of medical radioisotopes (notably Mo-99). Cancer therapy machines using Co-60 were developed at Chalk River as early as 1951. In 1976, the world's first linear accelerators for cancer treatment, developed by AECL, went into operation in London, Ontario and Houston, Texas. However, the CANDU was AECL's "flagship" product and in 1987, the CANDU Reactor was recognized at the Canadian Engineering Centennial as one of Canada's top ten engineering achievements of the previous century.

2.2 Application for Renewal of Operating Licence

The application from AECL to renew the Nuclear Research and Test Establishment Operating Licence for CRL was submitted to CNSC staff on 2005 November 30 with the document entitled *Licensing Basis Document for Chalk River Laboratories* [2-1] providing a clause-by-clause statement of compliance with all relevant requirements of the CNSC Regulations. The relevant regulations are as follows:

- General Nuclear Safety & Control Regulations,
- Radiation Protection Regulations,
- Class I Nuclear Facilities Regulations,
- Class II Nuclear Facilities Regulations: Class II Nuclear Facilities,
- Class II Nuclear Facilities Regulations: Class II Prescribed Equipment,
- Nuclear Substances and Radiation Devices Regulations,
- Packaging and Transport of Nuclear Substances Regulations, and
- Nuclear Security Regulations.

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1 CANada Deuterium Uranium, registered trademark of AECL.

Supplementary information was subsequently provided on 2005 December 16 with submission of the document entitled *Information in Support of Site Licence Renewal for Chalk River Laboratories* [2-2]. This document was prepared to replace the *Documentation in Support of Site Licence Renewal for Chalk River Laboratories* [2-3], which is referred to in the existing CRL operating licence. While broadly similar in structure to the RC-693-CRL [2-3] document, the detailed content and layout of the new document has been simplified to better reflect the compliance program and facility documentation currently in place at CRL in support of the operational infrastructure.

The newly prepared document comprises a main text and 19 facility-specific appendices arranged in two sets, as described below. The main text presents information that applies to the whole of the CRL site, whereas the individual appendices present facility-specific information pertaining to the various nuclear facilities located at CRL.

There are 14 nuclear facilities at CRL that are listed in Appendix B of the current CRL site licence. Each of these facilities is the subject of a separate appendix in the document. Each appendix has the prefix label "OF" to indicate operating facility, and is further labelled by means of the Facility Authorization numbering system.

Additionally, there are currently five facilities at CRL that are considered to be permanently shutdown nuclear facilities at various stages of decommissioning. These facilities are currently listed in Appendix C of the CRL site licence. Each of these five facilities is the subject of a separate appendix. These appendices each have the prefix label "PSD" (Permanently Shutdown) and are further labelled by a letter code.

In brief, the remainder of the proposed new licence reference document comprises the following:

- Section 2: Compliance programs (e.g., Radiation Protection Program, Environmental Protection Program) that are applied "across the board" (and hence are not specific to any one facility) at the CRL site.
- Section 3: Auxiliary programs that provide support to those compliance programs documented in Section 2.
- Section 4: A summary of the nuclear operations at the CRL site.
- Section 5: A summary of the decommissioning process at the CRL site.
- Section 6: Public Consultation Program.

2.3 Progress on Previous Licensing Actions

The Record of Proceedings of the Day Two CRL site licence renewal public hearing on 2003 April 09 identifies the following licensing actions, which were required to be dispositioned. These actions have all been addressed during the present licence period. Relevant information may be found in this document as identified in each bracket.

- Financial Guarantee for Decommissioning of the CRL site (Section 4.1),
- CRL Comprehensive Preliminary Decommissioning Plan (Section 4.1),
- Management Oversight (Section 2.5),
- Quality Assurance (Section 3.3),

- Training (Section 3.15),
- Waste management Facilities (Section 3.13),
- Public Consultation/Release of Information to the Public (Section 4.2),
- NRU Licensability Extension (Appendix C),
- Radiation Protection (Section 3.8),
- Argon-41 emissions from NRU Reactor (Section A7.2),
- Fire Protection (Section 3.10),
- Environmental Management System (Section 3.9), and
- Ecological Effects Review (Section 3.9.4).

2.4 Major Activities During the Proposed Licensing Period

A number of significant activities are planned for the proposed licensing period. These are listed below, with a reference to the section of this document where more information is provided:

- Implement a realigned organization that is more focused on operational performance and safety, with increased emphasis on reactor operations safety and performance improvements (Section 2.5).
- Resolve quality assurance issues. This will be addressed by developing and implementing an integrated performance assurance program using proven industry approaches (Section 3.3).
- Confirm the remaining NRU safety upgrades in-service, and complete the activities associated with the NRU Licensability Extension Program (Appendices A and C).
- Complete the NRU Improvement Initiative and move to continuous improvement (Appendix B).
- Complete the initial safety culture initiative and move to integration of safety culture in all aspects of CRL operation (Section 3.4).
- Continue improvements in the maintenance programs in the facilities (Section 3.1.2).
- Improve the internal event reporting system to provide increased assurance that significant events will be prevented, and continue to increase reporting and openness with CNSC staff (Section 3.2).
- Commence and make progress on the five year plan [2-4] associated with the Comprehensive Preliminary Decommissioning Plan (Section 3.14).
- Improve the scope and breadth of information provided to the public, and strengthen the public consultation process in accordance with a new public consultation framework [2-5] (Section 4.2).
- Develop further the criticality safety program to reflect internationally accepted standards (Section 4.3).
- Continue to implement effective actions to strengthen compliance with fire protection codes and standards (Section 3.10).

- Implement the priority activities associated with AECL's Environmental Plan [2-6], as well as activities required by the CNSC, to continue to improve CRL's environmental performance (Section 3.9).
- Integrate the Dedicated Isotopes Facility (DIF) operations organization into Nuclear Laboratories (Section 2.5).
- Transition of production of some medical isotopes from NRU to DIF following successful completion of DIF commissioning (Section 3.16).
- Determine whether NRU will continue to operate for a significant period of time after completion of the proposed licence period, and put in place appropriate plans depending on the outcome of the decision (Section C6).

2.5 AECL Nuclear Laboratories Organization

In 2006 March, the Vice-President of Nuclear Laboratories announced an update of the organization of AECL's Nuclear Laboratories. The main rationale behind the update is to achieve operational excellence through better coordination and greater effectiveness within the site. The coordination will be achieved through the consolidation of key functions and a number of site services or support functions that are currently spread across the lines of business. Increased efficiency, and improved safety and operational performance are expected to follow across AECL's various nuclear laboratory sites.

The restructured Nuclear Laboratories business unit, which will comprise 14 organizational units, is presented in Figure 2.1. These changes are a re-alignment of existing functions to consolidate and improve performance. The Vice-President's direct reports will first prepare change management plans to fully transition to this new alignment in a manner that minimizes distraction from the goal of obtaining operational excellence.

In 2006, AECL plans to incorporate the DIF operating organization into Nuclear Laboratories. The DIF operations will report to the General Manager, Reactor Operations. This will facilitate achieving greater consistency in reactor operations as well as sharing of resources. There has already been much interchange between DIF and NRU operations, particularly with respect to sharing of documents and training in the area of Event Free Tools (refer to Appendix B). Bringing DIF operations into Nuclear Laboratories will strengthen such initiatives.

The DIF project will remain separate from Nuclear Laboratories.

2.6 References

[2-1] AECL, *Licensing Basis Document for Chalk River Laboratories*, CRL-00521-LBD-001, Revision 0, 2005 November.

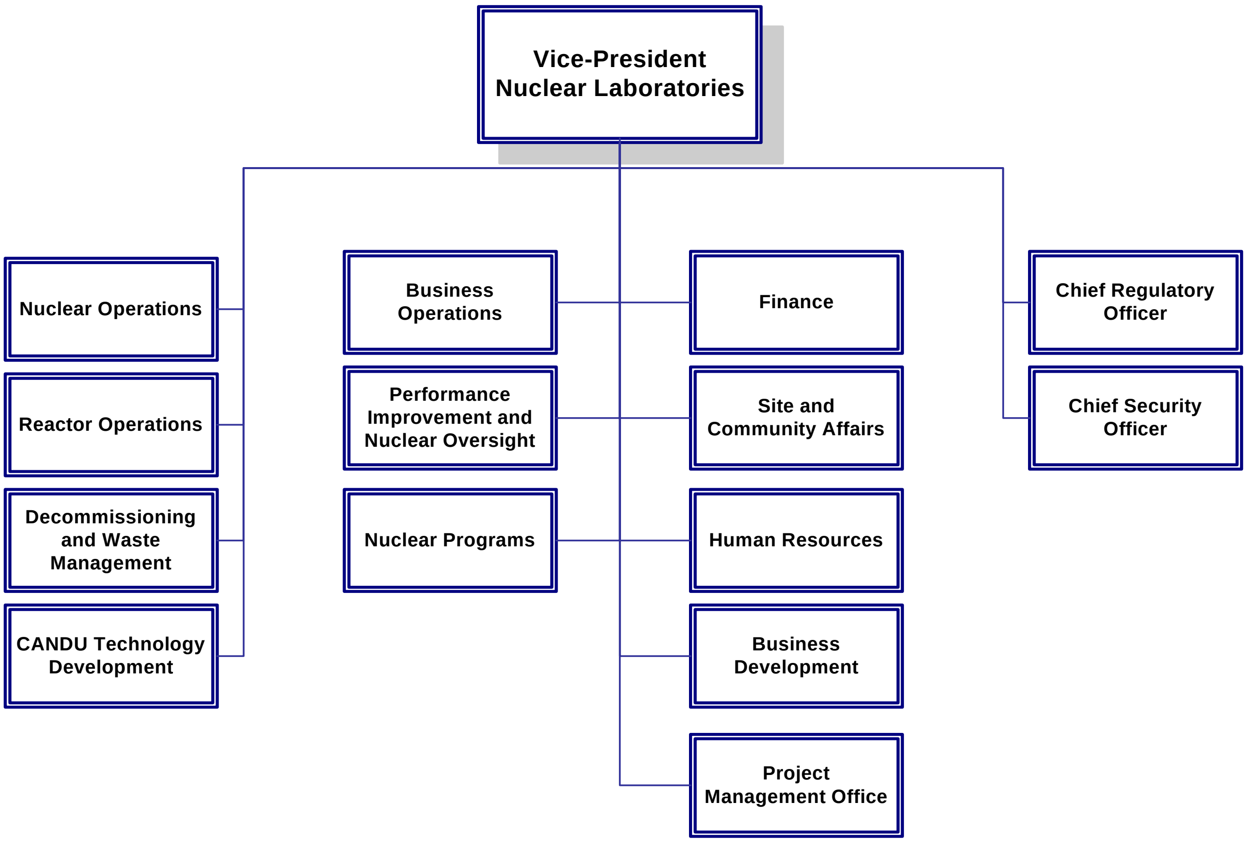
[2-2] AECL, *Information in Support of Site Licence Renewal for Chalk River Laboratories*, CRL-00521-LP-001, Revision 0, 2005 December.

[2-3] AECL, *Documentation in Support of Site Licence Renewal for Chalk River Laboratories*, RC-693-CRL, Revision 5, 2002 May.

[2-4] AECL, *Strategic Initiatives Document, Federal Nuclear Legacy Liabilities Management Plan, Conceptual Long-Term Technical Strategy for the Management of Nuclear Legacy Liabilities at AECL Sites: Five Year Operational Implementation Plan – Chalk River Laboratories,* 3600-01620-067-003, Revision 0, 2006 February.

[2-5] AECL, *Framework for a Communication and Public Consultation plan, Periodic Updating of the Public on the Comprehensive Preliminary Decommissioning Plan for Chalk River Laboratories,* 3600-07440-PLA-001, Revision 1, 2005 December.

[2-6] AECL, *Annual Environmental Plan for AECL Sites in Canada – 2005/2006,* AECL-MISC-388-05, Revision 0, 2005 May.



Note: Business Development and Human Resources group are indirect reporting structures.

Figure 2.1: Restructured Nuclear Laboratories Business Unit

CHAPTER 3 OPERATING PERFORMANCE AND PROGRAMS

3.1 Routine Operation

3.1.1 General

Since licence renewal in 2003, the following key changes have been implemented at CRL:

- The originally proposed date of 2005 December 31 to shutdown the NRU Reactor has been extended by seven months following an application to the Commission, and a subsequent decision recorded in the applicable Record of Proceedings. As part of this process, an Environmental Assessment Screening Report was prepared by CNSC staff and accepted by the Commission members following a public hearing held 2005 June 29.
- The NRU Reactor Improvement Initiative was established to effect positive changes to the operational and performance framework within the facility. This is described in Appendix B.
- A number of key decommissioning activities have been progressed to disposition associated nuclear legacy liabilities. For example, the Building 107 structure has been partially removed and this demolition will continue throughout 2006. This building was used for a variety of purposes during a life cycle originating in 1945. Radiochemical laboratories used for isotope separation, Van de Graaff, surface science, and laser work were established, as well as office space, storage areas and machine shops. As planned, the removal activity has been performed in a safe manner consistent with the objective of maximizing the amount of material that would be available for recycling.
- CNSC staff have recently approved an Advanced Decommissioning Work Package that will enable AECL to remove the water from the Building 204 Rod Bays, and therefore remove the source of a groundwater plume within Controlled Area 2. The work on the Advanced Decommissioning Work Package has commenced. These rod bays are connected to the permanently shutdown NRX Reactor.
- Active Drainage Tank 240-1 has been removed from service (late fall 2005), and drained of all residual liquid during 2006 January. The purpose of these acts was to remove the source contributing to a groundwater plume within Controlled Area 2.
- Following the 2004 November audit conducted by CNSC staff on fire protection at CRL, a comprehensive corrective action program was developed and submitted for acceptance. Outstanding progress has been achieved against the audit Directives and Action Notices. A recent follow-up inspection by CNSC staff (2006 February 15 and 17) indicated that AECL performance now meets CNSC staff's expectations with regard to the Fire Protection Program and its implementation.
- The remaining two systems that complete the installation of the NRU upgrades have been made fully operational (2005 December). This was completed in accordance with licence Condition 13.1. All of the safety upgrades are now fully operational, representing a significant improvement in defence-in-depth for the NRU facility.

- The Environmental Protection Program and associated documentation meets the ISO-14001 international standard for environmental management systems. The Chalk River Laboratories was first registered to ISO-14001:1996 in 2004, and as a result of a CRL surveillance audit in 2005 June, CRL was re-registered to ISO-14001:2004. A Type I CNSC inspection of the Environmental Protection Program in 2005 concluded that the program is well developed with only a few minor weaknesses. The inspection also concluded that the program is implemented in many of the facilities and is being implemented in the remaining facilities.

3.1.2 Facility Maintenance

Following the 2002 November comprehensive audit conducted by CNSC staff, AECL undertook a number of corrective actions related to the maintenance program. A key focus of this effort was to improve facility specific maintenance plans.

Since 2003 April, facility maintenance plans have been prepared and issued for the following licence-listed facilities, and have been provided to CNSC staff as evidence that AECL was satisfactorily dispositioning the directives:

- NRU Reactor,
- ZED-2 Reactor,
- Universal Cells,
- Mo-99 Production Facility,
- Fuels and Materials Cells,
- Recycle Fuel Fabrication Laboratories,
- Nuclear Fuel Fabrication Facilities (Buildings 405),
- Nuclear Fuel Fabrication Facilities (Building 429 A/B),
- Heavy Water Upgrading Plant,
- Combined Electrolysis Catalytic and Exchange Upgrading/Detritiation Test Facility,
- Tritium Laboratory,
- Waste Treatment Centre, and
- Waste Management Areas.

3.1.2.1 Preventive Maintenance

A general description of how preventive maintenance fits into a Facility Maintenance Plan is described below:

There are five basic categories of maintenance used at CRL:

a) Preventive Maintenance
   1) Preventive Maintenance
   2) Predictive Maintenance

b) Corrective Maintenance
   1) Breakdown Maintenance (Unscheduled)
   2) Corrective Work (Scheduled)
c) New Work
   1) Build
   2) Fabricate
   3) Modify
   4) Upgrade
d) Operation (Skilled Trades Support to Operations or Production)
e) Decommission and Demolish

Preventive maintenance is captured in a program by first identifying the facility equipment. Then a preventive maintenance routine is established for that equipment. The pertinent information is then loaded into the Computerized Maintenance Management System to allow for controlled planning and scheduling.

AECL recognizes that over time certain gaps may have developed in both the equipment database and preventive maintenance routines associated with some of the facilities. Over the next licensing period, the facilities, in conjunction with Maintenance Engineering and Planning, will undertake a comprehensive review of the Preventive Maintenance Program for each facility. The high-level tasks to accomplish this are as follows:

- Development or review of the Master Equipment List for each facility.
- Align the equipment significance or importance with the facility Safety Related Systems List.
- Re-categorize the preventive maintenance as “Reliability” (preventive maintenance credited in safety analysis and/or operating licence), “Mandated” (preventive maintenance mandated in order to meet codes or standards), and “Production” (preventive maintenance performed to maximize equipment reliability for economic reasons and based on engineering judgement, vendor recommendation, industry standard, etc.).
- For “Reliability” and “Mandated” preventive maintenance, document the technical basis for both the type and frequency of routine performed.
- For “Production” preventive maintenance, enhance the maintenance reporting to follow-up processes to ensure the preventive maintenance is adequate and effective.

Once the Computerized Maintenance Management System holds all preventive maintenance information for a facility, the various routines are automatically generated by the software and brought forward for planning and scheduling at the appropriate time. The schedule on which the preventive maintenance work appears also contains all the other work types. All maintenance activities are loaded onto the schedule on a monthly basis, and are carried out according to job priority, facility availability, resource availability and whether or not the work is ready to proceed. The monthly schedules are further refined as time progresses and a detailed weekly schedule is produced and issued to both the maintenance staff and all facilities.

3.1.2.2 Performance of Preventive Maintenance

The performance of the Preventive Maintenance Program is measured in a variety of ways in order to assist facility managers in assessing fitness-for-service of their equipment and systems. Some of the measures are as follows:

- activity weekly schedule compliance,
- activity monthly schedule compliance,
- ratio of preventive maintenance to corrective maintenance,
- number of overdue preventive maintenance routines, and
- number of overdue pressure safety valves inspections and tests.

The performance measures are summarized and published to all Facility Authorities and Managers, as well as senior management and maintenance support staff on a monthly basis. In addition, the preventive maintenance data and other information are available at all times in the Computerized Maintenance Management System and on several internal web pages.

Two examples of how this type of performance measuring is helping to drive improvements are shown in Figure 3.1. These particular examples demonstrate recent improvements in preventive maintenance schedule compliance, and pressure safety valves program compliance (Figure 3.2). Figure 3.1 demonstrates that we are close to completing 80% of all scheduled maintenance activities on time, almost doubling the number of scheduled activities performed during the 2004/2005 fiscal year. Although room for improvement remains, and will be pursued, the current level of performance is consistent with that observed across the nuclear industry. Figure 3.2 demonstrates that the backlog in pressure safety valves maintenance has been virtually eliminated.

3.2 Unplanned Events

Table 3.1 summarizes non-reportable and reportable events at CRL from 2003 to 2006 mid-March. The table presents data for each of the compliance programs, facilities, and other organizational units within CRL.

The trend in reportable events in NRU that led to the NRU Improvement Initiative (refer to Appendix B) is evident in the table. The increase in non-reportable events in NRU and the Mo-99 Production Facility (MPF) reflects an improved reporting culture and a lower threshold for internal reporting. It is expected that this increased reporting will allow earlier recognition of underlying trends so that early action can be taken to prevent significant events. During the proposed licence period, this trend in increased reporting will be extended to other areas at CRL.

A similar trend in reportable events is evident for the Nuclear Fuel Fabrication Facility (NFFF). Actions were taken early in 2006 by the Vice-President of Nuclear Laboratories to assess this trend and determine what corrective actions would be required. Actions taken include an independent review of NFFF operations by an external individual with extensive operational experience, supplementing the NFFF management team with a highly experienced former facility authority on a temporary basis, and inclusion of NFFF in the daily operations oversight teleconference. The outcome of these actions, together with the results of the investigations into the events, will be reviewed and further corrective actions taken, as necessary. CNSC staff has been kept apprised of AECL's actions in response to these NFFF events.

The significance rating of reportable events has improved slightly with an average of 2.17 in 2005, compared to 2.0 in 2004. The significance rating is based on a scale of 1 to 3, 1 being high significance and 3 being low. The significance rating takes into consideration the consequences and potential consequences of the event on the health and safety of personnel and the public, potential impact on the environment, the margin of safety remaining, and generic aspects of performance such as process, equipment and human performance. Event recurrence is also seen as a factor of increased significance. One event was reported with a significance of one so far in 2006, and one event in 2005, compared to five events in 2004.

Significance Levels 1 and 2, and all reportable events are reviewed by the Nuclear Laboratories management team on a monthly basis. The management team assesses the need for high-level actions in response to any observed adverse trends. The prompt response to recent reportable events in NFFF is an example of the effectiveness of this newly introduced level of management oversight.

3.3 Quality Assurance Program

As a result of the comprehensive 2002 November audit by CNSC staff, there were 14 resulting Directives and 7 Action Notices regarding Quality Assurance, Radiation Protection, Environmental Protection, Emergency Preparedness, and Training.

To date, AECL has submitted proposed closure of Directives D1 to D14 and Action Notices 1 to 7 to CNSC staff. On 2005 October 21, AECL met with CNSC staff to review outstanding actions and agree on remaining activities that would be deemed acceptable by the CNSC staff to close all Directives and Action Notices. The plan of action was submitted to CNSC staff, and AECL has submitted the remaining deliverables on schedule to CNSC staff. CNSC staff has accepted closure of Directives D1 to D4, D6 to D14 and Action Notices A2 to A7 related to Emergency Preparedness, Environmental Protection, Radiation Protection, Quality Assurance, and Training.

A key achievement during the current licence period was the acceptance by CNSC staff of the AECL Overall Quality Assurance Manual [3-1]. The revised *Nuclear Laboratories, Nuclear Operations Quality Assurance Manual* [3-2], has been submitted to CNSC staff (2005 August) for acceptance.

One of the major goals of the updated Nuclear Laboratories organization described in Section 2.5 is to support updating of the quality assurance program to an integrated performance assurance program. The new Performance Improvement in Nuclear Operations organization within Nuclear Laboratories will include the performance assurance function and will be responsible for developing and overseeing the implementation of this improvement.

The move towards integrated performance assurance has been successful at nuclear utilities, and AECL believes that a similar approach at the Nuclear Laboratories will facilitate resolution of quality assurance issues.

3.4 Safety Culture and Human Performance

During the current licence period, AECL commenced an initiative to improve safety culture across the company, with specific focus on Nuclear Laboratories. More recently, this has been complemented by an initiative to improve and sustain a higher level of human performance. These initiatives are described in this section. The Vice-President (AECL Nuclear Laboratories) initiated organizational changes in 2006 March (discussed further in Section 2.5), including creation of a group focussing on performance improvement and human factors enhancement. This group will ensure that these initiatives remain integral to operation of the CRL site.

An initiative to assess and continually improve safety culture in AECL began in 2004 in Nuclear Laboratories. The initiative includes a number of integrated activities designed to reflect change management methodology and sustain the developing culture. The initiative is founded upon a number of principles, including the pivotal role of the manager in change, a well planned approach supported by the Executive, a regular and focussed communication campaign, engagement of staff and unions, education and training and the need for Company programs and a management system that support the desired behaviours.

Initial efforts concentrated on the roll out of a half-day Safety Culture Workshop across the entire organization, in order to heighten awareness of safety culture and the need for improvement, as well as personal involvement. These workshops, led by line managers, have been designed as interactive sessions, in which the leaders discuss with their teams current views on safety culture and the relevance of these concepts to their work and safety. The final exercise results in a team action plan designed to address opportunities for improvement identified in preceding discussions, and the team members are asked to take on some responsibility for implementing the plan. A detailed safety culture survey, based upon the 2004 (then current) CNSC draft document *Guide to Licensee Self Assessment*, is being administered during these workshops. This survey is providing an internal benchmark against which to gauge future improvements. Having staff complete it during the workshop ensures 100% return and a more comprehensive understanding of the issues.

Other activities focus upon increased presence of leaders in the workplace, improved and consistent hazard signage, improved reporting, trending and education about lessons learned, involving more staff in safety inspections, a promotional and educational campaign, a new safety web page, safety culture metrics and ongoing assessment, integration of all safety groups, improved safety meetings, benchmarking, improved recognition for safe behaviours and consequences for inappropriate action, working groups involving all levels of staff and unions, integration of a wellness program and improved orientation emphasizing safety. Another key element of the safety culture initiative is the implementation of a Human Performance Program. Numerous meetings have been held with Ontario Power Generation, CANDU Owners Group and Bruce Power in order to ensure the initiative is on target, to build upon best practices and to share learning.

To date, about 80% of staff in Nuclear Laboratories have attended the Safety Culture Workshop, and an additional 400 have attended from Advanced CANDU Reactors and MDS Nordion Medical Isotopes Reactor (MMIR) Project. Twenty-four action plans have been submitted following the safety culture workshops, 10 safety culture survey reports have been produced for various groups, and the initiative is being incorporated into a Company-wide change initiative.

Another key element of the safety culture initiative is the implementation of a Human Performance Program. A plan to create this program is in place and elements of this are being applied in various facilities, with a drive to integrate this into one corporate program.

3.5 Occupational Safety and Health

Chalk River workers may have to deal with physical, chemical and biological hazards in the course of performing their work. Many measures are employed by AECL's Occupational Safety and Health (OSH) Program to ensure the protection of workers from these hazards. These measures include the use or application of:

- elimination or substitution of hazardous materials, processes or conditions where practicable;
- engineered protective systems or structures;
- ventilation systems to remove contaminants from the workplace;
- maintenance programs to ensure equipment fitness-for-service;
- operating procedures that describe the steps to be taken for the safe conduct of work;
- work control processes to ensure hazards are identified, evaluated and controlled prior to the start of work;
- procedural controls on access to hazardous areas;
- personal protective equipment and clothing;
- training of personnel; and
- management leadership in the setting of standards and ensuring adherence to those standards.

All CRL activities and operations comply with the Canada Labour Code Part II and the pursuant Canada Occupational Health and Safety Regulations, Nuclear Safety and Control Act and Regulations, Hazardous Products Act, Controlled Products Regulations, Workplace Hazardous Materials Information System (WHMIS) Regulations, and all other applicable federal and provincial health and safety related acts and regulations. In 2004 January, AECL rededicated itself to its health and safety commitments by issuing a revised corporate *Health and Safety* policy [3-3], which clearly placed health and safety as the company's highest priority.

The frequency and severity rates for CRL lost time injuries over the period 2001 to 2005 are shown in Figure 3.3. The continuous improvement evident from 2002 to 2005 is a reflection of improved performance in the areas of management support and participation, hazard identification and reduction, employee awareness and training, and return-to-work program management. Frequency is expressed as the number of injuries involving lost workdays per 200,000 person-hours of occupational work, and severity is expressed as the total number of lost workdays per 200,000 person-hours of occupational work.

AECL's OSH specialists support the OSH Program by developing and maintaining the program framework (e.g., program manual, procedures, training programs, etc.), providing field support (e.g., information, education, guidance, statistics, support services, etc.) to CRL workers, managers and safety committees, and by developing and delivering safety-related training courses. These courses encompass the areas of:

- general health and safety knowledge (New Employee and Contractor Safety Orientations, AECL Work Permit System, WHMIS Overview, Safety Management Systems, etc.);
- general regulatory requirements (Canada Labour Code Part II, Workplace Inspection, Incident Investigation, WHMIS, etc.); and
- job/task-specific training (First Aid/CPR, Confined Space Entry, Personal Fall Protection, Indoor Hoist and Crane Operation, Aerial Platform Operation, Fork Lift Operation, Lock Out Tag Out, Contractor Sponsors, etc.).

In 2004, for example, 25 different training courses were coordinated or delivered by OSH to a total of 1,042 CRL employees, with many of the courses being delivered multiple times.

AECL's Occupational Health Centre at Chalk River continues to be staffed by qualified occupational health nurses backed up by a physician contracted to provide consulting and advisory services. Among the more important responsibilities of the Occupational Health Centre are the provision of medical surveillance testing for employees who are exposed to occupational hazards, the provision of emergency response to CRL injuries with and without radiological contamination, the promotion of healthy lifestyle choices with employees and the coordination of the First Aid and Return to Work Programs. The Occupational Health Centre is also staffed with a trained and experienced workers' compensation coordinator who manages workers' compensation, and work-related return-to-work activities for all of AECL.

Oversight of OSH activities at CRL is provided by line management and by Nuclear Laboratories management, including the Vice-President, at monthly Operation Safety Oversight meetings. In addition, the joint employee-management Site Safety and Health Committee, the AECL Safety Review Committee, internal quality assurance audits, internal operational safety assessment reviews of licensed facilities and regular workplace inspections, all contribute to an effective OSH Program.

3.6 Emergency Preparedness

AECL's Emergency Preparedness Program addresses the requirements for emergency preparedness at AECL's Canadian sites and for the transportation of hazardous material, including the transportation of radioactive material. The program comprises the planning, training, exercises, and verification of adequate resources and equipment required to ensure that AECL is prepared to respond to an emergency on-site, or in the event of a transportation accident, or if called upon under the Federal Nuclear Emergency Plan, off-site.

All staff, including contractors, working without direct supervision at CRL are required to attend the General and Safety Orientation or Contractor Safety Orientation. Both these courses contain information on emergency response including actions to take in the event of a fire, Stay-In and/or Evacuation. In addition, specific training related to emergency response and refresher training as specified in the Emergency Preparedness Program, is given to those staff with specific roles in an emergency. These include the Building Officer-in-Charge, Building Emergency Stewards, Radiological Assessment Team, and members of the Emergency Operations Centre, Site Assessment Centre and Environmental Assessment Centre. In addition, CRL has a 24-7 coverage emergency response capability through on-site fire fighters, on-site Security, on-call

Radiological Assessment Team (comprised of Radiation Surveyors and Health Physicists) and on-call Environmental Field Teams.

Table 3.2 lists a summary of the exercises conducted at CRL and off-site in support of the Federal CRTI [2] program in 2003, 2004 and 2005.

In 2003, AECL hosted the CRTI Exercise EXASIS at CRL. AECL also participated in CRTI Exercise EXFO, held in CFB Suffield in 2005 and the Exercise Maritime Response in 2006. These exercises involved cooperative response of several Federal Agencies, including Health Canada, AECL, NRCan, Department of National Defence, and CNSC staff in responding to simulated terrorist events requiring radiological response. AECL also participated in the activities leading up to these exercises, including the training and development of these exercises and lessons learned. These activities help maintain AECL's Radiological Assessment Team trained and prepared to respond to radiological events both on-site and off-site.

Various improvements of equipment and facilities have been made at CRL over the last few years. These include a new Emergency Centre, consisting of the Emergency Operations Centre, Site Assessment Centre, and Environmental Assessment Centre with improved protection and security of the staff working in the centre, improved communications and improved resources available to the occupants, and the installation of a new emergency siren system.

In 2003, AECL registered two listed substances (chlorine and propane) under the Environmental Emergencies Regulations. AECL has confirmed that the emergency plans and procedures in place will address an event that may involve these substances.

AECL continues to work cooperatively with the Chalk River Regional Emergency Preparedness Committee and Emergency Management Ontario. In addition, to active participation in the planning meetings, AECL supports Chalk River Regional Emergency Preparedness Committee through radiation protection related training and maintaining supplies of KI (potassium iodide) tablets as identified in the provincial emergency plan. In 2004, a Funding Agreement was signed between AECL, the Town of Deep River and the Town of Laurentian Hills, making funds available to support Chalk River Regional Emergency Preparedness Committee.

In 2004, AECL and Emergency Management Ontario contracted International Safety Research to undertake an *Independent Study of Technical Issues Relating to Offsite Consequences Resulting from a Release of Radioactivity at Chalk River Laboratory* [3-4]. The results of the study were presented to, reviewed and accepted by, representatives from AECL, Emergency Management Ontario, Chalk River Regional Emergency Preparedness Committee, Health Canada, and CNSC staff. The report is forming the basis for a review of the planning zones and urgent protective measures contained in the Provincial Nuclear Emergency Plan. The study concludes that the current off-site emergency planning arrangements at CRL are found to be generally justified, but very conservative, and that it would be appropriate to reduce the size of the Primary Zone. It also suggests appropriate protective measures in line with the international guidance and the potential risk. The changes brought about by this independent study are expected to improve the emergency plans and, hence, the effectiveness of an emergency response in the area.

[2] Federal CRTI (CBRN Research and Technology Initiative)

Similarly, AECL is working with the Municipalité régionale de comté du Pontiac and Sécurité Civile du Québec to help ensure adequate emergency preparedness is in place on the Québec side of the Ottawa River, across from CRL. AECL's emergency plans include the notification of Sécurité Civile in the event of an emergency at CRL. In 2005, AECL met with the province of Québec representatives to give a presentation on the NRU planning basis and to assist in the development of the emergency procedures for the province of Québec, should an event occur at CRL.

3.7 Operating Experience

The Operating Experience Program (OPEX) provides the processes for reporting unplanned events, both internally and for external regulatory agencies, and provides the means to investigate these events to determine the causes and prevent recurrence through the application of corrective actions. These events and the causes are analyzed for trends, and the information is shared with AECL personnel and with the nuclear industry through our CANDU Owners Group counterparts, so that the safety and performance of operations site-wide and throughout the industry can be improved.

CNSC staff have previously raised some issues regarding the effectiveness of the OPEX Program, and particularly with the root cause analysis process and the ability of AECL to prevent events from recurring. CNSC staff also questioned whether sufficient personnel were available in the OPEX Program in order to achieve its objectives.

A meeting was held between AECL and CNSC staff in 2005 June in order to better understand the issues raised by CNSC staff, and a follow-up meeting was held in 2005 December. Following these meetings, an OPEX Improvement Initiative Plan was developed and submitted to the CNSC staff in 2006 February. This Initiative comprises 13 elements, addressing resources, documentation, quality of root cause analyzes, training, schedule compliance and other processes under the responsibility of OPEX.

Several of these items are either completed or at an advanced stage of completion. Resources dedicated to the OPEX Program were increased from two to eight in 2005. The root cause analysis process has been upgraded to reflect current industry standards, and additional training has been developed and given to lead investigators. Schedule compliance for apparent cause and root cause analysis reports has significantly improved, increasing from 46% in 2005 to 75% in 2006 to date. These numbers are based on the apparent and root cause analysis reports submitted to the CNSC staff within the OPEX Program limits of 30 days and 90 days for apparent cause and root cause analyzes respectively.

Implementation of the OPEX Improvement Initiative is scheduled for completion in 2006 September.

3.8 Radiation Protection

Section 4(a) of the Canadian Nuclear Safety Commission's Radiation Protection Regulations specifies the following regulatory requirements:

> *"Every licensee shall implement a radiation protection program and shall, as part of that program, keep the amount of exposure to radon progeny and the effective dose and equivalent dose received by and committed to persons as low as reasonably achievable, social and economic factors taken into account, through the implementation of:*
>
> *(i) management control over work practices,*
>
> *(ii) personnel qualification and training,*
>
> *(iii) control of occupational and public exposure to radiation and*
>
> *(iv) planning for unusual situations".*

AECL fulfills these requirements through the development and implementation of the Radiation Protection Program (*AECL's Radiation Protection Requirements* [3-5]).

AECL has adopted the recommendations of the International Commission on Radiological Protection in the development of its Radiation Protection Program. As recommended by the International Commission on Radiological Protection, the Radiation Protection Program recognizes the following three principles:

- ***Justification:*** No practice involving exposures to radiation will be adopted unless it produces sufficient benefit;
- ***Optimization:*** Doses, and the likelihood to receive doses, will be kept as low as reasonably achievable (ALARA), economic and social factors being taken into account; and
- ***Dose Limitation:*** The exposure of individuals shall be kept below relevant regulatory limits set to ensure that no individual is exposed to radiation risks that are unacceptable in any circumstances.

A number of measures are employed to ensure the protection of personnel from radiation hazards. The measures comprise containment of active materials within engineered structures, ventilation systems to remove contaminants from the air in the workplace, procedural zonal controls on access to hazardous areas, personal protective equipment, training, minimizing time spent in radiation fields by appropriate planning and work optimization, keeping procedures updated and maintenance and calibration of radiation measuring devices.

Improvements in the Radiation Protection Program have been continuously implemented since 1993 when AECL undertook a complete review of the program and practices with an aim of enhancing employee safety by ensuring the program incorporates the latest standards, including the recommendations of the International Commission on Radiological Protection, and meets regulatory requirements. Working groups of health physicists and facility representatives reviewed international standards, and practices at other nuclear facilities in Canada and abroad to identify specific areas for improvement, such as in training and qualifications, zoning, ALARA programs, dosimetry and work control. ALARA tools such as Dose Control Points and criteria for triggering ALARA reviews were developed and implemented. As a result, as illustrated in Figure 3.4, the collective dose associated with activities at CRL has steadily decreased since 1993, attributed in large part to this initiative and the resulting increased awareness shown by AECL employees towards radiation protection as a result of the increase in training.

This work continues today as AECL strives for continual improvement of its Radiation Protection Program and radiation protection performance. These improvements are being implemented on a unique and complex site. There are some 240 laboratories and associated nuclear facilities with radiological hazards at CRL. The age and history of operations at CRL is also a complicating factor. Some facilities date back to the 1940s and 1950s when the acceptable radiation protection practices were significantly different from what they are today.

Nevertheless, efforts towards continual improvement continued in 2004 and 2005 with the development and implementation of the formal ALARA Program, ALARA tools and the necessary training to support the program. A total of 140-radiation protection related courses were delivered in 2005 with 2,373 employees receiving training (427 using Computer Based Training). Of these 419 employees received refresher training in 2005. Other training activities included ongoing delivery of existing training courses and the development and delivery of new courses including the Radiation Protection Program Awareness for Line Supervisors and Managers. Ten (10) Group 1 Radiation Surveyors at CRL were trained and qualified in 2005. Another 15 were hired starting 2006 April 01 and will then commence their training program. The training program consists of 3 months of classroom and approximately 12 months of on-the-job training.

AECL's Radiation Protection Training Program (see Section 3.15.3) is an on-going program with courses being developed and regularly delivered either to obtain or maintain radiation protection related job qualifications, in accordance with AECL's Radiation Protection Requirements document.

The total numbers of radiation protection qualified employees at CRL for the past three years are presented in Table 3.3.

There have been a number of system and technology improvement initiatives including replacement and upgrade of the CRL electronic personal dosimeter system in 2004 and the development of a Company-wide dosimetry database and dose reporting system in 2005. The electronic personal dosimeter will aid our efforts to associate doses with specific tasks and, through the use of ALARA techniques, assess means for further dose reduction. The new dosimetry database, completed in 2006 March, improves the recording, tracking, trending, and reporting of doses received by AECL workers, visitors and contractors working for AECL. Managers and supervisors can check on-line their employee's doses against their Dose Controlled Points. Further improvements are scheduled to be undertaken in 2006 and 2007, which will improve our ability to schedule, track and report on internal dosimetry.

Other initiatives taken in 2004 and 2005 as continual improvement of the system and technology required to support AECL's Radiation Protection Program at CRL include the installation of new Continuous Air Monitors in the Universal Cells, radiation monitoring system upgrade in the MPF cells, new additional contamination monitors installed at the exit from Controlled Area 2 and a program to improve the laboratory and zone signage in buildings housing radiological laboratories on site.

Table 3.4 summarizes the dose associated with radiation work at CRL during 2004 and 2005. Figure 3.4 compares the whole-body doses for the period 1993 through 2005. The average whole-body doses have decreased by about 50% over the period. No employee has received a whole-body dose in excess of 20 mSv and the number of employees who have received a dose in excess of 10 mSv has been reduced to 49 in 2005, compared to 106 in 1996.

In 2004, there were three unplanned events resulting in exposures exceeding a dose Action Level: a calculated skin dose from a hot particle, a calculated committed effective dose from an internal intake of mixed fission products and actinides and a calculated extremity dose from a uranium sliver in a finger. The extremity dose, though shown to have no significant radiological consequences, was calculated to exceed the regulatory dose limit for an extremity. These events were reported to CNSC staff and investigated using AECL's OPEX Program. There were no unplanned events in 2005 resulting in exposures exceeding a dose Action Level.

AECL's dosimetry services are licensed by the CNSC and meet the Regulatory Standard S-106, *Technical and Quality Assurance Standards for Dosimetry Services in Canada* [3-6].

In 2004, the thermoluminescent dosimeter reader calibration for reporting personal dose equivalent was changed, based upon the result of an intercomparison, to better measure the dose quantity specified in CNSC's S-106. The data for 1993 through 2003 was adjusted upwards by approximately 10% to allow comparison to the 2004 and 2005 dose results.

3.9 Environmental Protection

3.9.1 General

AECL's Environmental Protection Program [3-7] applies to all operations and activities within AECL sites, including CRL. It is the framework that ensures AECL's *Environment* policy [3-8] is met at AECL sites in Canada. The *Environment* policy, issued under the authority of the AECL Board of Directors, states AECL's commitment to protecting the environment and establishes the overall principles and goals for environmental responsibility and performance expected of all its employees.

Following the 2005 Type I Environmental Management System inspection by CNSC staff, the program and its implementation were both provided a "B" rating.

The following statements are taken from AECL's environmental policy:

- "We practice responsible environmental management."
- "We are committed to the principle of pollution prevention."
- "We set environmental objectives and targets to support continual improvement of our environmental performance."
- "We comply with environmental laws, requirements and recognized standards and guidelines applicable to our activities."

- "We review the impacts of our activities, facilities, projects, services and products on the environment."
- "We meet all applicable environmental requirements of our customers."
- "We will seek to develop and improve technologies to advance environmental protection and clean air solutions."
- "We promote public and employee awareness of this policy."

As a means of achieving continual improvement in our environmental performance, environmental management system and in our system's and technology used to help ensure the protection of the environment, AECL prepares an annual environmental plan [3-9] incorporating the environmental objectives, targets and performance indicators. AECL's Environmental Panel oversees progress against this plan. The Panel is made up of Senior Managers and environmental support staff.

Over the last few years, significant effort has been invested in the continual improvement of AECL's environmental protection training for employees and managers. The program includes general awareness for all staff and contractors, generic and facility-specific Environmental Management System training for facility operators and staff whose work involves Significant Environmental Aspects and environmental protection training for managers and supervisors. This effort has increased the awareness of AECL's employees in environmental responsibility and AECL's Environmental Protection Program.

In 2004, CRL was successfully audited by the Quality Management Institute against the Environmental Management System Standard ISO-14001:1996. In 2005, CRL site registration to the ISO-14001 was successfully renewed and upgraded to the ISO-14001:2004 standard.

AECL maintains radiological emissions from CRL facilities to the environment below the limits defined in applicable regulations, and strives to maintain them as low as reasonably achievable (ALARA), taking into account relevant social and economic factors. Further, at the request of CNSC staff and to determine if AECL's activities were having an unacceptable impact on the environment, AECL commissioned Beak and ESG[3] to conduct an Ecological Effects Review (EER) of CRL. The EER followed guidance from the Canadian Council of Ministers of the Environment (1996) and the U.S. Environmental Protection Agency (1998). The report from this review [3-10], issued in 2005 January, and accepted by CNSC staff, concluded that there is no evidence of unacceptable environmental impact from AECL's activities at CRL. At most locations around the CRL site, radiation and chemical exposures are below the benchmark values defined by the National Commission on Radiation Protection, International Atomic Energy Agency, United Nations Scientific Committee on the Effects of Atomic Radiation and other acceptable international studies for terrestrial animals and aquatic biota. A few locations exceed these benchmarks or further information is required to define the possible impact. As a result, 10 actions are recommended in the report and, as described in Appendix D, are being addressed.

In addition to the annual reports required under the Nuclear Research and Test Establishment Operating Licence – Chalk River Laboratories [3-11 to 3-13], AECL prepares an Annual

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[3] The work was originally contracted to BEAK International Incorporated and ESG International Incorporated. During the period of the project, EcoMetrix Incorporated acquired the companies. The report, issued in 2005 January, is therefore from EcoMetrix.

Environmental Performance Report for all AECL sites within Canada [3-14]. A copy of the report for 2004, which includes a summary of environmental performance and activities at CRL, both radiological and non-radiological, is submitted separately for consideration at the Day One Public Hearing. The 2005 report will be prepared later in the year. These annual reports are made available to the public and all parties expressing interest.

3.9.1.1 Radiological Emissions

Environmental radiological emissions from CRL for the last five years are summarized in Table 3.5 and Figure 3.5 in terms of percent Derived Release Limits (DRLs). The DRLs are calculated using environmental pathway modelling and are set such that a continuous release of any radionuclide at a rate less than the DRL would result in exposures less than 1 mSv/a (the dose limit for a member of the public from activities at CRL). There were no radioactive emissions from CRL in excess of regulatory limits and emissions were generally very small fractions of the DRLs.

The sum of the average airborne weekly releases of all radionuclides from all monitored sources in 2005 was 11.2% of the DRL. This is similar to the emissions in 2004, and the past five years' average. Emissions of Ar-41 from the NRU/DIF stack continued to be the most significant radioactive releases from the CRL site, averaging 8.9% of the DRL compared to an average for the five years of 9.6% of the DRL. Argon-41 is produced by irradiation of air within the reactor structure.

All radioactive liquid emissions from CRL in 2005 were very small fractions of the respective DRLs. The total releases from all effluent streams, averaged 0.26% of the DRL, indicating no change from 2004. The liquid emissions in Table 3.5 include estimated releases through the groundwater. Estimated releases of groundwater to the Ottawa River along the shoreline below Controlled Area 2 totalled 0.0014% of the DRL, a value slightly lower than the 2004 value of 0.0016% of the DRL, and the previous five years' average of 0.0017% of the DRL. The release of radioactivity in groundwater represented about 0.50% of total radioactive liquid emissions from the site.

In addition to monitoring of effluents released from the sites, AECL continues to maintain extensive programs to monitor radioactivity in the environment at and around CRL, to verify effluent monitoring results. Monitoring included, for example, measurement of ambient gamma radiation, as well as sampling and analysis of drinking water, air, milk, fish, garden produce, and beach/river sediments. The results of the environmental monitoring continue to confirm that radiation doses resulting from CRL operations are below the regulatory dose limit for members of the public, 1 mSv per year, and below the typical background dose from natural radiation in Canada (see Table 3.5).

3.9.1.2 Non-Radiological Emissions

The largest non-radiological gaseous emissions from CRL are related to fuel combustion for building heating and steam generation purposes, and to inadvertent losses of halocarbons used in research, cooling and fire suppression applications. Table 3.6 summarizes the releases for the period 2001 to 2005 for CRL.

Liquid effluents from CRL are monitored for non-radioactive contaminants in order to measure conformance with AECL's internal guidelines for chemical substances in liquid effluents, or with directly applicable limits or guidelines established by regulatory authorities. The AECL guidelines are comparable with Environment Canada effluent guidelines for federal facilities and various other federal and provincial effluent guidelines.

The non-radiological effluent-monitoring program was originally set up voluntarily by AECL, based on the Ontario Ministry of the Environment's Municipal Industrial Strategy for Abatement (MISA) Program. This program continues to supply valuable information on the non-radiological environmental impacts of CRL's operations to the Ottawa River and the local environment. The two effluent streams, the Powerhouse Drain and the Sanitary Sewer, are the main contributors to estimated loadings. Detail information on the results from this monitoring are contained in the Annual Environmental Performance Report for all AECL sites within Canada [3-14]. The number of times AECL's internal monthly guidelines were exceeded between 2001 to 2005 are presented in Table 3.7.

3.9.2 Intercomparison Study by Université Laval

Université Laval was contracted to conduct an independent review of the radiological environmental monitoring program at CRL [3-15]. Similar to work done in 1999 and 2000, Université Laval has collected local samples of vegetation, water, air, milk, etc. for radiological analysis. A preliminary comparison was done between this Université Laval study and the previous Université Laval study completed in 2000, and no significant variations were noted. Once AECL compiles all of its 2005 data, AECL's results will be compared against those of the Université Laval study.

3.9.3 Integration of the AECL's Operational Control Monitoring Program, Groundwater Monitoring Program, Effluent Verification Monitoring Program and Environmental Management System

An initiative was undertaken to accelerate integration of the Operational Control Monitoring (OCM)/Groundwater Monitoring Program with the AECL Environmental Protection Program. The main areas of improvement were: to develop acceptance criteria, to develop a non-conformance process (using the acceptance criteria), and to coordinate the two programs in terms of sampling and analysis. Alignment of groundwater and surface water monitoring carried out in the Supervised Area around the Waste Management Areas (WMAs) and waste management facilities was also undertaken. This is intended to exclude similar monitoring between OCM and Environmental Protection Programs and to align the programs' reporting activities, thereby enabling improved overview of environmental data.

Further information on the groundwater-monitoring program may be found in Section 3.9.6.

3.9.4 Ecological Effects Review

As discussed earlier, the CRL EER was completed in 2004 and submitted to CNSC staff for their review and approval. In a letter back to AECL in 2004 September [3-16], CNSC staff concluded that the draft EER, which they had received for review, "adequately describes the status of the environment at CRL and adequately assesses risk to the environment in most areas" and that "the CNSC staff concludes the risk to the environment from CRL's activities is predominantly low." The EER was issued in 2005 January and is available to the public via AECL's website.

The EER contains a total of 10 recommendations for AECL follow-up (see Appendix D). CNSC staff requested that AECL address all 10 recommendations. An EER recommendations action plan has been developed outlining specific milestones for each recommendation. AECL's progress against the EER recommendations action plan remains on schedule. The schedule extends to 2008 April, at which time the final recommendation will be completed.

3.9.5 Environmental Assessments

AECL undertakes Environmental Assessments for projects at the CRL site in accordance with requirements of AECL's Environmental Protection Program of the Canadian Environmental Assessment Act. The environmental assessments under Canadian Environmental Assessment Act are invoked through regulatory approvals required for projects to proceed. The CNSC is responsible for the conduct of the environmental assessments requiring regulatory approval. Environmental Assessment Screenings for eight projects at the CRL site are in various stages of the environmental assessment process. A brief overview of the status of these environmental assessments follows.

- ***Continued Operation of NRU:*** The Environmental Screening for the Continued Operation of NRU was approved by the CNSC Commission in 2005 August.
- ***Liquid Waste Transfer and Storage Project:*** CNSC staff have prepared the Environmental Screening Report. The stakeholder review period for the draft Environmental Assessment Screening Report ended 2006 February 14. No comments were received. An environmental assessment decision is expected by 2006 April.
- ***Shielded Modular Above Ground Storage (SMAGS):*** CNSC staff have prepared the Environmental Screening Report. The stakeholder review period for the draft Environmental Assessment Screening Report will end 2006 March 30. An environmental assessment decision is expected shortly thereafter.
- ***Decommissioning of the Pool Test Reactor:*** AECL is finalizing the Environmental Assessment Study Report in response to comments received from CNSC/Federal Department Review. An environmental assessment decision is expected in 2006.
- ***Decommissioning of the Plutonium Recovery Laboratory, Plutonium Tower and Waste Water Evaporator:*** The Designated Officer has approved the CNSC Environmental Assessment Guidelines for these projects. AECL is preparing Environmental Assessment Study Reports for these projects.
- ***Fuel Packaging and Storage Project:*** CNSC Environmental Assessment Guidelines for the project have been approved. Outstanding issues relating to the guidelines have been

resolved. AECL plans to issue the Environmental Assessment Study Report to CNSC staff for review in 2006.

- ***Building 204 Fuel Storage and Handling Bays Decommissioning Project:*** CNSC staff is finalizing the draft Environmental Assessment Screening Report for distribution to stakeholders for review. A draft is expected to be issued to stakeholders by 2006 April. A CNSC environmental assessment decision is expected in the spring of 2006.
- ***Heavy Water Upgrading Plant Decommissioning Project:*** CNSC staff have accepted AECL's Environmental Assessment Study Report. CNSC staff will prepare the Environmental Assessment Screening Report. An environmental assessment decision is expected in 2006.

3.9.6 Groundwater Monitoring Program

AECL has a comprehensive groundwater-monitoring program to assess the environmental impacts of all operational activities from the WMAs, as well as from specific operations within Controlled Areas 1 and 2 of the CRL site. The key element for assessing groundwater contamination is a comprehensive network of boreholes with monitoring capability at various depths specifically selected to fully characterize the profile of any underground-contaminated plumes.

Figure 3.6 indicates the arrangement of the CRL Supervised Area Waste Management Facilities and Major Surface Water Features.

Specific site locations of boreholes are presented in Figures 3.7 to 3.14.

Groundwater monitoring at CRL is currently undertaken by a number of responsible authorities, with the scope of monitoring determined by the nature of the facilities involved. In all cases, however, the Safety and Environment group is provided with both the results generated by any groundwater monitoring programs and with the opportunity to provide input to the programs. At present, the five ongoing groundwater monitoring programs are:

1. Operational Control Monitoring/Groundwater Monitoring Program associated with CRL WMAs,
2. waterfront groundwater monitoring of the CRL Active Area (the Controlled Area 2 portion of the built-up part of the site),
3. groundwater monitoring around and downgradient of Active Drainage Tank 240-1,
4. groundwater monitoring around and downgradient of the NRU Reactor, and
5. groundwater monitoring around WMA "G".

Waste management areas, and other facilities at CRL, have been the subject of specific hydrogeologic investigations since the early 1950s. Routine monitoring of surface water quality in the CRL Outer Area also dates back to the 1950s with the program being modified and expanded over time. The OCM program, however, represents the first program to routinely monitor groundwater quality adjacent to, and in some cases within, waste management facilities at CRL, and was instituted in 1996 following a review and the development of the program's scope and objectives.

The scope of the OCM program has changed somewhat over the past nine years in response to findings in the annual reviews, but as a general statement, the program involves sampling groundwaters at approximately 100 locations, in most cases on a twice-yearly schedule, although two areas (i.e., CRL sanitary landfill and WMA "F", which contains contaminated soils from Port Hope, Ottawa, and Albion Mills) are sampled annually. The list of groundwater analytes is somewhat dependent on the area being monitored; in all cases groundwaters are analyzed for radiological parameters, an extensive suite of inorganic major ions and trace metals, and a number of standard suites of organic compounds, including halogenated and non-halogenated volatile organics, acid and base/neutral extractable organics, and in some cases PCBs and dioxins and furans. A full suite of analyzes would total 220 parameters.

In 2002, in response to a CNSC site operating licence condition requirement, AECL commissioned an independent review of the OCM program. Following that review, AECL proposed what has been termed the Groundwater Monitoring Program to CNSC staff, and AECL has been producing an annual report accordingly.

In 1999, routine monitoring of groundwater for radiological contamination along the Ottawa River waterfront of CRL's Active Area was instituted for the Safety and Environment group, and the results of this quarterly monitoring are reported to CNSC staff in Annual Effluent Reports. Routine groundwater monitoring for radiological contaminants adjacent to and downgradient of Active Drainage Tank 240-1 was instituted in 2000 for Waste Management Operations. The Environmental Technologies Branch reports those results to Waste Management Operations staff, with copies to the Safety and Environment group. For most of the past five years this monitoring has been conducted on a quarterly basis, although since 2005 June a subset of wells have been sampled for tritium on a weekly or bi-weekly basis, and monthly updates have been provided to Waste Management Operations and the Safety and Environment group. Routine groundwater monitoring adjacent to, and downgradient of, the NRU Reactor building has been conducted since 2003, again at a quarterly frequency, although since 2005 a subset of wells have been sampled bi-weekly for tritium. Results of this monitoring are reported to NRU staff with copies to the Safety and Environment group.

Annual groundwater monitoring for radiological contaminants at WMA "G", was instituted in 1995 for Waste Management Operations, as part of the licence conditions for that facility. Environmental Technologies Branch provides an annual report to Waste Management Operations staff, and information in that report is incorporated into the annual safety review of the WMAs.

3.9.7 Plumes Location and Reduction

3.9.7.1 Background

There are 10 distinct groundwater plumes containing radioactive nuclides on the CRL site (see Figures 3.15 and 3.16).

Several other impacted areas are listed immediately below, and are not discussed further here, since the impacts on groundwater are either very low or indistinguishable from background based on the results of groundwater monitoring programs.

- the glass block sites,

- the thorium pit,
- the tank farm,
- Waste Management Area "D",
- Waste Management Area "F",
- Bulk Storage Compound,
- Sanitary Landfill,
- Laundry Pit, and
- Liquid Dispersal Area and NRX pipeline route.

Further details surrounding the nature of the activities that are being undertaken to address the 10 plumes are provided in the information below. However, by way of an introduction to this topic, the following summary provides an overview of the marked progress that AECL has already made in remediating these plumes:

- Major upgrades have been completed to the Waste Treatment Centre. These upgrades have allowed AECL to discontinue discharges (permitted under the CRL licence) that were contributing to groundwater contamination.
- Three groundwater treatment facilities have been in operation for a number of years to remove contaminants from groundwater.
- Impermeable covers have been installed over parts of two WMAs to reduce water infiltration.
- An extensive groundwater sampling and analysis program was established in 1997 to ensure that the behaviour and nature of contaminated groundwater was closely monitored.
- Work is about to commence on emptying the NRX fuel bays, a source of one of the 10 distinct groundwater plumes.
- Projects have been initiated to address plumes whose origins are leaks in tanks or reactor fuel storage facilities. Monitoring results indicate that there appear to be improvements as a result of the actions associated with these projects.

3.9.7.2 Nitrate Plant Pit

The Ammonium Nitrate Plant was built in 1953 and was used to decompose the ammonium nitrate contained in the liquid wastes originating from a fuel processing operation located at the CRL site. The distillate from the process was discharged into a nearby lime filled pit, and the concentrate was returned to the Chemical Operations area for additional treatment and concentration. The Ammonium Nitrate Plant was shut down in 1954 and was subsequently dismantled with much of the equipment being buried in situ. Decontamination solutions were also released, and rubble from the demolition of the buildings was buried at the site. The plume contains an estimated 60 TBq of β/γ activity (35% Sr-90).

Current Status: The groundwater is currently being treated at the wall and curtain facility. The treatment process is lowering the concentration of Sr-90 in the influent from 366 Bq/L to less than 0.1 Bq/L in the effluent (see Figure 3.17). Sampling in the vicinity of the Nitrate Plant is performed as part of the Groundwater Monitoring Program, with results being reported to CNSC staff on an annual basis.

3.9.7.3 Waste Management Area "C"

Waste Management Area "C" was established in 1963 to receive low-level radioactive wastes with lifetimes of less than 150 years and wastes that could not be confirmed as being uncontaminated (i.e. "suspect waste"). It is located about 3 km west of the plant area and covers an area of approximately 4.5 hectares. Early operations consisted of waste emplacements in parallel trenches excavated directly into the sand and separated by intervening wedge shaped strips of undisturbed sand. In 1982, this practice was changed to the use of a continuous trench to make more efficient use of available space. In no cases were the trenches lined.

The plume originating from WMA "C" primarily contains tritium, although radionuclides such as Co-60 and C-14 have been detected in the past.

Current Status: Part of WMA "C" was covered with an impermeable cover in 1983 to reduce water infiltration. This resulted in a lowering of tritium releases to surface water.

The groundwater is routinely monitored through the Operational Control Monitoring Program, the results of which are annually reported to CNSC staff.

Plans are in place to install an additional impermeable cover in 2009, and there are also plans to perform a safety assessment to determine if it would be possible to use in situ disposal as a means for addressing the nuclear legacy liability associated with WMA "C".

Currently dewatered sludge is placed in aboveground containers, which are stored in WMA "C" until the proposed new landfill becomes available (see Section 3.9.10).

3.9.7.4 Waste Management Area "B" (West)

Waste Management Area "B" was established in 1953 to replace WMA "A" as the site for the management of solid radioactive waste resulting from both site operations and from off-site waste generators. The site is located on a sand covered area approximately 750 m west of WMA "A". Early waste storage practices for low-level radioactive waste continued with those of the type used in WMA "A", namely emplacement in unlined trenches capped with sandy fill, in what is now the northern portion of the site. Additionally, there were numerous special burials of components and materials, sometimes in concrete containers or directly in sand (e.g., the first NRU and the second NRX calandrias).

Asphalt-lined and -capped trenches were used for solid intermediate-level radioactive waste from 1955 to 1959 when they were replaced by the use of concrete bunkers constructed below grade but above the water table in the site's sands. Use of sand trenches in WMA "B" for low-level radioactive waste was discontinued in 1963 in favour of either concrete bunkers in WMA "B", or sand trenches in WMA "C".

Within WMA "B", concrete structures are used to store solid waste packages that do not meet sand trench acceptance criteria but, as well, do not require a significant amount of shielding. Early concrete bunkers took the form of rectangular structures, but these were superseded in 1977 by the currently used cylindrical structures.

High-level wastes are also stored in WMA "B", in engineered facilities known as tile holes. Tile holes are used to store radioactive material that requires more shielding than can be provided in concrete bunkers. Stored material includes irradiated fuel, hot cell waste, experimental fuel bundles, unusable radioisotopes, spent resin columns, active exhaust system filters and cemented fission product waste from the Mo-99 production process.

The source of the plumes originating from WMA "B" are primarily the unlined trenches, or the asphalt-lined and capped trenches with some contribution also coming from special burials.

The principle radioactive nuclides found in the groundwater plumes originating from WMA "B" are tritium, Sr-90, and Cs-137, with the latter being relatively immobile.

Current Status: Groundwater is currently being treated at the Spring B facility. In 2004, Sr-90 levels in the feedwater were reduced from 2,499 Bq/L to 21 Bq/L (see Table 3.8).

An engineer has recently been hired to begin developing upgrades to this facility. Current plans are that this treatment facility will be operated for approximately 50 years.

3.9.7.5 Waste Management Area "A" and Reactor Pit 1

3.9.7.5.1 Waste Management Area "A"

The first emplacement of radioactive waste into the CRL Supervised Area (formerly referred to as the Outer Area) took place in 1946 into what is now called WMA "A". These took the form of direct emplacements of solids and liquids into excavated trenches in the sand overburden. The scale of operations was modest and unrecorded until 1952 when the cleanup from the NRX accident generated large quantities of radioactive waste that had to be quickly and safely managed. At this time, approximately 4,500 m^3 of aqueous waste containing 330 TBq of mixed fission products was poured into excavated trenches. This was followed by smaller dispersals (6.3 TBq and 34 TBq of mixed fission products) in 1954 and 1955 respectively as part of an experimental program. No further additions were made following the 1955 dispersal.

Current Status: Work is underway to develop a Permeable Reactive Barrier facility to remove contamination from the groundwater. Pilot scale studies have been undertaken to develop an emplacement method for the reactive media (see Figure 3.18), and a full-scale treatment facility is scheduled to be in place in 2009.

3.9.7.5.2 Reactor Pit 1

Reactor Pit 1 was a natural topographical depression in the CRL Supervised Area used between 1953 and 1956 for the dispersal of large volumes of contaminated process water associated with reactor operations at CRL. Reactor Pit 1 had no engineered features. Dispersals included an estimated 74 TBq (2,000 Ci) of Sr-90, along with a wide variety of other fission products and approximately 100 g of Pu (or other alpha emitters expressed as Pu).

Between 1956 and 1998, the pit was backfilled with solid materials that included contaminated equipment previously stored in WMA "A" plus potentially contaminated soils from excavations in the Active Area, including rock rubble from the MMIR excavations. Wastewater from the Building 204 trench cleanup following the 1952 NRX accident was transferred to Reactor Pit 1, and the pit was used again in 1959 when modifications to the Building 204 Bays resulted in the dispersal of cleanup water.

The Laundry Pit was used intermittently over the period of approximately one year for wastewater from the Active Area Laundry, and was then taken out of service. The plume from the Laundry Pit is being addressed as part of the actions for the Reactor Pit 1 plume.

Current Status: Work is underway to develop a Permeable Reactive Barrier facility to remove contamination from the groundwater. Pilot scale studies have been undertaken to develop an emplacement method for the reactive media (see Figure 3.18).

3.9.7.6 Chemical Pit (1956 to 1996)

The liquid waste transferred to the Chemical Pit originated from the liquid wastes that were discharged from various laboratories and facilities into the active drain system. In addition to radiological contamination, the wastes contained alkalis, acids, and complexing agents. Total discharges are estimated to be 230 TBq of β/γ, 0.4 TBq of α, 70 TBq of tritium. The Chemical Pit was actually constructed rather than employing a natural depression as was the case with Reactor Pit 1, and was filled with coarse aggregate to assist with the dispersal of the liquids being discharged.

The Chemical Pit was constructed in two parts. In 1956, the pit was constructed, and then an overflow pit was placed adjacent to the first in 1958.

Current Status: Discharges to the Chemical Pit ceased in 1995/1996 through use of the Waste Treatment Centre.

Based on the results of the Groundwater Monitoring Program, the cessation of transfers to the Chemical Pit in 1995/1996 have led to a decline in tritium concentrations to levels at or only slightly above background concentrations. Following the termination of dispersal operations, the groundwater has shown a marked decline in Co-60 concentrations

Groundwater is currently being treated at the Chemical Pit facility. In 2004, Sr-90 levels in the feedwater were reduced from 870 Bq/L to 6 Bq/L (see Table 3.9).

3.9.7.7 Reactor Pit 2 (Sr-90 Plume)

Reactor Pit 2 was engineered to the extent that a series of gunnite (asbestos cement) barriers were placed in the pit together with granite cobbles to better ensure dispersal of the liquids being pumped into the pit. As was the case with Reactor Pit 1, large quantities of contaminated process water associated with reactor operations at CRL were directly discharged to Reactor Pit 2. The plume and source term contains a variety of radionuclides, with the inventory estimated to be 500 TBq of β/γ, and 0.5 TBq of α. Discharges to the reactor pit were approximately 15 million litres per year.

With the completion of the Waste Treatment Centre Upgrades, discharges to Reactor Pit 2 ceased in 2000, and there have been no further discharges since that date.

Current Status: Discharges to the reactor pit ceased in 2000 following the completion of the upgrades to the Waste Treatment Centre.

Based on the results of the Groundwater Monitoring Program, the concentrations of tritium and Co-60 have shown a steady decline commencing in 2000. Decreases in the results for total beta are not as marked, although some wells show a clear downward trend starting in 2000.

Future decommissioning initiatives have been identified to characterize the material that currently resides within the pit to determine an appropriate decommissioning strategy. Notwithstanding this characterization work, there is every expectation that a significant proportion of the cobbles will be retrieved.

3.9.7.8 Reactor Pit 2 (Tritium Plume)

Direct discharge to Reactor Pit 2 of large quantities of contaminated process water associated with reactor operations at CRL resulted in a plume and source term containing an estimated 1,000 TBq of tritium.

Current Status: Discharges to the reactor pit ceased in 2000 following the completion of the upgrades to the Waste Treatment Centre.

Based on the results of the Groundwater Monitoring Program, the concentrations of tritium and Co-60 have shown a steady decline commencing in 2000.

3.9.7.9 NRX Rod Bay

The plume associated with the NRX Rod Bay results from a leak in the bays. This plume has existed since an addition was made to the rods bays in the late 1950s.

Current Status: Plans have been developed for emptying the NRX Rod Bays beginning in 2006 March. CNSC staff approval to commence this work was received in 2006 March.

3.9.7.10 NRU Area

Tritium contamination is being found in manholes downgradient of the NRU Reactor. The source is postulated as being a leak in the NRU bays.

Current Status: A project has been initiated to better define the source of the leak. Current indications based on a comparison of evaporation rates versus the requirement for bay makeup water suggests a leak rate of on the order of several hundred litres per day from the bay.

A preliminary schedule to further characterize the source of the leak has been communicated to CNSC staff. This will involve meticulous work due to the small nature of the leak, and the large surface area being investigated. The strategy will be to commence with the inspection bay and isolation bay areas because access is easiest and the operators can get accustomed to the camera/dye inspection tools that will be employed. Based on the groundwater measurements from monitoring wells in the immediate vicinity of the NRU Rod Bays, AECL estimates that the tritium plume corresponds to a release of 0.0045% of the monthly DRL for tritium.

3.9.7.11 Active Drainage Tank 240-1

This tank was used to store contaminated process water from reactor operations prior to it being pumped to (i) Reactor Pit 1 or 2, or more recently (ii) the Waste Treatment Centre for processing. Several years ago, groundwater monitoring revealed that tritium contamination was originating from this tank. This tank had developed a leak in the 1980s, but monitoring following the installation of a liner indicated that the leak had stopped.

Current Status: The tank has been taken out of service, and would only be used in the event of an emergency. AECL is currently investigating other options related to the tank.

The fluid levels in the tank were lowered in late 2005, and the monitoring results indicated a reduction in contamination levels. However, in December, the levels began to rise again, and efforts were then focussed on removing the remaining liquid in the tank, which was completed in 2006 January. The monitoring results are once again indicating a marked reduction in the contamination levels found in the groundwater (see Figure 3.19). An action plan is being developed for possible removal of the residual sludge in the bottom of the tank.

3.9.8 NRU Follow-Up Monitoring Program

As required under licence Condition 13.2 of the CRL operating licence, AECL has implemented a follow-up monitoring program subsequent to the environmental assessment of the NRU Reactor, which was performed as part of the NRU Licensability Extension Project.

AECL has met all the requirements spelled out in Section 10 of the CNSC screening report, and a formal letter is currently under preparation to obtain acceptance from CNSC staff of the program's acceptability.

3.9.9 Hazardous Materials

AECL has initiated a campaign to remove unwarranted inventories of mercury from laboratories and facilities, and to safely dispose of the resulting waste product.

A site-wide inventory of mercury and mercury-containing products was completed in the fall of 2004. All managers were required to review their areas of responsibility for mercury-containing products in use or in storage. All users were asked to provide Environmental Protection Program staff with justification for the required uses and the amounts of mercury products required, after disposing of any unwanted mercury-containing products and/or wastes. A total of 628.2 kg of mercury-containing waste was collected by the fall of 2004 and transferred off site for recycling in 2005 January.

Waste Treatment Centre staff are continuing their efforts to reduce the amount of mercury in effluents. Primary sources have been identified and changes to mercury handling procedures and treatment procedures at the Waste Treatment Centre have yielded positive results. An action plan was prepared and submitted to CNSC staff.

As part of the ongoing Fire Protection Program implementation, many buildings on site have been thoroughly inspected and a comprehensive removal initiative was undertaken to drastically reduce the volumes of hazardous and combustible liquids and other miscellaneous material.

3.9.10 Update on Sewage Sludge Management

AECL's long-term strategy to manage sewage sludge at CRL was submitted to CNSC staff on 2005 September 30.

AECL plans to start construction of the proposed landfill by 2006 July 31. This new landfill will be designed according to the Ontario Ministry of the Environment Regulations. The landfill is expected to be in service by 2006 November.

AECL provided a report to CNSC staff that demonstrated that the makeup of the de-watered sewage sludge meets the MOE-347 Regulations with respect to hazardous substances. CNSC staff subsequently accepted this determination.

Progress on the landfill project is regularly discussed with CNSC staff.

3.10 Fire Protection

CNSC staff conducted a fire protection inspection of CRL from 2004 November 15 to 25, and issued 17 Directives and 1 Action Notice. Consequently, CNSC staff assigned an initial rating of "C" for the program and its implementation. The following initiatives were undertaken to address the inspection findings, and to go beyond them, to ensure an adequate Fire Protection Program at CRL.

3.10.1 Overview of Projects/Initiatives

3.10.1.1 AECL Fire Protection Action Plan

This project addresses all 17 CNSC Directives and 1 CNSC Action Notice. It comprises an action plan for completion of Fire Hazard Assessments for all existing buildings on the CRL site. CNSC staff has accepted AECL's action plan.

The corrective actions are being dispositioned in a timely fashion as committed to CNSC staff. As a part of the corrective actions, all facilities (including Controlled Areas 1 and 2 and WMAs) were reviewed for storage and use of dangerous goods, storage and use of combustible materials, handling and processing of flammable and combustible liquids, combustible loading and housekeeping of buildings. Also being reviewed are material processing and manufacturing process, change control of process modification, security mag-locked exit doors, fumehoods, laboratory fire separations, and fire doors. The action plan also includes activities to upgrade Fire Protection Program documentation, fire safety planning and pre-fire plans.

3.10.1.2 NRU Improvement Initiative

The overall NRU Improvement Initiative is discussed in Appendix B. The project has undertaken various initiatives related to fire protection on an area-by-area basis for the whole of the NRU building. This initiative concentrated on overall housekeeping and fire safety improvement of the NRU building.

Progress has been excellent, and has been witnessed by CNSC staff.

3.10.1.3 Fire Issue Resolution Effort Project

The Fire Issue Resolution Effort Project has been initiated to expedite resolutions for all current and newly discovered fire non-conformances in the CRL Fire Inspections Record database. The following project is composed of management group, a Fix-It-Now Team and a Site Clean-Up Team.

The management group oversees the operations of the Fix-It-Now Team and the Site Clean-Up Team and develops contracts with building managers to resolve outstanding fire issues. In addition, the managers provide weekly and monthly updates and scorecards showing the status of issues relating to fire. They also have a responsibility and are working with the Fire Prevention section to provide fire prevention education to CRL employees.

The Fix-It-Now Team is composed of three carpenters, a painter, an electrician, a pipefitter, and a millwright. These trade personnel are assigned to address small fire related non-conformances, which can be resolved with minimal design, equipment, manpower and material. These items include penetrations in fire separations, emergency lighting repairs, minor sprinkler issues, etc.

The Site Clean-Up Team is composed of three utility workers who have been assigned to assist facility managers with the removal of combustible materials from the buildings.

These teams have played a significant role in the disposition of 770 fire non-conformances in 2006 January and 2006 February.

3.10.1.4 Addressing the Issues of NRU Fire Hazard Analysis

Following the completion of the Fire Hazard Assessment (FHA) of the NRU Reactor facility (2004 June) [3-17], a project manager was appointed to evaluate the FHA recommendations and to develop an action plan. In addition, an external consultant, having expertise in fire protection, has completed an assessment of the rating for all fire doors in NRU. Other planned activities have been completed, such as sealing of penetrations around the main Control Room and the cable space below the main Control Room.

The action plan to disposition the FHA includes the following with proposed completion dates:

- ***Fire Doors:*** Review the fire rating requirements for doors identified in the NRU-FHA report, and the NRU Fire Door Survey 2005 October 07 for replacement. Replace identified fire doors with the appropriate fire rating units (2006 June 23).
- ***102G Platform:*** Remove wooden maintenance access platform. Design and install a metal replacement platform (2006 June 13).
- ***309A Stair Modification:*** Analyze and test access to Room 309A. Design and modify access to meet Fire Prevention requirements (2006 June 16).
- ***Penetrations in Fire Separations:*** Penetrations as identified in the NRU-FHA report, are analyzed, seals designed and installed (2006 July 04).
- ***Emergency Lighting:*** Commission and obtain an analysis of the emergency lighting system in NRU. A corrective action plan will be implemented based upon the analysis (2006 August 18).

- ***Firewater, Hose and Sprinkler Analysis:*** Commission and obtain an analysis of the fixed fire suppression system in NRU. A corrective action plan will be implemented based upon the analysis (2006 August 21).
- ***Fire Barrier in Tunnel:*** Analyze fire barrier requirements along the cable tray in the tunnel (Building 151) to the Powerhouse. Design and install fire barriers as identified (2006 September 04).
- ***Halon System Replacement:*** Analyze alternate fire suppression systems. Procure and install an improved system (2006 September 25).
- ***Replacement of Plastic Control Room Window:*** Analyze, design and replace plastic window glazing in the Control Room (2006 September 26).
- ***Fire Dampers:*** Install fire dampers in laboratory and diesel rooms as identified in NRU-FHA report (2006 October 12).
- ***241/242 Stairs and Platform:*** Remove, design and replace wooden stairs and platform in rod bay area with non-combustible material (2006 November 06).
- ***222 Stairs:*** Remove, design and replace wooden stairs under the reactor with non-combustible material (2006 November 24).
- ***Attic Renovation:*** Remove wooden walkways. Replace, as required, with non-combustible material (2006 December 20).
- ***Diesel Oil Containment:*** Design and install secondary diesel oil containment tanks under each day tank in the diesel generator rooms (2006 December 20).
- ***Fire Alarm System Modification:*** Design and install a fire alarm and detection system to replace the existing system. Add additional fire detectors as identified in the NRU-FHA report (2007 October 01).

3.10.1.5 CRL Fire Protection Program

3.10.1.5.1 Operations

A comprehensive review of the Fire and Emergency Services procedures has been completed; from this gap analysis revisions or new procedures were created. This includes procedures for the inspection, testing and maintenance of Fire Protection Systems, Emergency Response and Fire Prevention.

These procedures provide CRL with an inspection, testing and maintenance program that is compliant with the National Fire Code and National Fire Protection Association (NFPA 801). A bar-coding system has been purchased and is being implemented to manage this program.

The position Platoon Chief – Training has been created to develop a program that will improve the training of CRL fire fighters in safety and emergency response. In addition, the Fire Prevention Section has provided the fire fighters with training relating to building fire inspections and the issuing of hot work permits.

3.10.1.5.2 Fire Prevention

The following is a summary of the progress made in the area of fire prevention:

- The CRL site-wide Fire Prevention Program is implemented (see Appendix E).
- Fire Prevention inspectors are trained in the conduct of Fire Prevention Inspections.
- Monthly Fire Prevention Inspections are conducted in every room of every building. Non-conformances with remedial actions are entered into a database and emailed to responsible persons for action.
- Fire Prevention staff follow up on these actions and other projects mentioned above.
- Change Control is achieved for all modifications at CRL having an impact on fire protection, by the implementation of site-wide Fire Protection Screening Process.
- Fire protection requirements including third-party reviews and FHA are communicated to the proponent of modification through the Fire Protection Screening Process.
- Employee education and awareness of fire safety is undertaken on a site-wide basis.

3.10.1.5.3 Annual Third Party Review of Inspection, Testing and Maintenance of Fire Protection in CRL Site

To comply with CRL site operating licence Condition 10.4, an Independent Third-Party Review of Fire Protection Inspection, testing and maintenance is conducted every year. An action plan to address the findings from the third party is being implemented with status reports.

3.11 Nuclear Security and Robustness

AECL fully complies with the Nuclear Security Regulations. In addition, AECL has met all the requirements associated with licence Condition 11.2 regarding the CNSC Regulatory Standard S-298 [3-18].

3.12 Pressurized Systems

During the term of the current site operating licence, the AECL procedure *Code Classification and Design Registration of Pressure Retaining Systems and Components* [3-19] was incorporated into the CRL operating licence on an initial 12-month trial period. A licence amendment was subsequently issued by CNSC staff to remove the trial period status. In accordance with the requirements of the procedure, AECL submits quarterly reports to CNSC staff regarding classification and registration decisions that have recently been determined. CNSC staff have indicated their satisfaction with these arrangements.

3.13 Waste Management

3.13.1 General

During the current licence period, AECL has had many interactions and meetings with CNSC staff to resolve concerns regarding the medium term capacity of the CRL WMAs with respect to receiving current and future wastes arising from the operation of the site. The following summary of waste volume generation and storage capacity demonstrates that there will be adequate capacity throughout the proposed licence period.

3.13.1.1 Waste Storage Space Assessment

AECL has assessed the anticipated volumes of waste arising at CRL over the next five years to determine if the current and planned waste facilities are, and will be, adequate to cope with the projected waste volumes. The assessment was performed in a manner that was considered to be "conservatively realistic" in that it did not contain unreasonable expectations about the length and nature of the regulatory approval process, and did not take credit for such activities as volume reduction, or waste recovery initiatives of the type currently underway with circular bunkers in WMA "B".

The ability to provide adequate storage space for radioactive waste rests almost entirely on the availability of the following storage structures for the indicated waste streams:

Waste Type	Storage Structure Type
NRU Fuel	Tile Hole – Irradiated Fuel Elements
MAPLE Fuel (Future)	Tile Hole – Irradiated Material Disposal
Cemented Mo-99 Waste	Tile Hole – Irradiated Rod Parts
Non-Fissile Isotope Production Waste	Tile Hole – Irradiated Rod Parts
Non-Fuel High-Level Waste	Tile Hole – Cell Filters, Cell Waste, Reverese Osmosis Disposal
Low- and Intermediate-Level Waste (Operational, Decommissioning)	Circular Bunkers, Modular Above Ground Storage (MAGS), SMAGS

Therefore, in order to assess the ability of AECL to adequately manage future waste arisings, it was considered logical to focus on this specific set of structures and waste streams.

The assessment process involved the following steps:

- Determination of waste generation rates for the above storage structure types based on information contained in the past six annual safety reviews for the WMAs.
- Assessment of the availability of storage space that will be available over the next 5 to 10 years based on expectations that (i) Tile Hole Array 30 (THA 30), and (ii) SMAGS will be constructed and in operation before 2006 December 31.
- Analysis of when various types of storage facilities would be exhausted based on the information discussed above.

3.13.1.2 Waste Generation Rates

Table 3.10 contains information on the rates at which waste storage structures have been filled over the past six years based on information contained in the annual safety reviews. Based on this information, waste generation rates were derived for the various types of tile holes, as well as for the waste being placed into bunkers or MAGS (ultimately SMAGS).

3.13.1.3 Availability of Storage Space

Table 3.11 (Column 2) contains information on the number and volume of storage structures that are expected to be in place on 2006 December 31 based on (i) the number and volume of currently available storage structures, and (ii) the assumption that both THA 30 and SMAGS will be built and in operation by this time.

3.13.1.4 Results

The waste generation rates in combination with the number and volume of waste storage structures were then used to determine when the various types of waste storage structures would be exhausted.

The results, as presented in Table 3.11, confirm that with THA 30 and SMAGS, AECL can realistically manage the CRL waste arising over the next six to seven years.

Notwithstanding the above, the results indicate that attention needs to be focussed on licensing, designing, and constructing a New Dry Storage System to take the place of the tile hole system now being used for the storage of used fuel from the NRU Reactor, and for used fuel from the MAPLE reactors in the future. To this end, a project has been created and is well underway to develop a new dry storage system for Chalk River spent fuel. Such a facility would need to be operational in the 2011 to 2012 timeframe.

In concert with the New Dry Storage System we are proceeding with the Waste Analysis Facility to aid in developing a “likely clean” program at the CRL site as a means of minimizing the amount of waste being sent to the WMAs, and is also considering a thermal processing facility which would have a substantial effect in reducing waste volumes in the case of low- and intermediate-level waste.

3.13.2 Projects

3.13.2.1 General

Described below are three key decommissioning and waste management projects, which have been identified as having significant priority during the proposed licensing term.

3.13.2.2 Liquid Waste Transfer and Storage

AECL possesses radioactive liquid wastes that have accumulated over a period of over 50 years from research, operations and medical isotope production programs at the CRL site. These wastes include approximately 280 m^3 of intermediate- and high-level radioactive liquid wastes, referred to as the Stored Liquid Wastes, presently in 21 storage tanks on the CRL site. As shown in Table 3.12, the radioactive inventory of each of the tanks ranges from a few GBq to approximately 5 PBq of radioactive material[4]. The wastes also contain non-radiological hazardous substances such as toxic metals, acids and bases. The principal toxic metal in the wastes is mercury (260 kg), most of which is contained in one tank and is considered toxic under Canada's Environmental Protection Act. Other toxic or potentially toxic metals are chromium (40 kg total chromium), lead (20 kg) and cadmium (0.5 kg total cadmium). Lead, inorganic cadmium and hexavalent chromium compounds are considered toxic under Canada's Environmental Protection Act.

The wastes were generated as part of AECL's medical radioisotope program, fuel reprocessing program, decontamination of test loops in AECL's research reactors and regeneration of ion-exchange resins used for fuel storage bay purification. The generation of these wastes has been discontinued with the exception of some waste streams in the medical radioisotope program. The project addresses the waste inventory at the time of transfer and medical isotope waste additions up to the time of transfer. Some of the liquid wastes contain solid material that has settled to the bottom of the tanks. This solid material is referred to as "sludge".

The project objectives are:

- Reduction of the potential for leakage of radioactive wastes now stored in 20 of the 21 tanks (the high-level wastes from medical isotope production are not included in this category), where the age and condition of the tanks present a growing risk of leakage. The new storage system will provide secondary liquid confinement, leak detection and enhanced monitoring and sampling capabilities consistent with other engineered facilities in use around the world today.
- Reduction in the operational effort to maintain the safe storage of liquid wastes. This includes the high-level medical isotope production wastes. There is significant operational effort related to maintaining controls for criticality of the high-level medical isotope waste. Conditioning this waste through the addition of low U-235 isotopic content uranium will reduce controls and monitoring needed for continued safe storage. Furthermore, transferring the wastes from the 21 tanks into a single modern storage system will reduce operational effort and costs required to maintain safe storage.

All but one tank was built in the 1947 to 1960 period. All of the tanks are constructed of corrosion-resistant stainless steel. Two of the tanks are buried with no secondary liquid confinement or vault, so that leakage could result in environmental contamination and need for clean up. The newest tank, for high-level medical radioisotope waste, is a double-walled stainless steel tank built in the mid-1980s. While this tank meets current needs for liquid confinement, the waste is in a form that requires safeguards and criticality safety monitoring that impose significant operating costs.

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[4] One GBq is equal to 1×10^9 Bq. One PBq is equal to 1×10^{15} Bq.

AECL's long-term strategy is to convert the liquids into a solid form that is suitable for long-term management in a storage or disposal facility. The project will place the waste in a form and facility suitable for feeding a future waste processing and solidification plant, thereby moving forward towards a long-term management solution for the wastes.

3.13.2.2.1 Project Components and Activities

The project is the construction and operation of facilities for the transfer and storage of the liquid wastes currently held in 21 tanks on the CRL site.

The project components are:

- A storage system that will consist of two storage tanks and one spare tank with associated equipment and process tanks in a new stand-alone building.
- All infrastructure, equipment and systems required for retrieval, transfer and conditioning of the liquid wastes, and for the management of secondary project wastes.

The project construction activities are:

- Modifications of existing storage tanks to facilitate waste extraction and tank rinsing operations.
- Construction of temporary transfer pipelines and procurement of a transfer flask for transfer of the liquid wastes to the new liquid waste storage system.
- Construction of the storage system.

Project operations activities are:

- Waste retrieval and transfer to the new storage system.
- Waste receipt, consolidation and conditioning of the wastes in the new storage system.
- Storage and monitoring of the wastes in the new storage system.

3.13.2.2.2 Project Status

The project is presently in its third year of a five year schedule to design, construct and cold commission the systems required to transfer, store and condition the stored liquid waste.

AECL is awaiting a CNSC environmental assessment decision on construction and operation of the waste storage system. AECL project staff is addressing outstanding comments from CNSC staff reviews of technical submissions that are expected to form the basis of AECL's Construction Approval application for the waste storage system. The procurement of detailed design and construction of the waste storage system is underway. Planning is underway for procurement of retrieval and transport systems for all waste except for the Fissile Solution Storage Tank (FISST) solution. Feasibility and design development testing are being planned, and test equipment designed, for the retrieval of the FISST solution.

3.13.2.3 Shielded Modular Above Ground Storage

AECL is managing low-level nuclear waste storage facilities on behalf of the Federal Government for its legacy programs, including decommissioning requirements for external customers, and for current AECL nuclear facility operations. The existing facilities for low-level waste storage will be completely filled by 2006 September.

The SMAGS (see Figures 3.20 and 3.21) will replace the need for both the currently used MAGS buildings and bunkers, for lower unit storage costs. Each building will store approximately five years of low-level waste generation. There is space to construct six buildings in WMA "H", providing 30 years of storage.

The overall scope for the SMAGS Project is to construct and commission one building in WMA "H," while producing a design that can be replicated as required. It also covers the site grading and storm drains required by the environmental assessment, and replacement of the transformer serving WMAs "B" and "H".

The project has completed the design work, fire hazard assessments, an Environmental Assessment Study Report that is under review by the CNSC, Security and International Atomic Energy Agency (IAEA) Safeguards information, and a safety analysis report. A Request for Quotation for construction will be issued during 2006 March.

The project requires a CNSC environmental assessment decision authorizing site preparation work by mid-April, and construction approval by early May.

The project plans substantial completion of construction 2006 September, and handover of commissioned building, ready for operation, by the end of 2006 September.

3.13.2.4 Fuel Packaging and Storage

AECL has researched nuclear fuel at the CRL site for over 50 years. The used fuel has to date been stored in belowground, steel-lined concrete structures, known as tile holes. Some of the early fuel has begun to show signs of corrosion and has to be recovered from these tile hole array structures.

The retrieved fuel will be packaged in new stainless steel containers and vacuum dried prior to being placed in above-ground storage with a design-life of at least 50 years. This new storage system will house each of the retrieved cans of fuel in an individual storage location that will be filled with a dry, inert atmosphere, thus preventing any further significant corrosion.

The overall scope of the Fuel Packaging and Storage Project is to design, construct and commission the equipment and facilities that will enable these operations. The commissioned plant will then be handed over to an operations group to execute the retrieval, packaging, drying and storage activities (see Figure 3.22).

The design of the storage system is well advanced, and an Environmental Assessment Study Report is currently undergoing internal AECL review prior to submission to the CNSC. Technical Specifications for the design and construction of the transfer systems, and for the vacuum drying equipment have been completed and Request for Quotations will be issued shortly.

It is intended that a request for a Licence to Construct will be submitted in late 2007, and a request for a Licence to Operate will be submitted in the latter half of 2010, followed by handover to the operations group. Retrieval, packaging and drying operations are then scheduled to take place over the ensuing three to four years.

3.14 Decommissioning – Five Year Operational Implementation Plan for Chalk River Laboratories

AECL developed an optimized technical approach for decommissioning the nuclear legacy liability that spans a period of approximately 70 years.

To provide the details as to how the conceptual technical strategy would be actually implemented, a five year operational implementation plan as it applies to CRL was developed. This plan has been submitted to the Commission as a stand-alone document, and is summarized briefly here.

The five year plan comprises two major components, (i) a set of planning assumptions and strategic elements, and (ii) an implementation plan which includes a detailed Gantt chart showing the nature, timing, and duration of the activities that will be executed in the five year period.

The following key factors and considerations derived the scope of activities associated with the plan:

- The reduction of health, safety, security, and environmental risks.
- Maintaining compliance with regulatory requirements.
- The availability of enabling facilities.
- The minimization of costs associated with activities that do not contribute substantially to the reduction of risks or liabilities.
- The reduction/minimization of financial burden on future generations.
- Maximizing the extent of synergistic activities.
- AECL business requirements (including operational cost savings).

3.14.1 Planning Assumptions and Strategic Elements Underlying the Five Year Plan for Chalk River Laboratories

Development of the plan was based on the following key planning assumptions:

- ***Future Refinements to the Five Year Plan for CRL:*** The contents of this plan will need to be refined on an on-going basis as a result of inputs such as those arising from the Canadian Environmental Assessment Act and other public consultation processes. The progress of plan implementation will be reported to the Commission.
- ***Funding:*** The nature and timing of the activities contained in the five year plan for CRL are based on the explicit assumption that funding will be made available to the extent identified in the AECL 2006/2007 Corporate Plan.

- ***Optimized Approach to the Management of the Nuclear Legacy Liability:*** The primary consideration in establishing the optimized approach to the management of the nuclear legacy liabilities on the CRL site is that internationally, prompt decommissioning (i.e., reducing risks now rather than deferring action) represents optimization.
- ***Role of Enabling Facilities:*** The availability of enabling facilities (e.g., disposal facilities, processing facilities, storage facilities, etc.) will play a formative role in the timing and duration of decommissioning activities.
- ***Non-Radioactive Contaminants:*** Non-radioactive contaminants are included in the scope associated with this plan.
- ***Public Consultation Process:*** During the period of this five year plan, a public consultation process will be carried out that will focus on the overall conceptual technical strategy to be used in addressing the nuclear legacy liabilities on the CRL site in their entirety. Following this exercise, the conceptual technical strategy will be finalized and as part of the subsequent implementation process, the five year plan for CRL may require substantial revision.

  The environmental assessment process under Canadian Environmental Assessment Act will only be applied to the individual projects as they are implemented.
- ***Coordination of Operational and Decommissioning Activities:*** In view of the anticipated complexities associated with carrying out decommissioning activities within the confines of an operating site, it has been assumed that AECL will play a formative and long-term role (e.g., act a licence holder) in the management of the nuclear legacy liability program.
- ***CRL Decommissioning Model:*** The decommissioning of the CRL site will not take place as a single project, but rather as a series of individual projects. For the purposes of this five year plan for CRL, it is anticipated that the site will remain fully operational with decommissioning taking place as individual, discrete activities.

3.14.2 Implementation Plan

3.14.2.1 Principal Components of the Five Year Plan for Chalk River Laboratories

The principal activities associated with the five year plan for CRL comprise the following:

- further developing the overall decommissioning and waste management strategy, including (a) public consultation with affected communities, and (b) environmental assessments;
- submitting regulatory applications for early strategy-defined initiatives;
- constructing, commissioning, and operating characterization and storage facilities;
- addressing immediate health, safety, security, and environmental issues;
- decommissioning and dismantling shutdown buildings; and
- continuing care, surveillance, monitoring, and maintenance activities.

3.14.2.2 Gantt Charts

The summary of the activities in the five year plan for CRL starting 2006 April are presented in Gantt charts and are divided into the following categories:

- CRL
    - licence-listed facilities,
    - radiochemical laboratories,
    - low-hazard structures,
    - non-contaminated structures,
    - stacks and tanks,
    - affected lands, and
    - waste management areas.
- CRL Enabling Facilities
- General Program Costs

3.15 Training

3.15.1 General

The fundamental goals of AECL's training programs are to:

- identify and design training targeting any specific need to increase knowledge, skills, and competencies;
- develop customized training programs for all job levels, with particular expertise in the technical areas;
- conduct training process and program evaluations and validations as required;
- assess, value and cost effectiveness of courses required to be offered internally; and
- ensure that the programs developed comply with regulations and meet with the requirements of internal as well as external regulatory bodies.

3.15.2 Organizational and Technical Training

The Organizational Development & Training group supports managers and their work teams in their efforts to accomplish performance objectives, enhance their effectiveness, meet job competency/qualification requirements, and achieve the goals of AECL. Specifically, the group provides service in the following areas: facilitation and consulting, training design and development, coordination and conduct of training, and implementation of the systematic approach to training (as identified in *AECL Systematic Approach to Training*, CW-510000-MAN-001) [3-20].

Numerous instructor-led and computer based courses are offered internally, targeted at knowledge and skills training generic to AECL in the following program areas:

- General and Safety Orientation/Contractor Safety and Orientation;
- Basic Skills Training (i.e., Writing, Effective Presentation, etc.);
- Computer Skills Training;
- Technical (i.e., Nuclear Theory, Equipment Principles, Waste Management, etc.);
- Compliance Programs (i.e., Emergency Preparedness, Environmental Protection, etc.);
- Safety (i.e., Safety Culture, Event Free Tools, Fire, First Aid, WHMIS, etc.);
- Leadership/Management; and
- AECL Systems/Programs/Processes.

3.15.3 Radiation Protection Training Program

The Safety and Environment group, is responsible for the development and implementation of Radiation Protection Training at AECL. The Radiation Protection School, a section of Safety and Environment, is responsible for the development and maintenance of radiation protection training material consistent with the requirements of *AECL's Radiation Protection Program,* RC-2000-633-0 [3-5].

AECL continues to recognize that a good understanding and knowledge of the hazards associated with radiation work, correct use of protective measures against these hazards, and a high level of competence in one's trade are crucial in ensuring the safe operation of nuclear facilities. In order to determine responsibilities and required competence under *AECL's Radiation Protection Program*, RC-2000-633-0, it is required that all AECL employees and contractors at licensed nuclear sites be designated into one of four groups. The degree of radiation work control exercised for AECL employees will be commensurate with the level of individual responsibility assigned to each of the four employee groups. An outline description of these group designations and the associated degree of training is given below:

- **Group 4** employees are those who do not normally handle radioactive materials and/or work with radiation-emitting devices. They are neither trained nor authorized to undertake radiation work except in unusual circumstances under the strict provisions of a Work Permit.

  Group 4 training is sufficient to meet the requirements for Nuclear Energy Worker designation. Accordingly, the training addresses the following topics:

  (1) AECL commitment to a sound safety culture;
  (2) access and working restrictions;
  (3) Work Permit requirements for Group 4 employees;
  (4) recognition of radiation warning signs and alarms;
  (5) emergency signals and basic emergency response procedures for the site;
  (6) risks associated with radiation to which the person may be exposed to during the course of their work;
  (7) applicable dose limits; and

(8) meaning of employment as a Nuclear Energy Worker.

- **Group 3** employees are those who only handle radioactive materials or work with radiation-emitting devices while under a valid Work Permit.

  In addition to receiving the Group 4 training, the training of Group 3 employees is augmented so as to provide the employee with the skills and knowledge required to perform radiation work safely, while under a valid Work Permit. The training is specific to those hazards to which the employee is exposed during routine operations, or to which the employee may be exposed while controlling unplanned events and emergencies.

- **Group 2** employees are those who normally work with radioactive materials and with radiation-emitting devices within a defined routine envelope, and in accordance with detailed procedures and protocols that have been reviewed and approved by a Group 1 employee in advance.

  In addition to receiving the Group 3 training, the training of Group 2 employees is augmented so as to provide the employee with the required skills and knowledge to perform radiation work independently while performing routine, authorized operations. The training is specific to hazards to which the employee is exposed during routine operations, or may be exposed to in order to control unplanned events and emergencies in the employee's normal area of work.

- **Group 1** employees are those who are trained and qualified as radiation protection specialists reporting to the Radiation Protection Program Manager designated by the Radiation Protection Program Authority for the site or facility. Group 1 employees are responsible for providing radiation safety assessments and advice on the appropriate protection for any radiation work.

  The training for Group 1 employees provides all individuals in any of the occupations within Group 1 with both the theoretical knowledge and skills necessary to routinely take care of the radiation protection of others, including conducting radiation safety assessments, and providing authoritative advice to other AECL and non-AECL employees.

3.15.4 Training Activities

Training courses, when recorded in AECL's centralized training database "On Track", are categorized according to the American Society of Training's categories (see Table 3.13). The amount of training activity in each category is calculated as percentage of total training recorded.

AECL's top categories are technical processes and procedures and OSH/compliance. The increase in investment in technical engineering and nuclear operations supports the increase illustrated in the category of technical processes and procedures.

Recorded in AECL's centralized training database for 2004/2005 alone are a total of 1,264 instructor-led training sessions. An additional 1,263 records were also recorded to capture external courses, conferences and completion of self-study courses (see Table 3.14).

It may be seen from Table 3.14 that:

- The training organizations saw a 25% increase in internal training activity during 2004/2005 resulting in 188 more sessions coordinated by these departments.
- The training activity number increased by a total of 450 more sessions conducted than the previous year with a 38% increase in training hours for internal/instructor-led training.
- Increased utilization of the centralized training database to record training conducted in the licence-listed facilities training is evident.
- External training and conferences continue to be captured but the figures are probably low compared to the actual total activity.
- Training hours for external and self-study training and conferences were captured.
- The increase in self-study training is a result of the implementation of the General and Safety Orientation online training.

The records captured for 2004/2005 reflect an average investment of three days of training per employee, which is an increase from two days relative to the previous year.

3.16 Isotope Production

During the proposed licence period, the Dedicated Isotope Facility (DIF) is scheduled to complete all activities required to assume production and supply of Mo-99, Xe-133, I-125 and I-131 to MDS Nordion. Ending the production and back up production of these isotopes in NRU and the MPF will impact the mission of several licensed facilities at CRL.

With the production of these isotopes moved to DIF, NRU will focus on CANDU research and development support, National Research Council materials program and the continued production of Co-60, Ir-192 and C-14. Greater flexibility in operating schedule will be possible with this mission.

Dedicated Isotope Facility uses a different design of Mo-99 target, where enriched uranium particles are held in the annular space between zirconium oxide tubes, eliminating the need to produce the enriched uranium aluminium matrix targets in the NFFF. The NFFF facility will continue to produce both NRU and DIF driver fuel rods.

The isotopes produced in DIF will be processed in the New Processing Facility (NPF) eliminating the need for isotope production activities in the MPF. However, MPF will continue operations without production to support ongoing FISST sampling, the Liquid Waste Transfer and Storage Project, and the Tank Preparation for Decommissioning Project. The decommissioning plan for MPF will be updated as DIF operational dates become firmer.

All waste streams arising from processing the new Mo-99 targets will be stabilized in NPF with the high-level wastes calcined and sealed into small cans that can be stored in concrete canisters used for spent fuel. The concrete canisters at CRL are located in WMA “G”, which will require a change from a “Non-Operational” to an “Operational” facility status. No further high-level waste will be added to FISST or cemented and stored in tile holes. Low- and intermediate-level waste will be stabilized in a cementation process and stored in existing storage areas.

3.17 Safeguards and Non-Proliferation

To meet requirements for International Safeguards and Non-proliferation commitments, the IAEA has performed over 100 inspections at CRL, both routine and unannounced non-routine. These inspections confirm:

- Fissionable material inventories and material accounting practices.
- Status of IAEA equipment.
- Information provided regarding building activities and status.
- Design Information Verification of new construction (e.g., new tile holes at WMA "B").

The Nuclear Materials and Safeguards Management Compliance Program that governs the activities relating to meeting commitments for non-proliferation and safeguards was revised and issued for use in 2005 April. The compliance program is on a two-year revision cycle to ensure any new regulatory requirements are properly captured and addressed.

CRL has achieved all safeguards commitments for the past several years.

3.18 References

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[3-3] AECL, *Health and Safety*, Policy 00-009, Revision 0, 2004 January 30.

[3-4] International Safety Research, *Independent Study of Technical Issues Relating to Offsite Consequences Resulting from a Release of Radioactivity at Chalk River Laboratory*, 2004 March 31.

[3-5] AECL, *AECL's Radiation Protection Requirements*, RC-2000-633-0, Revision 2, 2000 October.

[3-6] CNSC, *Technical and Quality Assurance Standards for Dosimetry Services in Canada,* Regulatory Standard S-106, 1998 March.

[3-7] AECL Overview Document, *Environmental Management System for AECL Sites in Canada*, RC-2000-021-0.0, Revision 4, 2004 March.

[3-8] AECL, *Environment*, Policy 00-004, Revision 1, 2003 November.

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[3-11] AECL, *2004 Annual Report of Radiological Monitoring Results for Chalk River and Whiteshell Laboratories Sites, Volume 2 – Effluent Monitoring-CRL,* AECL-MISC-362-04-CRL, Volume 2, Revision 0, 2005 March.

[3-12] AECL, *2004 Annual Report of Radiological Monitoring Results for the Chalk River and Whiteshell Laboratories Sites, Volume 3 - Environmental Monitoring-Chalk River*, AECL-MISC-362-04-CRL, Volume 3, Revision 0, 2005 April.

[3-13] AECL, *Non-Radiological Emission Monitoring at CRL: The Results for 2004*, AECL-MISC-421-04, Revision 0, 2005 March.

[3-14] AECL, *AECL Annual Environmental Performance Report for 2004*, AECL-MISC-387-04, Revision 0, 2005 December.

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[3-17] FYREX Engineering Limited, *A Fire Hazards Assessment of the NRU Reactor Facility*, 04-NRU-FHA, Revision 1.1, 2004 June.

[3-18] CNSC, *Nuclear Response Force Standard*, Regulatory Standard S-298, Revision 1, 2003 October.

[3-19] AECL, *Code Classification and Design Registration of Pressure Retaining Systems and Components*, Procedure 120-541.3, Revision 3, 2004 May.

[3-20] AECL, *AECL Systematic Approach to Training (SAT)*, CW-510000-MAN-001, Revision 1, 2005 June.

Table 3.1: Summary of Non-Reportable and Reportable Events at CRL from 2003 to 2006 Mid-March

Description	Event Status	2003	2004	2005	2006
Compliance Programs					
Emergency Preparedness	Not Reportable	1	3	2	0
	Reportable	0	0	0	0
Environmental Protection	Not Reportable	0	1	1	0
	Reportable	0	0	0	0
Fire & Emergency Services	Not Reportable	2	0	4	0
	Reportable	0	0	0	0
Nuclear Materials and Safeguards Management	Not Reportable	0	4	5	1
	Reportable	0	0	0	0
Radiation Protection	Not Reportable	3	1	1	0
	Reportable	0	1	0	0
Radioactive Material Transportation	Not Reportable	0	10	2	2
	Reportable	0	0	0	0
Security	Not Reportable	1	2	5	0
	Reportable	5	5	6	1
Facilities					
Building 234 Universal Cells	Not Reportable	4	5	4	0
	Reportable	0	1	1	1
Fuels & Materials Cells	Not Reportable	0	1	6	0
	Reportable	1	0	0	0
Mo-99 Production Facility	Not Reportable	9	26	24	8
	Reportable	0	1	1	1
NRU Reactor	Not Reportable	62	68	108	41
	Reportable	1	5	4	2
Nuclear Fuel Fabrication Facility	Not Reportable	12	7	3	3
	Reportable	5	2	3	4
Recycle Fuel Fabrication Laboratories	Not Reportable	2	2	0	0
	Reportable	0	0	0	0
Tritium Laboratory	Not Reportable	2	6	5	0
	Reportable	0	0	0	0
Waste Management Operations	Not Reportable	5	4	17	1
	Reportable	1	1	0	0
Waste Treatment Centre	Not Reportable	12	7	10	1
	Reportable	0	0	0	0
ZED-2 Reactor	Not Reportable	0	0	5	0
	Reportable	0	2	0	1

Table 3.1: Summary of Non-Reportable and Reportable Events at CRL from 2003 to 2006 Mid-March

Description	Event Status	2003	2004	2005	2006
Other					
CANDU Technology Development	Not Reportable	3	4	6	2
	Reportable	0	0	0	0
Decommissioning	Not Reportable	6	9	10	7
	Reportable	0	1	0	0
Dosimetry Services	Not Reportable	0	0	0	0
	Reportable	0	0	0	0
Infrastructure & Site Services	Not Reportable	0	0	25	4
	Reportable	0	0	3	0
Manufacturing Services	Not Reportable	0	2	1	0
	Reportable	0	0	0	0
Nuclear Safety and Quality Assurance	Not Reportable	0	0	0	0
	Reportable	0	0	0	1
Quality Audit & Survey Section	Not Reportable	0	1	0	0
	Reportable	0	0	0	0
Radiation Biology & Health Physics	Not Reportable	0	3	0	1
	Reportable	0	0	0	0
Mechanical Equipment & Seal Development	Not Reportable	0	3	0	0
	Reportable	0	0	0	0
Heavy Water Technology	Not Reportable	4	0	0	0
	Reportable	0	0	0	0
Site Operations	Not Reportable	12	36	0	0
	Reportable	1	0	0	0
Fuel Development Laboratory	Not Reportable	0	0	0	2
	Reportable	0	0	0	0

Table 3.2: Emergency Preparedness Exercises in Support of Federal CRTI[5] Program

Year	Type of Exercises	# Conducted
2003	Static	1
	Communication	2
	Specialty drills: fire, bomb threat, radiological hazard and chemical spills.	40
	Major exercises: Stay-In and CRTI.	2
2004	Static	1
	Communication	2
	Specialty drills: fire, bomb threat, radiological hazard and chemical spills.	40
	Major exercises: Stay-In and transportation.	3
2005	Static	2
	Communication	3
	Specialty drills: fire, bomb threat, radiological hazard and chemical spills.	41
	Major exercises: Stay-In, CRTI, and transportation.	3

Table 3.3: Total Number of Radiation Protection Qualified Employees

Radiation Protection Qualification	Site	Total Number of Employees		
		2005	2004	2003
Group 1	CRL	54	44	46
Group 2	CRL	571	505	455
Group 3	CRL	761	642	672
Group 4	CRL	894	764	836

5 Federal CRTI (CBRN Research and Technology Initiative)

Table 3.4: Summary of Radiation Doses at CRL for 2004 and 2005

Radiation Exposure	2004	2005
Whole-Body and Skin Doses		
Largest individual whole-body dose (mSv)* (photon + tritium + neutron).	15.83	16.03
Largest individual surface dose (mSv)** (photon + beta + tritium + neutron).	20.66	23.98
External Whole-Body Photon		
Number of Workers with Detectable Dose	2123	2302
Collective Dose (person·Sv)	2.38	2.31
Average Dose (mSv)	1.12	1.01
Individual Largest Dose (mSv)	12.58	13.23
External Surface Photon + Beta		
Number of Workers with Detectable Dose	2123	2302
Collective Dose (person·Sv)	2.60	2.61
Average Dose (mSv)	1.23	1.13
Individual Largest Dose (mSv)	17.41	21.29
Tritium		
Number of Workers with Detectable Dose	318	338
Collective Dose (person·Sv)	0.32	0.36
Average Dose (mSv)	0.99	1.07
Individual Largest Dose (mSv)	4.44	5.82
Extremity		
Number of Workers with Detectable Dose	222	230
Collective Dose (Sv)	0.90	0.68
Average Dose (mSv)	4.05	2.94
Individual Largest Dose (mSv) ***	35.12	23.15
Neutron		
Number of Workers with Detectable Dose	13	13
Collective Dose (Sv)	0.001	0.001
Average Dose (mSv)	0.09	0.04
Individual Largest Dose (mSv) ***	0.66	0.11

* Regulatory limit is 50 mSv per year (and 100 mSv over five years) for whole-body exposure.

** Regulatory limit is 500 mSv per year for surface or skin exposure.

*** Regulatory limit is 500 mSv per year for extremity exposure.

Table 3.5: Summary of Radiological Emissions from CRL from 2001 to 2005

Year	2001	2002	2003	2004	2005	Five Year Average
Total Airborne Emissions (%DRL)	9.5	14.9	10.3	11.3	11.2	11.4
Ar-41 (%DRL) (Included in total airborne emissions.)	8.2	13.1	7.8	9.9	8.9	9.6
Total Liquid Emissions (%DRL)	0.22	0.21	0.19	0.26	0.26	0.22
Total Effective Dose (mSv/a) To most affected individual Airborne Dominant Pathway – Infant living at Upriver Boundary of CRL.	0.073	0.100	0.098	0.075	N/A	0.087
Total Effective Dose (mSv/a) To most affected individual Liquid Dominant Pathway – Adult living Downstream of CRL.	0.100	0.033	0.021	0.045	N/A	0.050

N/A: Data not available at this time.

Table 3.6: Summary of Non-Radiological Airborne Emissions from CRL from 2001 to 2005

Year	2001	2002	2003	2004	2005	Five Year Average
CO (tonnes)	-	6.15	6.33	6.61	6.35	6.36
NO_x (tonnes)	51*	56	56	59	58	56
SO_2 (tonnes)	348**	250	246	260	214	264
TPM (tonnes)		18.5	18.3	19.6	19.1	18.9
PM_{10} (tonnes)		16.0	15.8	16.9	16.3	16.3
$PM_{2.5}$ (tonnes)		10.4	10.3	11.0	10.6	10.6
VOC (tonnes)		0.37	0.40	0.40	0.46	0.41
CO_2 (tonnes) ***	27,800	30,300	30,698	32,793	31,541	30,626
Mercury (kg) ****	0.82	0.87	0.88	0.94	0.91	0.88

* With the installation of the new boilers, starting in calendar year 2000, emissions of NOx for CRL are based on emission factors calculated from stack measurements on each boiler. All other emissions are estimated using the US-Environmental Protection Agency emission factors given in AP-42.

** SO_2 estimates based on sulphur content specification of < 2%. In 2002, the actual content of sulphur in the fuel was measured to be 1.34%; in 2003 sulphur content was 1.32%; in 2004 sulphur content was 1.30%; and in 2005 sulphur content was 1.11%.

*** Emissions of CO_2 were estimated using the US-EPA AP-42 emission factors of 70.3 kg/GJ for #6 fuel oil and 35.2 kg/GJ for propane.

**** Starting in the calendar year 2000, the “manufacture, process or otherwise use” threshold used in the National Pollutants Release Inventory requirements to report mercury emissions was decreased from 10,000 to 5 kg. At CRL, the 5 kg “manufacture, process or otherwise use” threshold is exceeded. Therefore since the year 2000, AECL has been reporting all its mercury releases in accordance with the National Pollutants Release Inventory requirements. This includes the releases of mercury from the liquid effluents, which are calculated in the loading table above. This table provides the estimate of the airborne mercury released through the combustion of fuel oil. These estimates were calculated using the average concentration in #6 fuel oil of 0.0885 ppm.

Table 3.7: Exceedances of Monthly Guidelines for Non-Radiological Liquid Effluents

		Exceedances of Monthly Guidelines				
		2001	**2002**	**2003**	**2004**	**2005**
CRL	Number	44	42	23	21	30
	Annual Target	-	-	≤ 42	≤ 20	≤ 14

Table 3.8: Spring B Groundwater Treatment Plant Operations Summary

Operational Parameter	2000	2001	2002	2003	2004
Volume of Groundwater Treated (m^3)	3.03E06	2.46E06	2.79E06	3.12E06	3.18E06
Concentration Sr-90 Feedwater (Bq/L)	2617	3117	2690	2580	2499
Concentration Sr-90 in Discharge Water (Bq/L)	61	12	17	21	21

Table 3.9: Chemical Pit Groundwater Treatment Plant Operations Summary

Operational Parameter	2000	2001	2002	2003	2004
Volume of Groundwater Treated (m^3)	3.80E06	4.07E06	4.55E06	3.84E06	4.57E06
Concentration Sr-90 Feedwater (Bq/L)	1178	1255	1611	1675	870
Concentration Sr-90 in Discharge Water (Bq/L)	22	114	44	310	6

Table 3.10: Waste Generation Rates

	2000		2001			2002			2003			2004			2005		
Tile Hole	**Total Closed**	**Empty at Year End**	**Total Closed**	**Closed in Year**	**Empty at Year End**	**Total Closed**	**Closed in Year**	**Empty at Year End**	**Total Closed**	**Closed in Year**	**Empty at Year End**	**Total Closed**	**Closed in Year**	**Empty at Year End**	**Total Closed**	**Closed in Year**	**Empty at Year End**
IRP	2412	157	2477	65	92	2577	100	410	2686	109	301	2788	102	199	2904	116	83
CF	98	19	99	1	18	99	0	32	100	1	32	101	1	31	102	1	30
CW	258	7	260	2	6	267	7	75	271	4	71	274	3	67	281	7	60
IFE	397	85	414	17	68	431	17	51	448	17	34	449	1	33	465	16	76
ROD	48	44	50	2	42	50	0	42	50	0	42	50	0	42	50	0	42
IMD	242	30	243	1	29	248	5	26	248	0	25	250	2	24	250	0	24

		Waste Emplacement (m^3)			**Waste Emplacement (m^3)**			**Waste Emplacement (m^3)**			**Waste Emplacement (m^3)**			**Waste Emplacement (m^3)**			**Waste Emplacement (m^3)**
CD		611			598			742			395			202			236
MAGS								319			847			1267			1452
CD + MAGS (SMAGS)		611			598			1061			1242			1469			1688

Table 3.11: Availability of Storage Space

Tile Holes	Number/m^3 Available (2006 December 31)		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
IRP	553	Tile Holes Remaining	423	293	253	213	173	133	93	53	13	-27
		Annual Tile Hole Use	130	130	40	40	40	40	40	40	40	40
CF	28	Tile Holes Remaining	26	24	22	20	18	16	14	12	10	8
		Annual Tile Hole Use	2	2	2	2	2	2	2	2	2	2
CW	53	Tile Holes Remaining	45	37	29	21	13	5	-3			
		Annual Tile Hole Use	8	8	8	8	8	8	8			
IFE	156	Tile Holes Remaining	135	114	93	72	51	30	9	-12		
		Annual Tile Hole Use	21	21	21	21	21	21	21	21		
ROD	41	Tile Holes Remaining	40	39	38	37	36	35	34	33	32	31
		Annual Tile Hole Use	1	1	1	1	1	1	1	1	1	1
IMD	122	Tile Holes Remaining	119	114	98	82	66	50	34	18	2	-14
		Annual Tile Hole Use	3	5	16	16	16	16	16	16	16	16
Low- and Intermediate Level Waste			**SMAGS 1**			**SMAGS 2**			**SMAGS 3**			
SMAGS	8000	Space Remaining	6000	4000	2000	8000	6000	4000	2000	8000	6000	4000
		Annual Use	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000

Table 3.12 Stored Liquid Waste Streams: Locations, Volumes and Waste Characteristics

Waste Stream	Storage Location	Number of Storage Tanks	Total Waste Volume (m^3)	Waste Volume: Sludge (m^3)	Acidity/ Alkalinity (pH)	Radioactive Content (Bq)	Percent Total Radioactive Content (%)	Percent Total Waste Volume (%)
High-Level Medical Isotope Waste	Developed Area	1	23	0	0	4.7E+15	66.1	8
Isotope Processing Wastes	Developed Area	1	22	0.1	0	4.85E+14	6.8	8
Cobalt-60 Production [1]	Developed Area	2	60	1.0	14	1.98E+12	0.03	20
Historical Fuel Reprocessing	Outer Area	3	17	0	< 0.1	1.7E+15	24.3	6
Ion-Exchange Regeneration	Developed and Outer Area	6	153	1.2	0.5 to 12	1.94E+14	2.8	54
Loop Decontamination	Developed Area	8	12	2.6	9.0 to 14	5.97E+11	0.01	4
Total		**21**	**287**	**4.9**	**-**	**7.1E+15**	**-**	**-**

1) Current Volume and Content. Cobalt-60 production continues to generate ~ 3 m^3 of liquid waste per year.

Table 3.13: Course Types as a Percentage of Total Training Captured

Training Course Types	AECL 2001/2002	AECL 2002/2003	AECL 2003/2004	AECL 2004/2005
Basic Skills	-	1	1	2
Customer Relations	-	1	4	6
Employee Orientation	8	8	8	3
Executive Development	-	-	1	1
Information Technology Skills	12	17	10	4
Mgmt/Supervisory Skills	11	6	5	5
OSH/Compliance	30	27	26	19
Product Knowledge	-	-	-	4
Professional Skills	22	17	7	7
Quality and Business Practices	12	18	8	8
Technical Processes and Procedure	5	5	30	41

Table 3.14: Training Activity for 2004/2005

Instructor-Led Training	No. Sessions	No. Students	Total Training Hours
Corporate Quality	32	454	3038
Customer Relations	108	1231	8039
Information Technology	78	462	2676
Facilities and Nuclear Operations	492	1534	4860
Organizational Development and Training *	227	3373	26553
Radiation Protection	103	1255	9002
Technical Resources Planning and Training	224	3387	16038
Sub Total (Internal and Instructor-Led)	**1264**	**11696**	**70206**
External Courses	427	-	6310
Self-Study Courses (Including Computer-Based Training)	797	-	951
Conferences Attended	39	-	802
Total	**2527**	**-**	**78269**

* Includes Occupational Safety and Health training.

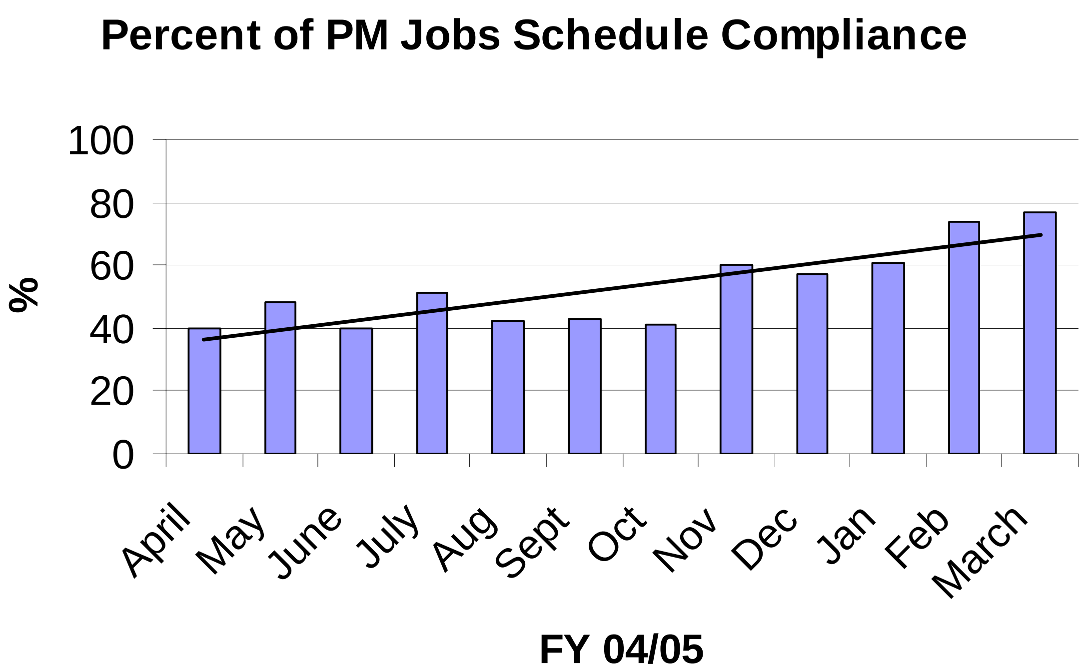


Figure 3.1: Preventive Maintenance Job Schedule Compliance for CRL Site

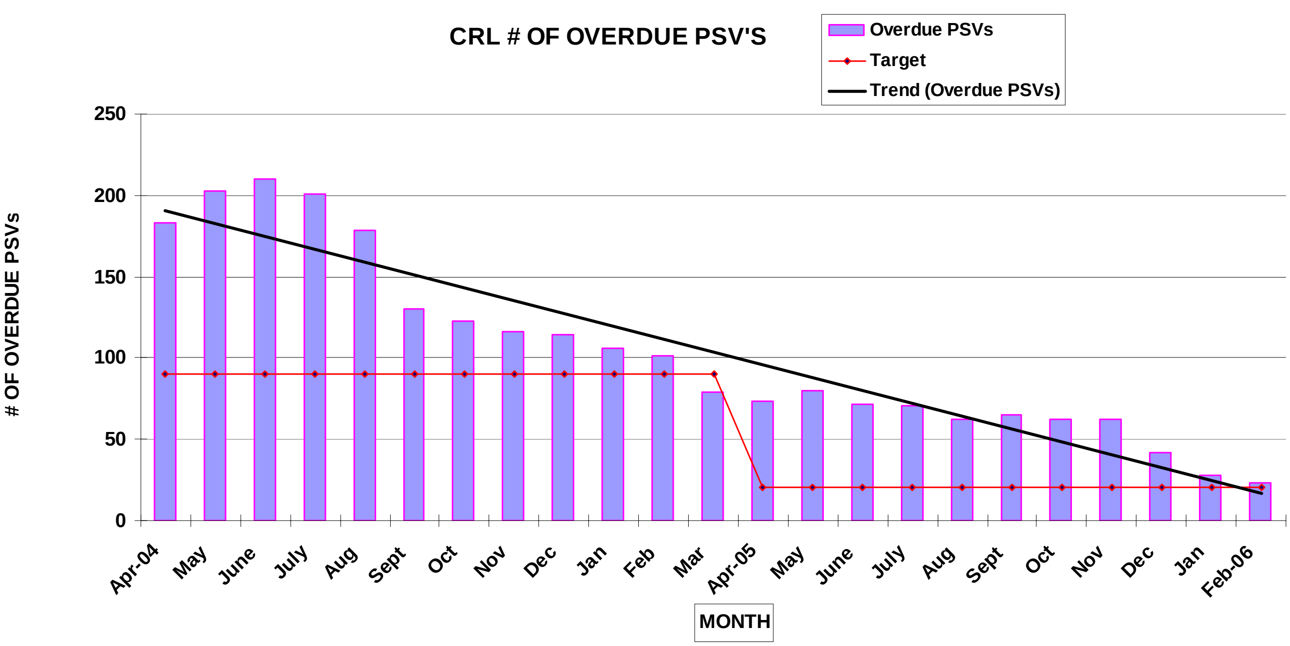
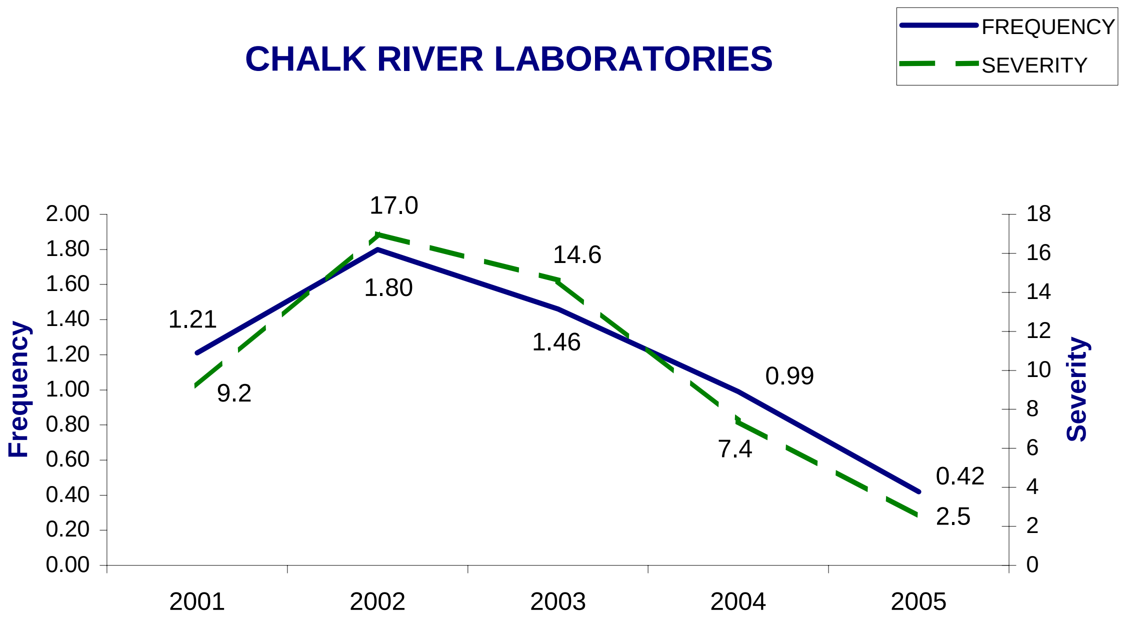


Figure 3.2: Pressure Safety Valves Program Compliance for CRL Site



Frequency = Number of Recordable Lost Time Injuries (RLTI) per 200,000 person-hours exposure
Severity = Number of work days lost as a result of RLTI per 200,000 person-hours of exposure

Figure 3.3: Recordable Lost Time Injuries at CRL from 2001 to 2005

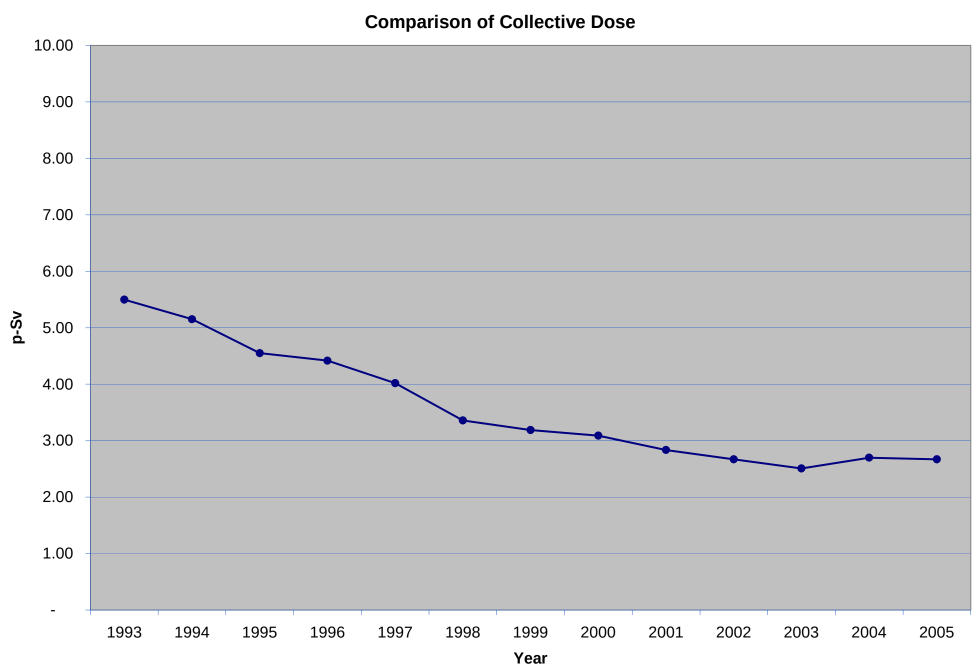


Figure 3.4: Comparison of Collective Dose at CRL

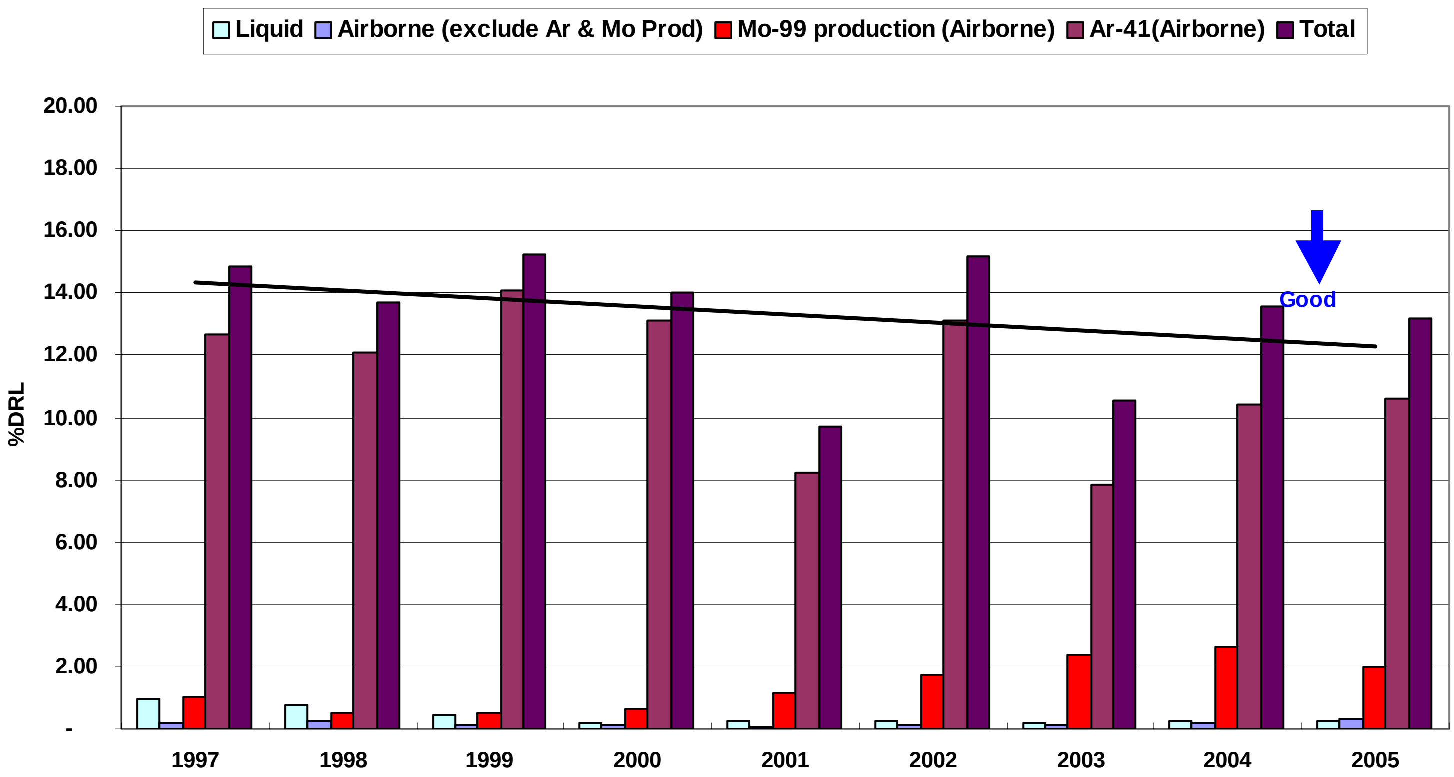


Figure 3.5: CRL Radiological Emissions from 1997 to 2005

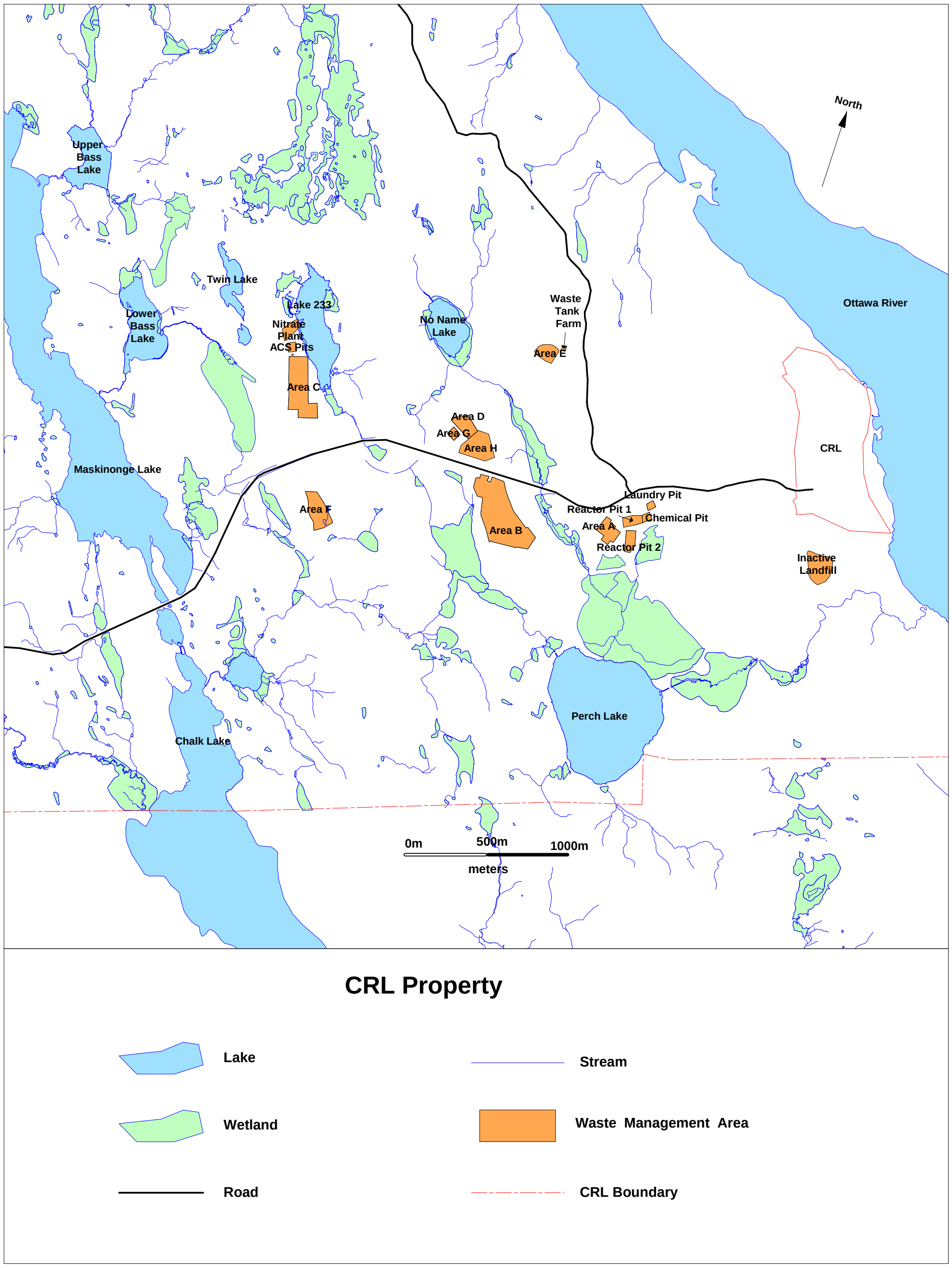


Figure 3.6: CRL Supervised Area - Waste Management Facilities and Major Surface Water Features

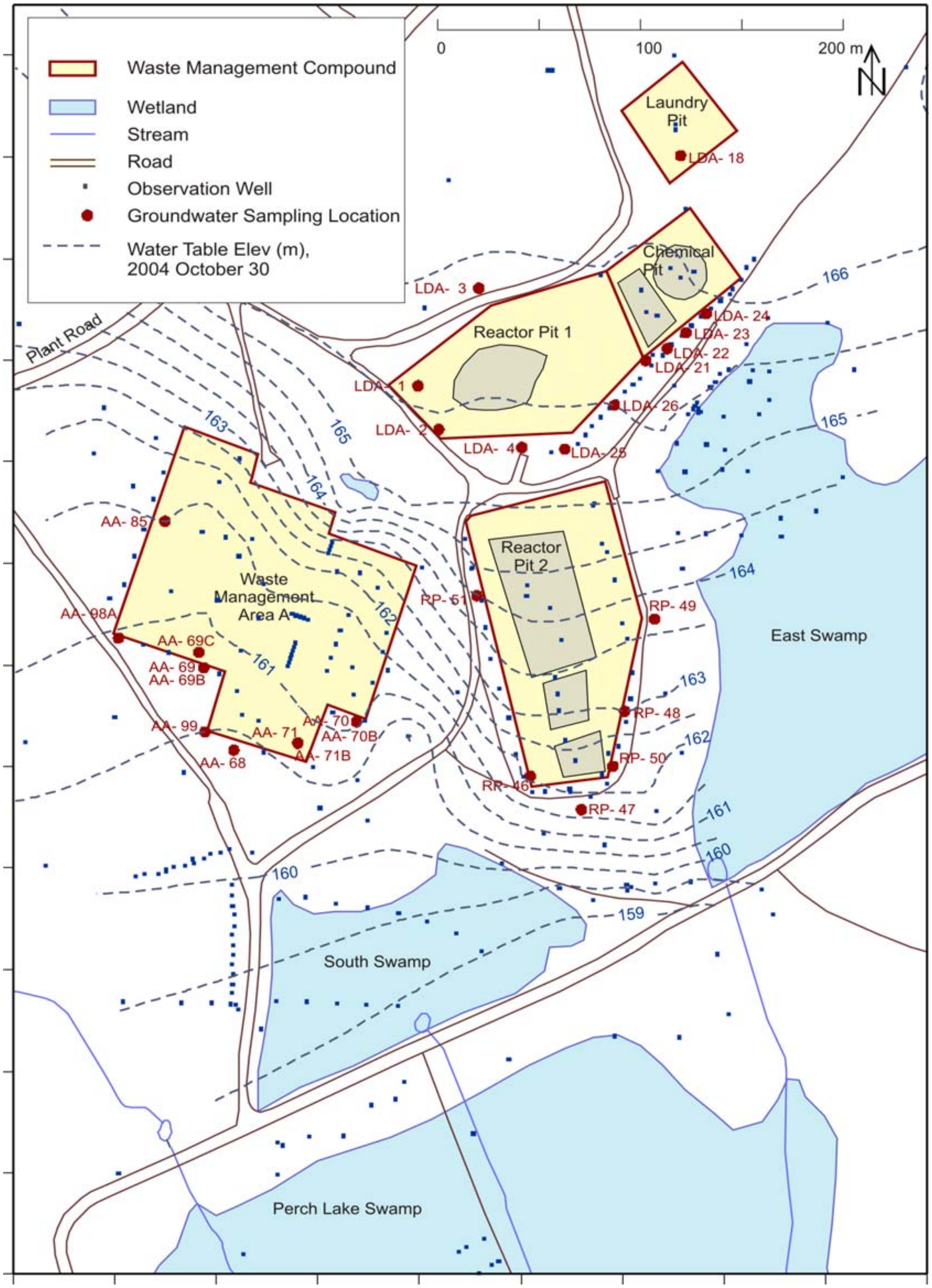


Figure 3.7: Liquid Dispersal Area and Waste Management Area "A" Facilities and Associated Groundwater Monitoring Wells

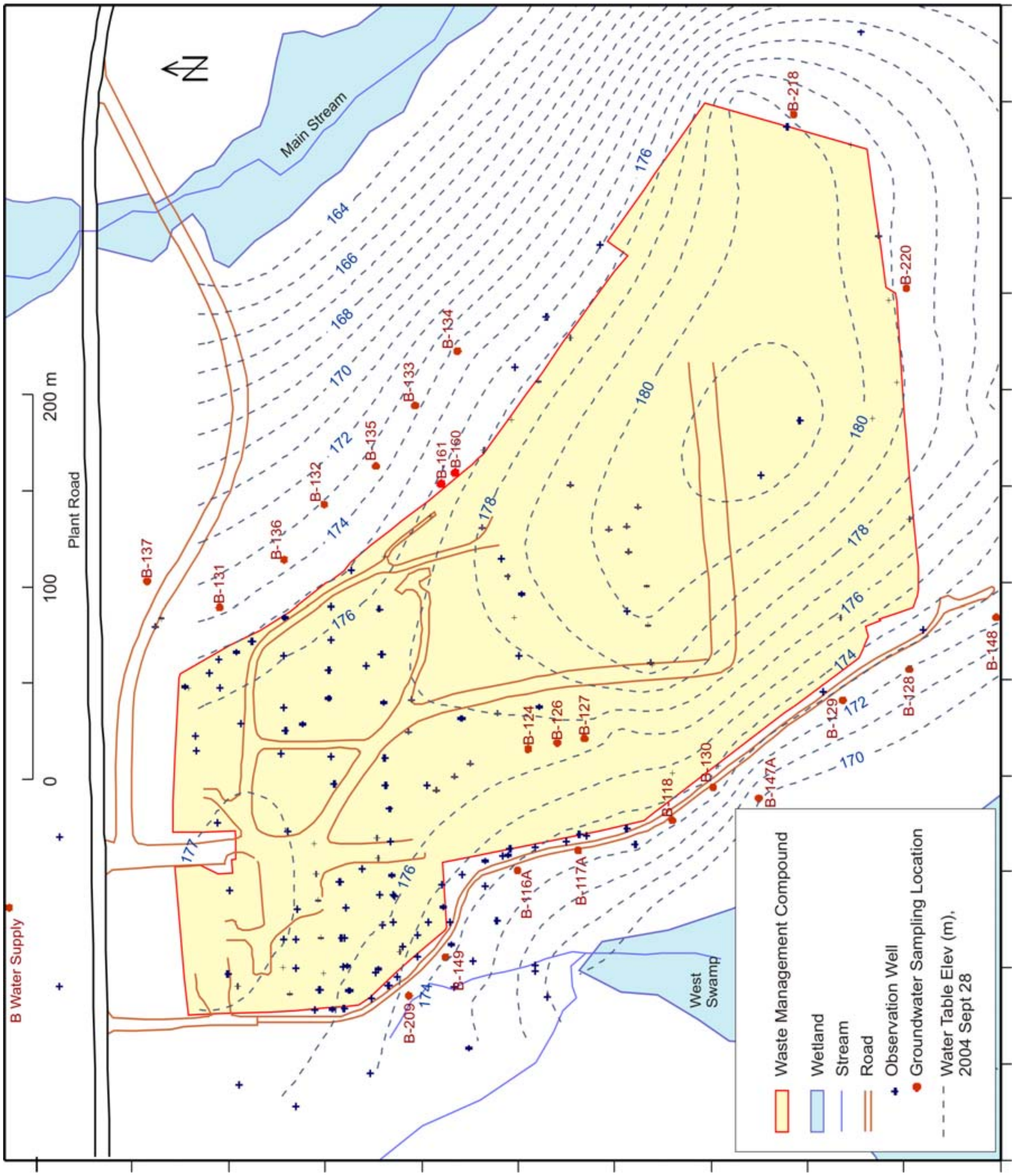


Figure 3.8: Waste Management Area "B" Layout and Associated Groundwater Monitoring Wells

Not shown on this plot are monitoring wells B-222 and B-228 located along the southern perimeter of the site.

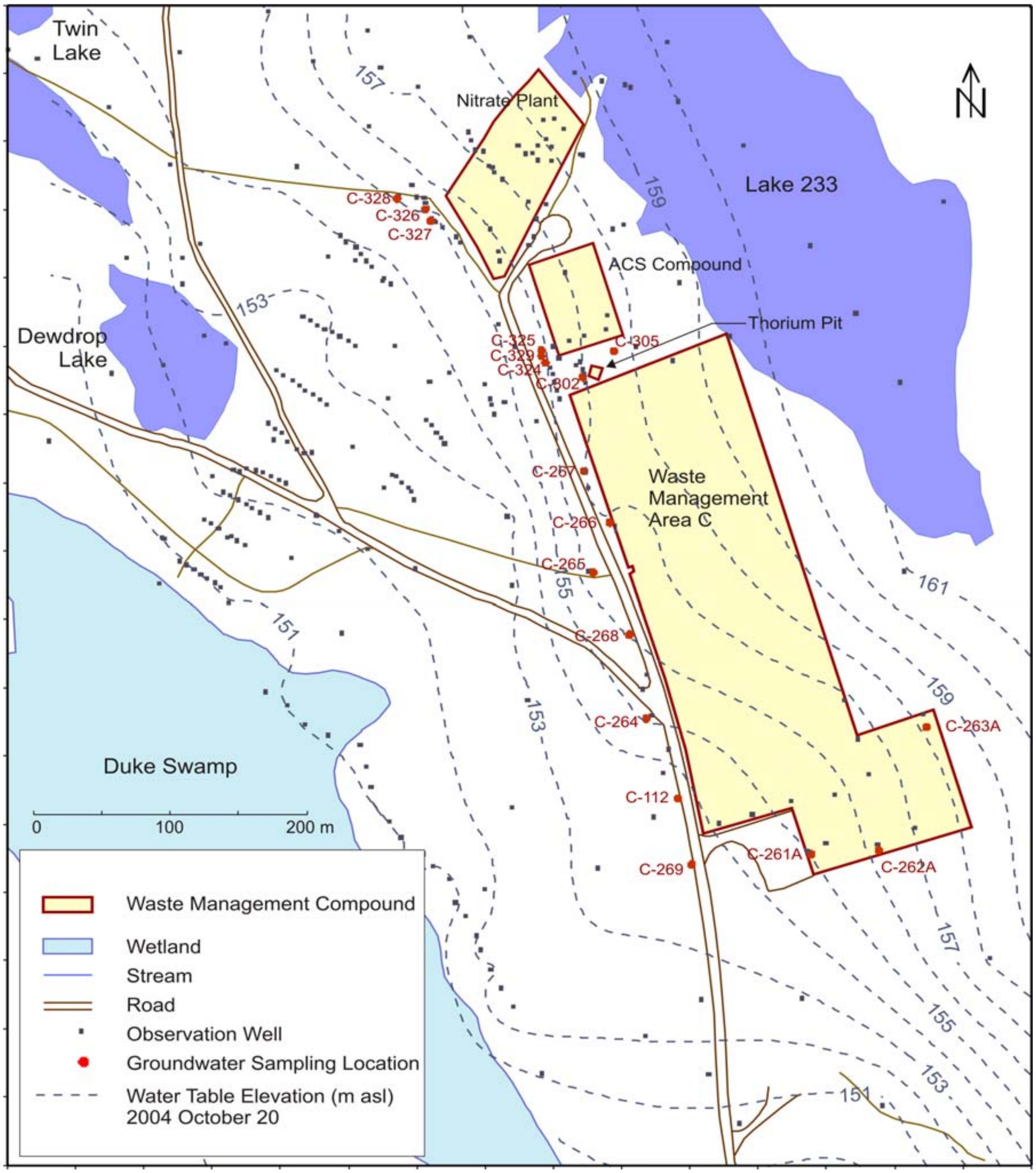


Figure 3.9: Waste Management Area "C", Acid Chemical Solvent and Thorium Pits, Nitrate Plant, and Associated Groundwater Monitoring Wells

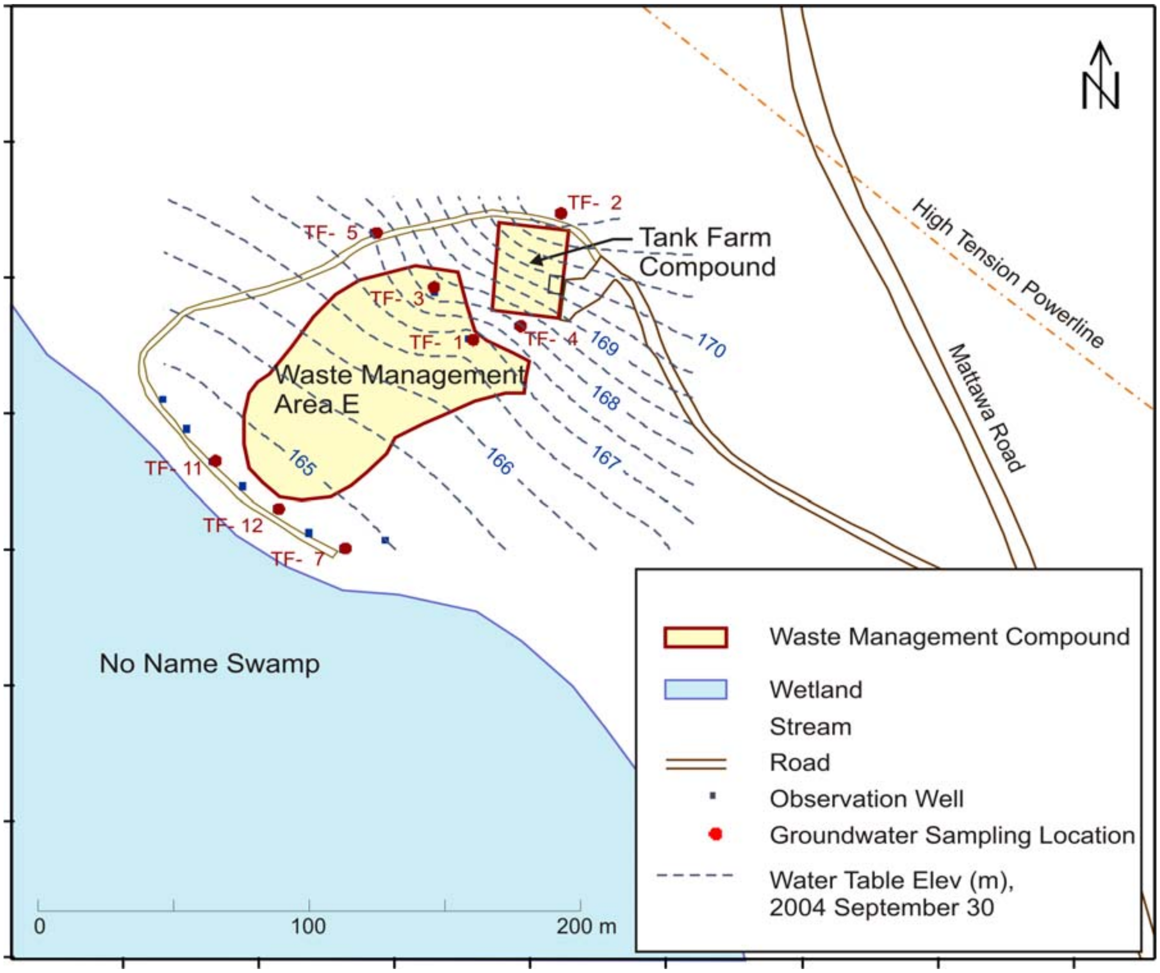


Figure 3.10: Waste Tank Farm, Waste Management Area "E" and Associated Groundwater Monitoring Wells

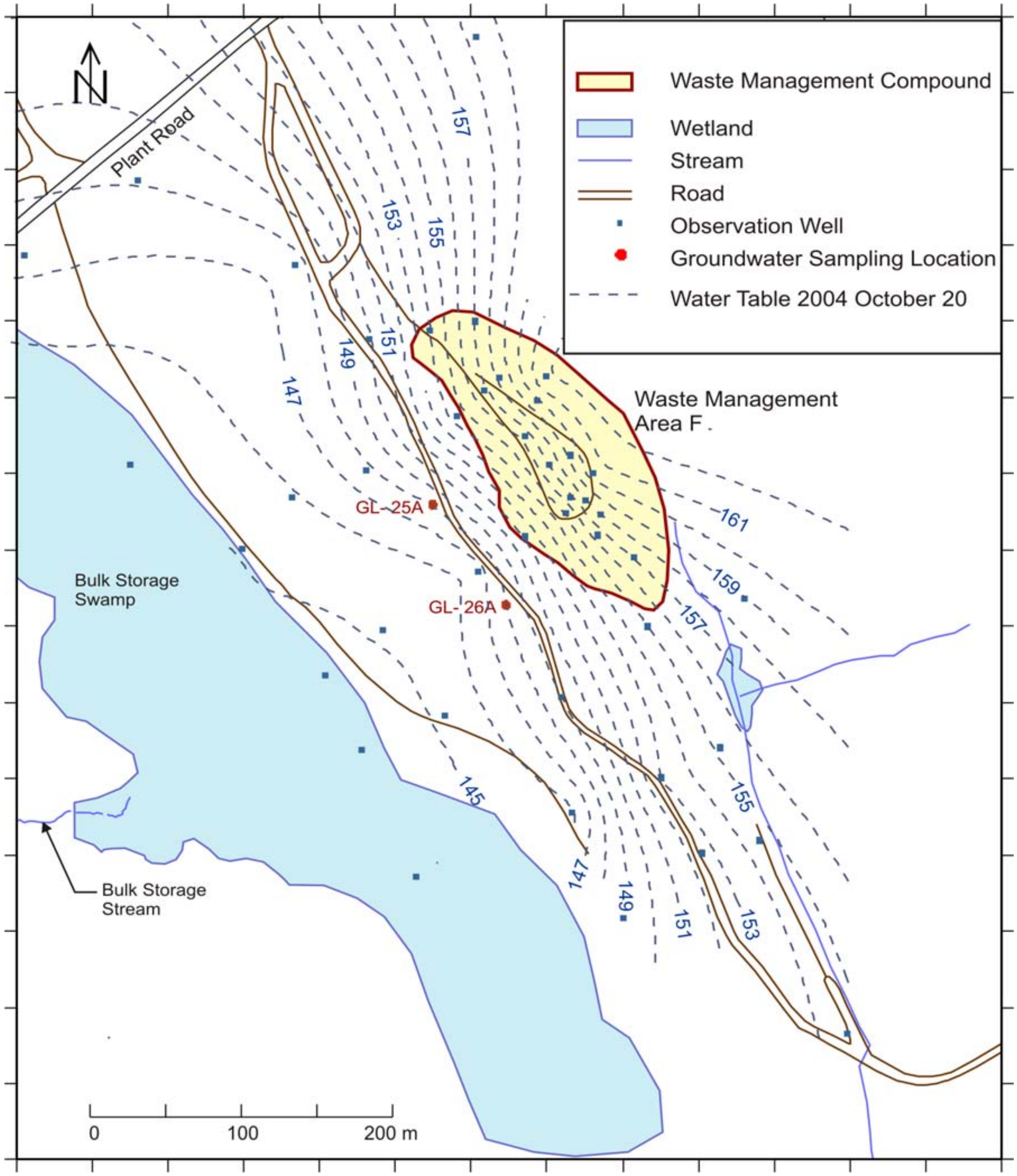


Figure 3.11: Waste Management Area "F" and Associated Groundwater Monitoring Wells

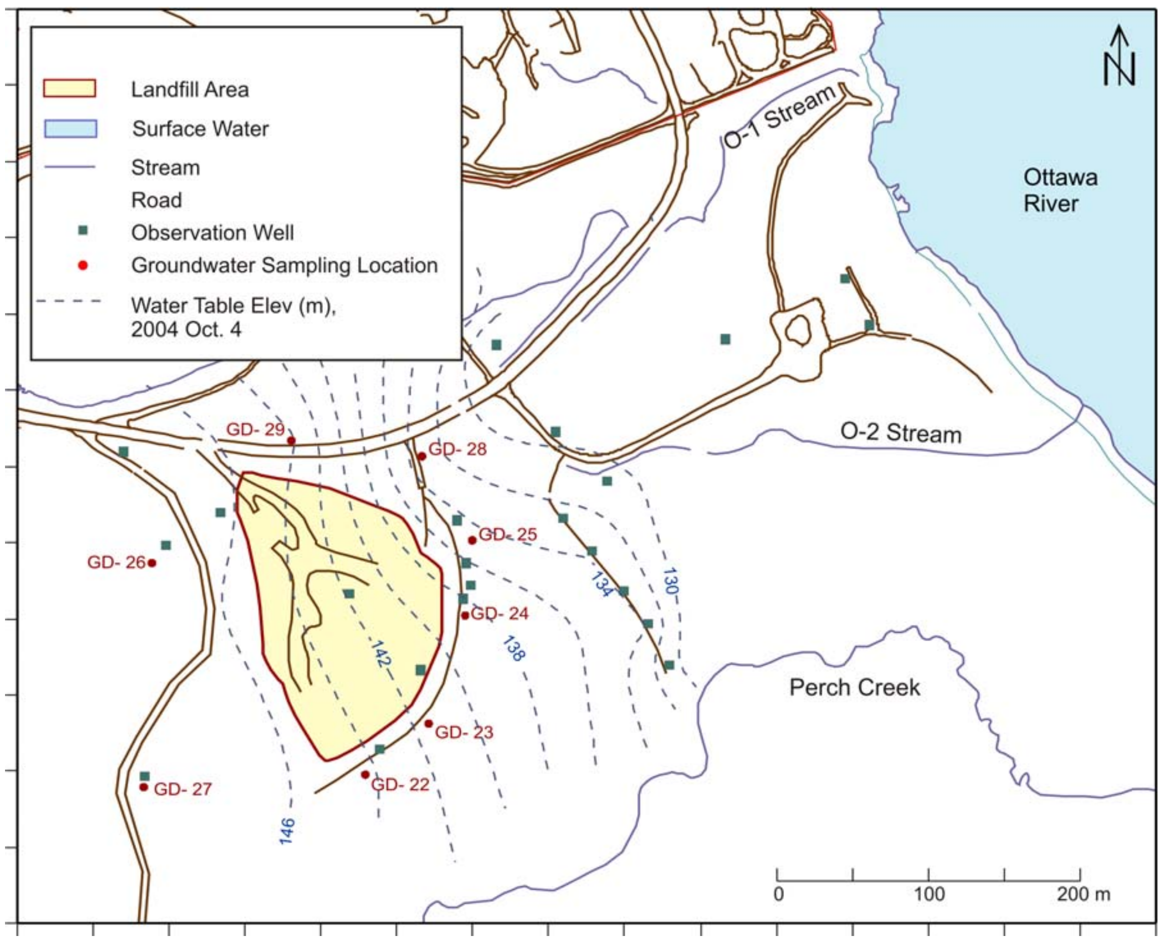


Figure 3.12: CRL Inactive Landfill and Associated Groundwater Monitoring Wells

Not shown on this plot is borehole GD-31, which is a replacement for GD-27.

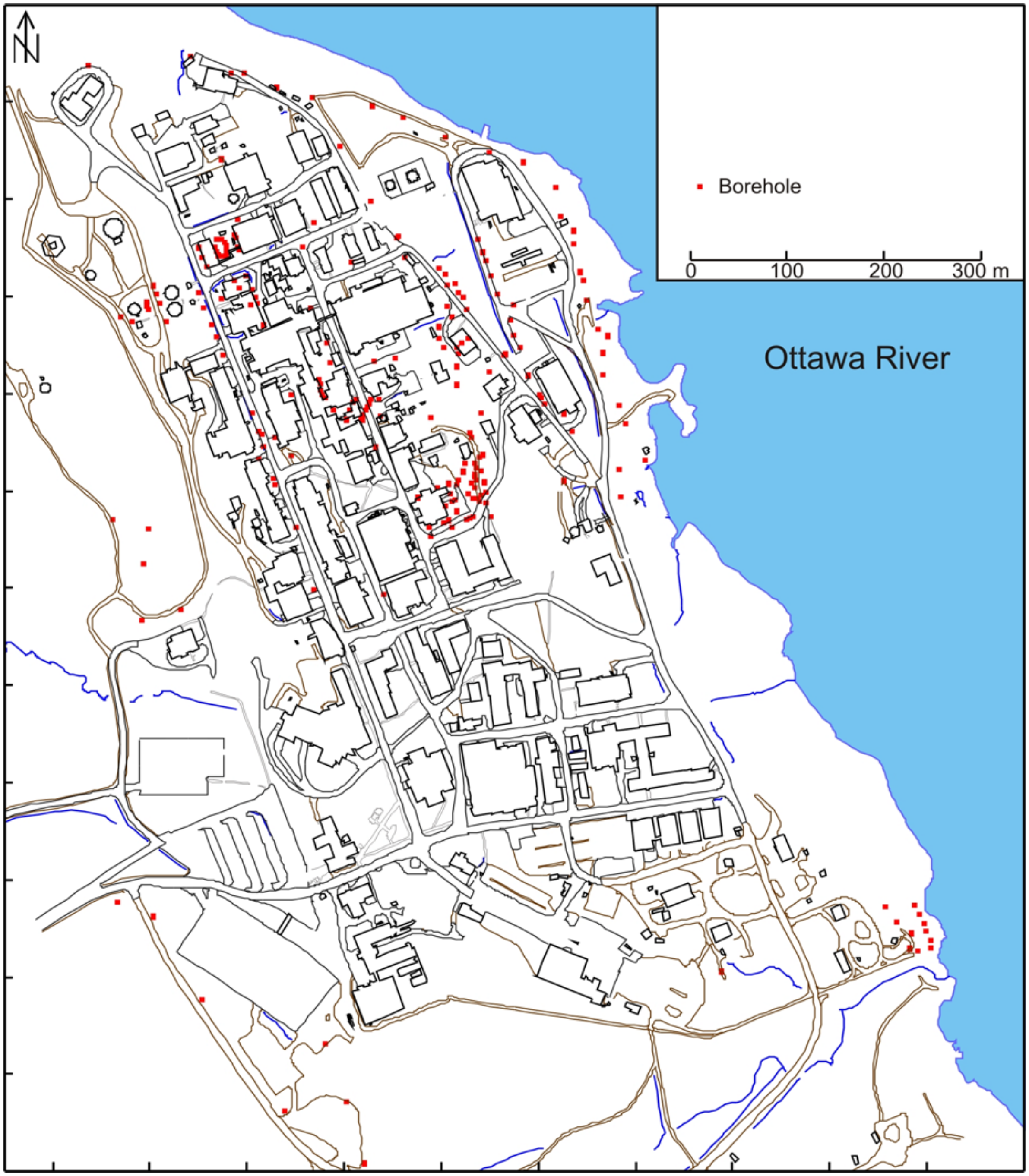


Figure 3.13: Monitoring Wells in Controlled Area 2 and Environs

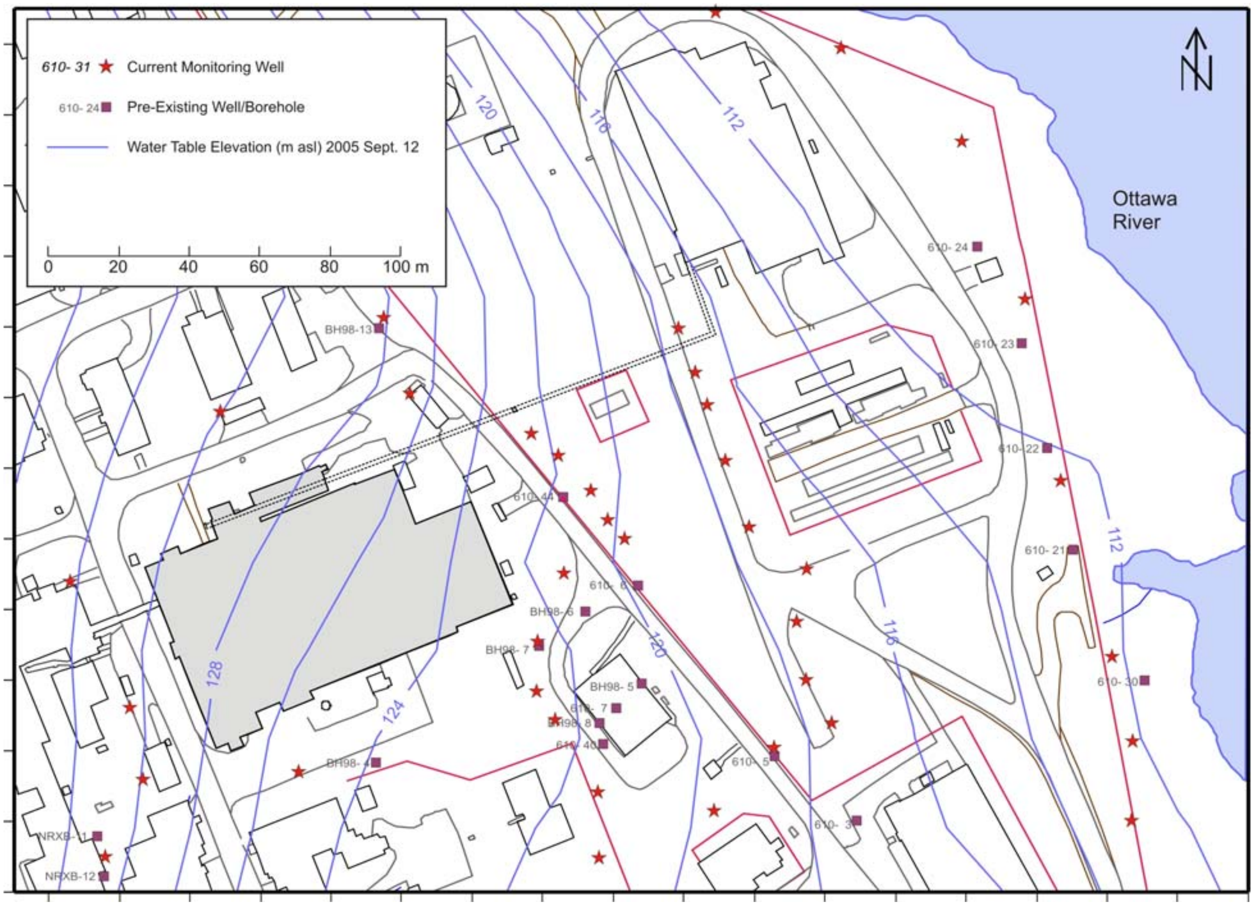
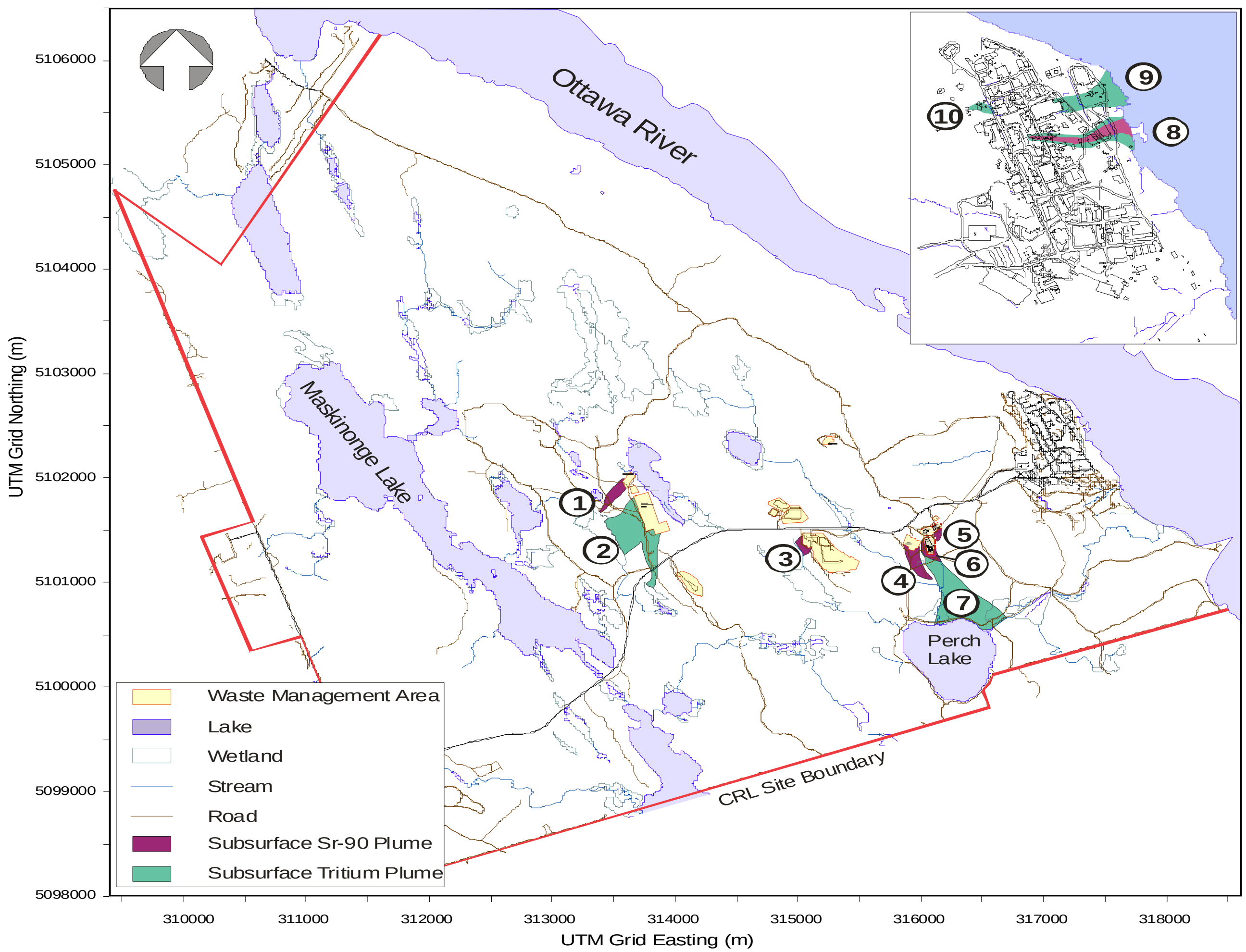


Figure 3.14: Monitoring Wells in the Vicinity of the NRU Reactor



1	**Nitrate Plant (Sr-90)**
2	**Area C (Tritium)**
3	**Area B West (Sr-90)**
4	**Area A and Reactor Pit 1 (Sr-90)**
5	**Chemical Pit (Sr-90)**
6	**Reactor Pit 2 (Sr-90)**
7	**Reactor Pit 2 (Tritium)**
8	**NRX Rod Bay (Tritium and Sr-90)**
9	**NRU Area (Tritium, trace beta)**
10	**Tank 240-1 (Tritium, trace beta)**

Figure 3.15: Plumes Located on the CRL Site

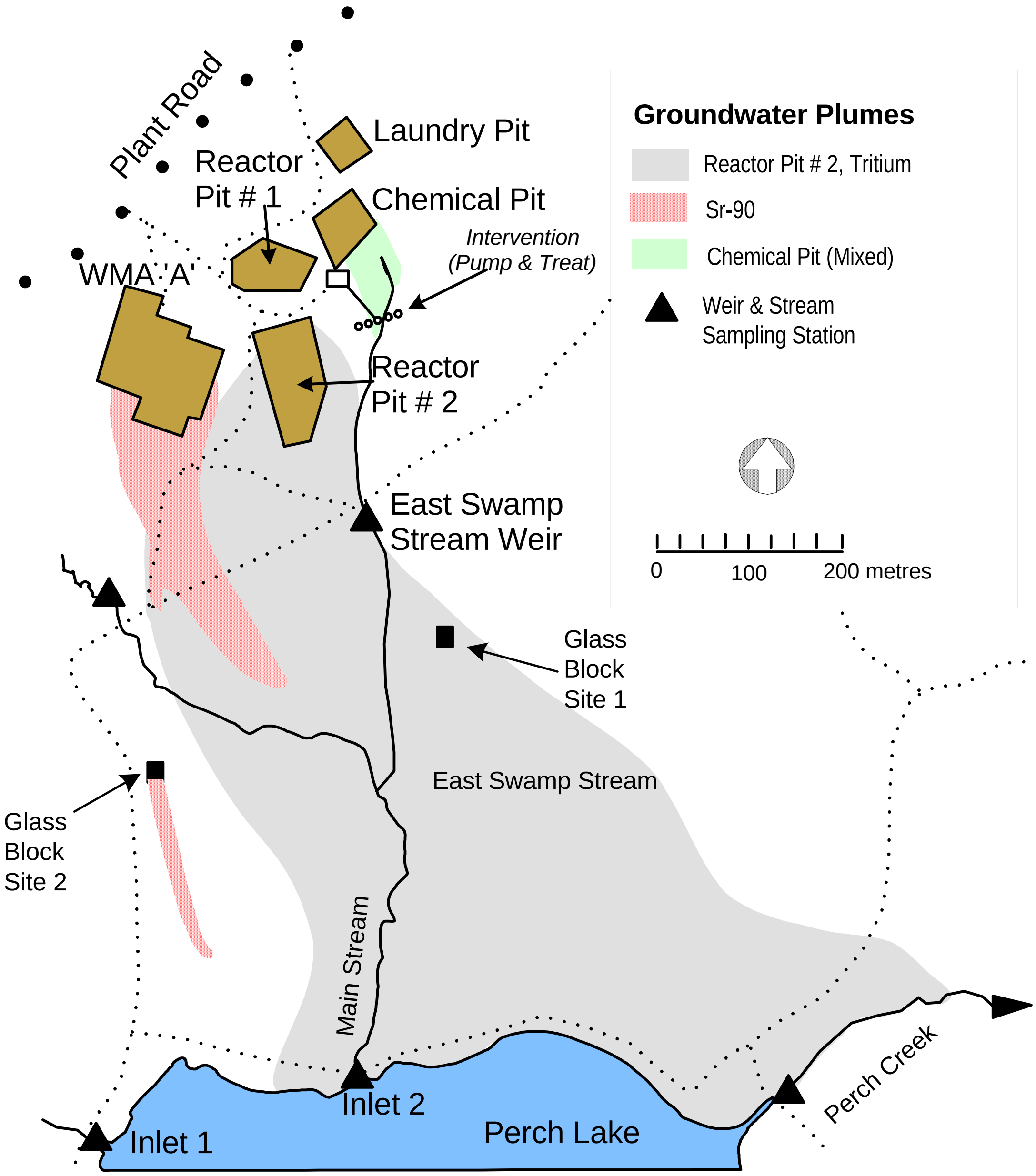


Figure 3.16: Details of Plumes Associated with Waste Management Area "A" and the Liquid Dispersal Areas

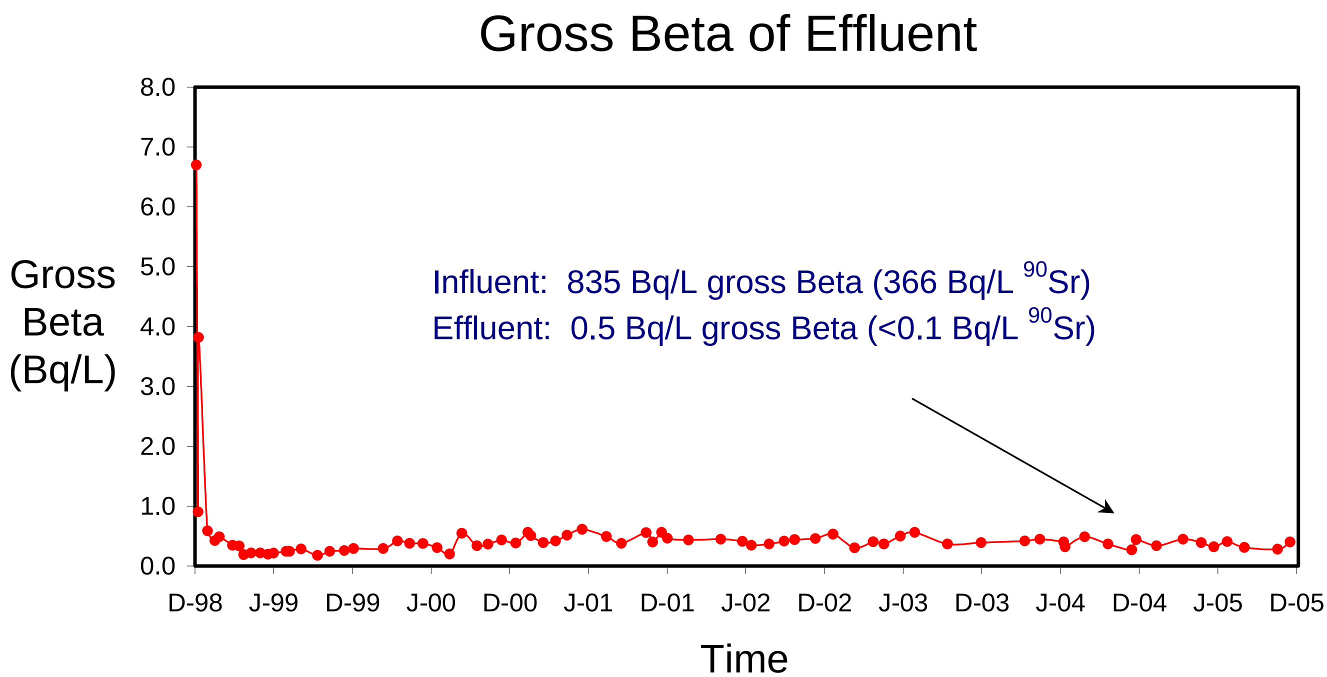


Figure 3.17: Wall and Curtain Treatment Facility Operations Summary

Figure 3.18: Pilot Study for the Placement of a Permeable Reactive Barrier – 2005 October

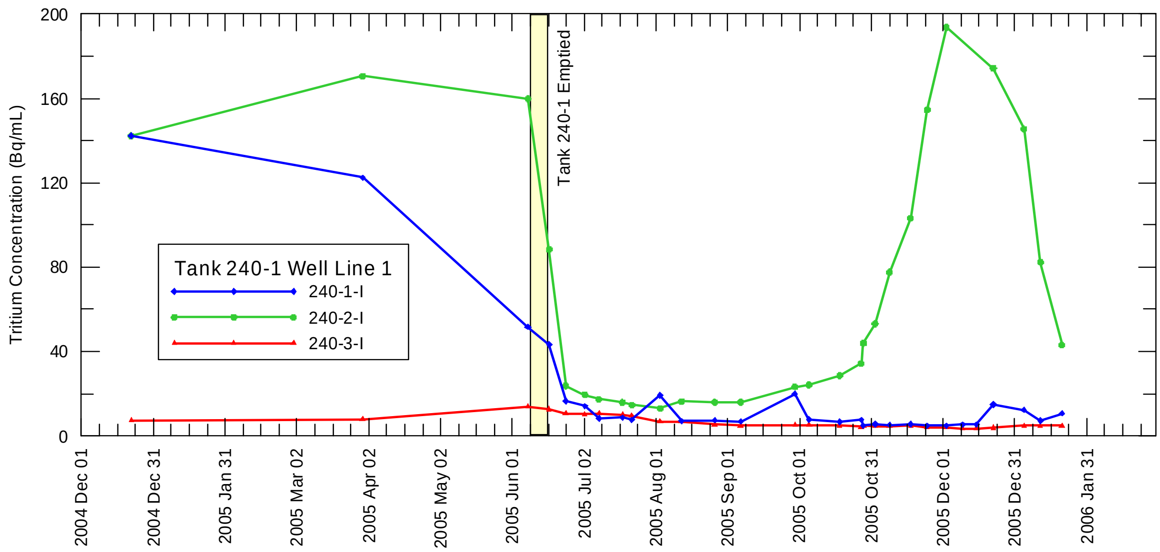


Figure 3.19: Monitoring Results Downgradient of Active Drainage Tank 240-1

Figure 3.20: Shielded Modular Above Ground Storage

Large concrete storage building planned for CRL WMA "H" to accept waste streams currently directed to Bunkers and Modular Above Ground Storage Buildings. The building depicted is the low-level waste storage building operated by Ontario Power Generation at the Bruce Western Waste Management Facility. AECL is using the same design for application at CRL. Effective storage volume: 8,000 m^3.

Figure 3.21: Conceptual Layout of Modular Above Ground Storage and Shielded Modular Above Ground Storage Buildings at Waste Management Area "H"

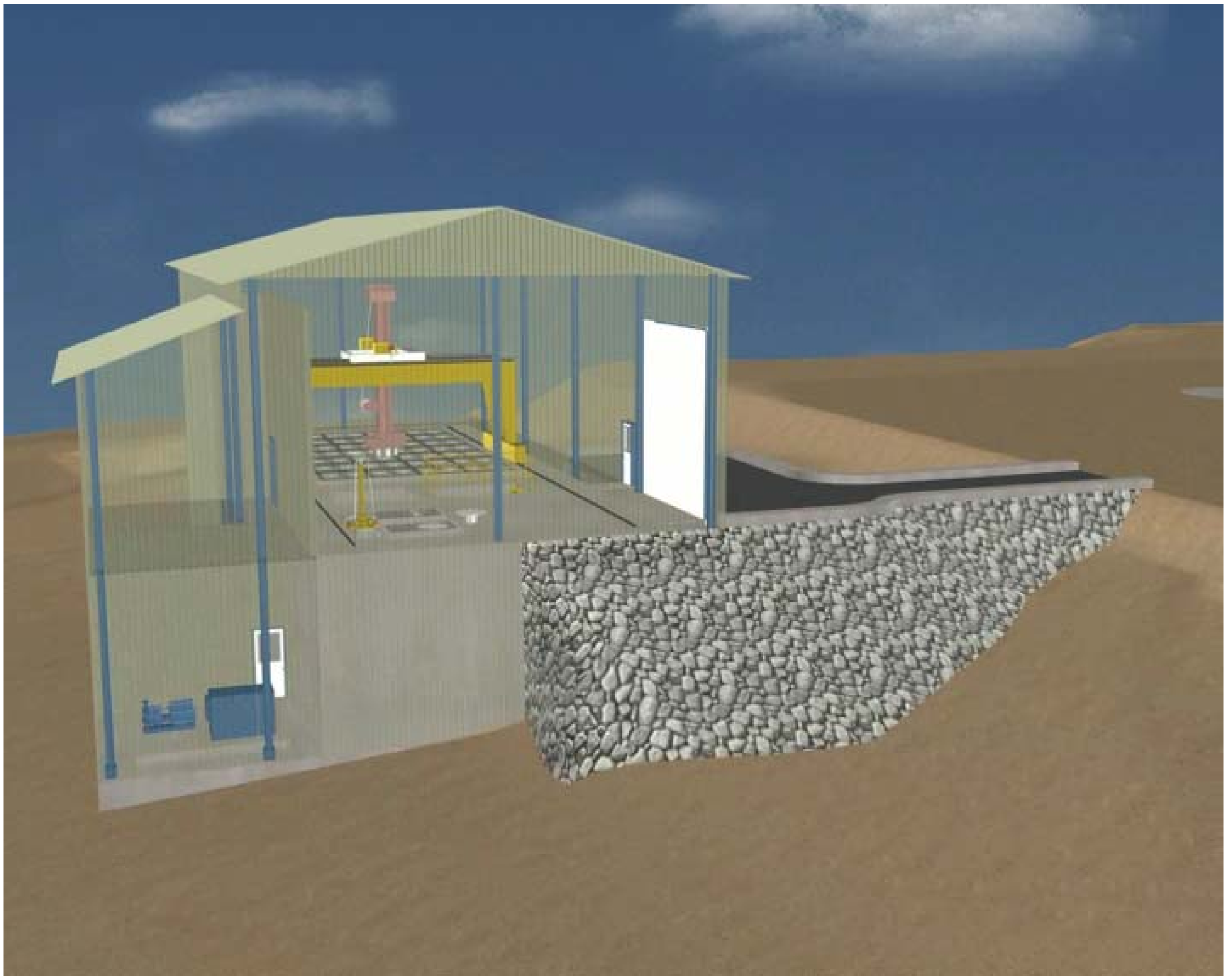


Figure 3.22: Fuel Packaging & Storage Project

Retrieval of tile hole contents from older Tile Hole Arrays in WMA "B", followed by packaging and vacuum drying, prior to emplacement in a new aboveground storage system.

The picture shows a representation of the new storage system with its transfer system.

CHAPTER 4 OTHER LICENSING MATTERS

4.1 Financial Guarantee for the Decommissioning of the Chalk River Laboratories, MAPLE Reactors and New Processing Facility

Following a public hearing held on 2004 September 16 and 2005 May 20, the CNSC announced on 2005 July 12 the adjournment of the hearing on the financial guarantee proposed by AECL for decommissioning of the CRL, including MAPLE reactors and the NPF.

In the Record of Proceedings, Including Reasons for Adjournment [4-1], The Commission concluded, "the acceptance of liability by the Crown is an acceptable form of financial guarantee." However, to fulfill the CNSC requirements for nuclear facility decommissioning preparations, the Commission ruled that an acceptable Comprehensive Preliminary Decommissioning Plan, including operational timelines for current (within the next five years) planned decommissioning activities and reasonable decommissioning cost estimates, must accompany the financial guarantee.

In addition, the Commission requested that AECL revise the Framework for a Communications and Public Consultation Plan [4-2] taking into account the concerns and the recommendations made during the hearing of 2005 May 20.

To meet the Commission requests, and in agreement with the previous commitments [4-3], AECL made the following submissions to CNSC staff: the Cost Estimate for the CRL Decommissioning Liability [4-4], the revised Framework for a Communications and Public Consultation Plan [4-5], the revised Comprehensive Preliminary Decommissioning Plan for the CRL site [4-6] and Five-Year Operational Implementation Plan [4-7].

The revised Comprehensive Preliminary Decommissioning Plan [4-8] together with the Cost Estimate for the CRL Decommissioning Liability [4-9] provide detailed cost estimate for the CRL decommissioning activities, including provision for "enabling" facilities required to fully address the nuclear legacy liability. The revised Comprehensive Preliminary Decommissioning Plan has been prepared to be consistent with the guidance contained in the CNSC Regulatory Guides G-219 and G-206.

The five year operational implementation plan [4-10], providing the operational timelines for current planned decommissioning activities for the CRL site, will be updated on a regular basis to reflect changes resulting from such considerations as decommissioning scope, regulatory developments and feedback from the public.

4.2 Public Consultation Program

AECL's Public Information Program continues to evolve and make steady progress. Proactive and transparent actions taken during the current licensing period are enhancing the program and further activities are planned for operations moving forward.

A major improvement to the program resulted from comments made by the Commission and interveners at the Day Two Public Hearing in 2003 April with respect to AECL being more open in its communications (reference was to redacted reports and timely delivery of information). As a result, AECL implemented a *Disclosure* policy [4-11] which is posted on the external website.

The introduction of the *Disclosure* policy was shared with the communities and public interest groups prior to being launched and since its launch in 2005 September, AECL has responded to about 1,100 requests for information. Furthermore, AECL is posting copies of annual environmental monitoring reports, the Ecological Effect Review of Chalk River Laboratories, the Comprehensive Preliminary Decommissioning Plan for Chalk River Laboratories, the associated Framework for a Communications and Public Consultation Plan and other key reports of interest on the external website as they become available. While all of these reports can be accessed on the website, copies are also provided to all stakeholders (this includes local and regional public interest groups) to ensure they are kept apprised in a timely manner.

As general public tours of the site are no longer possible due to enhanced security, it is important to find other ways to keep the public informed. During this period, regular briefings and discussions with regard to all aspects of our business continued with federal, provincial, county and municipal elected officials and councils on both sides of the Ottawa River. These meetings provide the opportunity for AECL to share information on the current status of our operations and projects and to listen to the concerns that councils or their constituents may have. Participants complete a survey at the end of each meeting to measure effectiveness and value. Collaborative efforts are made to promptly resolve issues. While no major issues have been raised, AECL continues to support the Municipalité régionale de comté du Pontiac in their efforts to develop an emergency response plan. AECL was invited to make a presentation on its emergency preparedness program to the Fort Williams' Cottagers' Association in 2003 July and AECL's Emergency Preparedness management met with representatives from Québec ministries 2005 October 11 to 2005 October 12 to tour the NRU Reactor and discuss the NRU planning basis. AECL also sits on the Chalk River Regional Nuclear Emergency Preparedness Committee and is currently working with the group to revise their plans to coincide with a new exclusion zone of 9 km. Information on emergency exercises, testing of the new site siren system as well as reportable events classified as Significance Level 1 or 2 is provided to community stakeholders and the Emergency Management Ontario Duty Officer.

Tours of the site are arranged on a case-by-case basis. AECL is proud of the work done at CRL and has been pleased to host the visit of our Deputy Minister, our MP and MPP for Renfrew-Nipissing-Pembroke, Renfrew County Warden and other Mayors and Reeves. Other members of the federal and provincial governments such as the Environment Critic, Natural Resources Canada Critic, and the Auditor General have also visited CRL. Visits for local contractors and business development officers in Renfrew County and Municipalité régionale de comté du Pontiac have taken place so that contractors understand AECL's expectations in order for them to carry out work for us. Standing invitations are open to all community stakeholders including local and regional public interest groups. Interested members of the public who participated in the public information sessions associated with the environmental assessment for the ongoing operation of the NRU Reactor beyond 2005 December 31, also took part in tours of the reactor in 2005 August. This resulted in positive interventions being made in support of the seven-month extension for operation of the NRU Reactor. AECL also met with an intervener in Municipalité régionale de comté du Pontiac to discuss AECL's environmental monitoring program. A tour of monitoring locations was provided and additional passive air monitors for tritium and C-14 have been installed in Demers Centre. Follow-up communication is planned with the community once monitoring data is retrieved, likely mid-2006. The installation and proposed follow up communication meeting was to the intervener's satisfaction.

Decommissioning and waste remediation projects continue to be a major component of CRL programs. The footprint of CRL is constantly being reviewed in order to reduce costs and environmental impacts. Details of these projects are shared with community stakeholders through activities such as, but not restricted to, letters, briefings, advertisements seeking public comment, brochures, information sessions, and media interviews. AECL is at various stages of executing long-term projects such as the Liquid Waste Transfer and Storage Project, the Fuel Packaging and Storage Project, decommissioning of the Pool Test Reactor and the Building 204 Storage Bays and the Shielded Modular Above Ground Storage Project. Information has been distributed and input sought on all of these projects. Communications are forthcoming on AECL's proposal for managing sewage sludge and on the activities associated with the Comprehensive Preliminary Decommissioning Plan.

In 2006 June, AECL will become a Responsible Authority under the Canadian Environmental Assessment Act and so increased communication is expected. One of the mechanisms that will assist AECL in its distribution of information and in receiving public feedback on matters of mutual interest will be a new Environmental Stewardship Council that will comprise members of AECL as well as interested members of the public and environment-focussed organizations. This new council will discuss all matters associated with site operations, not exclusively those related to decommissioning and waste remediation.

As the second largest employer in the Ottawa Valley, AECL maintains a key relationship with the business and education community. Staff members sit on Boards of Directors for Chambers of Commerce, Physicians' Recruitment, tourist associations, and school co-operative and apprenticeship programs. Employees participate in summer festivals, winter carnivals, and special events such as the annual Renfrew County skilled trades fair "Options", and act as judges at local and Renfrew County Science Fairs. AECL has improved its Speakers' Bureau and requests for presentations to schools and service groups are increasing. Furthermore, AECL continues to support the grade nine program, "Take Your Kid to Work Day", which allows students to grasp a better understanding of the work done at CRL. AECL has completed its 17th year as a major partner with the Deep River Science Academy, by providing opportunities for high school students to obtain science credits by working with researchers on real projects for six weeks each summer. Communities are supportive of AECL, and so AECL is involved in helping the community as well. Support was recently given to citizens who were successful in their efforts to keep local schools open through a letter defining recruitment initiatives and expectations that solid academic programs for current and future employees will be available. CRL employees also provide financially for their communities through annual support of the United Way, which have averaged $78,000 over the past three years. A new display is also being used to promote awareness of AECL in the community and for recruitment purposes.

AECL's community newsletter is being reinstituted and will be available to residents, businesses, and interested members of the public outside the immediate area within the second quarter of 2006. It will feature a note from the Vice-President of AECL Nuclear Laboratories, will profile the work done on site, will provide environmental monitoring results, feature staff and will provide an opportunity for community input with a question and answer section.

AECL's external website continues to improve. Recent changes include the addition of sections on the MAPLE reactors, the NPF, and the importance of medical isotopes and the posting of documents of public interest. Information on decommissioning and waste remediation projects is available and includes details on projects, dates and locations of public information sessions, letters to officials and public interest groups, and contact information. Information is updated as warranted. A new section on Community and Stakeholder Relations is under development and will be added in 2006.

Having supportive media is helpful when it comes to sharing information with the public. Local media are kept informed of activities through informal press conferences, submitted stories, profiles of employees and/or programs and through opportunities to visit the site. For example, editorial board meetings with the Daily Observer have resulted in a number of stories on the economic impact of CRL and the future of nuclear technology and a two-part series on work done at CRL was produced by the New RO (now A-Channel). Radio, print and television contacts are appreciative of the information we share.

A new display featuring AECL's accomplishments and business profile is available to the public at the Petawawa Research Forest Visitors' Centre. Letters of welcome to the Ottawa Valley are included in community Welcome Wagon packages, and new residents have followed up for information. All feature our toll-free number and website address.

Finally, the highlight for AECL's public information program is undoubtedly the successful transfer of Canada's first nuclear reactor, ZEEP, to the Canada Museum of Science and Technology in Ottawa this past October. This was a collaborative effort between AECL and the museum with tremendous care and attention being paid at all times to ensuring public safety. CNSC staff were kept informed throughout the transfer process and provided the necessary approvals.

4.3 Criticality Safety Documents

AECL has successfully addressed nuclear criticality safety from the earliest days of operation of the site. AECL experts participated in the development of methods and standards for criticality safety, and continue to do so. Following the criticality safety event in Japan in 1999, AECL initiated a review of its criticality safety documents by the chair of the ANSI/ANS-8 sub-committee on criticality safety standards. This review confirmed that AECL's practices are generally in line with these standards, and identified a few areas for improvement.

In 2005, CNSC staff requested that AECL commit that our criticality safety analysis be performed in accordance with the applicable ANSI/ANS-8 series of standards, and we have made this commitment. In further discussions, CNSC staff identified additional requirements and expectations that are considered necessary to demonstrate an acceptably low risk for criticality events. These were discussed at several meetings between CNSC and AECL staff, and in 2006 March AECL received a draft CNSC document that clarifies CNSC staff's expectations.

AECL is currently evaluating this information, and we will continue the dialogue with CNSC staff to ensure that our criticality safety program incorporates requirements and expectations from CNSC staff.

4.4 Update of Licensing and Safety Documentation

There are currently 17 licensed nuclear facilities on the CRL site. Of these, 14 are licensed under the CRL site licence and 3 (DIF) are licensed separately. Of the 14 licensed under the site licence and currently listed in Appendix B of the licence, 12 are operating and 2 are permanently shutdown. Of the 12 that are operating 11 are Class I Nuclear Facilities and the Health Physics Neutron Generator) is a Class II Nuclear facility. The two permanently shutdown facilities, the Heavy Water Upgrading Plant and the Combined Electrolysis and Catalytic Exchange Upgrading and Detritiation facility are Class I Nuclear facilities.

4.4.1 Facility Authorization Status

Eight of the Facility Authorizations currently listed in the site licence for the 11 operating Class I Nuclear facilities are dated prior to 2001, that is, prior to the Nuclear Safety and Control Act coming into force, and so need to be updated. Two of these Facility Authorizations have been recently updated and are either pending Facility Authority approval (AECL-FA-6 for the Universal Cells) or are pending CNSC approval (AECL-FA-16 for the Waste Treatment Centre). Plans are in place to revise a further four in 2006 (i.e., Facility Authorizations for the NRU Reactor, for the Recycle Fuel Fabrication Laboratories, for the Tritium Laboratory, and for the NFFF).

The three Facility Authorizations dated after 2001 are for the ZED-2 Reactor, for the MPF, and for the WMAs. The WMAs Facility Authorization has recently been revised and is pending CNSC staff approval.

Facility Authorization for the Health Physics Neutron Generator (AECL-FA-14) is dated prior to 2001.

Facility Authorizations AECL-FA-4 and AECL-FA-20 for the two permanently shutdown facilities are also dated prior to 2001.

4.4.2 Safety Analysis Report Status

Ten of the SARs for the 11 Class I Nuclear facilities are dated prior to 2001. Six have been or are currently being updated. The status of these documents is as follows:

- **Recycle Fuel Fabrication Facility:** Received conditional approval from AECL's Safety Review Committee.
- ***Waste Management Areas:*** Pending Facility Authority approval to issue to Safety Review Committee.
- ***Universal Cells:*** Pending Facility Authority approval to issue to Safety Review Committee.
- ***Fuels and Materials Cells:*** In the internal review process.
- ***NRU:*** In the internal review process.

The SAR for the permanently shutdown facility, Heavy Water Upgrading Plant, has been replaced by Safe Shutdown State Documents.

The SAR for the ZED-2 Reactor has been updated and approved by both the Safety Review Committee and CNSC staff.

4.5 CNSC Staff On-Site Offices

Following the announcement that CNSC staff were intending to establish a permanent office at the CRL site, AECL initiated a project to identify the most suitable location, in consultation with CNSC staff. Regular discussions were held throughout with CNSC staff, and the agreed solution was to relocate some AECL staff from Building 432 (Library) and to refurbish the vacated space in specific accordance with CNSC staff requirements such as space allocation, security, access control and communication. The target date for completion of the refurbished office space is 2006 April.

4.6 References

[4-1] Record of Proceedings, Including Reasons for Adjournment, Financial Guarantee for the Decommissioning of Atomic Energy of Canada Limited's Chalk River Laboratories Site, 2005 July 12.

[4-2] AECL, Framework for a Communications and Public Consultation Plan, *Periodic Updating of the Public on the Comprehensive Preliminary Decommissioning Plan for Chalk River Laboratories*, 3600-07440-PLA-001, Revision 1, 2005 December.

[4-3] G.V. Sotirov, Letter to W.G. Martin, *Supplementary Information in the Matter of the Financial Guarantee for the Decommissioning of AECL's Chalk River Laboratories (CRL) Site*, SPOC-05-026/4161-00521-021-000, 2005 March 18.

[4-4] G.V. Sotirov, Letter to L. Colligan, *AECL's Chalk River Laboratories, Cost Estimate for Decommissioning Liability*, SPOC-05-124/4161-00521-021-000, 2005 December 01.

[4-5] G.V. Sotirov, Letter to L. Colligan, *AECL's Revised Framework for a Communications and Public Consultation Plan on the Comprehensive Preliminary Decommissioning Plan for Chalk River Laboratories*, SPOC-05-136/4161-00521-021-000, 2005 December 21.

[4-6] G.V. Sotirov, Letter to G. Lamarre, *CRL Licence NRTEOL-01.03/2006 (Condition 12.1), MAPLE Reactors 1 and 2 Licence NPROL-62.002007 (Condition 11.1) and New Processing Facility Licence NSPFOL-03.00/2007 (Condition 10.1)*, SPOC-06-017/ 4161-00521-021-000, 2006 February 24.

[4-7] G.V. Sotirov, Letter to L. Colligan, *AECL's Chalk River Laboratories, Five-Year Operational Implementation Plan*, SPOC-06-018/4161-00521-021-000, 2006 February 28.

[4-8] AECL, *Comprehensive Preliminary Decommissioning Plan for AECL's Chalk River Laboratories*, CPDP-01600-PDP-002, Revision 1, 2006 February.

[4-9] AECL, *Basis of the Cost Estimate for the Chalk River Laboratories Decommissioning Liability*, 3611-01512-AB-001, Revision 0, 2005 November.

[4-10] AECL, *Strategic Initiatives Document, Federal Nuclear Legacy Liabilities Management Plan, Conceptual Long-Term Technical Strategy for the Management of Nuclear Legacy Liabilities at AECL Sites: Five Year Operational Implementation Plan – Chalk River Laboratories*, 3600-01620-067-003, Revision 0, 2006 February.

[4-11] AECL, *Disclosure*, Policy 00-008, Revision 0, 2003 September.

CHAPTER 5 CANADIAN ENVIRONMENTAL ASSESSMENT ACT

On 2006 June 12, Crown Corporations as defined in Subsection 83(1) of the Financial Administration Act will become Federal Authorities under the Canadian Environmental Assessment Act (the Act) and will be subject to the requirements of the Act. AECL as a Crown Corporation, will be responsible for the conduct of environmental assessments for projects where it is a) the proponent of a project; b) provides financial assistance to enable a project to be carried out; and c) provides lands to enable a project to be carried out.

Pursuant to Section 8(3) of the Act, the CNSC will continue to be responsible for the conduct of the Environmental Assessments for CRL projects requiring CNSC regulatory approval under Section 5(1)(d) of the Act. In other words, the CNSC will continue to be responsible for the conduct of Environmental Assessments for modifications to operating or permanently shutdown nuclear facilities listed in Appendices B and C of the CRL licence requiring regulatory approval and/or construction/operation of new nuclear facilities.

Projects for which AECL would be responsible for the Environmental Assessment Process under Canadian Environmental Assessment Act would be infrastructure projects for facilities not listed under the CRL site licence such as construction of new administration buildings, parking lot expansions, construction of fences and decommissioning of facilities not listed under the site licence. AECL currently performs Environmental Evaluations of such projects in accordance with Environmental Protection Program Requirements.

As a Federal Authority, AECL will also be subject to the requirements of the Federal Co-ordination Regulations. Under these regulations, AECL may be required to make available specialist information or provide expert reviews for Environmental Assessments undertaken by other Federal Authorities.

CHAPTER 6 CONCLUSION

This document has summarized CRL's performance during the present licence period, and in particular has described the progress made in areas of concern identified previously by the Commission, CNSC staff, AECL, and members of the public. Excellent progress has been made in all areas, though of course, additional improvements remain ongoing. This document has also described the major initiatives and activities for the proposed licence period.

AECL believes that it has satisfactorily addressed the concerns of the Commission regarding the Comprehensive Preliminary Decommissioning Plan, the cost basis for the plan and the related public consultation framework. We have also developed and submitted a more detailed plan for the first five years of the overall decommissioning program.

This document contains substantial information to demonstrate that continued operation of the NRU Reactor is safe and will continue to be safe throughout the proposed licence period, and beyond. AECL is committed to meeting the criteria established by CNSC staff for continued operation of NRU.

AECL is convinced that the key criteria in CMD 02-M12 for a longer licence period have been met:

- The proposed period is commensurate with the duration of the licensed activity and the planning cycle of the site, in that operation of the major facilities at CRL is planned to continue throughout the proposed licence period.
- The hazards associated with the licensed facility are well characterized, and their impacts are well predicted and are within the scope considered in the various safety and environmental assessments that have been performed.
- CNSC staff has accepted AECL's overall quality assurance program, and the quality assurance program for the Nuclear Laboratories has been updated to address CNSC staff concerns.
- Effective compliance programs are in place.
- Information contained in this document demonstrates a good history of operating experience and compliance in carrying out the licensed activity. Where deficiencies have existed, action plans have been developed, submitted to CNSC staff, and are being implemented.

In conclusion, AECL believes that the performance of CRL and the activities planned for the proposed licence period supports our application for a 63-month licence period for the CRL site.

CHAPTER 7 ACRONYMS

AECL	Atomic Energy of Canada Limited
AMP	Aging Management Program
ALARA	As Low As Reasonably Achievable, economic and social factors being taken into account.
CANDU	CANada Deuterium Uranium, registered trademark of AECL.
CAR	Control Absorber Rod(s)
CNSC	Canadian Nuclear Safety Commission
COPEC	Contaminants of Potential Environmental Concern
CRL	Chalk River Laboratories
DIF	Dedicated Isotope Facility
DRL	Derived Release Limits
EER	Ecological Effects Review
FHA	Fire Hazard Assessment
FISST	Fissile Solution Storage Tank
IAEA	International Atomic Energy Agency
LE	Licensability Extension
LWTS	Liquid Waste Transfer and Storage Project
MAGS	Modular Above Ground Storage
MISA	Ontario Ministry of the Environment’s Municipal Industrial Strategy for Abatement Program
MMIR	MDS Nordion Medical Isotopes Reactor Project
MPF	Mo-99 Production Facility
NECC	New Emergency Core Cooling (System)
NFFF	Nuclear Fuel Fabrication Facility
NPF	New Processing Facility

NRTEOL	Nuclear Research and Test Establishment Operating Licence
NRU	National Research Universal (Reactor)
NRX	National Research Experiment (Reactor)
OCM	Operational Control Monitoring
OPEX	Operating Experience
OSH	Occupational Safety & Health
PLiM	Plant Life Management
PSA	Probabilistic Safety Assessment
PSD	Permanently Shutdown
SAR	Safety Analysis Report
SMAGS	Shielded Modular Above Ground Storage
TSSA	Technical Standards and Safety Authority
WHMIS	Workplace Hazardous Materials Information System
WMA	Waste Management Areas
ZEEP	Zero Energy Experimental Pile (Reactor)

CHAPTER 8 APPENDICES

Appendix A: NRU Operating Performance
Appendix B: NRU Improvement Initiative Program
Appendix C: Continued Operation of NRU
Appendix D: Ecological Effects Review – Recommendations and Status
Appendix E: Fire Prevention Program Implementation Plan

Appendix A: NRU Operating Performance

A1 Operational Performance

Throughout the operational history of the NRU Reactor, AECL has adopted measures to ensure that the highest level of safety is maintained, and that all applicable regulatory requirements are met. The NRU Reactor has operated safely and reliably for over 48 years. As is evident in the NRU Reactor Annual Safety Reviews, performance of NRU has been safe and its design has proven to be robust. An improvement in facility performance has been demonstrated over the last 10 years, as presented in this appendix. To summarize:

- Protective and regulating systems have operated satisfactorily with the number of reactor trips, both planned and unplanned, showing a steadily reducing trend from five years ago.
- Event reporting has increased dramatically over the past few years due to expanded reporting criteria. An upward trend in the number of reportable events has resulted in a proactive initiative to address the issues via the NRU Improvement Initiative (Appendix B).
- The number of serious process fault trips and fires averaged less than one per year.
- Radioactive liquid and airborne releases were well below applicable DRLs.
- The reactor has maintained a consistent operating availability meeting customer demands for neutrons.

There has been no occurrence of an employee receiving a dose exceeding the action level in this period.

A2 Routine Operation

The NRU Reactor continues to operate as a neutron source for experimental and research programs and isotope production. Fuelling at high power continued and shutdowns were scheduled as required to service the experimental facilities and reactor equipment, to conduct maintenance, and to perform NRU upgrades work. Typically shutdowns were scheduled after three to four weeks of operation and shutdowns were scheduled at less than five days duration to ensure continued reliable supply of short half-life isotopes.

NRU Operations has effectively managed aging and obsolescence of the systems and components from its inception, and this has been demonstrated by consistently high availability[6] for a research reactor facility. Reactor availability has averaged 79% in the past five years and more than 70% throughout its lifetime (see Table A1 and Figure A1). During this period the seven major upgrades were tied in and commissioned without incident.

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[6] Availability is defined as yearly operating hours divided by hours in one year (8,760).

A3 Reactor Protective and Regulating Systems

The reactor protective and regulating systems are robust and reliable. There is an extensive number of reactor and experimental trip units that monitor system performance and ensure the reactor and experimental facilities operations are maintained within their safety limits. Over the life of NRU the reactor protective and regulating systems have operated satisfactorily, shutting down the reactor in all cases when called upon to do so. There have been no instances of control rod absorbers failing to drop into the reactor on demand, or of a trip failing to actuate when required.

Over the years, upgrades to the reactor protective and trip systems have been performed to deal with equipment obsolescence issues and to improve system reliability. The number of reactor trips per year (automatic shutdown of the reactor) has shown a reducing trend over the levels seen in the late 1990s.

In 1997 the Second Trip System was added to provide redundancy to the First Trip System. The Second Trip System also provides additional reactor trip parameters for seismic events, Class 4 power failures and major process water breaks.

The number of reactor shutdowns, both planned and unplanned, generally shows a steady decrease. The increase in total shutdowns in 2005 was attributed to additional shutdowns necessary to support isotope supply demands. The frequency of unplanned shutdowns has remained low over the past six years (see Table A2 and Figure A2).

A4 Unplanned Events

All staff are encouraged to report all abnormal events via the OPEX Program. Due to expanded reporting of events, NRU is reporting considerably more events via the Event Notification Form than previously. As a result, the number of unplanned events reported to AECL management from NRU has increased recently as shown in Table A3. This strong reporting culture ensures all events, regardless of their safety significance, are investigated and reviewed with AECL staff. Aside from the individual event investigation, all events are reviewed annually for trends. Corrective actions are implemented where adverse trends exist.

The number of serious process faults remains low.

An increase in reportable events versus an average of three per year over the last ten years was noted in 2004 and 2005. These events were reported to CNSC staff and have been analyzed using a detailed root cause investigation process. AECL, in response to this trend instigated a peer review of the facility operation and have instigated numerous improvement initiatives and event free tools (see Appendix B) to help avoid recurrences of these types of events.

A5 Class 4 Electrical Power Failures

The electrical supply to NRU has experienced, on average, slightly more than five power failures per year over the past ten years (see Table A4). The numbers of failures are dependant primarily on weather conditions and typically are of short duration. Power bumps are not classified as power failures even if they cause a reactor trip, because the standby emergency power is not required and normal power is available for operating essential equipment.

The NRU emergency power systems consists of two reactor diesel generators and two loop diesel generators. In recent years the Emergency Power Supply upgrade has been added to increase electrical system reliability and provide power to the NRU upgrades. The Emergency Power Supply is a hazards qualified system, which includes two independent divisions of power supply each supported by a diesel generator and battery banks. The power supply systems diesel (six units) performance has shown good reliability over the past seven years (see Table A5).

A6 Personnel Safety

Safety is a priority and a commitment at AECL and NRU. The NRU Reactor industrial and radiation safety performance has been good over the years with only a few (minor) lost-time accidents reported and no radiation doses above the administrative limits (see Table A6).

A6.1 Industrial Safety

The NRU facility is compliant with the OSH Program requirements. The NRU facility has implemented many programs over the years to improve employee safety. These include Workplace Hazardous Materials Identification Sheets, Lock Out Tag Out, confined space entry, fall arrest protection, Personal Alarming Dosimeters, safety culture training and event free tools.

The frequency and severity of lost time injuries has been low over the past few years.

While the incidence of fires has been historically low, a fire hazards assessment has recommended several improvements, which are being followed up for implementation. Corrective actions resulting from the CNSC’s audit of the CRL fire protection program are also being implemented (see Appendix E).

Good housekeeping practices are a key part of improved fire protection performance, and have been included as part of the NRU Improvement Initiative described in Appendix B. In a recent field visit, CNSC staff commended AECL on the excellent progress made towards these housekeeping improvements.

A6.2 Radiation Safety

AECL is committed to the As Low As Reasonably Achievable (ALARA) principle with regard to radioactive dose and environmental issues.

There have been no recent incidents of external radiation exposure or internal contamination that exceeded Action Levels or Regulatory Limits. All annual whole-body radiation exposures were below the Action Level of 20 mSv (see Table A7).

The average annual radiation doses show a steady decrease over several years, and then an increase in 2004 and 2005 (see Figure A3). The increase is due mainly to increased workload associated with the Plant Life Management (PliM) and Licensability Extension (LE) programs. In addition, the gamma dose equivalent has increased by 10% since 2004 compared to previous assessments due to a change in the thermoluminescent dosimeter reader calibration factor. Doses reported for years prior to 2004 have not been adjusted.

All personnel are required to wear thermoluminescent personal dosimeters. Facility personnel also wear personal alarming dosimeters that provide real-time measurement of dose rate and daily and four-week dose levels. Preset alarm points for these three parameters assist in providing indication of abnormal radiological conditions. Extremity thermoluminescent dosimeters were used, as required, to measure doses to the tissues of the hands, forearms, feet, and ankles.

A7 Liquid and Airborne Effluents

AECL's monitoring programs are well established and regularly verify both radioactive and non-radioactive liquid and airborne effluents. During 2004, the CRL site became certified under ISO-14001:1996. The certification process used by the third-party auditor included NRU.

As part of AECL's commitment to protecting the environment and in compliance with ISO 14001 Environmental Management System principles, actions are continuously taken to find ways to further reduce or eliminate our emissions (e.g., the completed Ar-41 Emissions ALARA Study in 2004).

Radioactive releases remain well below the DRLs and regulatory Action Levels for CRL. Consequently, doses received by members of the public due to radioactivity releases from the CRL site, including those directly resulting from NRU operations, remain at a small fraction of the public dose limit of 1 mSv/year.

The CNSC has completed an Environmental Screening report on NRU, taking into account the *Ecological Effects Review of Chalk River Laboratories* [A-1]. The scope of the EER included all current and historical releases from the site. The EER concluded that the established compliance monitoring program controls provide:

- reasonable protection of the environment;
- radioactive wastes are appropriately managed; and,
- that the effects of habitat manipulation at CRL are likely to be minor and comparable to the effects of similar activities throughout the region.

In announcing its decision following the Environmental Assessment Screening Hearing in 2005 July, the Commission noted that extending operation of NRU "is not likely to cause significant adverse environmental effects".

A7.1 Liquid Effluents

The average monthly tritium, Na-24, As-76 and P-32 releases from the process drain are shown to be well below the applicable DRLs and Action Levels (see Table A8).

Activities continue to increase monitoring and to locate the source of elevated levels of groundwater contamination (tritium) discovered in the groundwater downgradient from NRU. Recent significant reductions in the levels close to NRU give guarded optimism that the work to isolate any leak has been successful, but due to the slow diffusion rate it may take up to two years before more definite conclusions can be reached. An action plan has been developed to monitor systems and investigate potential leak sources.

A7.2 Airborne Effluents

The airborne releases through the reactor stack and NRU building vents are shown in Tables A9 and A10, along with the applicable DRL and Action Level. All releases, including Ar-41, are below the applicable DRL and Action Level.

A8 Licence Conditions

- ***Nuclear Materials Control:*** The handling and storage of nuclear materials within the NRU facility has been performed in accordance with all Nuclear Materials Management [A-2] and Radioactive Materials Transportation Program [A-3] requirements. The NRU Operations group successfully met the quantity and timeliness goals according to IAEA Safeguards Criteria, thereby meeting full Goal Attainment. The NRU facility has also complied with Physical Security Program requirements.
- ***Training:*** The NRU Operations group has recently completed a comprehensive update of the Operator training program to meet the *AECL Systematic Approach to Training* [A-4] guidelines. Training manuals, On Job Training/Field Checkout procedures and classroom training materials have been developed as required. The Operator training program implementation is progressing well, with 24 trainees completing various levels of formalized training towards qualification as a nuclear operator.

  The development of the Senior Reactor Shift Engineer training material to meet the Systematic Approach to Training guidelines is progressing. This formalized training program will form the basis for the certification of Senior Reactor Shift Engineer personnel.
- ***Upgrades:*** Installation of seven safety upgrades to the NRU Reactor was identified as a separate condition in the 1998 CRL site licence. All seven upgrades are now fully operational and, except for the New Emergency Core Cooling (NECC) and Emergency Power Supply systems, have been declared in service. A letter defining “fully operational” was submitted and accepted by CNSC staff.
- ***Periodic Inspection Program:*** A set of Periodic Inspection Program documents have been developed comprising an Overview Periodic Inspection Program and individual Periodic Inspection Plans for the loops and heavy-water piping, pressure vessels, etc. per the requirements of CAN CSA 295-4. The Heavy Water Periodic Inspection Program has been issued for approval after incorporating CNSC staff comments. The Overview Program, U-1 and U-2 Periodic Inspection Program documents are in various stages of review and approval. The U-1 and U-2 loop documents supplement the Pressure Tube Periodic Inspection Program documents already in use.

A significant portion of the Main Heavy Water System inspections have been completed, and is on schedule for completing the first cycle of inspections during 2006. As agreed with CNSC staff, inspection results will be reported annually. The summary report for 2005 has been issued to CNSC staff.

- ***Emergency Preparedness:*** the NRU facility emergency preparedness response and readiness meet the requirements of the Emergency Preparedness Program. Emergency response plans are tested regularly and include the NRU staff participation in radiological emergency exercises, fire drills and site-wide emergency evacuation drills. Availability of emergency system and equipment is confirmed through the facility surveillance-testing program.
- ***Overpressure Protection:*** AECL is preparing an overpressure protection report for NRU. Previous assessment and operating experience has demonstrated that overpressure protection is effective for normal and upset transients. AECL is reviewing the faulted conditions for the reactor vessel and when this work is completed, the overpressure report will be issued and submitted to CNSC staff for acceptance. This work will be explicitly identified in the action plan to be submitted by 2006 June on the NRU Pressure Boundary issues.
- ***Codes and Standards:*** As part of the on-going discussion with CNSC staff on pressure boundary matters, AECL is establishing the classification for all the major systems in NRU. Once this is completed, AECL will propose a process to have the classification approved by CNSC staff, to be followed by registration of the critical structures, systems and components with the Technical Standards and Safety Authority (TSSA). The schedule and milestones of the process will be provided as part of the action plan related to NRU pressure boundary activities.

A9: Reference

[A-1] EcoMetrix Incorporated, *Ecological Effects Review of Chalk River Laboratories,* 04-1178, 2005 January.

[A-2] AECL, *Nuclear Materials and Safeguards Management Compliance Program Manual*, 9100-01900-MAN-001, Revision 0, 2005 April.

[A-3] AECL, *Radioactive Materials (RAM) Transportation Compliance Program*, 9200-01900-MAN-001, Revision 0, 2004 July.

[A-4] AECL, *AECL Systematic Approach to Training (SAT)*, CW-510000-MAN-001, Revision 1, 2005 June.

Table A1: Summary of NRU Reactor Operating Performance

Parameter	Year									
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Operating Time (h)	6913	6461	6845	6584	6829	6837	6913	7037	7095	6603
Power Production (MWd)	34800	32178	33553	32305	33329	31582	32807	30861	30514	29287

Table A2: Summary of NRU Reactor Trips and Shutdowns

Parameter	Year									
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Number of Trips	24	33	20	32	15	14	17	21	18	21
Number of Shutdowns	48	65	47	40	36	32	31	29	28	42
Planned	39	58	36	32	32	29	27	25	26	39
Unplanned	9	7	11	8	4	3	4	4	2	3

Table A3: Unplanned Events

Parameter	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number of Unplanned Events	10	29	43	58	33	46	44	62	73	113
Number of Reportable Events	2	3	10	4	4	3	2	1	5	4
Number of Serious Process Fault Trips	0	2	0	0	1	1	1	0	1	0

Table A4: Class 4 Power Supply Failures

Parameter	Year									
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Off-Site Failures	2	6	10	8	4	3	6	9	2	4
On-Site Failures	1	0	2	0	0	0	0	0	0	0
Total Failures	3	6	12	8	4	3	6	9	2	4

Table A5: Diesel Power Supply Performance

Parameter	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Demands	100	81	76	105	109	94	75	97	107	80	100
Total Failures on Demand	3	1	2	4	1	0	1	1	0	0	0

Table A6: Industrial Safety Incidents

Parameters	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number of Fires	0	0	1	1	0	1	0	1	0	0
Number of Lost-Time Accidents	6	4	9	7	1	1	4	6	2	1

Table A7: Average Individual Doses

Average Individual Doses (mSv)	Year									
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Whole-Body	8.7	8.3	7.4	7.1	7.4	6.9	5.9	5.7	7.6	6.7
Surface Doses to NRU Operations Personnel	8.9	8.4	7.7	7.4	7.6	7.2	7.1	5.9	7.7	7.2
Tritium Doses to NRU Operations Personnel	1.39	1.25	1.15	0.97	1.06	1.16	1.35	1.24	1.63	1.69
Whole-Body Doses to NRU Maintenance Personnel	5	4.6	4.5	4.7	4	2.9	2.8	2.9	3.4	3.2
Surface Doses to NRU Maintenance Personnel	5.3	4.8	4.6	5	4.2	3.2	3.0	3.1	3.7	3.6
Tritium Doses to NRU Maintenance Personnel	0.67	0.68	0.65	0.68	0.47	0.49	0.57	0.48	0.59	0.64

Table A8: Liquid Effluents

Parameters	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Derived Release Limits**	**Action Levels**
Tritium (TBq)	3.5	7.3	8.89	2.1	2.9	2.33	3.55	11	3.83	1.85	13,3000	20,000
Sodium-24 (TBq)	0.19	0.09	0.139	0.084	0.007	0.037	0.006	0.02	0.06	0.12	969	145
Arsenic-76 (GBq)	5	8	8	4.5	0.86	0.77	0.76	2.5	2.02	1.23	147,000	22,100
Phosphorus-32 (GBq)	2	3	1	0.36	0.37	0.56	0.18	0.23	0.51	0.54	485	72.8

Table A9: Airborne Effluents for Reactor Stack

Parameters	Year (Weekly Average)											
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Derived Release Limits**	**Action Levels**
Argon-41 (PBq)	0.44	0.37	0.36	0.41	0.38	0.24	0.38	0.23	0.32	-	2.93	1.47
Iodine-125 (GBq)	0.021	0.028	0.019	0.003	0.002	0.002	0.003	0.004	0.002	0.0181	136	20.4
Iodine-131 (GBq)	0.06	0.11	0.056	0.031	0.009	0.004	0.013	0.009	0.061	0.0257	181	27.2
Particulate Alpha (MBq)	0.003	0.003	0.003	0.002	0.001	0.001	0.001	9E-04	9E-04	9E-04	7270	1090
Particulate Beta (MBq)	0.48	1.7	2.7	7.8	3.2	2.58	3.3	2.02	2.61	2.21	107000	16100
Carbon-14 (TBq)		0.012	0.013	0.016	0.015	0.009	0.007	0.013	0.019	0.0686	38.1	5.72
Tritium (TBq)	1.5	1.4	2.2	2.2	2.1	0.915	0.953	2.05	2.55	2.74	6100	915

Table A10: Airborne Effluents for NRU Building Vents

Parameters	Year (Weekly Average)											
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**Derived Release Limits**	**Action Levels**
Iodine-125 (GBq)	0.002	0.006	0.002	1E-04	0.001	5E-04	4E-04	4E-04	3E-04	0.02	136	20.4
Iodine-131 (GBq)	0.002	0.001	0.002	0.001	5E-04	5E-04	7E-04	7E-04	0.002	0.001	181	27.2
Particulate Alpha (MBq)	-	1E-04	1E-04	9E-05	9E-05	9E-05	9E-05	7E-05	7E-05	7E-05	7,270	1,090
Particulate Beta (MBq)	-	0.004	0.004	0.005	0.002	0.004	0.003	0.003	0.004	0.004	107,000	16,100
Tritium (TBq)	1.7	1.8	1.47	1.9	1.8	2.07	2.63	2.78	3.12	3.31	6,100	915

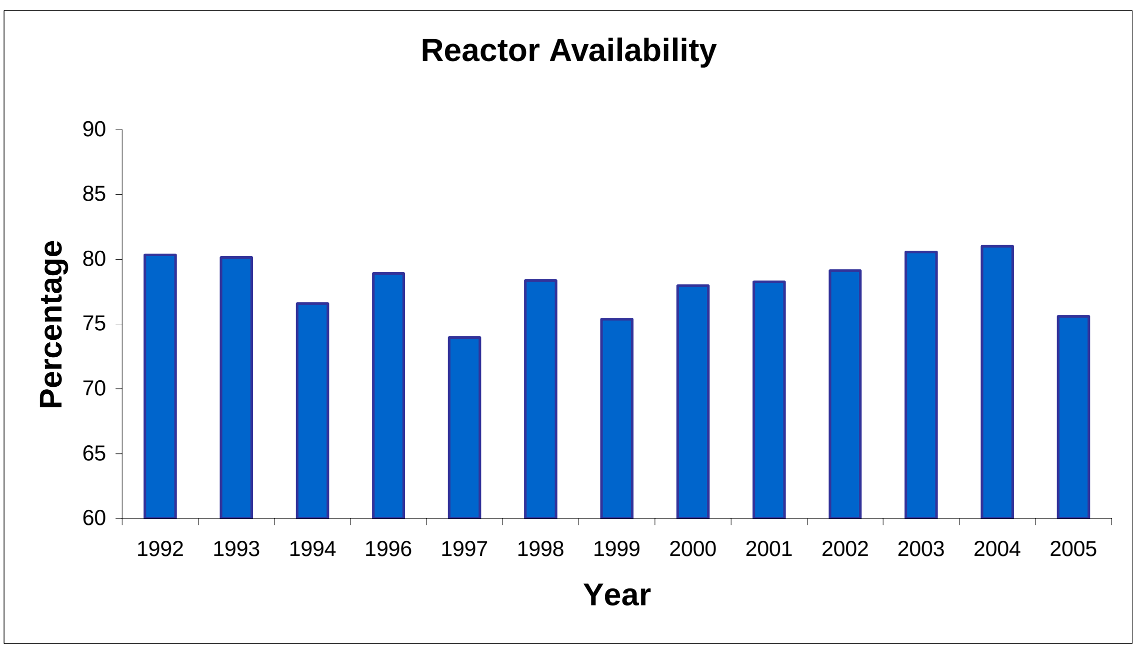

Figure A1: NRU Availability Trend

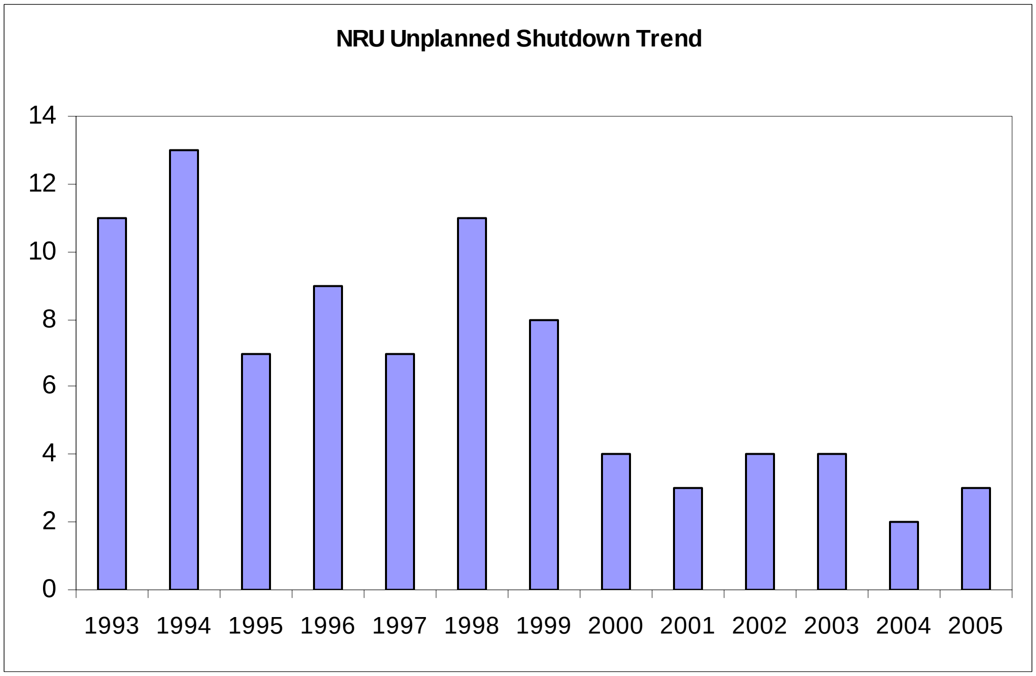

Figure A2: NRU Unplanned Shutdown Trend

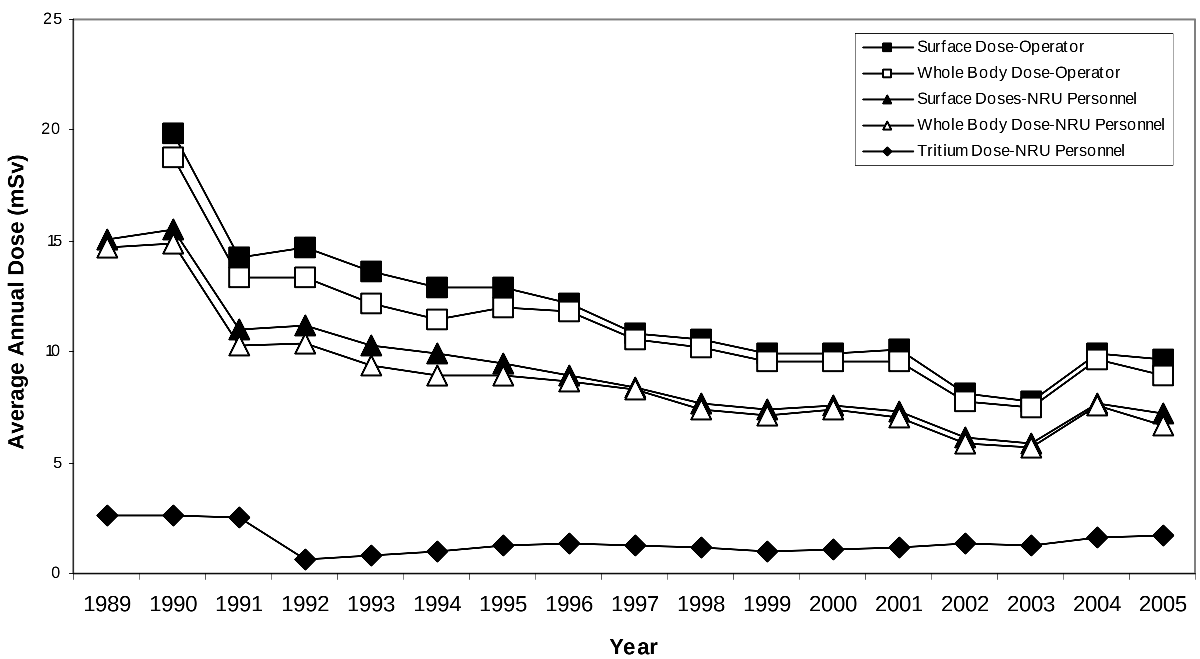

Figure A3: Average Annual Radiation Doses to NRU Personnel

Appendix B: NRU Improvement Initiative Program

B1 NRU Workforce Study

Program Introduction

The NRU Improvement Initiative Program objective is to achieve rapid implementation of short-term measures that will improve safety at NRU, and ensure that both short-term and long-term improvements are sustainable. Part of the objective is to achieve industry best practices in operations and maintenance within three years, while continuing to operate NRU safely and delivering products and services, including isotopes, to NRU clients.

The scope of the program covers the areas for improvement identified by an industry peer review team that conducted an extensive review of NRU operations and maintenance in 2005:

- ***Human Performance*****:** Improve human performance improvement through application of error reduction tools such as procedure adherence, pre-job briefings, self-checking, and three-way communications.
- ***Operational Decision Making:*** Apply defence in-depth in operational decision-making processes.
- ***Plant Status Control:*** Improve methods of tracking the status of plant systems and equipment.
- ***Housekeeping:*** Establish formal housekeeping standards and implement.
- ***Learning Organization:*** Applying the knowledge gained in the rest of the industry regarding methods for improving performance and sustaining that improvement.
- ***Foreign Material Exclusion:*** Implement procedures for avoiding inadvertent introduction of foreign material into the reactor and other plant systems.
- ***Conduct of Maintenance:*** Improve maintenance processes and practices to the level of industry standards.
- ***Management Effectiveness:*** Improved corporate oversight of the facility as well as facility management establishing high standards and holding staff accountable.

The short-term activities cover the following:

- raise staff awareness and provide a sense of urgency for change;
- improve facility condition by raising standards of housekeeping and at the same time reducing fire hazards;
- implement event free tools with focus on self-checking, verification, and pre-job briefing;
- provide more day-to-day management safety oversight;
- improve management effectiveness; and
- provide adequate resources.

These activities are intended to achieve immediate improvements, and to reduce the nuclear safety risk of operation.

The long-term activities cover the following:

- improve skills/work methods,
- improve processes,
- improve NRU status control,
- improve NRU facility condition, and
- improve support to NRU.

The frequency and severity of events are expected to decline as a result of implementing this program. The long-term actions are also intended to increase NRU nuclear safety performance to the standards of Canadian utilities.

The schedule takes into account experience from previous similar improvement programs at other facilities. This experience indicates that being overly aggressive in implementing process improvements at operating facilities carries a high risk of program failure, and loss of credibility with staff at the facility. Therefore, the schedule must recognize the need for expeditious improvements while at the same time being realistic in terms of the pace of change in an operating facility.

Several methods are used to ensure that the NRU Improvement Initiative meets its objectives. The measures include the following:

- Detailed activity plans to track and verify the effectiveness of each of the major improvement activities as they are completed.
- The Observation and Coaching Program is used for observing and reinforcing correct behaviours. The use of event free tools, accountability for meeting commitments, and discipline in work permit preparation, are examples of areas that are well suited to this tool.
- Initial benchmarking of Canadian nuclear utilities.
- Use of industry experts with knowledge and experience from Canadian utilities.
- A follow-up industry peer review will be conducted at an appropriate point in the implementation of the overall program.

The OPEX Program will periodically review NRU events to assess performance trends and compare against causes of previous events.

Status of Program

1. Raise staff awareness:
   - Communication plan prepared.
   - Program objectives presented to NRU staff, CRL Site Management Team, all CRL staff, CRL based unions and oversight committees including the Safety Review Committee and the Research and Development Advisory Panel.
   - Ongoing updates provided to NRU staff.
   - Communication tools prepared to assist use of industry methods.

2. Improve facility condition by raising standards of housekeeping and at the same time reducing fire hazards:
   - Housekeeping standard issued, staff awareness training provided.
   - Housekeeping improvements to bring the facility up to standard well underway, improving facility condition, reducing fire-load and improving equipment and material storage.
   - Further housekeeping improvements are planned as part of Phase 2, continuing throughout 2006.

3. Implement event free tools**:**
   - Three expectation documents were released for use completing the Phase 1 Event Free Tools documentation:
     - self-checking (NRU-508220-STD-001),
     - verification (NRU-508220-STD-002), and
     - pre-job briefing (NRU-508220-STD-004).
   - Three awareness training packages are being delivered to NRU staff, completing Phase 1 Event Free Tool training:
     - self-checking (NRU-508220-STD-001-MLD-01),
     - verification (NRU-508220-STD-002-MLD-01), and
     - pre-job Briefing (NRU-508220-STD-004-MLD-01).
   - The initial rollout of training to NRU staff on these first three event free tools has been completed with refresher courses and make-up courses planned.
   - The Conservative Decision Making training as covered in the Safety Culture Course has been completed as planned.
   - Training in Observation and Coaching provided to over 40 managers and first line supervisors. Observation and Coaching is in use to verify the correct use of event free tools.

4. Provide more day-to-day management safety oversight:
   - The new Facility Restart Policy, NRU-514210-PRO-002, was issued for use and all Senior Reactor Shift Engineers trained in the new policy.
   - The new Operating Decision Making Process, NRU-514210-PRO-001, was released for use and has been applied to recent operating decisions.
   - This completes the work under this activity.

5. Improve management effectiveness:
   - NRU Organizational Review and Implementation Stage 1 Recommendation of Revised NRU Management Structure and Responsibilities (NRU-510100-PLA-002) released.
   - A daily operations meeting is held by conference call involving the lead operating staff, line management and site support and service groups to review performance and secure required support to resolve any emerging issues. Key initiatives affecting operations are scheduled for status review at the daily operations meeting.

6. Provide adequate resources.
   - Staff levels have increased from 118 to 142, including 15 new professionals, 8 operators and 1 technician.
   - Staffing activity for Maintenance Engineering and Planning in support of NRU improvement initiatives include 2 Engineers, 5 Assessors, 5 Planners and 3 Specialists. Four positions have been filled, six job offers have been made and accepted and recruiting for the remaining four vacancies is underway.
   - The NRU Workforce study continues. All 23 interviews with shift-staff are complete and the draft report released to AECL management for review and comment. The 31 day-staff interviews are underway and the draft report will be released to AECL Management for review and comment by end of March. The 19 interviews planned for the maintenance staff began in mid-March and the draft report will be issued for internal review and comment by mid-April. Final reports for these three stages are targeted by the end of 2006 May.

7. Improve skills/work methods:
   - Phase 2 of the event free tools is now being deployed.
   - Conservative Decision Making (NRU-508200-STD-003) was released for use.
   - Conservative Decision Making training package (NRU-508220-STD-003-MLD-01) was released for use and is being piloted.
   - Expectation documents are in review and comment stage for the following: Verbal Communication, Procedural Compliance and Safe Practice, Infrequently Performed Tasks and Evolutions, and Observation and Coaching.
   - Work continues on the review and rewrite of the 324 maintenance procedures.

8. Improve processes:
    - The Foreign Material Exclusion practice used at the utilities was reviewed and an expectation document for NRU is being drafted.
    - An improved process for managing regulatory commitments and correspondence is under development in conjunction with DIF.

9. Improve NRU facility condition:
    - Work to clean up the rod bays continues.
    - The new storage building has been designed, with construction planned for the spring.
    - Work continues at the 300-elevation and 500-elevation for housekeeping and fire-load reduction.

10. Concluding Remarks

Phase 1 of the Improvement Plan has been completed with all of the short-term tools and standards prepared and implemented. At the end of 2006 March, 64 CNSC commitments have been met, including 4 commitments ahead of schedule (as shown in Figure B1). One activity due in March will be completed in early April. The commitment dates for two activities (hiring the new Management Team and implementation of the new Infrequently Performed Tasks and Evolution procedure) have been extended. All remaining activities have been assigned a lead manager with 27 of the 31 remaining activities in progress.

The most noticeable change in NRU is the implementation of the new housekeeping standard and the resulting improvement in facility condition and reduction of fire-load. Significant gains have been made in raising staff complement with 24 new staff joining NRU over the last year. Phase 1 event free tools are in active use throughout NRU with training on the remaining tools either underway or planned. NRU supervisors are applying Observation and Coaching methods to verify use of the event free tools and to monitor work performance. Safety oversight is enhanced through the use of Operational Decision Making and Reactor Restart Policies. Line management and the support groups are actively involved in NRU Operations through the Daily Operations Meeting.

NRU Improvement Plan
Report Date
31-Mar-06

CNSC Commitments

Activities	Number	Due	Finished	In Progress	Not Started	Late
1.Communication – create awareness	4	4	4	0	0	0
2.Housekeeping and Fire Load Reduction	21	20	20	1	0	0
3.Implement Event Free Tools	11	8	11	0	0	0
4.Improve Management Oversight of Safety	4	4	4	0	0	0
5.Improve Management Effectiveness	5	5	5	0	0	0
6.Resolve Resource Issues	15	13	13	2	0	0
7.Improve Skill and Work Methods	14	4	4	10	0	0
8.Process Improvement	9	1	1	8	0	1
9.Improve NRU Status Control	5	0	0	2	3	0
10.Improve Facility Condition	5	1	1	3	1	0
11.AECL Support to NRU	2	1	1	1	0	0
Total	95	61	64	27	4	1

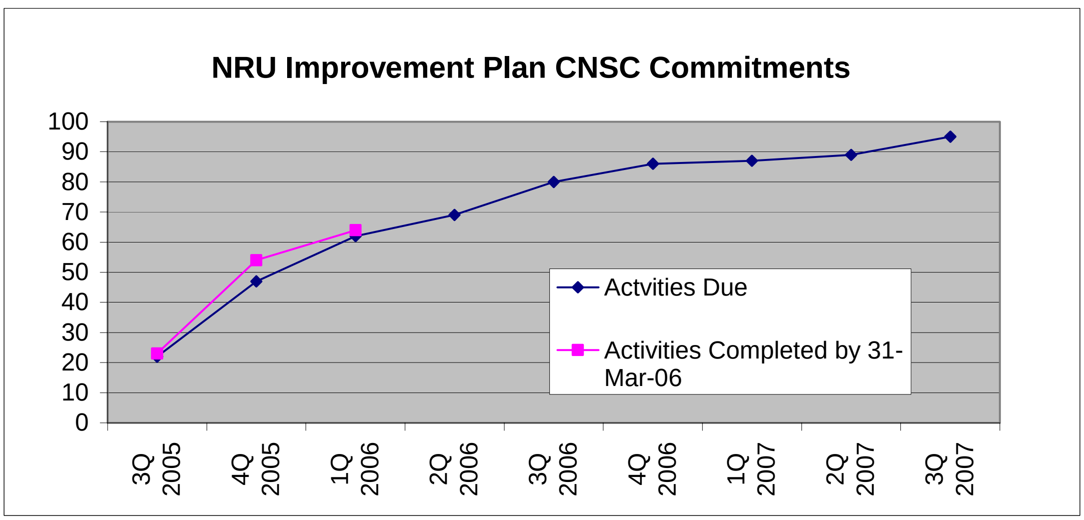

Figure B.1: NRU Improvement Plan Implementation Curve

Appendix C: Continued Operation of NRU

C1 PURPOSE

This appendix provides support for continued operation of the NRU Reactor beyond 2006 July 31.

AECL's first priority for NRU is to operate safely. This commitment is being implemented through two main initiatives:

- ***NRU LE Program:*** the objectives of the program are to demonstrate that the reactor will continue to operate safely, reliably, and in compliance with appropriate regulatory requirements, to identify corrective actions and implement necessary improvements. The NRU LE program provides assurance of the safety and reliability of the facility.
- ***NRU Improvement Initiative:*** this initiative will strengthen operating and maintenance processes and procedures, the operating organization and the supporting management infrastructure. This provides additional assurance that the resources, skills and executive oversight exist to align NRU operations and maintenance with industry best practices, and sustain the process.

This appendix summarizes the status of the NRU LE program and also presents an overview of reactor safety on NRU (see Section C4). Details of the NRU Improvement Initiative Program are discussed in Appendix B of this submission. CNSC staff have prepared a Regulatory Plan [C-1] for continued operation of NRU. AECL's commitment to address the CNSC Regulatory Plan is discussed in Section C5. The long-term future of NRU is discussed in Section C6.

C2 BACKGROUND

C2.1 NRU Design

The NRU Reactor is a heterogeneous, heavy-water moderated and cooled reactor. It is fuelled with low-enriched uranium fuel rods. The low-enriched uranium fuel is composed of high-density uranium silicide in a continuous aluminium matrix. The core of the reactor is a cylindrical vessel that is surrounded by the main reflector, a blanket of distilled light water.

The reactor operates at a maximum power of 135 MW (thermal), and operates at a pressure slightly above atmospheric (plus hydraulic head). The maximum coolant temperature is approximately 55ºC. The core fission product inventory is about 3 to 5% of a typical CANDU power reactor.

The NRU Reactor also has two experimental loops, the U-1 and U-2 loops, which are used for CANDU fuel testing and development. These loops are fairly small in terms of volume and inventory. The operating conditions are similar to those in a typical CANDU power reactor.

The NRU Reactor has been in operation since 1957 November. It is the only major materials and fuels testing reactor in Canada and is also the principal reactor for materials development programs under the National Research Council's Canadian Neutron Beam Centre. The NRU Reactor is also vital for the production of more than half of the world supply of specialized medical diagnostic and therapeutic radioactive isotopes. Throughout NRU's operating life, AECL has modified systems and replaced equipment and components to address aging and obsolescence, thus ensuring that the reactor continues to meet its design requirements and safety performance. Substantial modifications have been made to the reactor over the course of its life, including a vessel replacement in 1972.

Further modifications were initiated in 1994, resulting from a comprehensive engineering review and inspection program conducted in 1991/1992. Seven major safety system upgrades have been installed to improve the safety capability of NRU. A companion Reactor Safety Evaluation Project was also completed, using current analytical tools in a comprehensive safety review, resulting in a revised SAR, which has been submitted to CNSC staff. The NRU safety and operational performance has improved steadily over the last 10 years.

C3 NRU LICENSABILITY EXTENSION PROGRAM

C3.1 Overview of NRU Licensability Extension Program

AECL established three key goals related to extending NRU operation beyond 2005 December:

- to demonstrate that the NRU Reactor and its systems can be safely and reliably operated to current safety standards and licensing requirements;
- to complete the NRU upgrades and maintain the reactor configuration consistent with the assumptions credited in the revised NRU SAR, and
- to ensure programs are in place to monitor, inspect, maintain, or replace Systems, Structures and Components, important to safety, on an ongoing basis.

To satisfy these goals, AECL initiated an NRU LE Program and has undertaken the following major work programs:

1. A Safety and Licensing Plan which demonstrates that:
    - NRU compares favourably with current Canadian and International standards for research reactors, and
    - the SAR incorporates up-to-date methodologies and its scope is comprehensive.
2. Completion of the commissioning of the NRU upgrades and incorporation of their design and operation into the NRU Facility Authorization**.**
3. A PLiM and Aging Management Program (AMP).

The following sections describe the status of each of the three elements of the program.

C3.2 Status of Safety and Licensing

As part of the NRU LE Program, AECL commissioned a Periodic Safety Review and committed a list of activities to disposition the gaps identified in the review. This is described in the NRU LE Safety and Licensing Plan [C-2]. To date, 18 of the 20 safety and licensing action items have been completed and have been submitted to CNSC staff. AECL continues to have an on-going dialogue with CNSC staff on the review of these submissions. As presented in Section C5, AECL is committed to resolve the CNSC staff comments in a timely manner. The only two outstanding items are the completion of the NRU SAR and the Severe Accident Management

Guidelines; AECL has agreed to a timeline acceptable to CNSC staff to complete these two items. In particular, the updated safety analysis report will be submitted in 2006 in accordance with a schedule agreed to with CNSC staff. The Severe Accident Management Guideline framework has been issued for review within AECL. Once approved, it will be submitted to CNSC staff. It is expected that it will take approximately two years to develop and implement the Severe Accident Management Guidelines in NRU.

C3.3 Status of NRU Upgrades

The seven seismically and environmentally qualified safety upgrades identified in earlier engineering and safety reviews have been completed. These safety upgrades significantly improve the safety capability of NRU, and provide greater assurance of a robust mitigating response to a postulated accident or external hazard.

On 2005 December 23, the last of the safety upgrades was placed into operation. Upon completion of the following actions, the safety upgrades will be formally declared “in-service”:

- Final Safety Notes and Limiting Conditions of Operations for the respective systems completed and accepted by AECL’s Safety Review Committee and CNSC staff.
- Completion Assurance Certificates accepted by the Facility Authority.
- Maintenance procedures in place and personnel trained.

The CNSC staff selected two systems of the safety upgrades for a Type I inspection, which was completed 2006 March 01. An exchange of comments and dispositions has taken place and CNSC staff is currently evaluating their observations.

C3.4 Plant Life Management Project and Aging Management Program

The PLiM Project for NRU addresses the material condition of the plant systems, structures and components at the present time, and provides input into the AMP. This is done through a formal aging assessment process and the results are used as one of the inputs to the AMP to provide ongoing actions to maintain systems, structures and components fit for service.

C3.4.1 Plant Life Management

The overall status of the PLiM aging assessments is shown in Tables C1 and C2. Table C1 presents those systems, structures and components, which have the highest importance to safety and reliability of the facility. The aging assessments for these systems, structures and components have been completed under Phase 2A of PLiM and the recommendations identified have been recorded for action and follow-up in a database (Action Items registry).

Other systems, structures and components which are important are being addressed through Phase 2B of PLiM. Their assessment status and projected completion dates are shown in Table C2.

C3.4.2 Inspections

An important criterion for continued operation of the NRU Reactor is its material condition. Inspections carried out included special inspections to support aging assessment conclusions. Periodic inspections have been carried out in conformance with design codes.

A Periodic Inspection Program has been developed for the heavy-water system pressure boundary. Inspections have been performed in accordance with this Periodic Inspection Program and are on target to meet the committed schedule, namely, completion of the first inspection cycle by 2006 December. As defined in the Periodic Inspection Program, a report of the inspection results will be submitted annually to CNSC staff by the end of March. The report for 2005 has been submitted to CNSC staff.

The results of the inspections carried out to date support the prognosis that the reactor's critical systems, structures, and components support continued operation safely and reliably.

C3.4.3 Aging Management Program

NRU operations have effectively managed aging and obsolescence of the systems and components since inception, and this has been demonstrated by reactor availability, 70% over its lifetime and over 78% in the last five years.

A formal AMP is now being implemented. This AMP builds on existing practices in the organization and uses currently accepted international guidelines to establish a systematic and formally documented aging management process.

The NRU AMP consists of the following elements:

- Implement actions and disposition findings arising from the PLiM aging assessments.
- Definition of the technical basis and the processes required to ensure that the AMP will provide reasonable assurance that the safe and reliable condition of NRU is maintained.
- Provision of basic information for asset management (i.e., technical information for repair and replacement).
- Provide systematic assessment of maintenance and establish or confirm the technical basis for the maintenance program.
- Perform system and major component health monitoring with regular status reports.

An update on progress on this program is provided below:

- All recommendations arising from the Phase 2A aging assessments have been recorded in the Action Items Registry database.
- An initial review to consolidate, classify (priority) and categorize (risk level) the Action Items Registry records has been completed.
- Selective recommendations are in progress. For example, the main heavy-water pump motor power cables have been replaced on four of eight pumps. This replacement will continue in future reactor outages.

- A Management Committee to disposition recommendations has been established, and a systematic review and disposition of the recommendations in the Action Item Registry has started using the Operational Decision Making process.
- A review of maintenance practices, particularly the way in which actions are taken and inspection results recorded has been concluded and improvements are being implemented to facilitate system and component health monitoring.

C4 NRU REACTOR SAFETY OVERVIEW

This section presents a summary of a document prepared by AECL to provide an overview of the NRU Reactor safety. This overview illustrates that operation of NRU in the past years has been successful in preventing the occurrences of significant abnormal incidents. It indicates that the NRU engineered safety systems will ensure that the radiological consequences from all design basis accidents are low and below acceptance limits, and that the residual risk from much less likely non-design basis accidents is very small, and that the applicable safety goals are met.

This section also addresses the overall design adequacy of the NRU safety systems in relation to requirements for power reactors. Specifically, the issue of two independent and diverse shutdown systems, an emergency core cooling system effective for all sizes of pipe breaks, and a containment system, is discussed.

It is described that the present NRU design, including the recently completed safety upgrades, provides adequate protection. Accident consequences are within applicable limits and the overall risk associated with the facility meets widely accepted risk-based criteria.

The overall conclusion is that the present design of NRU, complemented by an effective AMP, supports continued operation for a prolonged period. Nevertheless, in the interest of further increasing safety margins and risk reduction, a systematic review will be undertaken to identify practical design change options that could enhance the performance of the key safety systems. Once these have been identified, a cost-benefit analysis will be carried out to determine if the implementation of these design change options is indeed appropriate from a risk perspective, after which implementation of the beneficial and practicable design changes will be carried out in a timely fashion. This undertaking is a natural extension of the recently updated final SAR, the consolidated Probabilistic Safety Assessment (PSA), and the recently completed Severe Accident Assessment. It will integrate the safety insights from these activities, and is a complementary activity to the development of Severe Accident Management Guidelines, an initiative that will commence in 2006.

C4.1 Ongoing Maintenance and Upgrading

Substantial modifications have been made to the reactor over the course of its life, including a vessel replacement in 1972, the addition of the Emergency Filter System to the NRU ventilation exhaust in 1986, and the placement into service of a new seismically qualified stack duct in 1992.

The following seven major safety system upgrades have been installed to improve the safety capability of NRU:

1. Qualified Emergency Response Centre,
2. Second Trip System,
3. Liquid Confinement Vented Confinement,
4. Main Pump Flood Protection,
5. Qualified Emergency Water Supply,
6. New Emergency Core Cooling, and
7. Emergency Power Supply.

To determine the extent to which NRU meets modern standards, a Periodic Safety Review Gap Analysis was carried out. It consisted of a systematic review, by an independent expert, of the NRU SAR against the requirements of:

- IAEA Periodic Safety Review for Nuclear Power Plants,
- CNSC Regulatory Documents for CANDU Power Reactors, and
- Draft IAEA Safety Standard for Research Reactors.

The Periodic Safety Review Gap Analysis concluded that the majority of the issues identified by the review were independent of operating lifetime and there was no technical reason why these issues, if addressed, should present a barrier to operation of NRU beyond 2005 December. It further remarked that the main impediment to continued operation could only be the material condition of the reactor and associated facilities. All the findings have been dispositioned and the remaining gaps are addressed in the Safety and Licensing Plan as discussed in Section C3.2. It is also important to note that the IAEA Safety Guide NS-G-2.10 on Periodic Safety Reviews of Nuclear Power Plants does not impose full compliance with current standards and practices, but that an overall assessment of safety should be conducted. The guide recommends the use of risk-based decision making to achieve reasonable and practicable resolution of any shortcomings.

C4.2 Safety and Operational Performance

NRU safety and operational performance was satisfactory in the past. As documented in the NRU annual safety reviews, the reactor protective and regulating systems operated satisfactorily from 1995 to 2004. The number of reactor trips, both planned and unplanned, showed a steady decrease. The number of fires and serious process fault trips averaged less than one per year over the same period. Furthermore, radioactive liquid and airborne releases were well below applicable DRLs in each of the last 10 years. Lastly, not a single person received a dose exceeding the dose action level in the same period. However, there was an upward trend in the number of unplanned events in 2004 and the first half of 2005, following several years of an improving downward trend. In response to this indicator, a proactive NRU Improvement Initiative (see Appendix B) was expeditiously undertaken to address the issue. To summarize, the overall operational evidence in the last 10 years shows that the operation of NRU has been safe, its design has proven to be robust and operation of this robustly designed nuclear facility has succeeded in preventing the occurrences of abnormal operating incidents that could have significantly impact on workers, the public or the environment.

C4.3 NRU Design and its Mitigating Capabilities Against Accidents

By virtue of their low probability of occurrence, accidents rarely occur over the lifetime of a nuclear facility. This is due to the inherent robust design of nuclear facilities and the disciplined operation and maintenance practices. There are exceptions of course, and the root cause of accidents that have occurred can usually be traced to a combination of aberration from all three factors mentioned above.

Since accidents do not occur, or occur only on very rare occasions, analytical techniques are used to assess the mitigating capabilities of a given nuclear facility. The goal of these safety assessments is to show that the facility design, its engineered safety features in particular and operations and maintenance practices are capable of mitigating the consequences of hypothetical accidents.

The classical analytical techniques are the Deterministic Safety Analysis of Design Basis Accidents, Probabilistic Safety Analysis, and Severe Accident Assessment.

The results of these safety assessments and the implications on NRU Reactor safety and its mitigating capabilities are discussed in the next two sections.

C4.3.1 Safety Analysis of Design Basis Accidents

In order to demonstrate that the upgraded NRU (the original design plus the safety upgrades) is capable of mitigating the consequences of all design basis accidents, a comprehensive safety analysis has been performed. The details of the safety analysis are reported in the *NRU Safety Analysis Report*. The safety analysis addresses all credible accident event sequences (greater than 10^{-6}/a), which could lead to significant fuel failure, the release of radionuclides from their normal location, and potential doses to the public. These credible accidents include Loss of Regulation, Loss of Coolant Accident, Loss-of-Primary Coolant Flow, Loss-of-Secondary Coolant (Loss of Heat Sink), Experimental Loop Failures, Process Support System Failures, Fuel Handling and Storage Failures, Failures while Shut Down, and Hazards. A conservative approach is taken in arriving at both the estimated frequencies and dose consequences for these accidents. Safety analysis results show that there are no predicted fuel failures in all cases, and therefore, no dose consequence to the public with safety systems working except for the following scenarios:

- ***Single Channel Flow Blockage:*** Only one fuel rod is affected. The failure of a single fuel rod results in a very small-predicted dose to the public, about 0.02 mSv. Since the estimated frequency of the event (~ 1.3 $x10^{-4}$) places it in Class 3 of CNSC document C-006 [7] [C-3], the predicted dose meets the C-006 (Revision 1) limit with a large margin.

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[7] This document is applicable to power reactors. The NRU design and safety analysis was not performed to meet the requirements of C-006, nevertheless, the event classes and corresponding dose limits in C-006 provide useful surrogates to assess the NRU deterministic safety analysis results.

- ***Global Loss of Flow:*** The case represents a postulated loss of heavy-water flow in all the eight circuits. Some fuel rods fail. The predicted dose to the public is small, about 0.92 mSv. Since the estimated frequency of the event (~ 5 x 10^{-4}) places it in Class 3 of CNSC document C-006, the predicted dose meets the C-006 limit with a large margin.
- ***Loss of Coolant Accident Plus New Emergency Core Cooling Failure:*** Melting of all fuel rods and release of the total fuel fission product inventory are conservatively assumed. Fission product releases into confinement and dose consequence to the public are conservatively determined, and as such, the analysis is simplistic and not representative of the actual physical behaviour that would occur. An analysis initiative is underway to re-examine this scenario and the revised analysis will be reported in the *NRU Safety Analysis Report* update. It is expected that the dose consequence will remain within the limit of CNSC document C-006.
- ***U-1 or U-2 Loop Loss-of-Coolant Accident Plus Loop Emergency Cooling System Failure:*** Fuel fails and 100% of the fission products in the loop are assumed released from the fuel. The predicted dose to the public, about 9 mSv. Since the estimated frequency of the limiting event (~ 6.9 x 10^{-5}) places it in Class 4 of CNSC document C-006, the predicted dose meets the C-006 limit with a large margin.
- ***Fuel Handling Failures:*** Only one fuel rod is affected. The failure of a single fuel rod in the worst-case scenario results in a very small-predicted dose to the public, about 0.002 mSv. Since the estimated frequency of the limiting event (~ 2 x10^{-4}) places it in Class 3 of CNSC document C-006, the predicted dose meets the C-006 with a large margin.

The results of the safety analysis show that the upgraded NRU will not pose an unacceptable risk to the public, even if hypothetical design basis accidents were to occur. It follows that these safety upgrades will continue to serve NRU well into the future, as long as the material condition of NRU systems remain fit-for-service. This is because the material condition of structures, systems, and components will affect their assumed failure frequencies and integrity. The important issue of ensuring the soundness of material conditions of safety structures, systems and components has already been discussed in Section C3.

Finally, to complete the safety assessment of NRU, the residual risks posed by non-design basis accidents have also been addressed, and are summarized in the next section.

C4.3.2 Probabilistic Safety Assessment and Severe Accident Assessment

The safety analysis discussed in the above section addresses design basis accidents and failure combinations with frequencies as low as 10^{-6} per year. Probabilistic Safety Assessments of power reactors indicate that combinations of internal events with frequencies lower than this widely used threshold might be risk-significant. Therefore, there is a need to perform PSA and Severe Accident Assessment studies to quantify the residual risks posed to the public due to the hypothetical occurrence of non-design basis accidents at NRU.

There are three levels of PSA:

1. A Level 1 PSA identifies and quantifies the sequences of events that may lead to the loss of core structural integrity and massive fuel failures.

2. A Level 2 PSA, starts from the Level 1 results, analyzes the containment behaviour and evaluates the radionuclides released from the failed fuel and quantifies the releases to the environment.
3. A Level 3 PSA, starts from the Level 2 results, analyzes the distribution of radionuclides in the environment and evaluates the resulting effect on public health.

All three levels of PSA and Severe Accident Assessment have been carried out for NRU, and reports have been prepared documenting the deterministic and probabilistic assessments of severe accidents initiated by rare combinations of internal failures in the upgraded NRU facility. The assessments not only estimate risks stemming from NRU operation, but also provide data for the development of Severe Accident Management Guidelines.

Since there is no prescribed regulatory requirement for research reactors in Canada for PSA and Severe Accident Assessment, the following guiding principle is adopted for NRU: an accident in a nuclear reactor should not present the public with additional risks that are significant in comparison with other risks to which they are normally exposed. Insignificant accident risk is interpreted as 1% of the normal risk. The following table shows the goals adopted for NRU. These acceptance criteria are consistent with internationally accepted safety goals for operating power reactors.

Criterion	Value (Per Year)
Severe Core Damage Frequency	$< 10^{-4}$
Individual Early Fatality Risk	$< 4 \times 10^{-6}$
Individual Delayed Fatality Risk	$< 4 \times 10^{-5}$
Large Release Frequency	$< 10^{-6}$
Large Release Risk	$< 7 \times 10^{-4}$

The Severe Core Damage Frequency is a broadly accepted criteria that is not directly correlated to radiological risk. The intent of this measure is to ensure that the reactor design is balanced such that safety is not unduly relegated to the containment function. The numerical value for this criterion (10^{-4} per year) is used in the assessment of all existing CANDU power plants.

The Individual Early Fatality Risk and Individual Delayed Fatality Risk criteria interpret the above-mentioned guiding principle. The “insignificant risks” used to derive the numerical values of the Individual Early Fatality Risk and Individual Delayed Fatality Risk criteria in the above table are 1% of Canadian prompt fatalities from all accidents and 1% of Canadian cancer fatalities, respectively.

The Large Release Frequency and Large Release Risk criteria are used to judge the acceptability of long-term consequences of the accident to take into account risks other than those directly related to fatalities. Both are based on the risk of having to relocate large groups of people. It has been shown in the Level 3 PSA that the large release risk is also met when the individual delayed fatality risk is met.

The following table shows results of the severe accident assessment:

Criterion	**Calculated Value (Per Year)**
Severe Core Damage Frequency	3.7×10^{-5}
Individual Early Fatality Risk	3.1×10^{-9}
Individual Delayed Fatality Risk	5.1×10^{-8}
Large Release Frequency	8.8×10^{-9}
Large Release Risk	Automatically met if Large Release Frequency criterion is met.

The total Severe Core Damage Frequency is estimated at 3.7×10^{-5} in the Level 1 PSA and meets the acceptance value of 10^{-4}, which shows that NRU's safety design is balanced, and in particular, its single shutdown system and its NECC are sufficiently effective so that reactor safety is not unduly relegated to the confinement system or the exclusion zone. The calculated early and delayed fatality risks, and the large release frequency, meet the accepted values with very large margins, more than two orders of magnitude. Therefore, an accident will definitely not present the public with additional risks that are significant in comparison with other risks to which they are normally exposed. AECL is confident that this conclusion will remain valid even if there are some uncertainties in the assessments. There is no fundamental weakness in the NRU design and the overall risk of NRU operation is very small.

C4.3.3 Concluding Remarks

The above discussions show that:

- NRU has operated safely in the past, its design has proven to be robust and the disciplined operation of the facility has succeeded in preventing the occurrences of abnormal incidents.
- PLiM and AMP will provide assurance that the material conditions of the critical systems, structures and components remain fit for service in the future years of reactor operation.
- The upgraded NRU will not pose any unacceptable risk even if hypothetical design basis accidents were to occur.
- The upgraded NRU will not pose an unacceptable risk even if the extremely rare severe or non-design basis accident were to occur, that is, no unacceptable residual risks from the extremely rare severe accidents.

- Based on the above observations, NRU has shown, by actual operating experience, that it has been successful in the past in preventing the occurrences of significant abnormal incidents. Furthermore, safety analyzes have shown that NRU is capable of mitigating the consequences of design basis accidents as well as the very rare severe accidents to acceptable levels. Finally, the material conditions of NRU's critical systems, structures and components have been shown to meet "as built" specifications and will be assured of the same in the future.

NRU has operated safely and will continue to do so in the future as a result of the Aging Management Program combined with effective operating and maintenance practices.

C4.4 Further Assessment of the Safety Systems

The systematic Periodic Safety Review gap analysis against the requirements of CNSC Regulatory Documents (R7, R8 and R9) for CANDU Power Reactors, resulted in the following finding:

> *"The SAR demonstrates reasonable compliance with power reactor requirements with the exception of vented confinement, a single shutdown system, and an emergency core cooling system not designed to cover the full range of pipe breaks."*

The need to further improve the performance of the Confinement System, the Shutdown System, and the NECC system are examined in this section.

One of the difficulties in dealing with this issue is the lack of explicit regulatory requirements for research reactors such as NRU in Canada. Since the regulatory requirements in R7, R8 and R9 are intended for CANDU power reactors, the above finding does not necessarily imply any deficiency in NRU.

The IAEA has published a Safety Standard on the Safety of Research Reactors, NS-R-4, which could be used as a guide for assessing the safety requirements of NRU. This IAEA document states the following requirements for these three safety systems:

- *"Where required, means of confinement shall be designed to ensure that a release of radioactive material following an accident involving disruption of the core does not exceed acceptable limits"*.
- *"At least one automatic shutdown system should be incorporated in the design"*.
- *"Where required, an emergency core cooling system shall be provided to prevent damage to the fuel in the event of a loss of coolant accident"*.

NRU complies with the above safety requirements. However, as stated earlier, the need for further improvement to these three safety systems is examined in the interest of reactor safety and defence-in-depth.

To further improve a given safety system, basically, two aspects could be considered: one, its effectiveness and two, its unavailability. The three NRU safety systems: the confinement system, the shutdown system and the new emergency core cooling system are examined in turn.

C4.4.1 Confinement

C4.4.1.1 Effectiveness

The present confinement system can contain liquid releases but must continuously vent airborne releases. Therefore, for liquid releases, the "contain" function is achieved by the confinement system. This is not the case with respect to airborne releases. However, as discussed in Section C4.3.1, the estimated doses from the accident failure sequences are smaller than the applicable dose limits in CNSC document C-006 [C-3], thereby demonstrating that the present confinement system is sufficiently effective.

The confinement is sufficiently effective due partly to its efficient emergency filtration system design which is similar to those of CANDU power reactors, as well as due partly to the specific design and operating characteristic of NRU and the advantageous site characteristics. The NRU Reactor operates at a much lower power level than a typical power reactor: 125 MWth versus 2000 MWth or higher and has a much smaller core fission product inventory, approximately 5% of a typical power reactor. Therefore, the source term in confinement is small and the reliance on the confinement system is not overly excessive. The NRU Reactor also operates at much lower temperature and pressure than a CANDU power reactor: 55ºC and 0.6 MPa versus 300ºC and 10.5 MPa, so there is no high-pressure discharge from the reactor following a pipe break. Hence, there is no pressurization of the surrounding rooms, thereby reducing the need for the "contain" function. Finally, the NRU site has a large exclusion zone and is located in a sparsely populated region resulting in less demand for the controlled release function of the confinement system.

C4.4.1.2 Unavailability

The predicted unavailability of the various critical sub-systems of confinement is about 10^{-3} or less: a failure of the emergency filtration system to operate on demand occurs with a probability of 5.5×10^{-4}, the value for "box-up" dampers failing to close is 1.1×10^{-3}, and the independent probability of the failure of the operation of at least one lead fan is 9.7×10^{-4}. The predicted system unavailability is 7.5×10^{-3}. This value represents a reasonably reliable system and is close to the current design target for containment system of CANDU reactors.

C4.4.2 Shutdown System

The present shutdown system comprises 18 Control Absorber Rods (CARs) triggered to drop into the core by two independent trip systems, the First Trip System and the Second Trip System. The Second Trip System is among the first of the seven safety system upgrades installed.

C4.4.2.1 Effectiveness

C4.4.2.1.1 Depth of Shutdown

Only two to four CARs are required to shutdown the reactor following any postulated design basis accident. During normal operation, at least 11 CARs are fully withdrawn from the core and poised for shutdown action. With at least 11 CARs poised for shutdown action at all times, the effectiveness of shutdown action is not in doubt and so further improvement to shutdown depth is not required.

C4.4.2.1.2 Speed of Shutdown

In the SAR, the assumed CAR drop time is 2.1 seconds whereas actual drop time is less than 2 seconds. Therefore, the speed of the shutdown system is acceptable. The NRU Reactor does not need a very fast acting shutdown system because it has an integrated moderator/coolant system and a negative voiding coefficient, so that unlike a CANDU power reactor, a Loss of Coolant Accident will result in a reduction in reactor power rather than a rapid increase in reactor power.

C4.4.2.2 Unavailability

The predicted unavailability of the present shutdown system is 2.2×10^{-6} or less for all accidents except for the single flow tube blockage event, which is predicted to be 2.7×10^{-4}. (Manual operator action in 15 minutes was not credited. Since flow and temperature of every channel are monitored, operator action can be a reliable back up to trip the reactor in the event of a flow tube blockage event.) Also, this latter accident will only result in localized damage in one fuel channel and will not affect the rest of the NRU core. Any radioactivity release will be very small, less than 1% of the core inventory. Therefore, the reliability of the shutdown system for this accident is not a concern. The NRU shutdown system unavailability is sufficiently small for all other accidents, thereby negating the need to carry out speculative analysis involving failure of shutdown action.

The NRU shutdown system has been designed and proven to be highly reliable. Over the operation history of NRU, there have been 35,000 individual rod drops without a single failure on demand. This translates to a failure of a single rod to drop on demand (i.e., its unavailability, of $< 2 \times 10^{-5}$). Besides being seismically qualified, the second trip system was added to enhance the reliability of the trip function. The first trip system and the second trip system resulted in two completely independent trip systems to initiate CAR releases. There are at least two highly reliable trip parameters for all accidents except for the single flow tube blockage event.

C4.4.3 New Emergency Core Cooling System

C4.4.3.1 Effectiveness

The present NECC system provides effective fuel cooling for a wide range of Loss of Coolant Accidents up to and including the guillotine break of 2.5 inch diameter piping. However, it is not designed to ensure adequate fuel cooling for guillotine failure of large bore piping, termed Large Loss of Coolant Accident for this discussion. Due to a number of constraints, it was not feasible to design and install an emergency core cooling system fully capable of catering to all sizes of Loss of Coolant Accidents in NRU. These deliberations were documented and it was deemed that the practical solution was to include inspection of the large diameter piping in the Periodic Inspection Program as required by CSA N285.0 to minimize the potential for such a failure.

Inspection results show that large bore piping is in an excellent "as-new" condition after over 40 years of service, due in part, to the benign operating conditions of NRU, as well as to the routine operational tight control of the heavy-water chemistry. The heavy water is maintained at more than 99.75% isotopic purity, and its chemistry is regularly monitored and controlled to maintain a near neutral pH and at very low conductivity and impurities conditions to minimize piping corrosion. Further, as confirmed by a systematic assessment, there is no conceivable failure mechanism with the potential to cause a large, rapid failure of the large bore piping. The material of the large bore piping is Type 304 stainless steel and the propagation rate of stress corrosion cracking is very slow under NRU's operating conditions. Thus the piping will leak for a long time, in the order of weeks, before suffering a guillotine rupture. Consequently, advantage can be taken of the reliable heavy-water leak detection systems to detect a leak and effect timely corrective actions as required. A leak in NRU developed in Line 1212 in 1991; the results of the subsequent comprehensive assessments and inspections concluded that the occurrence was unique to Line 1212 because its material had a carbon content higher than that specified for Type 304 stainless steel and high-residual stresses were found in its weld. Such conditions were not found in the large-bore piping. As the chloride excursion in 1985 was a causal factor, one lesson learned from this event was that it is very important to maintain the tight control of the heavy-water chemistry.

As a result of the reasons presented above, a guillotine failure of large-bore piping in NRU is not considered as part of the design basis for the NECC system.

C4.4.3.2 Unavailability

The predicted unavailability of the NECC system is 1.25×10^{-3}, which is reasonably close to the target of 10^{-3}, prescribed for CANDU power reactors. There is therefore no need to further improve this attribute of the NECC system.

C4.5 Final Remarks

It has been demonstrated that the safety systems in NRU can successfully mitigate the consequences of accidents in NRU, from design basis accidents to the very rare severe accidents. Accident consequences are within applicable limits, and the overall risk associated with the facility meets widely accepted risk-based criteria.

Issues have been raised regarding the scope and effectiveness of NRU's safety systems relative to more modern designs. The safety case summary described in this Appendix demonstrates that NRU is safe and meets adopted acceptance criteria and safety goals. Nevertheless, it is prudent, from an overall safety management perspective, to review the results of the recently updated final SAR, the consolidated PSA, and the recently completed severe accident analysis, to determine if there are cost-effective enhancements that can be made that will further increase safety. A systematic review will be undertaken to identify practical design change options that could enhance the performance of the key safety systems. Once these have been identified, a cost-benefit analysis will be carried out to determine if the implementation of these design change options is indeed appropriate from a risk perspective, after which implementation of the beneficial and practicable design changes will be carried out in a timely fashion. This undertaking is a natural extension of the recently updated final SAR, the consolidated PSA, and the recently completed Severe Accident Assessment. It will integrate the safety insights from these activities, and is a complementary activity to the development of Severe Accident Management Guidelines, an initiative that will commence in 2006.

C5 CNSC Regulatory Plan

Since the submission of the NRU LE Safety and Licensing Plan in 2004 [C-2], AECL and CNSC staff have had regular meetings and discussion sessions on the progress and deliverables of the NRU LE Project. These meetings included discussions on review comments and expectations on issues including the NRU Design Adequacy. The CNSC staff licensing strategy for the NRU LE Project was issued to AECL in 2006 February [C-1] and it lists a number of prerequisites for continued operation of NRU. These prerequisites are grouped as short-term actions, medium-term actions and on-going generic issues. There are a total of 11 short-term actions, which require AECL to commit and present action plans to address these issues. AECL is currently reviewing and defining the required scope and resources for this work and is committed to submit the action plans and schedules by 2006 June to meet the acceptance criteria defined by CNSC staff. This commitment will include a systematic review to identify practical design change options that could enhance the performance of the key safety systems. AECL is committed to operate NRU safely and strives to seek opportunities to enhance safety in the interest of reactor safety and defence-in-depth.

C6 Long-Term Operation of NRU

Until NRU is replaced, its operation is essential to support current and future CANDU technology development, and to provide neutrons for NRC and Canadian University materials science programs using neutron scattering. Until the DIF facilities are in full operation, NRU is also essential for production of medical isotopes. Even after DIF is in operation, NRU will be required for production of isotopes, not produced in DIF, such as Co-60, for medical purposes. AECL therefore plans to operate NRU throughout the proposed licence period, taking necessary steps to ensure its continued safe operation. During the licence period, AECL and NRC will assess the need and options for an updated nuclear research facility. Options being examined include a major refurbishment of NRU, a new multi-purpose research reactor, or several new special purpose facilities. It is expected that during the proposed licence period a decision will be made on the long-term future of NRU. This decision would lead to pre-licensing activities regarding regulatory requirements for a refurbished NRU, or a new facility.

C7 Summary and Conclusions

AECL has completed a systematic and wide-ranging review of topics pertaining to the safety of continued operation of the NRU Reactor. The conclusion is that NRU can continue to operate with a very high degree of assurance of safety and reliability, based on the following:

- NRU has and will continue to operate safely.
- With the safety upgrades implemented, NRU meets the intent and performance requirements of relevant CNSC regulations and IAEA safety guides for research reactors.
- Safety analyzes have shown that NRU is capable of mitigating the consequences of design basis accidents as well as the very rare severe accidents to acceptable levels.
- The material condition of NRU and its critical systems, structures, and components will support continued safe and reliable operation.
- The Aging Management Program also addresses ongoing condition monitoring. Periodic inspection will provide continued assurance and documented evidence of the reactor's fitness-for-service.
- The results of the assessment of reactor material condition and the review of safety support continued operation of NRU.
- The NRU Reactor safety overview shows that NRU is safe and meets established acceptance criteria and safety goals.

In conclusion, AECL is committed to implement the Aging Management Program to ensure the material condition in NRU remains fit for service and to undertake a systematic review to identify practical design change options that could enhance the performance of the key safety systems. These prudent actions provide confidence that NRU will continue to operate safely for a prolonged period of time.

C8 References

[C-1] G. Lamarre, Letter to B.E. McGee, *Licensing Strategy for AECL's NRU Licensability Extension Project*, 2006 February 28.

[C-2] AECL, *NRU Licensability Extension (LE) Program Safety and Licensing Plan*, NRULE-00521-PLA-001, Revision 0, 2004 March.

[C-3] CNSC, *Safety Analysis of CANDU Nuclear Power Plants*, Draft Regulatory Guide C-006, Revision 1, 1999 September.

Table C1: Life and Condition Assessment of High Priority Systems, Structures, and Components

		Status	Target Completion Date
Life Assessments			
31101	LA-1 Reactor Vessel	Completed	
31102	LA-2 Thermal Shields	Completed	
31103	LA-3 Main Cooling System Pumps	Completed	
31104	LA-4 Main Cooling Heat Exchanger – Preliminary	Completed	
31104	LA-4 Main Cooling Heat Exchanger – Final	Completed	
Phase 2A Condition Assessments			
31301	CA-2 Control and Adjuster Rods	Completed	
31306	CA-6 Heavy Water System	Completed	
31309	CA-9 Reactor Ventilation	Completed	
31310	CA-10 Reactor Control System	Completed	
31311	CA-11 Electrical - Class 1 Distribution	Completed	
31312	CA-11 Electrical - Class 2 Distribution	Completed	
31313	CA-11 Electrical - Class 3/4 Distribution	Completed	
31315	CA-15 U2 Loop	On Hold	Included in the return to service requirements.[8]
31318	CA-18 Fire Protection System	Completed	
31323	CA-23 Reactor Protective System	Completed	
31324	CA-24 Fire Detection System	Completed	
31325	CA-25 Main Heavy Water Pump AC and DC Drives	Completed	
31347	CA-47 Power and Control Cables	Completed	

[8] The U-2 loop is currently out-of-service for repair of piping external to the reactor. It is expected to return-to-service in late 2006.

Table C2: Condition Assessments of Lesser Priority Critical Systems, Structures and Components

		Status	**Target Completion Date**
31330	Thermal Column Graphite	80%	2006 May
31331	Fuel Rod Assemblies	80%	2006 July
31332	I-125 Production system	50%	2006 July
31333	Fuel Rod Flask	50%	2006 September
31334	J-Rod Flask	50%	2006 September
31335	Active Rod Elevators	50%	2006 September
31336	Rod Storage Block	50%	2006 July
31337	Rod Storage Bays	35%	2006 December
31338	Loop Liner Cooling System	80%	2006 May
31339	Calandria Pressure Relief System	80%	2006 October
31340	Process Water System	80%	2006 October
31341	Building 440 Supply	50%	2006 December
31342	Rod Monitoring System	80%	2006 May
31343	Radiation Protective Systems	80%	2006 May
31346	Reactor Civil Structures	50%	2006 December

Appendix D: Ecological Effects Review – Recommendations and Status

***Recommendation 1*: In the few instances where radiation or chemical doses were predicted to exceed benchmarks and, in the case of chemicals, to exceed background, it is recommended that AECL confirm exposure conditions (concentrations in biota for radioactivity, concentrations in the environment for chemicals) and confirm the presence of VECs[9] or ecological receptors similar to VECs assessed herein. Measurements should also be made to confirm site-specific transfer parameters in these areas (sediments/soils Kds, bioconcentration factors, etc.). Where exposures are confirmed to exceed benchmarks (and background), it is recommended that an assessment of population and/or community health be undertaken, or that mitigation measures to reduce the exposure be implemented.**

AECL Status: Surface water and sediments have been collected in inland waters on and off the CRL site. In addition, complementary sampling was conducted in the Ottawa River upstream, downstream and adjacent to CRL. Samples have been processed and are currently being analyzed for radiological and non-radiological Contaminants of Potential Environmental Concern (COPECs).

Site-specific measurements of COPECs have been completed for 57 locations. Kd values have been established for these locations and a report is being prepared accordingly.

Preliminary sampling of aquatic and terrestrial non-human biota (including plants, fungi, invertebrates, amphibians, fishes and mammals) was initiated as a subset of the on-site and off-site locations (representing both Ottawa River and inland water sites) at which surface waters and sediments were sampled. Sample processing is underway in preparation for analysis of non-radiological and radiological COPECs.

A terrestrial C-14 exposure characterization study has been carried out in Duke Swamp to quantify C-14 concentrations to which resident non-human biota are being exposed. In general, C-14 concentrations in Duke Swamp have been declining over time and the area showing the highest C-14 levels is highly localized. From the work done to date, doses to Duke Swamp biota from C-14 fall far below those that would be expected to cause detrimental effects to non-human biota.

A preliminary terrestrial exposure study has also been undertaken north of Perch Lake to complement the Duke Swamp study. Additional work is planned in 2006/2007.

A gap analysis is being initiated to compile a list of existing ecological information available for the CRL site. A comparison will be performed to identify areas where gaps in ecological information exist and where receptor biota may potentially receive exposure from chemicals and/or radionuclides that may cause effects. An inventory of key receptor species and their occupancy at identified site(s) of interest will then be compiled for such areas.

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[9] VEC is Valued Ecosystem Componetns.

***Recommendation 2*: It is recommended that a rigorous evaluation of background concentrations of metals be completed in the Ottawa River and in inland waters (water, sediment). This should be carried out prior to completion of follow-up monitoring of chemical effects at potentially impacted locations, as outlined in (1) above. In most cases, it is expected that an improved picture of background concentrations will demonstrate that most potential metal effects identified here are distinguishable from background, and would not warrant further assessment.**

AECL Status: Surface water and sediments have been collected in inland waters on and off the CRL site, as well as upstream, downstream and adjacent to CRL in the Ottawa River. Samples have been processed and are currently being analyzed for radiological and non-radiological COPECs. Once the analyzes are complete and the data evaluated, a report will be compiled.

***Recommendation 3*: Since groundwater-monitoring wells near the Chemical Pit have detected polychlorinated biphenyls (PCBs) and tetrachlorodibenzofurans (TCDFs), it is recommended that the potential for migration of these substances should be addressed, either by modelling or by monitoring in East Swamp.**

AECL Status: Preliminary sampling has been conducted at East Swamp Weir to measure PCBs and TCDFs in the aquatic receiving environment downgradient of the Chemical Pit. The samples have been analyzed and the results are currently being compiled for evaluation. Once the results have been evaluated, a report will be compiled which will be reviewed to establish any changes to routine monitoring requirements.

***Recommendation 4*: The lack of monitoring data for metals in the water and sediments of West Swamp should be rectified in future monitoring programs so that potential metal doses to riparian wildlife can be addressed. Mercury and lead are of particular interest, since these metals have been detected in upgradient groundwater.**

AECL Status: A study was undertaken in 2005 to measure metals, including lead and mercury, in West Swamp. Sampling of West Swamp surface waters was conducted over a six-month period. Sediments were also collected. These data will be used to complement existing heavy metal data collected in 2003. Once the results have been evaluated, a report will be compiled which will be reviewed to establish any changes to routine monitoring requirements.

***Recommendation 5*: Vegetation control programs should be maintained in most waste management areas, as this will discourage colonization by biota and minimize the potential for doses such as estimated for organisms assumed to inhabit the Laundry Pit and Reactor Pit 2.**

AECL Status: Vegetation control programs have now been established in all WMAs, including Laundry Pit and Reactor Pit 2, by the WMAs Facility Authority/Facility Manager. Consequently, AECL considers this recommendation to be completed.

<u>Recommendation 6</u>: Fencing should be designed to exclude large mammals from waste management areas and perhaps other contaminated areas (e.g., South Swamp), and "game breaks" should be considered to permit large mammal passage through high fences elsewhere on the site, as recommended by Chaput et al. (2002).

<u>AECL Status</u>: Installation of fencing designed to exclude large mammals from WMAs and perhaps other contaminated areas (e.g., South Swamp) has now been installed. In addition, "game breaks" have also been installed to permit large mammals passage in order to exit the fenced areas should they somehow obtain access into the contaminated areas. Consequently, AECL considers this recommendation to be completed.

<u>Recommendation 7</u>: Although no significant ecological effects are expected in the river due to radiation exposure, and chemical exposures are expected to be comparable to background, environmental effects studies should be conducted to confirm these conclusions. Such studies were commenced in 2002.

<u>AECL Status</u>: Surface water, sediments and freshwater biota samples have been collected from the Ottawa River adjacent to the CRL site (as well as regionally) to facilitate comparison and evaluation of concentrations of COPECs. Samples have also been obtained from other locations on the CRL site. All surface water samples have been measured for metals, and a representative subset has also been measured for radionuclides. All sediment samples collected on the CRL site have been measured for metals and radionuclides, and most Ottawa River sediment samples have been analyzed similarly. Analyzes of metal concentrations in a subset of freshwater biota have also been undertaken.

<u>Recommendation 8</u>: Further to Item 7, it is suggested that field investigations be undertaken in the Ottawa River to delineate the aquatic plumes originating from representative offshore and shoreline discharges.

<u>AECL Status</u>: AECL has initiated a thermal plume study of NRU cooling-water outflow. The study will provide information on the trajectory of the plume as well as pertinent information regarding the mixing zone. During 2005, approximately 25 km of Ottawa River surface thermal data was collected in the immediate areas of the Ottawa River adjacent to CRL (i.e., Process Sewer to Pointe Aux Baptême and from the Ontario shore to the Québec shore). Preliminary information collected to date indicates that the thermal plume of the Process Sewer outflow extends approximately 1.3 km down-river and is about 500 m wide initially and then narrowing to about 300 m wide. Vertical profiles show only very small variations in temperature occurring from river bottom to surface, with the maximum increases in temperature in the upper 5 m. The largest temperature difference measured (0.8ºC) to date was measured at the surface just downstream of where the Process Sewer enters the Ottawa River.

During 2005, CNSC staff contracted the consultant Golder & Associates to assess the thermal effluent mitigation of six Canadian Nuclear Power Plant sites. Representatives of Golder & Associates visited CRL and met with AECL staff during 2005, since CRL was being included within the scope of their study. AECL staff provided Golder & Associates representatives with the preliminary CRL data and information collected to date.

***Recommendation 9*: Due to potential localized adverse effects of traffic mortality on herptofauna, it is recommended that a study be completed to document the importance of road kill to such species during critical periods of the year.**

Roadkill specimen is being collected, identified and their locations are being documented over the course of a year.

AECL Status: All CRL "road kill" specimens, including herptofauna, have been collected, identified and their specific "specimen kill" locations documented over the course of one year. A report outlining the number and species killed over this period is currently being prepared.

***Recommendation 10*: It is recommended that fish impingement rates be determined in the MAPLE intake water (former NRX intake) after the full-power start up of the MAPLE reactors.**

AECL Status: Cumulative rates of impingement have been quantified over a six-month period for the MAPLE intake and for a 12-month period for the NRU intake. Further work on the MAPLE intake had to be suspended until such time as MAPLE reactors begin operating again. The results of the NRU and MAPLE impingement studies indicate a low number of fish being impinged, and that the impingement rates have no significant impact on the populations of those species being affected in the reach of the Ottawa River, on which the CRL site is located. The results of the studies have been documented in a series of reports and memoranda. The reports on the impingement studies have been supplied to both the Department of Fisheries and Oceans and (Ontario) Ministry of Natural Resources staff.

Appendix E: Fire Prevention Program Implementation Plan

Action	Target Completion Date	Status/Comments
1. Fire Prevention section within CRL Fire & Emergency Services is formed.	2005 Jan 17	***Status: Complete*** • Fire Prevention Section includes three Fire Prevention personnel. Support staff and professional training requirements for staff are addressed.
2. Facility Fire Prevention Inspection Program Upgrades	2005 Nov 30	***Status: Complete*** • Monthly Fire Prevention Inspections are scheduled and implemented. • All buildings on site are divided into groups based on size and proximity to undertake these inspections. • Inspection reporting templates are modified.
3. Fire Fighters trained to conduct monthly Fire Prevention Inspections in every room during working hours.	2005 Sep 20	***Status: Complete*** • Fire fighters of CRL Fire & Emergency Services are trained and tested by the Deputy Chief to undertake monthly Fire Prevention Inspections.
4. Fire Prevention Inspection Guide to provide additional guidance for Fire Prevention Inspections.	2005 Nov 30	***Status: Complete*** • This document will be an easy reference for Fire Prevention Inspections and for data entry in the Fire Inspections Records (FIRE) database.
5. Fire Prevention staff to inspect buildings/structures not inspected by CNSC staff to address similar deficiencies as reported by CNSC staff.	2005 Oct 31	***Status: Complete*** • Buildings not inspected by CNSC staff are inspected by Fire Prevention Section to report similar deficiencies as pointed out by CNSC Fire Protection Auditor.
6. Upgrade Fire Inspections Records (FIRE) database to accommodate the volume of monthly building inspections/follow-up inspections/CNSC supporting observations, enhanced building specific tracking of suggested remedial actions for specific deficiencies, corrective actions taken, trend analysis and effective monitoring of backlog.	2005 May 10	***Status: Complete*** • Fire Inspections Records (FIRE) database was completely overhauled. • Building specific Fire Prevention Inspection reports will be automatically generated from the database upon the entry of observations from inspections. • This Oracle database allows queries, sorting and printing of entries by building, category, findings, status (pending, remedied and not remedied), name of inspector, responsible person for corrective action, priority level etc. • The database also provides graphs for the number of identified non-conformances and backlog based on the priority attached.

Appendix E: Fire Prevention Program Implementation Plan

Action	Target Completion Date	Status/Comments
7. Assign priority level and timelines for fixing identified deficiencies, non-conformances and fire hazards during Fire Prevention Inspections. • Immediate Hazard (IH) – remedial action on the same day (or spot corrected by inspector). • Priority 1 – High – remedial action within one week. • Priority 2 – Medium – remedial action within four weeks. • Priority 3 – Low – Long-term projects within one year.	2005 May	***Status: Complete*** • Comparison of industrial practices was conducted through phone surveys with fire protection personnel of other nuclear facilities and fire organizations. Meetings were held with Infrastructure and Site Services group to provide an understanding of the assigned priority levels. • Priority Levels IH, 1, 2, and 3 with timelines are attached to the findings based on industrial practices. • Priority level appears on the inspection reports emailed to person responsible for corrective action.
8. Forest Fire Prevention Program	2005 Jun 31	***Status: Complete*** • Forest Fire Prevention Program is implemented and ongoing.
9. Follow-up of CNSC reported findings.	2005 Sep 30	***Status: Complete*** • CNSC reported findings from 2004 November audit were entered into the database and reported to responsible staff for corrective actions. Dedicated follow-up inspections were conducted and the status obtained from facility staff. Open items in the database are monitored.
10. Process for change control of modifications having potential to impact protection from fire in CRL site.	2005 Sep 30	***Status: Complete*** • Fire Protection Screening Process (procedure and form) was developed and implemented for review of proposed modifications; including design changes, change of occupancy and new constructions. • Information session (presentation to all managers) was provided. An AECL bulletin was posted to inform proponents of modifications of this new process. • This process will identify the requirements for third-party reviews, Fire Hazard Analysis, governing codes and standards to be applied and the documents requiring revision due to proposed modifications.

Appendix E: Fire Prevention Program Implementation Plan

Action	Target Completion Date	Status/Comments
11. Hot Works Permit/Fire Safety Clearance for Hot Works, Daily Patrol Program and Inspection of Construction and Demolition Program.	N/A	***Status: Complete*** • Hot Work Permit System is implemented as part of AECL Work Permit System. Daily Patrol Program and Inspection of Construction and Demolition Sites are in place.
12. Fire Prevention Level 1 documentation.	2005 Sep 30	***Status: Complete*** • CRL Fire Prevention Program – overview document is prepared. • Fire Prevention Program Document outlines the activities required in CRL for an effective Fire Prevention Program. • This document is based on the Fire Prevention Document requirements of NFPA 801.
13. Smoking Policy of AECL, smoking restrictions and approval of designated smoking areas.	N/A	***Status: Complete*** • Smoking is not permitted in any of AECL's buildings or vehicles, but in outdoor designated areas. • The designated smoking locations are identified and approved by Occupational, Safety and Health, Fire & Emergency Services, and Site Planning and Property Management staff in accordance with federal legislation to ensure the location does not constitute a fire hazard, a hazard to building occupants or an impediment to site operations. • Fire & Emergency Services staff ensure that the designated areas for smoking do not constitute a fire hazard. • Evidence of smoking in locations other than the designated areas is reported to the responsible staff for corrective action.

Appendix E: Fire Prevention Program Implementation Plan

Action	Target Completion Date	Status/Comments
14. Ensure responsible staff take corrective actions: (checking of findings reported by CNSC and Fire Prevention Inspectors of CRL Fire & Emergency Services to ensure corrective actions are taken).	On Going	***Status: Ongoing (20% Complete)*** • Non-Conformance Reports are issued to persons responsible for corrective actions of findings prioritized as imminent hazard category. • Staff responsible for corrective action is reminded through emails and follow-up inspections. • Next Step: o Issue Non-Conformance Reports to all overdue findings. o Monitor effectiveness of above mechanism. o Ensure effectiveness. (Note: Non-Conformance Reports will be issued independent of the fire prevention inspection reports emailed out to the responsible persons for corrective actions.)
15. Promoting Fire Safety (Presentations and Information Sessions)	2007 Mar 31	***Status: Ongoing (30% Complete)*** • Fire safety information session will be delivered to facility staff. Training sessions will be scheduled through Occupations, Development & Training following the principles of AECL Systematic Approach to Training. • Although the Fire Prevention Inspection training session is targeted to Fire & Emergency Services staff, it can be tailored to train inspectors of Occupational Health & Safety and Facilities Safety and Licensing who conduct inspections in licence-listed facilities, including decommissioning. • Next Step: o Post Fire Safety Bulletin every month on internal website. o Schedule information session for all facilities through Occupational Training & Development. o Deliver information session in all facilities every two years. o Schedule at least one information session to managers as a part of the Fire Protection Program Roll Out.
16. Fire Drill Program	N/A	***Status: Complete*** • Fire Drill Program is implemented and proceeding on schedule.

Appendix E: Fire Prevention Program Implementation Plan

Action	Target Completion Date	Status/Comments
17. Prepare/update Pre-Fire Plans for all buildings.	2006 Dec 01	***Status: Ongoing (10% Complete)*** • Pre-Fire Plan template has been updated. • Next Step: o Pre-Fire Plans of all licence-listed facilities will be updated based on the Fire Hazard Analysis. For facilities without a Fire Hazard Analysis, Pre-Fire Plans will be prepared based on the available data and facility tour. o Floor plans from building emergency procedures will be obtained for all buildings. These plans will be used for identifying the required items of Pre-Fire Plans. A database of editable floor plans will be created. Facility Information System will also be used for floor plans. o Data will be entered into the template. Uniform symbols will be used on all the plans. o Buildings will be toured to confirm accuracy of data and missing data entered to pre-plans. o Pre-Fire Plans for all buildings on site need to be prepared. Fire Prevention Staff will maintain and update a database of all Pre-Fire Plans. (Note: Pre-Fire Plans for reactors will be updated as a priority.)
18. Fire Extinguisher Training Program	2007 Sep 01	***Ongoing: (20% Complete)*** • Fire extinguisher demonstration is provided to employees as part of Fire Prevention Week. • Fire extinguisher hands-on training is provided to facility operational staff every six months. • Next Steps (Two Year Plan): o All AECL employees will attend a presentation on the use of portable fire extinguishers, for the familiarization of equipment usage. o Hands-on training will be scheduled for all employees. o Hands-on training will be provided to all employees.