AECL EACL

Comprehensive Preliminary Decommissioning Plan

Comprehensive Preliminary Decommissioning Plan for AECL's Chalk River Laboratories

CPDP-01600-PDP-002
Revision R1

2006 February

fevrier 2006

Chalk River Laboratories
Chalk River, ON K0J 1J0
Canada

Laboratoires de Chalk River
Chalk River (ON) K0J 1J0
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Preface

AECL's Chalk River Laboratories (CRL) site is large and diverse and contains many structures and features, some dating back to the beginning of the site's first establishment in 1944. The site is expected to continue in operation as a licensed facility for a wide range of nuclear R&D/Industrial and production activities for many years to come. Several of the original structures have been decommissioned over the life of the site and the decommissioning of specific facilities is expected to continue in the future, as structures age or as business needs change. Also, the site has seen new structures and facilities installed to meet business and other needs: this too is expected to continue for many years to come. In other words, structures and facilities will come and go over the site's operational life, subject to regulatory oversight and control. For planning purposes the reference operational life of the site, during which some selective decommissioning may take place, is assumed to be approximately 100 years (2000 – 2100).

Accordingly, the decommissioning model for the CRL site, including the Waste Management Areas, is one of individual decommissioning projects for its various components over time rather than a single project for the site as a whole at some time in the future designated as the end of operational life. Priorities for decommissioning projects are established based on Health, Safety & Environment (HS&E) risks and also take into consideration operational requirements and business priorities. The individual decommissioning projects are grouped into seven 'Planning Envelopes' where each Planning Envelope is a grouping that has a degree of similarity, which lends itself to the application of common planning assumptions. The individual projects will, in general, take each respective structure or feature to a documented end-state while the site as a whole continues in operation. However, some projects will be implemented at the end of the site's operational life to qualify the site as a whole for a period of Institutional Control (IC) – the reference being 300 years (2100 – 2400), based on the radioactive decay of residual ^{90}Sr and ^{137}Cs (roughly 10 half-lives). During this period, selected parts of the site may be turned over for industrial re-use in accordance with then-current laws and regulations. Meanwhile, radioactive decay and natural geophysical/geochemical processes will take the balance of the site to a predictable, final end-state and site-wide qualification for industrial re-use.

This document presents a Comprehensive Preliminary Decommissioning Plan (CPDP) for the CRL site in its 2005 January configuration, e.g. without attempting to anticipate additional operational buildings, facilities and other structures. Future revisions to this Plan will take these changes into account as they occur. The document has been prepared to be consistent with the guidance contained in the Canadian Nuclear Safety Commission Regulatory Guide G-219. PDPs have been previously prepared for facilities listed in Appendix A of the CRL Site Licence and these are referenced within this document.

This plan includes the range of activities encountered in a decommissioning project, including preliminary planning activities (engineering), characterization, decontamination/dismantling and waste handling/disposition. Scheduling of decommissioning activities is based on timeframes considered to be short-term (less than 10 years) and long-term, which extends to the assumed operational period for CRL as a nuclear R&D/Industrial site. Planning for the short-term items is considered to be relatively firm, while the long-term plans are expected to undergo change, which will be documented in future revisions of this document.

1. INTRODUCTION & SCOPE

The Chalk River Laboratories (CRL) is a large nuclear R&D/Industrial site operated by Atomic Energy of Canada (AECL) in accordance with a Canadian Nuclear Safety Commission (CNSC) Nuclear Research and Test Establishment Operating Licence. This document was prepared with licence No. NRTEOL-1.0/2006 as the basis for the CRL site and facility description. The document was issued initially to meet Licence condition PS1 of the previous operating licence – NRTEOL-1.03/2002 – which specified that the Licensee had to prepare, a preliminary plan for eventual decommissioning of the 'overall CRL site'. This document, the Comprehensive Preliminary Decommissioning Plan (CPDP) for eventual decommissioning of the 'overall CRL site', has been prepared to be consistent with the guidance contained in the CNSC Regulatory Guide G-219 [1] and with additional requirements as noted by the CNSC [2].

This plan includes information about the 'overall CRL site' in its configuration as of 2005 January and is consistent with the facilities described in the CRL Nuclear Research Test Establishment Operating Licence (NRTEOL) issued by the Canadian Nuclear Safety Commission (CNSC). The 'overall CRL site' includes those items on the CRL site not considered part of facilities for which PDPs have been separately submitted (Licence Listed Facilities in Appendix A and C of the Site Licence). The facilities in Appendix A and C are listed in this PDP so that it is clear where the entire CRL infrastructure is captured. Also, AECL will continue to construct new facilities, as required, and their decommissioning planning will be prepared, as necessary, either as facility-specific PDPs or in future revisions of the CRL Site CPDP.

CNSC Regulatory Guide G-219 suggests that a preferred decommissioning strategy be selected. For the CRL site decommissioning, this decommissioning plan as presented is one of discrete decommissioning activities planned to take place within an operating site. The discrete decommissioning activities, which make up the plan, are each based on selection of a preferred strategy such as:

- **prompt removal** – (e.g. administration buildings) from turnover to a decommissioned site in less than 2 years;
- **deferred removal** – (e.g. research reactors) with initial activities directed at removing hazards, while maintaining and improving the building structure and required systems to allow for additional storage to facilitate dose reduction; and
- **in-situ disposal** – (e.g. low level waste management facilities) several of the Waste Management Areas (WMAs) are considered to be suitable for in-situ disposal. A safety case will be prepared seeking approval to abandon these facilities and associated wastes in-situ.

The decommissioning that has taken place over the past 5 to 10 years at CRL is consistent with the plan described in this document. The decommissioning has been performed in the context of an operating site with decommissioning activities focused on specific facilities that are declared redundant. Based on this experience and the projected future for the CRL site as a nuclear R&D/Industrial site with the ongoing production of medical isotopes and continued support for nuclear power generation in Canada, it was determined that projecting this strategy into the future as a basis for decommissioning of the site was not only reasonable but realistic.

Periodic updates of the CRL CPDP will be prepared, as required, to reflect changes in the proposed plan. This is an important aspect of the CPDP, since this means that this plan can and will change over time to reflect the current understanding of the decommissioning process planned for CRL. It should also be noted that, in addition to this CPDP, for each operating facility listed in the CRL Site Licence, the preparation and approval of a facility-specific Detailed Decommissioning Plan (DDP) and Environmental Assessment, where triggered by the Canadian Environmental Assessment Act (CEAA), is a requirement prior to decommissioning taking place in that facility.

The plan for the CRL site also takes into consideration financial constraints presented by the current, projected availability of funds to conduct the Decommissioning Program, as reflected in the AECL Corporate Plan. This necessarily constrains certain activities and generally results in long timeframes for the decommissioning of the CRL site.

1.1 CONSIDERATIONS IN THE PREPARATION OF THE CRL COMPREHENSIVE PRELIMINARY DECOMMISSIONING PLAN

The Canadian Nuclear Safety Commission Regulatory Guide G-219 provides guidance regarding the preparation of decommissioning plans for activities licensed by the CNSC.

It is AECL’s position that the Comprehensive Preliminary Decommissioning Plan (CPDP) for the CRL site is consistent with the contents and intent of G-219, based on the fact that:

- the approach described in the CPDP is technically feasible;
- the plan for decommissioning the CRL site presented in this plan is and will be supported by systems and programs at the CRL site that ensure that health, safety, and the environment are protected, i.e., the AECL compliance programs;
- financial systems are in place to ensure that the decommissioning strategy is capable of being implemented, although the rate of implementation is still uncertain.

The basis for AECL’s position is detailed below.

1.1.1 Technical Feasibility

The strategies contained within this plan do not rely on any technologies that are not available through either AECL, Canadian, or international experience, and will use accepted decommissioning strategies based on the principles of prompt removal, deferred removal, or in-situ disposal.

Over the past 10-15 years, AECL has (i) placed 5 prototype reactors into a safe shutdown state (WR-1, NRX, G1, NPD, and Douglas Point), (ii) decontaminated and demolished numerous redundant facilities and buildings on the CRL site, (iii) implemented technologically advanced strategies to remediate groundwater contamination, (iv) prepared major technical cases for both low-level waste and nuclear fuel disposal facilities, (v) carried out sophisticated repairs and upgrades to major nuclear facilities, (vi) successfully completed billion dollar projects for nuclear power plants, (vii) designed, licensed, commissioned and operated complex technical facilities, etc. In comparing the above activities to those typically associated with decommissioning, it can be reasonably concluded that the technical requirements contained in this PDP are well within the experience of AECL or other Canadian or international organizations.

1.1.2 Protection of Health, Safety, Security and the Environment (HSSE)

The protection of health, safety, and the environment at the CRL site is ensured through more than simply the contents and strategies embodied in this plan, and in fact the protection is afforded through the various functional layers discussed in Section 2.5, **Support Facilities and Services**. In particular, the existing infrastructure provided through nuclear materials and waste management, and nuclear site infrastructure and capability focuses on the protection of health, safety, and the environment.

A fundamental planning assumption and underlying tenet associated with this plan is that appropriate components of the CRL infrastructure will remain in place throughout the decommissioning process.

Two of the components involved in providing assurance that health, safety, and the environment are protected, and that merit further discussion, are presented below.

<u>Compliance Programs</u>

The protection of health, safety, security and the environment at the CRL site are explicitly and formally supported through a series of eight compliance programs , and, i.e.,

- Occupational Safety and Health
- Radiation Protection
- Environmental Protection
- Emergency Preparedness
- Operational Experience
- Nuclear Materials Management
- Transportation of Radioactive Goods
- Security

These programs play a significant role in supporting decommissioning activities, as required in the CRL site licence. Accordingly, these programs are expected to remain in effect during the implementation of the decommissioning plan.

<u>Decommissioning Prioritization Process</u>

The contents of the this CPDP identify the scope and nature of the decommissioning liability associated with the CRL site as described in seven planning envelopes, where Planning Envelopes 1 to 4 are for above-ground structures, Planning Envelope 5 is for distributed services, Planning Envelope 6 is for affected lands, and Planning Envelope 7 is for waste management areas.

Given the number and states of the various buildings, facilities, and areas associated with each of these planning envelopes, AECL has developed a methodology to ensure that the HSE risks associated with decommissioning facilities are being identified, assessed, prioritised, and addressed in a systematic fashion. The methodology relies on a prioritization approach utilizing (i) expert knowledge (including input from compliance programs) and (ii) a series of systematic assessments, characterizations, and inspections.

Since 1997, on a bi-annual basis, a formalized process has been used to prioritize decommissioning issues based on risks to health, safety, the environment, and business.

As a consequence of this process, a number of major initiatives have been undertaken to reduce HSE risks including the following:

- Liquid Waste Transfer and Retrieval Project: to address stored liquid wastes
- Waste Treatment Centre Upgrades Project(s): to enhance AECL's ability to treat radioactively contaminated liquids.
- Fuel Packaging and Storage Project: to address corroding fuels stored in below ground facilities.
- Waste Analysis Facility Project: to enhance AECL's ability to analyze decommissioning wastes for radiological contamination.
- Modular Above Ground Storage Project: to enhance the isolation of low-level radioactive wastes from the environment.
- Shielded Facilities Refurbishment Project: to enhance AECL's hot cell facilities for use in the safe handling of certain decommissioning wastes.
- Firebreak and Fencing Enhancement Project: to enhance firebreaks and fencing around and within the CRL site.
- Groundwater Treatment Facilities to mitigate impacts associated with past practices.
- Bldg 204 Bays Project: to remove a source of groundwater contamination.
- Demolition of Redundant Buildings to reduce energy and maintenance (SWS) costs, and reduce fire risks.
- IRUS Project: to develop and implement a disposal facility for low-level radioactive waste.
- Groundwater Monitoring Program: to monitor and further determine the levels of trends of radiological and non-radiological species in groundwater on the CRL site.

1.1.3 Implementation of the CRL CPDP

Given that the strategy in this plan is technically feasible, and that systems are in place to ensure that HSE risks are managed at the CRL site, the primary question surrounding the issue of the implementability of the plan centers on the availability of funding. Central to addressing this question is the fact that funding availability was assured in a letter from the Honorable Herb

Dhaliwal dated 2003 December 11, stating that “As an agent of Her Majesty in Right of Canada, AECL’s liabilities are ultimately liabilities of Her Majesty in Right of Canada”.

In addition to the above, the following relevant points should be also mentioned:

- In 1996, AECL reached an agreement with the Treasury Board whereby heavy water revenues would be deposited in a decommissioning fund within AECL accounts towards decommissioning and waste management costs. Since that time, funds have been used for that purpose. The agreement established in 1996 also states that “Unless the program is renewed at the end of the ten-year program, the arrangements for dealing with heavy water and decommissioning will revert to the system in place in 1995/96” (Parliamentary appropriations). This arrangement will ensure some level of continued funding for CRL decommissioning activities.
- In 2000 September, AECL applied for and received a Treasury Board Program Integrity Allocation, a one-time special appropriation to augment the Decommissioning Segregated Fund. The purpose of the funding was to enable AECL to accelerate the work on a set of projects previously identified as being “high priority” in AECL’s decommissioning and CRL site plans. The projects were intended to establish the facilities necessary for the safe, long-term management of AECL’s nuclear infrastructure, nuclear materials, and radioactive waste. The justification for the allocation was based on three primary drivers, i.e., (i) health, safety, and environmental (HSE) concerns, (ii) strong CNSC expectations or commitments, and (iii) liability cost growth. Although this supplementary funding was a “one-time” special appropriation, it is possible that similar future agreements could be arranged.
- AECL has been the focus of the Government of Canada's nuclear research and development for over 50 years. Funding from the federal government has been continuous over this time period, and there is every reason to expect this support to continue.

Given the information presented above, it is considered reasonable to conclude that the financial systems are in place and will be in place to ensure that the strategy presented in this plan is capable of being implemented, although the rate of implementation is still uncertain.

1.2 Sources of Uncertainty in Estimating the Decommissioning Liability

It must be recognized that uncertainties would apply to any estimates of the decommissioning liability for CRL. In large measure they would include the factors discussed below:

- Uncertainties in future regulatory requirements and responses

  Primary examples of this uncertainty include:

  - The extent to which *in-situ* disposal will be accepted
  - The nature and level of free release (waste clearance) criteria
  - The nature and level of site abandonment criteria
  - The nature of current and future revisions to disposal regulations (R-104)

  To mitigate these uncertainties, safety cases and proposals will be made to various regulatory bodies to secure a higher level of regulatory certainty.

- Technical uncertainties

  In a number of cases, the technical approach that will be required to address decommissioning liabilities is speculative (specific requirements yet to be determined) in nature, and therefore the costs associated with the corresponding facilities is also speculative.

- Inclusion of enabling and support facilities.

  As identified in this plan, a series of enabling and support facilities will be required to carry out the decommissioning process. However, these facilities may also have operational applications, and therefore could be funded through programs outside of the decommissioning allocation. As a consequence, the extent to which these enabling should be included in the liability estimate remains uncertain.

- Plans and requirements of other organizations

  A prime example of this uncertainty lies with the Nuclear Waste Management Organization (NWMO). The nature of the NWMO recommendation and the response of the government, particularly in terms of implementation schedule, will impact on the duration, nature, and cost of the CRL decommissioning program. Delays in establishing a disposal facility, the requirement for long-term storage facilities, re-locating wastes, etc. are some of the factors that could affect the costs. AECL continues to work with the NWMO to try and reduce the uncertainties of this issue.

  Similarly, the Waste Acceptance Criteria associated with the nuclear fuel management option that is ultimately selected and implemented will have large implications for the CRL decommissioning program. If, for example, extensive processing, packaging, and immobilization programs are required to qualify AECL's highly varied and non CANDU-type waste types to be accepted into a used fuel repository, then major facilities will be required at a significant expense. These same concerns are not generally applicable to those waste generators with primarily CANDU fuel.

- Public input

  The results of public input could have profound effects on the total spend for the decommissioning program. Public demands for either prompt decommissioning or a longer-term program could affect the total costs to an extent comparable to that identified above. To mitigate this uncertainty, a communications program will need to be initiated to begin gathering public input on both the preferred general approach as well as on specific projects.

2. DESCRIPTION OF STRUCTURES TO BE DECOMMISSIONED

2.1 Location & Characteristics

2.1.1 Location

The Chalk River Laboratories are located in Renfrew County in the Province of Ontario on the south shore of the Ottawa River, ~160 km northwest of Ottawa as illustrated in Attachment E, Figure E1.

Detailed descriptions of the CRL site's location, characteristics and surrounding environment are described in detail in an AECL regulatory support document [3] and in previously submitted PDPs (e.g. Reference [4]). The following information is summarized from these documents.

2.1.2 Surrounding Population

The area population is relatively stable. The population surrounding CRL lives in Ontario, in Renfrew County, which has a widespread population of ~90,500 residents and an overall population density of ~12 persons/km^2 and in Quebec in the sparsely populated Pontiac County, which has ~15,100 residents and an overall population density of ~1 person/km^2. The Province of Quebec, north of the river and opposite the CRL site, is normally uninhabited except during the summer months when a few cottage dwellers may be present. The closest permanent residents are ~11 km down river, in the Harrington Bay area.

2.1.3 Land Use

Land use in the region consists primarily of forestry, recreation and tourism, with limited agriculture, trapping and mining. Upriver of CRL, the majority of settlement and development is located on the Ontario side of the Ottawa River. Very little development has taken place on the Quebec side of the river, northwest of Allumette Island. The nearest area of significant agriculture is ~35 km downstream on the Ontario side of the river and further downstream on the Quebec side.

2.1.4 Surface Hydrology

The Ottawa River is the dominant drainage feature in the area, with the lowest and highest daily average river flows between 1950 and 1994: 267 $m^3 \cdot s^{-1}$ (1987 September) and 3,080 $m^3 \cdot s^{-1}$ (1960 May), respectively for this 44-year period [5]. Ottawa River flows are controlled and measured by Ontario Power Generation at the Des Joachims Generating Station, ~35 km upstream of CRL near Rolphton.

2.1.5 Habitats & Wildlife

The area is characterized by a forest cover consisting of white, red and jack pine; white and yellow birch; hemlock; white, red and black spruce; beech, sugar and red maple; red oak and poplar. The pine species are the most significant from a commercial viewpoint.

The area supports a wide range of wildlife species, including moose, deer, black bear, ruffed grouse, hare and waterfowl. The area also supports many fur-bearing animals such as beaver, mink, fisher, martin, otter, muskrat, fox and raccoon. The surrounding area is not situated within a major waterfowl flyway; however numerous wetlands provide a suitable nesting habitat for waterfowl.

The Ottawa River is an important area for sport fishing. There is very little opportunity for commercial fishing. Fish found in local waters within and surrounding the CRL property include pike, bass, walleye, muskellunge and sturgeon.

No hunting or fishing is permitted on the CRL property.

2.1.6 Geology & Soils

The CRL Supervised Area is typical of its immediate surroundings – a mixture of exposed bedrock, glacial till, fluvial sand, small lakes and marshes. Elevations vary from the level of the Ottawa River 111 m (365 feet) to 220 m (725 feet) above mean sea level.

2.1.7 Climate & Weather

The climate of the area is classified as humid continental, with warm summers, cold winters and no distinct dry season. In quantitative terms, based on data collected at CRL since 1963:

- The daily mean air temperature ranges from -12º C in January to 19º C in July, with historic minima and maxima of -39º C and +39º C respectively.
- The distribution of wind velocities and direction has been found to vary little from year to year. Prevailing winds are from the west-northwest (parallel to the Ottawa River valley) with velocities being most frequent between 4 and 5 $m \cdot s^{-1}$ (14 to 18 $km \cdot h^{-1}$) and exceed 10 $m \cdot s^{-1}$ (36 $km \cdot h^{-1}$) 2.5% of the time.
- Annual precipitation has ranged from 570 to 1,080 mm of water equivalent with an average of 820 mm. Monthly precipitation averages approximately 45 mm in January to approximately 80 mm in the summer months. Approximately 20% of the annual precipitation falls as snow.

Sixty percent of the annual precipitation is lost by evapotranspiration; the remaining 40% either runs off directly to local surface water bodies or infiltrates the ground to recharge groundwater flow systems.

2.2 Construction & Operating History

Construction of the Chalk River Laboratories began in August of 1944. Prior to construction, portions of the site were occupied by several small farms. Nuclear research at the Chalk River site began in 1945 under the administration of the National Research Council (NRC) with the completion of the Zero Energy Experimental Pile (ZEEP) that was designed to provide basic information of the physics of neutrons in a natural uranium/heavy water environment and to optimize the design of the planned 20 MW (th) National Research Experimental (NRX) reactor – raised to 30 MW (th) in 1950 and to 40 MW (th) in 1954. In 1946, the Atomic Energy Control Act established the Atomic Energy Control Board (AECB) and the AECB asked the NRC to continue to operate CRL on their behalf.

NRX and its associated facilities began operation in 1947. The focus of the early NRX program was the production and recovery of plutonium and ^{233}U and the complex included facilities for processing irradiated uranium and thorium and packaging the recovered products. Government approval to proceed with the National Research Universal (NRU) reactor was received in 1950.

The Canadian government formed AECL, a Crown Corporation with the mandate to develop peaceful uses of nuclear energy, to take over operation of the Chalk River site from the NRC – as Chalk River Nuclear Laboratories (CRNL) – in 1952. That same year, NRX suffered an accident that resulted in extensive fuel failure, severe damage to the reactor core and release of radioactive material. There were no injuries to workers and no off-site consequences but cleanup and repairs interfered with research and isotope production for 14 months and contamination persists in the vicinity of the NRX building. Solid and liquid wastes from the NRX accident, including reactor components, were taken to Waste Management Area A (WMA A). The use of the remaining waste capacity at WMA A also made necessary the construction of Waste Management Area B.

In 1954, a revision of the Atomic Energy Control Act changed the relationship between the AECB and AECL, with AECL now reporting directly to the designated Minister. The research focus shifted in 1954 from plutonium production to the application of nuclear technology for electrical power generation based on the natural uranium fuelled, heavy water moderated concept, subsequently dubbed CANDU® (CANada Deuterium Uranium). Nuclear facilities were installed to support this program, e.g. for development, fabrication, testing and post-irradiation examination of fuels and reactor components, and engineering programs were initiated to support development of the prototypes for the CANDU® nuclear power reactor and advanced reactor concepts. Support facilities and services such as machine and instrument shops, analytical laboratories, engineering, computation, stores, radiation protection, environmental and biological research, nuclear materials and waste management, administration, cafeteria, etc. were installed, as required.

The larger, 200 MW (th), NRU reactor and its associated facilities began operation in 1957. It too suffered an accident involving loss of coolant to a fuel rod in 1958. The reactor damage was less extensive than that for NRX and cleanup and repairs were completed within three months.

Significant industrial/commercial activities are generated from the nuclear programs, including production of cobalt-60 gamma-ray sources and molybdenum-99 for medical diagnosis, fabrication of fuel for AECL's research reactor customers and post-irradiation examination services for nuclear utilities.

CRL was also home to a particle accelerator development program for many years but this program was discontinued in the mid-1990s and terminated by 1997.

Currently, two new pool-type reactors – MAPLE 1 and MAPLE 2 are in the process of being commissioned. These, together with the associated New Processing Facility, will form the Dedicated Isotope Facility that will take over the production of medical diagnostic isotopes - principally Mo-99 – from NRU, prior to its scheduled shut down.

Total staff count at CRNL (now Chalk River Laboratories, CRL) peaked in the mid-1960s at about 2,500 Scientists, Engineers, Technicians, Trades, Clerical Staff, etc. Employment has since decreased to the current level of about 1,900, as a result of program reductions and transfers to other sites.

2.3 Site Layout

2.3.1 General

The CRL site consists of three types of designated areas under progressive degrees of access control as follows [6]:

- Supervised Area: Work with radiation sources and the storage of radioactive materials is not permitted without appropriate authorization;
- Controlled Area 1 (CA-1): Areas where the predominant hazard is external radiation; and
- Controlled Area 2 (CA-2): Areas where the predominant hazard may be either external and/or internal.

2.3.2 Supervised Area

The CRL Supervised Area consists of ~37 km^2 of land owned by AECL in the Town of Deep River. The land boundaries are shown in Figure E2. The boundary with the Ottawa River is the high water mark along the southwest shore of the Ottawa River.

The natural features within the Supervised Area are typical of the surrounding land – forested, uneven terrain interspersed with small lakes, wetlands and rock outcrops. The more significant features are identified in Figure E2.

The Supervised Area is accessed via a paved road from Highway 17 in the Village of Chalk River. All vehicular traffic must pass a checkpoint (the “Outer Gate”) that is staffed with AECL Security personnel. CRL employees, approved contractors and attached staff enter and leave past the checkpoint in buses (operated by a private contractor) or their own vehicles, which are issued a windshield sticker to identify them as qualified for unsupervised access. Occupants of vehicles without stickers (e.g. public or business visitors) must register with the Security personnel prior to entry.

A series of unpaved roads provide access to the interior of the Supervised Area for authorized personnel, e.g. for environmental monitoring and research, Security patrols, etc.

The Supervised Area contains five permanent buildings (e.g. not counting sheds, trailers, towers and tanks) used for applications not involving work with radioactive materials, such as the outer guardhouse, visitor centre, low background counting and emergency assembly buildings. These buildings represent a total floor area of ~2,000 m^2 and a gross volume (based on exterior dimensions) of ~8,700 m^3.

The CRL WMAs, discussed in more detail in Attachment D, are located within the Supervised Area. Each of these is designated as a Controlled Area 2 and enclosed within a security fence. Access is permitted only to authorized personnel.

2.3.3 Controlled Area 1

The CRL Controlled Area 1 is a fenced area of ~40 hectares (~600 m in the north-south direction by ~700 m in the east-west direction).

The primary access to CA-1 is from the Supervised Area via the main gate on the south side. Other access points are normally locked except when required for special shipments, etc. under Security supervision.

CA-1 contains many permanent buildings with a total floor area of ~57,000 m^2 and a gross volume (based on exterior dimensions) of ~270,000 m^3. The buildings are generally used for inactive applications such as engineering laboratories, research not involving radioactive materials for the most part, workshops, administration, storage and other services. There are a few minor exceptions, such as the use of radioisotopes used in the Biological Research Facility.

Approximately 50% of the buildings (by gross volume) in CA-1 are of steel frame construction, with the balance being reinforced concrete or masonry (30%) and wood frame (20%).

Buildings in CA-1 can generally be considered, with a high degree of confidence, to be uncontaminated. However, there have been incidents of inadvertent transfer of minor contamination from facilities in CA-2 and, consequently, any transfer of equipment or materials from CA-1 is subject to a mandatory procedure that includes monitoring for alpha, beta and gamma contamination [6].

2.3.4 Controlled Area 2

The main CRL Controlled Area 2 (exclusive of the Waste Management Areas) is a double-fenced area of ~30 hectares (~700 m in the north-south direction by ~400 m in the east-west direction). Access is limited to a single gatehouse (Building 701) that is staffed by Security personnel who check vehicular and personnel qualifications for entry to CA-2. At the exit of CA-2, sensitive monitoring portals have been installed to check for possible radioactive contamination when leaving CA-2.

The main CA-2 contains many permanent buildings and facilities (e.g. not counting sheds, trailers, towers and tanks) with a total floor area of ~81,000 m^2 and a gross volume (based on exterior dimensions) of ~420,000 m^3. The buildings in CA-2 are intended to accommodate and support nuclear facilities such as reactors, hot cells, radioisotope laboratories, nuclear materials storage, etc. The more significant of these facilities are listed on the CRL Site Licence and are operated in accordance with formal documentation, including a Safety Analysis Report (SAR), Facility Authorization (FA) and Conduct of Operations Manual.

Almost 70% of the buildings (by gross volume) in CA-2 are of steel frame construction, with the balance being mainly reinforced concrete or masonry. Only about 5% by volume is wood frame.

Many rooms in the buildings in CA-2 are reserved for non-nuclear uses, such as offices, conference rooms, corridors, stores, etc. These rooms will, by and large, be uncontaminated but their proximity to nuclear facilities means that confidence in their "clean" condition will be lower than if they were in CA-1. In recognition of this, there is a formal procedure in place to control all transfers of equipment and materials from CA-2 to CA-1 [6].

The WMAs are designated as Controlled Area 2.

2.3.5 Summary of Buildings Usage

A summary of the usage of buildings on the CRL site is presented in Table E1.

2.4 Operating Status & Management Status

Chalk River Laboratories is one of several sites managed by the federal Crown Corporation Atomic Energy of Canada Limited. The Corporation's executive offices are located in Mississauga, Ontario. Operational facilities and services on the CRL site, including the CRL Site Licence, are managed by the General Manager of Facilities & Nuclear Operation (FNO). CRL decommissioning activities are managed under the General Manager of Decommissioning & Waste Management. The General Managers report to the Vice-President of AECL Nuclear Laboratories, who also serves as the CRL Site Head.

Key functions within the CRL site management organization include the following:

- Site Operations (SO) – formal "ownership" and Landlord function of buildings, common site services and grounds with responsibilities for upkeep, maintenance and repairs.
- Waste Management Operations (WMO) – responsible for collection and management of all (radioactive, hazardous, non-hazardous, etc.) wastes generated on the CRL site (this includes the recycle, re-use and reduce wherever possible).
- NRU Operations – responsible for the operation of NRU, the largest nuclear facility on the CRL site.
- Nuclear Facilities Operations (NFO) – responsible for operating designated nuclear production and support facilities (other than NRU), including shielded facilities and heavy water services.
- Decommissioning Planning & Operations (DP&O) – responsible for planning, establishing priorities, allocation of funds for decommissioning activities and executing decommissioning projects. The Decommissioning Facilities Manager, as defined in Reference [7], then assumes custody of facilities/buildings as they are transferred to decommissioning
- Safety, Environmental & Radiological Protection (SERP) – responsible for radiation protection training and support, industrial safety support and health physics.

Operating facilities on the CRL site fall under the custody of either SO, or in the case of facilities listed in Appendix A of the CRL Site Licence under the custody of the designated Authority. When facilities are considered redundant, custody is transferred to DP&O following safe shutdown.

Research and development facilities located within buildings managed by FNO are operated and maintained by their respective management within FNO and Candu Technology Development (CTD), reporting to the Vice-President of AECL Nuclear Laboratories. These facilities include nuclear facilities listed on the CRL Site Licence (e.g. the ZED-2 research reactor, the Recycle Fuels Fabrication Laboratory and the Tritium Laboratory) and various Radiochemical Laboratories.

2.5 SUPPORT FACILITIES and SERVICES

In order to decommission the CRL site, it will be necessary to have support facilities and services that will include two fundamental components (i) an underlying site infrastructure comprising both physical facilities and management systems, and (ii) those specific “enabling” facilities that will be required to fully discharge the nuclear legacy liability issues, e.g., storage facilities, processing facilities, and disposal facilities.

The site infrastructure required to affect decommissioning is currently in place in that the CRL site is currently licensed for operations, and the associated infrastructure will continue to be maintained to the extent required to complete the decommissioning process.

The enabling facilities will be designed, licensed, constructed, commissioned, and operated as needed. The associated projects and funding will be either an operational or decommissioning responsibility depending upon the nature and use of the facility.

Details surrounding each of these topics are provided below.

2.5.1 CRL SITE INFRASTRUCTURE

The CRL Site is physically complex comprising over 170 buildings, many kilometres of underground services, and over 1.5 million square feet of building space. However, the complexity runs deeper than just physical considerations as a result of the multifaceted nature of the facilities and activities that exist on the site, the implications associated with potential health, safety, security, and environmental issues, the highly regulated nature of the activities, and the level of public interest related to nuclear issues. To address these complexities, an infrastructure has been developed both in terms of physical facilities and management systems, and a model created to convey the concept of the infrastructure.

Using this model, the nature of the facilities and capabilities associated with the CRL site can be represented as a series of functional layers whereby each layer receives direct support from the underlying layers. For example, before a reactor can be operated or subsequently decommissioned, a basic industrial site infrastructure must be in place to provide office space, utilities, management systems, maintenance, etc. Similarly, various programs and facilities must be established to ensure the safe and compliant management of radioactive material.

The various layers can be classified as follows

- Base Site and Landlord Functions
- Conventional R&D and Industrial Production
- Nuclear Site Infrastructure and Capability
- Nuclear Materials and Waste Management
- Nuclear Liability Management (Decommissioning)
- Nuclear R&D and Nuclear Production Services

In the context of this CPDP, it is clear that even if decommissioning were to become the predominant activity at the CRL site, the first three layers would still be largely required, and in fact represent a pre-requisite to decommissioning.

2.5.2 Base Site and Landlord Functions

The Base Site incorporates all services and facilities typically necessary to operate an industrial-type site, such as might be found in any industrial park. The CRL site is more complex than a "typical" industrial park in that it is geographically isolated, and therefore can not avail itself of services that would generally be available in a large municipal area, e.g., water, sewer, waste management, etc. In the case of CRL, the Base Site is defined as including the following:

- Municipal-type distribution systems (steam, electricity, air, water, etc.)
- Powerhouse including main power grid substations, boilers for the production steam used in district heating, and main pumping stations for process, service and fire water,
- Sewage treatment plant
- Water treatment facilities
- Waste pickup and landfill operation
- Medical Services
- Property management
- Public Affairs
- Human resource management
- Financial services
- Legal services
- Communication systems
- Information Technology
- Purchasing and stores
- Training
- Fire protection
- Roads and grounds maintenance
- Management of industrial support functions, such as trades, work management, project management, plant engineering, etc.
- Office and administrative buildings
- Space utilization planning
- Basic support services, i.e.,
    - Labour pool
    - Transportation services
    - Custodial and food services
    - Laundry
- Library
- Records management
- Compliance Programs necessary for the operation of a Base Site, i.e.,
    - Environmental Protection – Non-Nuclear
    - Quality Assurance – Non-Nuclear
    - Physical Security – Non-Nuclear

  - Occupational Safety and Health – Non-Nuclear
  - Employee Compensation and Benefits
  - Employment Equity and Official Languages

2.5.3 Conventional R&D and Industrial Production

Having established a base site with the pre-requisite facilities and support programs, and before moving to specialized facilities that are required for conducting nuclear research and development or decommissioning, there are those non-nuclear and unique (related to R&D) support functions and capabilities that would not be found in a more typical industrial site. This is where CRL begins to depart from the norm. The kind of facilities that would typify non-nuclear R&D and industrial production include the following:

- Non-nuclear labs and experimental facilities, e.g.,
  - Analytical chemistry
  - Environmental and biological sciences
  - Computer science and mathematical modelling
- Non-nuclear shops and manufacturing services, e.g.,
  - Machine shops
  - Trades shops
  - Quality Control inspection
  - Engineering services
  - Calibration services
  - Skilled labour

2.5.4 Nuclear Site Infrastructure & Capability

The next step towards the establishment of a nuclear research facility is to secure and maintain a licence from the Canadian Nuclear Safety Commission (CNSC). An extensive management and administrative system is required for work with radioactive and nuclear materials and these systems must be in place before any work of a nuclear nature can be contemplated. This is a very large undertaking requiring extensive resources, and CRL's licence for nuclear operations makes it uniquely positioned as a Canadian research site. Activities that contribute directly to the acquisition and maintenance of a site licence are:

- Site licensing support
  Those resources required to: (i) interact with regulatory agencies, (ii) prepare documentation required in obtaining site licences, (iii) prepare safety cases and environmental analyses to demonstrate that the site and nuclear facilities can be operated in a safe and environmentally responsible manner, (iv) interpret and provide advice on applicable laws and regulations, and (v) provide consistency in the manner in which AECL interacts with regulatory agencies.
- Compliance Programs necessary for the operation of a nuclear site, i.e.,
  - Environmental Protection – Nuclear
  - Quality Assurance – Nuclear
  - Physical Security – Nuclear
  - Occupational Safety and Health – Nuclear

- Operating Experience
- Radiation Protection (including dosimetry)
- Emergency Preparedness
- Nuclear Materials Management
- Transportation of Radioactive Materials
- Nuclear Operations

2.5.5 Nuclear Materials and Waste Management

- Nuclear Safety

Programs under the responsibility of technical specialists to assess the safety of nuclear operations and activities, and provide advice.

- Safety Review Committee (SRC)

The SRC reviews activities and operations on AECL sites in Canada to ensure they are conducted in accordance with AECL requirements; health, safety and environmental laws and regulations; and good health, safety, and environmental practices; and

- Criticality Safety Panel

A panel that specifically examines activities and operations involving the use of fissile or fertile material to ensure that criticality safety is not compromised.

- Training

A program to address the extensive training requirements necessitated by the highly regulated and complex facilities at the CRL site.

- Waste Management

In addition to establishing programs that are required before a licence can be obtained from the CNSC to operate a nuclear facility, it is also necessary to establish those support facilities that must be in place before nuclear operations can be carried out. One of the most important considerations in this area centres on the issue of radioactive waste management.

To address this requirement, facilities and programs have been established at the CRL site to manage the radioactive and hazardous waste that is generated as part of site activities. This is a major undertaking involving the following activities:

- Waste storage
- Waste disposal
- Processing and conditioning of solid and liquid wastes
- Records management
- Waste characterization
- Operational Control Monitoring (ground water monitoring program)
- Maintenance and surveillance.

2.5.6 Nuclear Liability Management Site

AECL and the nuclear industry recognize that in the course of operating a nuclear site, facilities and programs, contaminated facilities/land and radioactive wastes are produced that require long-term management. These facilities, land and waste constitute legacy liabilities that are managed through AECL's Decommissioning program and associated waste remediation and waste enhancement projects. The mandate of the program is to remove or reduce to the extent required, health, safety and environmental risks and liabilities, as well as business risks, associated with nuclear legacy facilities, waste and contamination on AECL sites.

The final stage in the life cycle of a nuclear facility is decommissioning during which actions are taken to retire the facility from service in a manner that provides adequate protection for the health and safety of the workers, the general public and the environment. The Decommissioning program comprises the following programs and capabilities:

- Development of decommissioning strategies and facility/site specific plans
- Facility and waste characterization
- Environmental risk assessments
- Decontamination and dismantling of nuclear facilities
- Remediation of contamination arising from legacy wastes
- Capital projects to design, build, construct and commission waste processing facilities for nuclear fuel and liquid wastes
- Maintenance and surveillance of decommissioning facilities
- Contribution to national efforts to establish disposal for nuclear wastes

The execution of this program would not be possible without having the four previously discussed support levels in place.

2.5.7 Nuclear R&D and Nuclear Production Services

Execution of the decommissioning will require active R&D and Nuclear Production Services including:

- Shielded facilities (hot cells)
- Nuclear Isotope labs and experimental facilities
- Shops for radioactive materials

2.6 Planning Envelopes

For the purposes of this CPDP and to facilitate decommissioning cost estimating, the facilities, structures and features of the CRL site have been grouped into seven Planning Envelopes (PE), each containing elements with similar attributes, level of hazard and decommissioning strategies.

The Planning Envelopes are summarized in Table E2. Further details regarding the scope of each PE and the decommissioning approach are provided in later sections of, and attachments to, this document.

2.7 Physical Status

The CRL site contains a wide variety of buildings, WMAs and structures used directly, or in support of, nuclear/Industrial R&D and production, most of which are in continued operation. However, several buildings have been put in a safe sustainable shutdown state and will remain in that condition until safety or business needs arise necessitating their decommissioning to their respective final end-states. Additionally, new facilities are under construction or in commissioning. This dynamic status will continue in the foreseeable future.

The site contains an extensive network of installations (infrastructure) to provide civil and electrical services to the buildings and facilities. The conventional services include water, process and sanitary drains, steam, electrical power, compressed air and communications. Additionally, the nature of the programs at CRL requires specialized services such as active drains, shielded ventilation ducts and access to industrial gases. All services, conventional and specialized, are considered within the scope of this decommissioning plan.

In addition to the buildings, WMAs, structures and services that are used for or support current nuclear R&D/Industrial activities, there are several areas and features on the site resulting from previous operations and unplanned events. These areas and features (see Planning Envelope 6 in Table E2) are discussed in Section 8.6.2.1 and Attachment C and are designated as "affected lands".

3. CONDITIONS AT END OF SITE OPERATIONS

The current use of the CRL site in nuclear R&D, production and services can be expected to continue for the foreseeable future and it is not possible to define a single condition at "end of operations" with any degree of detail and other potential alternative conditions of the CRL site may evolve by 2100 rather than the reference condition. However, this Preliminary Decommissioning Plan is based on a credible "end of operations" condition with the recognition that it can be adjusted in future periodic revisions. Accordingly, the reference planning assumption for this current decommissioning plan is that over the 100-year operating period of the site, the nuclear activities will continue, but at some point will decline in scope and that by the year 2100, when nuclear R&D/Industrial activities are terminated:

- All facilities that currently exist on the CRL site will be in acceptable end-states. More specifically, buildings and structures will have been decommissioned and the building sites will have been brought to an end-state of either industrial re-use or Institutional Control (IC).
- Similarly, the facilities, buildings and structures - currently in the planning stage but not yet constructed - will complete their entire life cycle within the 100-year period and therefore will also have been decommissioned to their end-states by the year 2100.
- Facilities, buildings and structures that are planned and constructed later in the 100-year period and that are within their operating life-cycle by 2100 (e.g. facilities in support of ongoing decommissioning operations) may remain at the end of the 100-year period and these will, at that time, either be released for industrial re-use or will be subject to decommissioning.

The following general statements, which are considered to be planning assumptions, can be made regarding the condition of the CRL site when nuclear R&D/Industrial activities are terminated in 2100.

- Most Listed Facilities (e.g. PE 1 type facilities) will have been removed and the building sites taken to a final end-state of unrestricted use or industrial re-use, but a small number (e.g. certain Waste Management Areas) will have been qualified for long-term IC.
- The Listed Facilities remaining at the time will have been declared out-of-service and will be ready for decommissioning in accordance with approved DDPs.
- All buildings containing Radiochemical Laboratories (e.g. PE 2 type facilities) will have been declared out-of-service and will be ready for decommissioning in accordance with documented plans containing the detail appropriate to the complexity and level of potential hazards.
- A number of buildings and structures will remain standing, either empty or occupied, for various administrative and other functions in support of site decommissioning activities.
- Affected lands will have been stabilized and qualified, through remediation and monitoring programs, for either unrestricted use, industrial re-use or long-term IC. For the lands that are affected as a result of activities that occur late in the operating period of the CRL site, remediation and monitoring programs will be in place or under way.

- Unaffected lands will have been surveyed and certified as being available for unrestricted re-use.

In summary, at the end of the site operating period, the CRL site will be in a Safe Shutdown State, with all significant hazard sources removed and any other hazards remaining stabilized in-situ (where deemed appropriate through safety/environmental analysis and confirmed through monitoring). Sufficient resources will be retained to implement the associated monitoring/surveillance/maintenance programs and to manage and complete the remaining planned and documented decommissioning actions.

4. HAZARDS ASSESSMENT

4.1 General

Hazards expected to be present during the decommissioning of structures and features of the CRL site will be addressed in documentation prepared prior to physical decommissioning activities taking place, with the documentation containing detail appropriate for the structure or feature.

In general, for any structure the level of radiological hazard is reflected by the Planning Envelope. Facilities listed on the CRL Site Licence have a regulatory requirement for the preparation and maintenance of PDPs through their operation life. The listed facilities (excluding the Waste Management Areas) are grouped in PE 1. In addition, it is required that DDPs, as well as Environmental Assessments, be prepared and receive regulatory approval prior to transfer of the facility to Appendix C of the CRL Site Licence. PE 2 consists primarily of Radiochemical Laboratories in CA-2 and the radiological hazards associated with these facilities are considered to be substantially less than those in PE 1, either because of lesser facility complexity and/or the nature of operations that took place in the facility during its operational life. For PE 2 facilities, decommissioning planning documents will be prepared and submitted for AECL Safety Review Committee (SRC) and, in some cases, regulatory approval prior to decommissioning activities taking place. The buildings and structures in PE 3 have even less radiological hazards, although small quantities of radioactive material may have been introduced over time, under controlled conditions. The planning assumption is that PE 4 facilities have no radiological hazards associated with them. Distributed services (PE 5) and affected lands (PE 6) each contain a variety of elements or features that range from hazard levels similar to PE 2 to routine industrial hazards. Some of the Waste Management Areas (PE 7) have the most diversified radiological hazards.

The assignment of buildings to Planning Envelopes PE 2, 3 or 4 is done on the basis of their current status, historical usage, level of hazard and other currently available information. The costing assumptions for the overall cost of decommissioning the CRL site, discussed later in this document, are on a PE basis, and not on individual buildings and structures. Therefore, in keeping with the requirement to provide conservative cost estimates [1, 8], buildings have been assigned to the higher PE category where there is uncertainty about which category they should be considered to be included in. It is reasonable to assume that, as more information becomes available for the buildings, the assignment to Planning Envelopes may change and this will be documented in future revisions of this document. Furthermore, the assignment to PE 2, 3 or 4 has been done on a broad basis (entire buildings or large portions of buildings): in the future this could be revised to consider individual rooms or areas within a building.

The following sections provide some estimates of the hazards that might be present on the CRL site at the time of general decommissioning.

4.2 Radiological Hazards

4.2.1 Radiological Safety Zones

All areas in buildings within CA-2 are assigned a Radiological Safety Zone (RSZ) number on a scale of 1 ("very low" hazard) to 5 ("very high" hazard) [6]. The Radiological Safety Zoning is reviewed on a periodic basis. The RSZ has two components: external (gamma) radiation field and contamination (beta/gamma and alpha). Most areas outside Listed Facilities, excluding the Waste Management Areas, are classified as RSZ-1 or RSZ-2 ("very low" and "low" hazards respectively). Access to RSZ-1 and 2 areas is not restricted, although unescorted entry into CA-2 is limited to personnel designated as Nuclear Energy Workers, having the appropriate security clearance.

A minority of areas are classified as RSZ-3 ("moderate" hazard). The RSZ-3 classification applies if the external field in a given room or area is up to 1 mSv/h <u>or</u> if surface contamination is present up to 40 Bq/cm^2 (total) or 2 Bq/cm^2 (removable on swipe). Occupation of RSZ-3 areas is subject to time limits and/or boundary controls to limit accumulation of 'whole body' dose and prevent the spread of contamination. Additional precautions are taken if work is to be done on equipment or structural components within RSZ-3, such as would be involved in decommissioning.

Generally, there are no areas outside Listed Facilities, including the active drain and ventilation systems, that are designated as RSZ-4 and RSZ-5 and this is expected to continue for the foreseeable future.

4.2.2 Radiation Dose Rates

Radiation dose rates presented by decommissioning of RSZ-1 and RSZ-2 areas will not exceed those presented by normal (pre-decommissioning) operations in those areas. RSZ-3 areas may present potential radiation dose rates resulting from the close approach to source terms during decommissioning.

Decommissioning activities can be expected to disturb surface contamination resulting in airborne contamination that could, if inhaled, result in a body-burden that contributes towards the annual radiation dose. Control of contamination and uptake of air-borne contamination is recognized as a primary radiological safety concern during decommissioning of areas designated as RSZ-3.

4.2.3 Nuclear Criticality Control

Accountable quantities of fissionable materials are restricted to Listed Nuclear Facilities (PE 1 and PE 7) and will not be present on the CRL site in general outside these facilities. Furthermore, where practical, inventories of fissile material will be removed from the facilities as part of establishment of the respective Safe Shutdown States (SSS). Accordingly, nuclear criticality control will be only a limited issue during the decommissioning of the CRL site.

4.3 Industrial Hazards

Physical decommissioning of CRL structures and buildings will include elements of a demolition project that present potential industrial hazards, additional to those recognized during facility operation. In general, the severity of these hazards will be consistent with those presented by conventional demolition jobs for low-rise structures. Potential examples of industrial hazards include:

- Tripping and falling;
- Handling heavy objects;
- Working at heights;
- Working near heavy machinery;
- Fires;
- Confined space entry;
- Drowning;
- Electric shock;
- Power tool injuries; and
- Cave-ins, if large-scale excavation is required.

4.4 Chemical Hazards

Operational inventories of chemicals, such as acids, alkalis and solvents, will be removed as part of the establishment of the Safe Shutdown State for each building or structure in preparation for the turnover to DP&O. Examples of the remaining chemical hazards that may be encountered during decommissioning include:

- Residual inventories of industrial chemicals;
- Perchlorates;
- Mercury switches;
- Asbestos materials, such as pipe insulation, siding, floor tiles, transite, etc.;
- Lead-based paint;
- Lead bricks and sheet; and
- Polychlorinated Biphenyls (PCB) in transformers, fluorescent light fixture ballasts, etc.

4.5 Precautions

Precautions for working in radiation fields and with contaminated equipment and materials are well understood, following practices that have been developed and proven during operation and maintenance of nuclear facilities at CRL and documented in formal radiation protection requirements. These include actions to reduce the fields and contamination levels, prior characterization of each work site, installation of local shielding/confinement/ventilation when necessary, and the use of protective clothing and on-line monitors. Establishment of temporary radiation protection zones, with monitoring at zone boundaries and local ventilation, will be provided, where appropriate. These precautions will ensure that the hazards will be localized to the decommissioning work sites.

The primary safeguard against industrial hazards is the use of qualified personnel (including contractors) working in accordance with approved procedures. In particular, this includes AECL's Work Permit System [9] that provides a systematic approach to identifying hazards and ensuring that staff are properly qualified and equipped for the workplace. This or an equivalent procedure will be maintained to support decommissioning activities on the CRL site.

Contractors providing goods and services at the CRL site are selected based on their past performance and are required to have measures in place to ensure that their personnel are competent to perform the tasks specified in the contract. Prior to awarding the contract, the Contractor's Quality Assurance Program and training may be audited. All contractor staff are required to attend a course to familiarize them with the requirements for working on the CRL site. Additional AECL and project-specific training will be the responsibility of AECL.

4.6 Support Programs

CRL will continue to operate as a nuclear R&D/Industrial site for at least the next 100 years. During this time, AECL will continue to maintain supporting programs such as Safety, Environmental & Radiological Protection (SERP), Environmental Protection, Occupational Safety & Health (OS&H), Waste Management, Quality Assurance, Emergency Preparedness, Fire Protection and Security together with purchasing, manufacturing, maintenance and other services. These functions (services and programs), including their associated training programs, will be updated, as required, to reflect changing business or regulatory circumstances and technological advances.

5. POTENTIAL IMPACT ON THE ENVIRONMENT

5.1 Natural Environment

Decommissioning of structures and features on the CRL site will have little negative impact on the natural environment, especially beyond the perimeter of the Supervised Area. This expectation will be confirmed prior to each specific decommissioning project in the overall site decommissioning program that involves any structure or feature with the potential for environmental impact during decommissioning, including but not limited to Listed Nuclear Facilities.

One potential environmental impact that will need to be assessed at some time in the future is that of large-scale transportation of materials to postulated (but not yet scheduled) licensed repositories for radioactive wastes. It is assumed that this assessment will be carried out as part of the licensing process for the repositories.

Some materials generated as a result of decommissioning activities are expected to be reused/recycled and, as such, are not considered waste and are not included in waste volume estimates.

5.2 Socio-Economic Environment

AECL's CRL site is a major employer and user of services in the local area and rapid termination or major reduction of activities would have a significant negative impact on the local socio-economic environment. However, the reference model is that nuclear R&D/industrial activities will be re-configured and/or reduced over a period of many years, with decommissioning projects being undertaken periodically. This will allow the local communities to adapt relatively smoothly and avoid major disruption.

5.3 Environmental Assessments

Environmental assessments will be prepared, as required, to meet regulatory requirements to support the DDPs for Listed Nuclear Facilities (PE 1 and PE 7). A site-wide environmental assessment will be prepared in the event that, some time in the future, an application is to be made for a general CRL decommissioning licence.

6. STRATEGIC APPROACH TO DECOMMISSIONING

The following sections highlight the key elements associated with the decommissioning of the seven planning envelopes represented at CRL. Figure E3 in four parts, A, B, C, D illustrates the overall operating plan for decommissioning of the CRL site. The flowcharts in Figure E3 show the major activities that will be undertaken over the total decommissioning period, including the enabling facilities required to condition and dispose of the various radioactive wastes. The charts cover several groups of features of the CRL site, such as stored used nuclear fuel, stored liquid wastes, stored solid wastes, buildings & other structures and contaminated grounds, each of which will have its own strategic approach to achieving its final end-state.

The bars in Figure E3 are identified with the major activity that they represent and are set against a timeline that indicates that all structures and features that currently exist on the CRL site are expected to be removed or taken to their final end-state by the year 2080. This includes the enabling facilities (other than disposal facilities).

The required enabling facilities are identified, together with their life cycle stages identified as segments in the horizontal bars as follows:

Planning: All the activities required prior to commitment of resources or contracts to design and construct the facility. These include evaluation of alternative approaches, development of the preferred concept, selection of a suitable site, completion of safety and environmental assessments as required and liaison with regulatory agencies to secure their approvals.

Design & Construct:	Detailed design & engineering, construction, commissioning and preparation for operation (staff recruitment and training, preparation of operating procedures etc.) and securing the operating license.
Operate:	Operate the facility to complete its mission. In the case of conditioning facilities, what is shown as a single segment involves several activities such as receiving, processing, interim storage and shipping the target inventories taking place concurrently over years or decades as inventories are being dispositioned. In the case of disposal (end-state) facilities, this segment refers to the duration of the waste emplacement phase.
Shut down:	In the case of a conditioning facility, this refers to the cessation of processing operations following completion of its mission, followed – perhaps with a short lag for technical or business reasons – by physical decommissioning and demolition of the structure. In the case of a disposal (end-state) facility, this will involve final closure and documentation in accordance with the design concept.
Institutional control:	This applies only to end-state facilities and is included in the long-term program of supervision and environmental surveillance of the CRL site at the completion of decommissioning.

The bar at the top of Figure E3C represents the ongoing decommissioning program for buildings, structures and those waste management areas that require excavation of inventory and/or sub-structures. The diagonal line in the bar is meant to illustrate the progressive conversion of the site from the operating state to the decommissioning end-state. This process has already started and is scheduled to be complete (for currently-existing structures) by approximately 2080.

The general strategy for decommissioning of the CRL site is in keeping with a sustained nuclear industrial site, which will become suitable for industrial/commercial re-use with stratified depth restoration. This means that for depths more than 1.5 metres below surface there is no intent to retrieve or remove materials (footings, walls, etc.) that have no identified contamination issue and do not impose an industrial safety hazard.

6.1 Above-Ground Structures (Planning Envelopes 1 to 4)

6.1.1 Strategic Approach

The CRL site includes many facilities, buildings, structures and features that will have their operations terminated over the next several decades. The overall approach is that decommissioning of the CRL site will be accomplished by a series of decommissioning projects for the individual structures and features within the site as they are taken out of service.

Conceptually, the process begins with a facility or structure being declared out-of-service. The operating organization is then responsible for putting the structure into a Safe Shutdown State (SSS) in which hazards are removed or stabilized to the extent practical and the structure's condition characterized and documented for turnover to DP&O.

Prior to turnover, DP&O in consultation with Decommissioning Operations and Landlord functions, determines the decommissioning approach and schedule. For the purpose of developing cost estimates, the following steps, as depicted in Figure E4, are assumed to occur. When a facility is decommissioned, specific individual steps may or may not be followed, for example Step 4 is a period of Storage With Surveillance (SWS), which may or may not occur. The main steps consist of some or all of the following:

1. Preparation of documentation to describe the proposed technical approach, potential hazards and waste management requirements. The scope and detail of this documentation will depend on the complexity and potential hazards presented by the decommissioning. In the case of Listed Nuclear Facilities, documentation will include submission of a DDP and an Environmental Assessment Report to the SRC and to the CNSC. Structures such as office buildings in CA-1 will require much less extensive documentation, subject to AECL internal review and approval.
2. A possible period of SWS with the structure in the SSS, e.g. to maintain the building and its services while the Step 1 documentation is being prepared, reviewed and accepted. When then appropriate documentation is accepted then turnover to DP&O will occur.
3. Removal of process systems and laboratory components (applicable to Planning Envelopes 1, 2 and 3, e.g. Building 513).
4. A possible period of SWS of the empty structure.
5. Preparation for demolition, including aggressive actions to remove remaining hazards, where appropriate.
6. Demolition of the structure to achieve the defined final end-state.

The process developed for the purpose of establishing decommissioning costs is illustrated generically in Figure E4 (for structures that are expected to contain radioactive fields and/or contamination, e.g. those in Planning Envelopes 1 and 2) and Figure E5 (for structures where contamination is not expected but is recognized as a possibility that has to be taken into account, e.g. Planning Envelope 3). Planning Envelope 4 decommissioning is expected to be more simplified but for costing purposes a process like the one in Figure E5 has been used. In practice, a structure or building may be prepared for re-use, rather than demolition, with turnover back to Site Operations.

It should be emphasized that the illustrations are generic and schematic and will be subject to adjustment for any given structure. In particular, large and/or complex structures may be divided into different Planning Envelopes that follow independent stages and schedules. Such structures will generally have a decommissioning plan created specifically for them. This is certainly the case for Listed Nuclear Facilities (PE 1).

Milestones identified in Figure E4 and Figure E5 are as follows:

Milestone 0: Formal statement issued that the structure has been taken out of service.

Milestone 1: All necessary documentation prepared, issued and accepted by the appropriate management and/or regulatory authority.

Milestone 2: All process and/or laboratory equipment removed. The building itself and its services remain functional for possible industrial re-use, as required.

Milestone 3: Building shell in a "potentially clean" state ready for demolition.

Milestone 4: Structure removed and the site returned to a condition that is suitable for industrial re-use, as required.

Typical Work Packages in the numbered Cost Elements in the figures are summarized in Table E3.

6.1.2 Rationale

The strategic approach consists of two main components:

1. **Storage With Surveillance period(s) while plans are being formulated and approved.** In some cases, these periods may be extended when delay is advantageous, e.g. to allow radioactive decay to reduce hazards, wait for the availability of large-scale repositories to accept wastes and/or business reasons. The CRL site will continue to be supported by key services such as full-time Security, Radiation Protection and multi-disciplinary engineering and trades staff for as long as CRL continues in operation as a nuclear R&D/Industrial site (100 years is the planning reference). These services will be available to monitor and maintain the shutdown structures and features. However, if any shutdown structure or feature exhibits degradation that cannot be remediated and/or poses a hazard to health, safety or the environment, physical decommissioning of that structure or feature will be assigned a high priority. Otherwise, decommissioning will be scheduled according to business considerations, such as the need for the building or site space, availability of waste management facilities, cost/benefit analyses and budgets.
2. **Advance preparation prior to demolition.** This component applies primarily to buildings and structures in Planning Envelopes 1 and 2. The rationale is two-fold: to prepare an empty structure or "shell" that is as clean as possible for demolition, albeit under careful Radiation Protection (RP) supervision; and to segregate the radioactive wastes from the larger volumes of uncontaminated building debris. Since the building or structure is slated for demolition, preparation can be as aggressive as required to remove contamination, including removal of internal finishes, scabbling concrete, opening the structure to expose services, etc. However, it is recognized that it might not be possible or practical to remove all contamination in advance of demolition, e.g. in unfinished crawl spaces, load-bearing foundations, etc. These exceptions will be documented so that additional precautions can be taken during demolition.

6.2 Distributed Services (Planning Envelope 5)

6.2.1 Strategic Approach

The strategic approach to decommissioning distributed services on the CRL site is that they will be retained in place until the termination of all nuclear R&D/Industrial activities on the site. As aboveground services become obsolete during the CRL site operational period, they will be replaced and the redundant structures removed. Obsolete buried services will be retained under SWS. Under certain circumstances, such as obsolete active liquid drain lines, it may be necessary to implement a targeted intervention program to stabilize and qualify them for the SWS period. All below/ground physical structures will be excavated to a depth of 1.5 metres following removal of the then-existing aboveground structures and the excavations will be backfilled to grade. Any below/ground physical structures that have identified contamination issues or impose an industrial safety hazard will be completely removed.

6.2.2 Rationale

Belowground features are distributed throughout the CRL site, often independently of the location of aboveground structures. In some cases, they cannot be completely removed without prior removal of the aboveground structures. For the most part, obsolete distributed services are benign: they pose no radiological or industrial hazards that would dictate their excavation prior to the end of the site operational period. Where an obsolete service poses a hazard or represents a source of contamination, a hazard analysis will be performed. The recommendation from the hazards analysis will then be executed to qualify the service for SWS.

It should be noted that:

- The planned decommissioning approach for the active drain system is also discussed in its own separate PDP, which has been submitted to the CNSC; and
- Active ventilation systems are included in the PDP for their respective facilities.

6.3 Affected Lands (Planning Envelope 6)

6.3.1 Strategic Approach

During the operational life of the CRL site, portions of the property that are not directly associated with specific facilities, but which have become contaminated (radiologically or non-radiologically) or which have been physically affected by site activities or actions, will initially be characterized and, if necessary, managed through a SWS plan. Should the initial characterization of such an area so indicate, further evaluations will be carried out to develop a more extensive safety/environmental analysis of the area. The resulting analysis will then provide the basis for any remedial actions needed to bring the area to its final end-state. The safety analysis may also provide the technical justification for the management of the area without such remedial actions, e.g. where the final end-state can be achieved by passive means such as radioactive decay. In either approach, the affected lands will also be subject to environmental monitoring, as required (e.g. surface water and groundwater monitoring), to confirm that environmental conditions are stable or improving. The extent of monitoring (confirmational monitoring) at an affected lands' site will be commensurate to the level of radiological or non-radiological substance and where monitoring is required, the planning assumption is that monitoring will be required for approximately 50 years (see Section 6.3.2), as after this duration sufficient data should be available to fully characterize the environmental conditions and support a case to abandon the area, thus ending the monitoring period.

Because the bulk of the affected lands were affected from activities in the past decades, these characterization, evaluation, remediation/intervention and environmental monitoring activities are underway at most affected lands' sites. Accordingly, a general planning assumption is that by the end of the 100-year operating period of the CRL site, most of the affected lands will have been brought to their final end-state, with the 50-year confirmational monitoring completed and the safety case to abandon the area completed.

Where future site operations result in new affected lands' sites (e.g. spills), the same approach in managing the areas will be followed, but the confirmational monitoring period may extend beyond 2100 into the IC period in some cases. This may also be the case with some of the current affected lands' sites (e.g. WMA plumes) where the confirmational monitoring may extend beyond the 50-year period, depending on how the environmental conditions progress in the interim. On this basis, another planning assumption is that some degree of confirmational monitoring will continue into the IC period.

Another planning assumption is that most affected lands can be brought to a Safe Shutdown State largely by passive means, e.g. without a need for targeted intervention. Further, where intervention is found to be required, whether the installation of an infiltration cover or the removal of affected soil, the remedial actions will need to be carried out over relatively small areas. Accordingly, it is assumed that the volume of soils removed during this remedial work will be limited.

Any lands affected by non-radiological substances or industrial hazards (e.g. excavations, boreholes, oiled roads, etc.) will be remediated, as required, during or at the end of the site's operational life by targeted intervention and subject to safety/environmental analysis to confirm that they are then in their final end-state.

6.3.2 Rationale

Research at CRL into the movement of radionuclides in the environment and environmental monitoring have shown that a limited suite of radionuclides has undergone transport and dispersal from operations or facilities that have released radionuclides. Those radionuclides that are currently present in or dispersed from facilities and that have half-lives on the order of 10 years (e.g. tritium and ^{60}Co) will disappear by radioactive decay during the 100-year operating period of the CRL site. Isotopes with half-lives up to 30 years (notably ^{90}Sr and ^{137}Cs) will be reduced in abundance by an order of magnitude at the projected end of 100-year operating period and by an additional factor of 1000 at the end of the subsequent 300-year IC period. As well, the concentrations of non-radiological substances will also be reduced through dispersion and some may also decompose during the CRL site's 100-year operating period.

These passive reduction processes will form the basis for safety analysis – together with any targeted remediation that may be required – to qualify the affected lands to be in their interim states at that time with predictable progression towards their final end-states. As discussed previously, this progression will be confirmed through confirmational monitoring that will involve surface water and groundwater monitoring, as required, of radiological and non-radiological parameters. This approach is consistent with the monitoring programs carried out currently at CRL. The results of the current monitoring demonstrate that the groundwater conditions at many affected lands' sites have shown trends of stable or improving conditions in as short a time as 10 years since the time that the lands were last affected (e.g. plume originating at the Liquid Dispersal Area). On this basis, the planning assumption is that, in most cases, confirmational monitoring will not be needed for more than 50 years. The purpose of this monitoring is confirmational – to ensure that there are no significant departures from what is expected. Confirmational monitoring could also initiate a review to re-assess the planning assumption. After the confirmational monitoring is complete, continued monitoring will be provided as an element of the IC program, but the scope of this monitoring will be very limited and will gradually decline over the IC period. The main purpose of the IC period, however, is to control access to those areas.

These passive reduction processes also form the basis for the assumptions concerning the limited need for interventions and the limited volumes of soils to be removed from the affected lands. The substances that will not decay, degrade or disperse passively to low concentrations over the site's operating life and IC period are those that are not mobile in the environment (e.g. alpha-emitting nuclides and heavy metals). Accordingly, they will stay close to their original locations, occupying relatively small areas.

For non-radioactive substances, the remediation strategy will take into account the guidance found in the Canadian Council of Ministers of the Environment (CCME) guides or other appropriate standards or guidelines in place at that time.

It should be noted that AECL has other initiatives underway with the CNSC that may affect the long-term management strategy for plumes (as well as other areas of contamination). The Environmental Effects Review (EER) is in the progress, and will help determine those areas at the CRL site potential impacts to non-human biota are most likely, thereby guiding the decommissioning program.

6.4 Waste Management Areas

6.4.1 Strategic Approach

Because of the diversity of waste forms, inventories, storage facilities/structures and operating histories of the WMAs at CRL (see Attachment D), an application of the decommissioning strategy will be developed for each WMA, as required, which will include specific objectives, scopes, end-states and schedules. Additionally, application of the strategy to facilities/structures within each WMA will be based on analysis of the present and potential future hazards posed by the current configurations. The buildings within the WMAs are included in Planning Envelopes 2, 3 and 4. In some cases, the existing buildings could be used to support decommissioning related activities and, as the planning process evolves to a more detailed state, the requirements for these buildings will be more clearly defined.

Similar to the decommissioning approach and rational for PE 1 to 4 (see Section 6.1), the decommissioning process for each WMA or facility will generally proceed in the following three phases (see Figure E6):

1. Phase 1: Establishment of a sustainable, safe Passive Operational State (POS) by reducing the hazards and minimizing and stabilizing releases of contaminants to a predefined level. At the end of this period the facility will be ready to enter next phase.
2. Phase 2: Storage With Surveillance. The facility or the WMA will be maintained by Waste Management Operations under SWS until a decision is taken (for business needs

or to address health, safety or environmental concerns) to implement conversion to the final end-state.

3. Phase 3: Establishment of final end-state. Most of the Low Level Radioactive Waste (LLRW) is expected to be managed in-situ. For the wastes that cannot be managed in-situ, the plan assumes that alternative facilities (notably disposal) for management of these wastes will be available before the planned achievement of the final end-state.

It should be noted that for some WMAs or facilities (e.g. Area G), some of the phases may or may not be followed.

At the completion of Phase 3, all actions will have been completed to achieve the planned final end-state and establish the initial stage of the IC period, which is expected to last a century or more. During the initial stage of the IC period, the waste facilities will be under an appropriate monitoring program maintaining access control to the extent necessary to ensure continued environmental protection and safety. During this period, actions may be taken to ensure that the facilities meet the safety and environmental protection requirements. Following the initial IC period, the facilities will continue in IC, for up to two more centuries, with specified land-use options for all or parts of the CRL site.

Additionally, the decommissioning of the WMAs will be coordinated with the Nuclear Waste Management Organization as it evolves, especially in regard to the potential future availability of a High Level Waste/Spent Fuel Repository.

6.4.2 Rationale

Previous and current characterization, monitoring and surveillance programs have generated a considerable amount of data regarding the status at the WMAs. These data are still being accumulated and will be used to support predictive modelling for, and feedback to, the future evolution of the decommissioning of the WMAs.

Interpretation of these programs confirms that:

- During the history of waste management at CRL (dating back approximately 50 years), the performance of the WMAs has been predictable and slow to change. With a few recognized exceptions, this is expected to continue in the future.
- Those exceptions to slow changes have been the subject of early actions to ensure a safe, stable state is restored.
- Monitoring is in place to verify status and indicate trends and this will continue, as appropriate, under the umbrella of an operating site for a period of 100 years.
- The planning assumption that a substantial portion of the existing wastes will be managed in-situ is supported by information available about concentrations and migration of radiological and non-radiological substances in those wastes. This information indicates that only a small and predictable fraction of such substances have migrated from the original emplacement areas and the majority of the

radioactive hazards will decrease through radiological decay during the extended storage period.

- A facility (or facilities) for long-term containment (e.g. disposal) will be required for Low, Intermediate and High Level Radioactive Wastes (LLRW, ILRW and HLRW) and for clearable wastes (landfill). The availability of these facilities (shown in Figure E3) is one of the most important factors affecting the timing of decommissioning.

The phased approach for actions and milestones is illustrated schematically in Figure E6.

7. DECOMMISSIONING END-STATES

7.1 Site Overall

The overall final end-state for the CRL site is that, following the reference 300-year period of IC, all areas of the site will qualify for industrial re-use. Qualification will be based on laws and standards in effect at the end of the site's operating licence (e.g. the start of the period of IC) while taking into account the hazard-reduction processes of radioactive decay and dispersion that can be predicted during the period of IC.

The characteristics of the site will be documented in detail to qualify it for the planned period of IC. This documentation will include identification and quantification of the hazard-reduction processes using accepted models and demonstration that the process will reduce hazards to levels consistent with industrial re-use.

7.2 Individual Features & Structures

Most of the existing individual areas and structures will be taken to their end-states prior to the start of the IC period. A relative few will be taken to an interim state that will be converted to the final end-state by the end of the period of IC, either by planned action or by the passive processes listed previously. These features and structures will determine the scope of monitoring and control during the IC period and will probably include:

- Large, above-surface and buried concrete components from nuclear facilities listed on the CRL Site Licence, including components from former reactors, fuel bays and shielded facilities. The PDPs for these facilities detail the interim state(s) and final end-state.
- Affected lands as summarized in Table C1 of Attachment C.

7.3 End Points

This plan makes assumptions regarding the end points of disposal. Should disposal facilities be located at the CRL site, they would have similar requirements for the IC period as stated previously. The requirement for IC is reflected in Figure E3D by the extended shaded boxes for the disposal end-points.

8. PLANNING ENVELOPES & WORK PACKAGES

8.1 Planning Envelope 1 - Listed Nuclear Facilities

8.1.1 Scope

Planning Envelope 1 consists of nuclear facilities as listed in Attachment A, Table A1. These facilities are also referred to as "Listed Nuclear Facilities" as they are listed on the CRL site licence and include, for example, the NRX and NRU reactors.

8.1.2 Technical Approach & Rationale

Each PE1 facility has its own specific PDP. Subsequently, a DDP will, in due course, be prepared that details the technical approach to decommissioning, anticipated hazards and waste arisings/disposition in accordance with SRC requirements (R-4) and CNSC guidelines (G-219). It should be noted that many of the facility-specific Decommissioning Plans refer to an interim state in which all facility-specific systems and components are removed but the building "shell" is not demolished. Facilities, or portions of facilities, in PE 1 that have achieved their end-state and are de-listed, may be transferred to Planning Envelopes 2 or 3, as appropriate. Any realignment of building "shells" within Planning Envelopes will be recorded during the next scheduled revision to this document.

8.1.3 Anticipated Hazards

The primary hazards during decommissioning of Listed Nuclear Facilities are presented by radiological contamination, plus activation products in the case of reactors and the WMAs. Industrial hazards are also present. Details are provided in the respective PDPs.

8.1.4 Waste Arisings & Disposition

Decommissioning of Listed Nuclear Facilities will generate significant volumes of diverse materials as LLRW with radiological contamination – alpha, beta/gamma and activation products. These will be followed by much larger volumes of "potentially clearable" building demolition debris.

The LLRW from facilities that will be decommissioned will be stored in the appropriate WMAs on the CRL site until such time as disposal facilities become available. The current planning assumption is that no large scale or national repositories for LLRW will be available until 2025. Additionally, the planning assumption is to segregate the building demolition debris into "potentially clearance" and LLRW streams.

Facility-by-facility details of waste arisings and their anticipated disposition are provided in the respective PDPs.

8.2 Planning Envelope 2 - Radiochemical Laboratories

8.2.1 Scope

Planning Envelope 2 consists of buildings that contain – currently or previously – one or more Radiochemical Laboratories or facilities for storage of radioactive materials. These structures are located exclusively in CA-2. See Attachment A, Table A2, for details.

8.2.2 Technical Approach & Rationale

The presence of a Radiochemical Laboratory in a building – particularly one of older design and construction – presents a significant likelihood that decommissioning will expose contamination beyond the confines of the laboratory, spread via the ventilation and drainage systems, spills and other abnormal events. Accordingly, the current planning assumption is that structures in Planning Envelope 2 will be decommissioned as an entity and will involve building-wide precautions, protective measures and cost impacts.

The reference is that, following departure of the building's tenants along with their furniture and other removable contents, structures will be decommissioned in three stages as follows:

1. **Remove process/laboratory equipment** (cost element 3 in Figure E4) – Removal of remaining furnishings, systems, fittings and other components from the designated active areas (laboratories, workshops, service rooms, etc.); decontamination of the immediate structure, using whatever level of aggressive techniques are required, followed by a characterization survey to document the achieved state. The structure will then be in a safe stable state that can be qualified for a period of SWS, if required, for business or financial reasons.
2. **Preparation for demolition** (cost element 5 in Figure E4) – removal of remaining furnishings, services, fittings, etc. from the balance of the structure with appropriate precautions against the possibility of finding unexpected contamination, removal of any such contamination and other hazards to the extent possible and a final hazard survey to document the condition of the remaining "shell". The removal of components and materials will be achieved by whatever level of aggression and intrusiveness is necessary to achieve the desired objective. The reference is that there will then be no significant delay before proceeding to the final stage.
3. **Demolition** (cost element 6 in Figure E4) – removal of the "shell" following procedures based on the hazard surveys, including waste characterization and segregation.

8.2.3 Anticipated Hazards

Preparation for demolition will pose known and quantifiable hazards from radioactive or chemical/industrial contamination within the laboratories and other facilities in each building. Additionally, it can be assumed that patches of contamination will be exposed beyond the designated contaminated areas. These hazards can be mitigated by having all preparation work performed following the appropriate Radiation Protection and Occupational Safety & Health Procedures [6, 9,10].

Demolition of the empty and nominally clean "shell" will pose conventional industrial hazards, but the possibility to expose contamination will exist and therefore all work will be done under the appropriate Radiation Protection Procedures. The decision on the abandonment or removal of footings and foundations will be based on the history of the building, the results of the radiological sampling and characterization on a case-by-case basis. Note that any buried services and affected land within 1 metre of the building's perimeter are considered within the scope of the building's decommissioning project.

8.2.4 Waste Arisings & Disposition

Removal of process and laboratory equipment (Stage 1 in Section 8.2.2) will generate modest volumes of contaminated components such as fumehoods, active drains, ventilation ducts, interior finishes, etc. Contaminated waste volumes will be kept to a minimum by actions such as concrete scabbling to segregate contaminated portions of bulk materials from the non-contaminated balance. Prior to the availability of repositories for radioactive waste, all contaminated materials will be stored in the appropriate WMAs at CRL.

Preparation for demolition (Stage 2 in Section 8.2.2) will generate modest volumes of "potentially clearable" miscellaneous components/materials and much larger volumes of "potentially clearable" building demolition debris will be generated during demolition (Stage 3 in Section 8.2.2).

"Potentially clearable" means that all the wastes must be processed through the Waste Segregation Program as they are generated to prove that they qualify for 'clearance' in accordance with the then-current standards. If facilities or services are not available to qualify large volumes of "potentially clearable" wastes for clearance at the time of decommissioning, demolition debris will be segregated and stored on-site until such facilities or services become available. When such facilities or services become available, the processed waste material determined to meet clearance criteria would be disposed of either on-site or off-site

8.3 Planning Envelope 3 - Low Hazard Structures

8.3.1 Scope

Planning Envelope 3 currently consists of buildings which are used for service and support for Radiochemical Laboratories and Listed Nuclear Facilities, located primarily in CA-2. See Attachment A, Table A3, for details.

The services provided by some buildings, such as the powerhouse (Building 420), will be maintained as part of the operation of CRL as a nuclear R&D/Industrial site, either by life-extension or by replacement. Such capability will be among the last to be decommissioned.

8.3.2 Technical Approach & Rationale

These structures are not expected to contain significant quantities of radioactive material. However, for PE 3, because they are, for the most part, located in CA-2 there is a possibility that areas of contamination will be exposed during decommissioning. The reference is that each structure will be decommissioned as an entity in two stages with little or no intermediate delay:

1. **Preparation for demolition** (cost element 5 in Figure E5) – removal of remaining furnishings, services, fittings, etc. with appropriate precautions against the possibility of finding unexpected contamination, removal of contamination and other hazards to the extent possible and a final hazard survey to document the condition of the remaining "shell".
2. **Demolition** (cost element 6 in Figure E5) – removal of the "shell" following procedures based on the hazard survey, including waste characterization and sorting.

8.3.3 Anticipated Hazards

Preparation for demolition can be expected to present only modest hazards such as unexpected radioactive or chemical/industrial contamination. These can be mitigated by having all preparation work performed following the appropriate Radiation Protection Procedures.

Demolition of the empty and nominally clean "shell" will pose conventional industrial hazards, but the possibility to expose contamination will exist and therefore all work will be done under the appropriate Radiation Protection Procedures. In PE 3 the likelihood of contaminated footings/foundations is assumed to be small, although sampling characterization will be performed before removing or abandoning the footings/foundations. Note that any buried services and affected land within 1 metre of the building's perimeter are considered within the scope of the building's decommissioning project.

8.3.4 Waste Arisings & Disposition

Large volumes of "potentially clearable" building services and demolition debris will be generated together with the potential for small quantities of contaminated materials. If necessary, all materials will be segregated and stored on-site until they are qualified for clearance or dispositioned as LLRW.

8.4 Planning Envelope 4 - Non-Contaminated Structures

8.4.1 Scope

Planning Envelope 4 currently consists of buildings in CA-1 and the Supervised Area that are used for R&D not involving radioactive materials, offices, site services, etc.

See Attachment A, Table A4, for details.

8.4.2 Technical Approach & Rationale

Structures in PE 4 will – to a high degree of confidence - not contain any radioactive contamination. However, their location on the CRL site means that the possibility cannot be completely discounted that areas of contamination will be exposed during decommissioning.

The reference is that each structure will be decommissioned as an entity in two stages with little or no intermediate delay:

1. **Preparation for demolition** (cost element 5 in Figure E5) – removal of remaining furnishings, services, fittings, etc. with appropriate precautions against the possibility of finding unexpected contamination, removal of contamination and other hazards to the

extent possible and a final hazard survey to document the condition of the remaining "shell".

2. **Demolition** (cost element 6 in Figure E5) – removal of the "shell" following procedures based on the hazard survey, including waste characterization and sorting.

8.4.3 Anticipated Hazards

Preparation for demolition can be expected to present only modest hazards such as unexpected radioactive or chemical/industrial contamination. These can be mitigated by having all preparation work performed following the appropriate radiation protection procedures.

Demolition of the empty and nominally clean "shell" will pose conventional industrial hazards, but the possibility to expose contamination will exist and therefore all work will be done under the appropriate Radiation Protection Procedures. Following such procedures will be important as footings/foundations are removed. In PE 4 the likelihood of contaminated footings/foundations is assumed to be remote, although sampling characterization will be performed before removing or abandoning footings/foundations. Buried services and affected land within 1 metre of the building's perimeter are considered within the scope of the building's decommissioning project.

8.4.4 Waste Arisings & Disposition

Large volumes of "potentially clearable" building services and demolition debris will be generated together with the potential for small quantities of unexpectedly contaminated materials. All materials will be segregated and stored on-site until they are qualified for clearance or dispositioned as LLRW. The waste materials that are determined to be clearable, as defined by the Waste Segregation Program, will be disposed of in an off-site or on-site landfill, as required, based on clearance criteria in place at that time. If facilities or services are not available to qualify large volumes of "potentially clearable" wastes for clearance at the time of decommissioning, demolition debris will be segregated and stored on site until such facilities or services become available. When such facilities or services become available, the processed waste material determined to meet clearance criteria would be disposed of either on-site or off-site

8.5 Planning Envelope 5 - Distributed Services

8.5.1 Scope

Services distributed around the CRL site total approximately 90 km of civil services (process water, storm drains, sanitary sewers, active drain system, steam and gas lines, etc.) and approximately 270 km of electrical cables (power, communications, data, etc.). Except for the active drain system, the distribution is divided roughly equally between CA-2 and CA-1. The active drain system is located in CA-2 exclusively. Approximately 95% of all services (civil plus electrical) are buried. The civil services consist of a variety of structural materials (concrete, cast iron, glazed clay, steel, copper, Polyvinyl Chloride (PVC) and copper in diameters from 12 mm (½") up to 1.8 m (72"). Details of the distributed services around the CRL can be found in Attachment B.

A PDP for the active drain system has been issued (2003 January) as an addendum to the PDP for the CRL Waste Treatment Centre.

8.5.2 Technical Approach & Rationale

The distributed services are a conventional feature of any large R&D/Industrial site and the reference is that they will be dispositioned either as required (e.g. if and when they are replaced or their location is required for other purposes) or as part of eventual qualification of the entire site for the period of IC.

Options for disposition consist of:

- Isolation and abandonment – applicable primarily to deeply-buried electrical cabling with low scrap value;
- Grouting, capping and abandonment – applicable primarily to deeply-buried, low-value, small diameter civil services; and
- Excavation, removal and backfilling to grade – applicable primarily to large diameter civil services or those of high scrap value or at shallow burial depth.

Although disposition will be determined on a case-by-case basis, the general guidelines for the services to be removed are:

- All services buried at a depth of 1.5 metres or less;
- Civil services of diameter greater than 300 mm; and
- Civil services constructed of transite (an asbestos-based material) regardless of depth.

8.5.3 Anticipated Hazards

Removal of most of the distributed services will present recognized industrial hazards associated with excavation and handling of heavy sections. For the electrical services, the main hazard is electrocution. The possibility of cutting through a 'live/energized' wire will be minimized by following the Work Permit System [9]. The removal of the active drain system will have the additional hazards associated with radioactive systems. The precaution against all hazards, radiological and industrial, is the use of qualified and experienced staff following approved procedures, equipped with appropriate machinery.

Additionally, there is the potential that pockets of contaminated soil will be encountered during excavation, in particular the active drain system. To guard against this presenting a hazard to the work crew, all excavation will be done under SERP supervision so that additional precautions can be taken, if required. The potential for encountering contamination will be higher in the CA-2 area compared with CA-1.

8.5.4 Waste Arisings & Disposition

Removal of distributed services, except for the active drain system, will generate modest volumes of "potentially clearable" wastes that will be candidates for conventional landfill disposal or scrap recovery. Some of the buried distribution lines that are nominally clean or meet clearance criteria would be left in-situ. The removed waste materials that are determined to be clearable, as defined by the Waste Segregation Program, will be disposed of in an off-site or on-site landfill, as required based on clearance criteria in place at that time. A small quantity of contaminated material may arise that will require decontamination to qualify it for landfill disposal or, if adequate decontamination is not possible, managing as LLRW.

The waste arisings from the active drain system will be LLRW and packaged appropriately for interim storage in the WMAs at CRL and eventual disposal, when a repository becomes available.

8.6 Planning Envelope 6 - Affected Lands

8.6.1 Scope

The term "affected lands" captures those areas of the CRL site, not included as part of an identified structure or building, that have been modified, changed or otherwise "affected" by the construction and operation of the CRL site. Although affected lands primarily pertain to the CRL Supervised Area, there are also items considered to be affected lands within the CRL Inner Area (CA-1 and CA-2). At the same time that affected lands are defined or identified, unaffected lands are in turn delineated.

A list of known affected lands on the CRL site is presented in Attachment C.

8.6.2 Technical Approach & Rationale

The approach to preliminary planning for the affected lands is to capture them into several categories representative of their current status or intended uses. These categories are as follows:

- Roads;
- Site Support areas;
- Experimental facilities;
- Boreholes (if not associated with experimental facilities);
- Plumes (primarily from past operations in the WMAs); and
- River Sediments.

Each of the categories indicated above includes items that were examined with several factors in mind (as applicable): quantity of waste; degree of potential hazard (radiological and non-radiological); presence of radionuclides and non-radionuclides in soil or groundwater; and also if there were any special circumstances which need to be considered.

Two time frames are considered for actions for affected lands and they are:

- short-term 0 – 10 years; and
- long-term 11 years and beyond.

The last category includes those items that will be required for ongoing site activities in keeping with the assumption of a nuclear-industrial site for the next 100 years.

8.6.3 WMA Plumes, Monitoring & Remediation

The plumes are monitored as part of the effort to track radiological and non-radiological substances as they migrate from the waste management facilities. The plumes arising from the WMAs will be examined on the basis of their relative priority. Factors which are considered in determining when and to what degree a plume is characterized include source information, type and concentration of radiological and non-radiological substances, biosphere/surface emergence and expected impacts. Examples of efforts to characterize plumes include the efforts on the WMA A ^{90}Sr plume as described in RC-1959 [11] and RC-2172 [12].

Technologies exist to implement remedial actions at locations where current conditions or future projected conditions are found to warrant remediation. A wide variety of technologies have emerged during the past 15 years that are intended for use in mitigating transport of radiological and non-radiological substances [13]. Two technology types have been applied at the CRL site for the remediation of three plumes.

Two plumes at WMA B Spring B and the Chemical Pit plume are being intercepted and treated using 'Pump and Treat' technologies. In these installations groundwater is captured using conventional well extraction methods and put through a multiple stage chemical treatment system, which produces a cementitious waste form. For the ^{90}Sr plume originating from the Nitrate Plant, an impermeable wall and sorbing bed have been installed to provide in-situ treatment of the plume. This installation is known as the 'Wall and Curtain' and it became operational during 1998 December. Groundwater is directed through a large sorptive bed of clinoptilolite where the ^{90}Sr is captured.

A portion of the characterization effort now underway is aimed at identifying priorities for remedial action. These mitigating actions may include a range of technologies in addition to 'Wall and Curtain' and 'Pump and Treat', including caps and covers, soil washing or removal of some of the more of the contaminated source materials. Also relevant is section 6.3.2 in this report.

8.6.4 Anticipated Hazards

The level of hazard associated with affected lands is, in general, considered to be low, similar to the hazard arising with structures in PE 3 and PE 4. For many of the individual items listed in Attachment C, little decommissioning is assumed to be required except for confirmatory monitoring that the situation is evolving as expected. Monitoring related to plumes is an example where, during the site operational period (100 years) if ongoing monitoring programs provide confirmation of the expected trends of declining radionuclides and non-radionuclide levels, no further actions would be planned. Where specific decommissioning actions are anticipated (as listed in Attachment C), routine precautions and safety measures will be applied, as required, to mitigate hazards.

8.6.5 Waste Arisings & Disposition

Waste arisings from PE 6 are assumed to be small as indicated in Attachment C. Where applicable, assumed waste arisings are indicated with the approximate timeframe during which these wastes will be generated. The waste materials that are determined to be clearable, as defined by the Waste Segregation Program, will be disposed of in an off-site or on-site landfill, as required, based on clearance criteria in place at that time. The contaminated material that arises will require decontamination to qualify it for landfill disposal or, if adequate decontamination is not possible, managing as LLRW. For affected lands, the disposition of wastes will be assessed in a separate study, which will consider among other options, in-situ disposal, as required.

8.7 Planning Envelope 7 - Waste Management Areas

8.7.1 Scope

The WMAs and other areas with radiological inventories are located within the CRL Supervised Area as illustrated in Figure E2. See Attachment D for details.

8.7.2 Technical Approach & Rationale

The decommissioning process for each WMA will proceed in three phases. Further details are presented as follows:

<u>Phase 1: Establishment of a sustainable safe Passive Operational State (POS)</u>

- Waste Management issues a formal statement declaring that the structures within the WMA are closed and will not accept additional waste materials; however, future remedial actions are not precluded.
- The operators define and secure acceptance for the sustainable Passive Operational State (POS). In respect to a waste management facility, a POS is one in which:
  - the radiological and industrial hazards are reduced to a pre-defined acceptable level;
  - transport or migration of radiological and non-radiological substances across the boundary of the WMA are minimized and stable within pre-defined limits;
  - access to the facility is controlled; and
  - the state of the facility is documented, with particular attention being paid to the radiological and industrial hazards.

The state, and the actions required to achieve it, will typically be different for each WMA.

- Operations staff will put the facility into the POS, typically by:
  - closing open storage structures;
  - retrieving wastes that are deemed to be inconsistent with a sustainable safe state, conditioning and/or repackaging them and either returning them to interim storage on the WMA site or transferring them to other storage facilities. In particular, high-level and intermediate-level liquid wastes will be immobilized to a stable, solid form suitable for long-term storage;
  - recovering inventories from storage structures that are deemed not to provide sustainable safe storage and transferring them to competent structures; and

- installing structures or systems to control migration of radioactive species beyond the boundaries of the WMA. (Some are already in place)

Additional facilities may be required to enable the above tasks, including facilities to improve characterization of wastes, immobilize liquids, condition unstable wastes and to store stabilized wastes.

These actions will be performed by WD&O under the provisions of the operating FA [14] and/or any new FAs governing the operations of any new facilities that may be required.

- A scoping survey will be conducted in accordance with a formal protocol to characterize the radiological condition of the facility and identify remaining radiological or other risks.

At the end-point of this stage, the facility will be consistent with the defined POS and facilities and programs will be in place for monitoring and surveillance to ensure continued safety.

Phase 1 activities that will contribute to the overall disposal cost (Section 10.4) are:

- characterization of legacy wastes, as required;
- plume treatment, where warranted; and
- continuing the monitoring program.

Phase 2: Storage With Surveillance

The WMAs will be maintained by Waste Management Operations, under SWS, until a decision is taken, for business needs or to address safety or environmental concerns, to implement conversion to the final end-state.

Waste Management will be responsible for supervising this period and for responding to AECL's business needs or potential safety or environmental concerns, as they might arise.

The actions performed during Phase 2 will be described in a SWS Plan. Monitoring of these facilities will be performed, as required, under regulatory requirements. At this time, it is expected that the SWS Plan will include periodic physical inspections and maintenance of any services, with particular attention to protective services such as Security to prevent unauthorized access.

If, at any time during this phase, any storage structures or waste packages are observed to be degrading to the point that they present potential threats to health, safety or the environment, appropriate intervention/remediation actions will be implemented. In some cases, this may involve selective waste retrieval, re-packaging and emplacement in competent storage structures, with CNSC approval.

Safe SWS will be maintained for as long as the CRL site continues to be managed and maintained as an operating facility and through the IC period of 300 years. Alternatively, if it is in AECL's business interests – taking into account ALARA considerations – to physically decommission any WMA or structure earlier, (e.g. if a suitable repository is constructed and licensed to accept the inventories) then one or more inventory retrieval and relocation program may be initiated. Business interests include considerations such as an identified use for a parcel of land or a building, which may accelerate planned contamination removal or cleanup to make re-use possible. Other business considerations could include the availability of specialized staff/skills and equipment, which could also provide rationale to accelerate plans, while this expertise or equipment was available.

Phase 2 activities that will contribute to the overall disposal cost (Section 10.4) are:

- continued plume treatment, as required;
- continued monitoring;
- facility maintenance; and
- remediation, as required.

Phase 3: Establishment of the Final End-State

The reference position is that a final end-state will be defined for each WMA such that long-term projections for potential health and environmental effects, both within and beyond the CRL boundary, meet AECL's environmental protection objectives and all applicable regulations, without need for active intervention but recognizing that the CRL site will continue under long-term IC.

For each WMA, an optimal configuration will be defined for the final end-state taking into consideration key factors such as:

- the nature and extent of activities during the operational period;
- the characteristics of the wastes in the WMA – inventory (Bq), half-life, concentration, mobility, retrievability, etc.;
- the nature of any storage structures and buildings;
- the requirements for managing wastes in other WMAs;
- the extent of Institutional Control that can be expected for the CRL site, subsequent to the operational period;
- the long-term projections of potential health effects for candidate configurations; and
- ALARA considerations to balance short-term dose commitments associated with active intervention against potential long-term health effects following termination of Institutional Control some time in the future.

Qualification of the final end-state for each WMA will be supported by its own project proposal, submitted for advance acceptance by the SRC and CNSC. Each proposal will include detailed descriptions of the proposed final end-state configuration, supported by a rationale for its selection, a list of the work packages to be implemented to achieve the configuration and schedule and cost estimates for the project.

It is expected that final end-state implementation will be phased and prioritized based on HS&E considerations and program funding. Only general indications will be presented in this plan.

The Facility Authority will apply to have the facility transferred from Appendix A (operational facilities) of the CRL Site Licence to Appendix C (permanently shutdown nuclear facilities).

The facility will be turned over to DP&O for implementation of the final end-state configuration. Following turnover, all work in the facility will be considered to be part of the overall decommissioning project, supervised and controlled under the provisions of the prevailing Site Licence.

DP&O will be responsible for all facility actions under Phase 3.

Phase 3 activities that will contribute to the overall disposal cost (Section 10.4) are:

- continued remediation;
- retrieval of wastes;
- processing/packaging and interim storage, as required;
- transport;
- ultimate disposal; and
- safety case for abandonment.

Institutional Control

At the completion of Phase 3, all actions will have been completed to achieve the planned final end-state and establish the IC period, which is expected to last 300 years, based on the radioactive decay of residual ^{90}Sr and ^{137}Cs (roughly 10 half-lives). During the IC period, the waste facilities will be under a monitoring and surveillance program that will assess and report on the facility performance and maintain access control, to the extent necessary, to ensure continued safety. During the IC period, further actions may be taken to ensure that the facilities meet safety requirements.

Institutional Control activities that will contribute to the overall disposal cost (Section 10.4) are:

- long-term monitoring at a reduced level.

8.7.3 Anticipated Hazards

8.7.3.1 Radiation Doses

The external radiation hazards presented during operation of the WMAs are described and addressed in the Safety Analysis Report [15] and Annual Safety Reviews [16]. These hazards are documented and derived from site characterization and surveillance programs plus characterization and segregation of incoming wastes so that they may be emplaced in appropriate storage facilities. The emphasis on characterization and segregation has increased in recent years and has reduced dose rates to personnel in the operating sites.

General radiation fields at the perimeters and within the WMAs, as recorded by periodic surveys, are consistently less than 10 μGy/h. There are a few locations with higher radiation fields that are segregated and signed appropriately. Collective annual whole body and surface doses accumulated by operating staff have been consistently below 10 mSv. The portion of this dose that derives from waste reception and emplacement operations will terminate after the facilities have been placed in the state of safe, sustainable SWS.

8.7.3.2 Radioactive Contamination

The potential health and environmental risks *inherent* in the wastes are primarily functions of their radionuclide content, and their physical and chemical nature including any hazardous constituents. For radionuclides, the potential risk is a function of the type and amount of radiation emitted (alpha, beta or gamma) and its energy and effective half-life. The *actual* risks from the waste to workers, the public and the environment depend, to a large extent on the effectiveness of the storage methods in providing containment and isolation.

The majority of the risk is determined by the effectiveness of containment and isolation in controlling the degree and timing of water access to the wastes and its ability to mobilize the radionuclides along pathways that could lead to impacts to workers, the public and the environment. Migration will be influenced by the barriers presented by the waste form and its container, the facility storage structure (if any) and the environmental setting. Other pathways include atmospheric release or vegetative uptake. Some years subsequent to the waste emplacement, additional migration and intrusion barriers may be constructed as a remedial or decommissioning measure.

Engineered waste management facilities in the CRL Supervised Area – concrete bunkers, tile holes and canisters – are designed and operated to contain radioactivity and minimize the spread of radionuclides within the WMA and to the environment. In this regard, their performance is being confirmed by the Groundwater Monitoring Program [17]. This program concentrates on radiological and non-radiological constituents in groundwater in the vicinity of the storage facilities. It was brought into full operation in 1997 and the annual report for that year confirms that the facilities continue to meet their design intent.

For the non-engineered facilities – liquid dispersals, burials in sand trenches, etc. – radionuclides may be released into near-surface overburden and their movement through it is dependent on the retardation characteristics of the radionuclides and the soil. Though containment of many radionuclides and heavy metals in the CRL soils is very effective, retention of some nuclides, such as tritium and ^{90}Sr, is limited and plumes have formed down gradient of some waste management facilities such as the LDA and sand trenches.

If the exposure pathways do not extend beyond the CRL boundaries, public exposure will be limited, during the long anticipated industrial life of the site by active access controls and later by passive Institutional Control through such measures as surveillance and land use regulation.

8.7.4 Waste Arisings & Disposition

8.7.4.1 Radioactive Waste

There will be several secondary streams of radioactive wastes generated by the decommissioning of the WMAs (e.g. additional to the recorded waste inventories in the WMA). These include:

- the existing packaging removed from the inventories during the course of retrieval and re-packaging for transfer to an alternative storage structure;
- contaminated internals of structures that contain packages that do not meet modern containment standards; and

- localized soil contamination from the early practice of storage in unlined earth trenches.

In general, it is expected that these contaminated components and materials will be classifiable as LLRW and, if retrieved, capable of being packaged with external radiation fields less than 1 mGy at 30 cm. Most are expected to either be managed in-situ or stored in approved, surface facilities pending eventual transfer to an approved waste disposal facility.

Approved shipping containers will be used if any of these secondary waste streams are transferred to an off-site approved waste storage/disposal facility.

8.7.4.2 Other Wastes

The primary contributors to non-radioactive waste volumes will be broken-up concrete, clean metal components, building materials, etc. These wastes will be managed according to established AECL procedures and in accordance with all applicable federal and provincial regulations. Where possible, equipment and materials will be re-used for other applications within AECL or offered for recycle or scrap value through established channels such as Crown Assets.

8.8 Summary of Waste Arisings

A summary of the estimated waste arisings by Planning Envelope is presented in Table E4.

9. CONCEPTUAL SCHEDULE

9.1 General

The CRL site consists of many individual structures and features – current and future – that will be decommissioned individually and to their own schedule. However, as discussed in Section 3, the reference is that all of the presently existing structures and features and most of those constructed over the site's operational period will be decommissioned to a defined end-state and by approximately 2100, the projected termination of the site's operational licence. At this time, the remaining structures (e.g. decommissioning support facilities) will be decommissioned and the site will enter the IC period, a reference 300-year period of environmental monitoring and institutional control (e.g. to the year 2400). As discussed previously, the duration of the IC period is based on the radioactive decay of Sr and Cs in plumes (over 10 half-lives). Following the year 2400, the entire site, subject to confirmational monitoring, will be available for industrial re-use in accordance with the federal and provincial laws and standards then in force.

9.2 Short-Term (10 Years)

CRL Site Planning maintains a rolling 10-year plan for new, replacement and obsolete structures and services. Information from CRL Site Planning as well as from Decommissioning Planning & Operations is used to determine the structures and services that are expected to be declared out-of-service and/or decommissioned over the next 10 years.

9.3 Longer Term

Over the longer term, beyond the 10-year timeframe, decommissioning priorities and schedules will be determined in part by:

- Business decisions regarding research, development and production programs;
- The Life Cycle Index for buildings that is maintained and updated annually for each structure on the CRL site;
- Resource availability; and
- Conformance to a funding profile.

10. COST ESTIMATE AND ESTIMATING PROCESS

10.1 Structures (Planning Envelopes 1 to 4)

The generic decommissioning models presented in Figure E4 and Figure E5 identify up to 6 cost elements and 3 waste streams that can apply to the decommissioning of structures on the CRL site.

A cost and waste model has been developed using building and room information from the Site Information Management System (SIMS) database plus unit cost estimates ($\$/m^2$ or $\$/m^3$, as appropriate) for each element derived from industrial and AECL experience and judgment factors. The cost component of the model can be used to estimate the decommissioning cost elements for structures in Planning Envelopes 1, 2, 3 and 4. Similarly, the waste component of the model can be used to estimate the types and volumes of decommissioning/demolition wastes, together with the costs for their management (interim storage plus final disposition).

The decommissioning/demolition costing model is described in Reference [18].

Preliminary Decommissioning Plans are maintained for Listed Nuclear Facilities (Planning Envelope 1) and include estimates for the cost elements that are referenced in the plans. Note, however, that the PDPs sometimes refer to an end-state that consists of turnover of the building for re-use rather than demolition of the structure (cost elements 5 and 6 in the model). In these cases, the costs and waste arisings associated with eventual demolition can be estimated by the model.

10.2 Distributed Services (Planning Envelope 5)

A cost and waste model for decommissioning distributed services has been developed based on the matrix of site services (length by diameter, material and type of construction) plus unit costs for excavation, removal and backfill derived from industrial benchmarks and AECL experience. For the purposes of this plan, it is assumed that all civil services 12” and more in diameter (plus transite of all diameters) will be removed. Electrical services buried at depths greater than 1.5 metres will be isolated and abandoned.

10.3 Affected Lands (Planning Envelope 6)

As discussed earlier in this document, for many of the items included under affected lands, it is assumed that confirmational monitoring over an extended period will allow for the eventual abandonment without aggressive recovery efforts. Ongoing monitoring costs have been determined based on existing costs from current monitoring activities. The number of boreholes required over an extended monitoring period like the one proposed (the planning assumption is 50 years of monitoring during the operational period) will be relatively small with new monitoring locations included over time and old monitoring points taken out-of-service.

10.4 Waste Management Areas (Planning Envelope 7)

The estimated cost for decommissioning the WMAs at CRL must include the ultimate cost for disposal, which has been included by the IRUS and LILW geologic disposal facilities indicated on Figure E3. The determination of this cost has taken the following elements into account:

- Characterization (Phase 1);
- Plume Treatment (Phases 1 and 2);
- Monitoring (Phases 1 and 2);
- Facility Maintenance (Phase 2);
- Remediation (Phases 2 and 3);
- Retrieval (Phase 3);
- Processing/Packaging and interim storage, as required (Phase 3);
- Transport (Phase 3);

- Disposal (Phase 3);
- Safety Case for Abandonment (Phase 3); and
- Long-Term Monitoring (Institutional Control).

10.5 Cost Estimate

The information assembled in this document presents the results of a process spanning several years to develop a decommissioning plan for the lands and structures currently present at CRL. In parallel with the development of the plan, projects were defined to implement the required decommissioning activities. These projects have provided the basis for estimating the cost of the liability and provide the information needed to characterize the overall liability.

The cost information is presented in the document "Basis of the Cost Estimate for the Chalk River Laboratories Decommissioning Liability" [19] and was used to support an audit by the office of the Auditor General (OAG) of the liability estimates published in the AECL 2005 Annual Report. The basic work breakdown structure (WBS) and the proposed schedule of decommissioning activities that were used for the OAG audit have been retained in that document [19].

The cost estimate for decommissioning CRL has been derived through a comprehensive analysis that addresses three essential elements for the estimation process, namely:

1. Define the scope by identifying all activities that will be required to achieve the decommissioning objectives,
2. Define the time frame during which the activities will be conducted, and
3. Apply methodologies for estimating cost that will meet the accuracy requirements.

The cost estimating methodology is consistent with the requirements in the Canadian Nuclear Safety Commission (CNSC) Guide G-206. The methodology applied to derive the cost estimate used information developed on the basis of:

1. ongoing operational costs (e.g., Storage with Surveillance (SWS), groundwater treatment systems)
2. ongoing monitoring (environmental monitoring)
3. current project estimates (for projects that are established and underway)
4. cost models for building decommissioning and WMA decommissioning
5. scaling from existing facilities and projects for future facilities
6. expert opinion

As a result of discussion with the OAG, the overall cost estimate carries an allowance for cost uncertainty of 20%. From G-206, Grade C are described as: "estimates are generally performed quickly using shortcut techniques, such as escalating and/or scale up from previous estimates, cost curves, and/or preliminary process design and equipment sizing, without plot plans or major equipment quotations". However, some activities estimated as part of the legacy liability are Grade-A or B estimates since they are based on costs already experienced within ongoing programs (e.g. monitoring or SWS costs), or are based on project estimates which have been through AECL's formal project review process and/or include cost estimates which have been prepared and/or detailed design has been completed to support a bidding process for delivery of the activity. Consistent with G-206, elements 1-3 in the list above are generally considered to provide Grade A estimates, element 4 generally provides Grade B estimates, and elements 5 and 6 provide Grade C estimates.

The schedule and costs are based on a program start of April 1, 2005. The cost for decommissioning AECL's Chalk River Laboratories as presented in this document has a Net Present Value (NPV) $1.97 Billion. This is part of the $2.75 Billion liability reported in the AECL 2005 Annual Report.

It is anticipated that this estimate will undergo future revisions where improvements will be made to the estimate as an increased experience base is developed. The schedule for future revisions will be set as required by AECL's financial management process. In addition, as public input to the plan is received (as one of the activities planned to be conducted in the first five years) changes may be made to address their input.

10.6 Source of Funding

Funds for decommissioning at CRL are provided through a ten-year arrangement by which the Decommissioning Program is funded by proceeds from the sale of the heavy water inventory. Prior to 1996/1997, AECL's Decommissioning Program was separately funded by parliamentary appropriations. In the absence of a renewal or extension of the current ten-year program agreement, the program will revert back to the parliamentary appropriations system in place in 1995/1996.

A financial guarantee for the decommissioning of the CRL site was provided to the CNSC in December 2003 by the Minister of Natural Resources Canada [20].

11. OPERATIONAL RECORDS

In addition to facility-specific records, the Site Engineering and Project Management Services Division oversees AECL's Information Management Centres, who manage CRL's Operational Records:

1. Information Centre - Central Records and Photography; and
2. Technical Service Section (TSS) - CRL Engineering Records.

Site Operational Records, which are maintained for decommissioning planning, management and projects, are:

- <u>Operating Records</u>, such as, Operating Logs, Fuel Records, Waste Records, Operations Manuals/Procedures/Limits/Conditions, Maintenance Records.
- <u>Configuration Records</u>, such as, Maps, Drawings, Photographs, Engineering Records, Design Records, Technical/Materials Specifications, Change Control Information.
- <u>Environmental/Radiological/Incident/Regulatory Records</u>, such as, Annual Reports, Unplanned Event Reports, Radiation Zone Surveys, Survey Logs, Environmental Panel

Meetings, Hazardous Materials Inventory/Control/Surveys, Licensing Reports, Compliance Reports, Safety Analysis Reports.

Since the mid 1940's, the Site Operational and Historical records have been and will continue to be maintained in AECL's Information Management Centres. These records include both paper and electronic information and are managed in a Records Management System. In addition to the Site Operational Records, each of the CRL Listed Facilities has facility-specific records, which are referenced in their individual PDPs.

Both the records and system are managed, and will be periodically reviewed to ensure that the records are protected, managed and accessible and to take advantage of any new advances in records storage, practices and technologies. Records management for the CRL site is an ongoing process and as the site is decommissioned, information storage will continue to be protected and may be relocated at the appropriate time, as required.

12. CONCLUSIONS

This document outlines a technically feasible preliminary plan for decommissioning the CRL site and associated facilities, in a manner that protects the health, safety and security of workers, the public and the environment. At the conclusion of the project, all current facilities will have been decommissioned and the remaining facilities and sites will be available for other activities conducted by AECL or other successor organizations.

13. REFERENCE DOCUMENTS

[1] CNSC, “Decommissioning Planning For Licensed Activities”, CNSC Regulatory Guide G-219, 2000 June.

[2] CNSC, W.G. Martin CNSC letter to G.V. Sotirov AECL , Re: CNSC Staff Requirements and Expectations for the Revised Preliminary Decommissioning Plan (PDP) for AECL’s Chalk River Laboratories (CRL) Site, November 10, 2004.

[3] AECL, “CRL Site Characteristics”, NSN-RQASD-035, Revision 4, **PROTECTED**, 2004 January.

[4] AECL, “NRX Reactor and Bldg. 100 Preliminary Decommissioning Plan”, 3611-01610-PDP-004, Rev. 0, **PROTECTED**, 2002 October.

[5] Hydat CD-ROM, Version 1.05.8, Water Survey Division Environment Canada, 1999 November 20.

[6] AECL, “Radiation Protection Manual”, RC-2000-633-1.

[7] AECL, “Decommissioning Planning & Operations Quality Assurance Plan”, 3600-01913-QAP-001, Revision R1, **CONTROLLED**, 2004 November.

[8] CNSC, “Financial Guarantees for the Decommissioning of Licensed Activities”, CNSC Regulatory Guide G-206, 2000 June.

[9] AECL, “AECL Work Permit System”, 00-812.2.2, Rev. 0, 2000 March 08.

[10] AECL, “Occupational Safety & Health Program Manual”, 00-07010-MAN-01, Revision 1, **CONTROLLED**, 1999 November.

[11] AECL, “Update on the Location of the Leading Edge of the Area A Contaminant Plume - 1997”, RC-1959, 1997 November.

[12] AECL, “The 1997 Subsurface Distribution and Inventory of ^{90}Sr at Waste Management Area A”, Chalk River Laboratories”, RC-2172, 1998 November.

[13] Gee, G.W. and Wing N.R, “In-situ Remediation: Scientific Basis for Current and Future Technologies”, Proceedings of the 33rd Hanford Symposium on Health and the Environment, Pasco, Washington, 1994.

[14] AECL, “Facility Authorization for the Operation of the Waste Management Areas at the Chalk River Laboratories”, AECL-FA-18, Revision 4, 2001 October.

[15] AECL, “A Safety and Hazards Analysis of the Chalk River Laboratories Waste Management Areas”, AECL-MISC-306, Rev. 2, **PROTECTED-Proprietary**, 1995 July.

[16] AECL, “CRL Waste Management Areas, Annual Safety Review YEAR”, AECL-MISC-306-xx (where xx are the last two digits of the year)

[17] AECL, “CRL Waste Management Areas Operational Control Monitoring Annual Report for 1997: Baseline Study”, AECL-MISC-403, 1998 August.

[18] AECL, “A Summary of the Quantitative Cost Model for Decommissioning and Demolition of Structures on the CRL Site”, CPDP-01620-067-002, Revision R0, **PROTECTED**, 2002 September.

[19] AECL, “Basis of the Cost Estimate for the Chalk River Laboratories Decommissioning Liability”, 3611-01512-AB-001, Revision R0, 2005 December.

[20] Hon. H. Dhaliwal, P.C.,M.P., Minister of Natural Resources Canada, letter to L. Keen, President and Chief Executive Officer, Canadian Nuclear Safety Commission, 2003 December 11.

Attachment A

Structures on the CRL Site – Planning Envelopes 1 to 4

The following tables summarize the structures on the CRL site, broken out by Planning Envelope (see Section 2.5 in the body of this document). The data are extracted from the AECL-wide Facility Information System (FIS) that is used to collect and record data such as location, floor area and usage at the building and room level. The tables present for each structure the building number, its description/use and the total floor area. These data were reviewed for completeness by checking against the latest version (2005 January 1) of the CRL site map. Additionally, for Planning Envelope 1, nuclear facilities listed on the CRL site license, the included structures were checked against both the Facility Authorization and the latest version of the relevant decommissioning documents (PDP or DDP).

All structures in PE1, 2 and 3 are included in the relevant tables. For PE4, only buildings with floor area greater than 50 m^2 are listed to exclude small structures such as sheds and small trailers that can be removed with very little effort. Assignment of buildings to PE 4 was also revisited based on the January 2005 update. Indicated floor areas are internal, i.e. they are based on the sum of all the room areas listed in FIS. Note, that several buildings on the CRL site are given "A", "B", "C", etc. suffixes to identify distinct functions or phases of construction. For the most part, these suffixes are ignored in the tables, e.g. "B456" includes B456A, B, C and D and the room type designations refer to the whole building. Exceptions are made when, for example, the "A" and "B" structures are assigned to different planning envelopes.

Table A-1: Planning Envelope 1 – Nuclear Facilities Listed on the CRL Site Licence (Appendices A and B)

Facility	Scope (Building(s) or Area)	Facility Status (as of 2005 January	Documentation		Floor Area (m^2) (Buildings only)
			Facility Authorization	PDP/DDP	
NRU Research Reactor	150, 156, 162, 163, 164, 165, 166, 204A (part), 440, 440A, B, C, D, 548	Operational	FA-01 R4	PDP: RC-2434 [A1]	19,865
NRX Research Reactor	100, 100 annex (part), 100X, 101, 101X, 103, 104, 122, 126, 133, 144, 157, 204A/B	Decommissioning	N/A	PDP: 3611-01610-PDP-004 [A2] DDP: B204 Bays RC-2593 [A3] PDP: Ancillary Buildings RC-2753 [A4]	6,002
Heavy Water Upgrading Plant	210, 212 (part)	Decommissioning	FA-04 R3	PDP: B210-05270-PD-1 [A5] DDP: RC-2720 [A6]	1,506
ZED-2 Research Reactor	145 (part)	Operational	FA-05 R4	PDP: RC-1938 [A7]	837
Nuclear Fuel Fabrication Facility, Building 405	405	Operational	FA-19 R3	PDP: RC-1964 [A8]	1,735
Nuclear Fuel Fabrication Facility, Building 429	429A/B	Operational	FA-02 R3	PDP: RC-1965 [A9]	694

Facility	Scope (Building(s) or Area)	Facility Status (as of 2005 January	Documentation		Floor Area (m^2) (Buildings only)
			Facility Authorization	PDP/DDP	
Recycle Fuel Fabrication Laboratory	375 (part)	Operational	FA-03 R2	PDP: RC-1693 [A10]	301
Tritium Laboratory	250 (part)	Operational	FA-15	PDP: EVALPN-01610-PLA-001 [A11]	261
Combined Electrolysis Catalytic Exchange Upgrader Demonstration Facility	215	Decommissioning	FA-20	PDP: CECEUD-9000-1-PD [A12]	1,311
Waste Treatment Centre (includes the Active Drain Line System)	570, 570A, B, C, D, F, G, T, 574, 205, 205X, 207, 222, 222A, 222X, 224, 240, 242, 243, 244, 538.	Operational	FA-16	PDP: WTC-01602-1-PD [A13]	3,491
Universal Cells	234	Operational	FA-06	PDP: RC-2727 [A14]	1,077
Fuel Materials Cell Facility	375 (part)	Operational	FA-17	PDP: EVALPN-01610-PLA-001 [A15]	665
Mo-99 Production, Building 225	203, 205, 206, 225, 225A, 229	Operational	FA-07	PDP: RC-1933 [A16]	1,352
Health Physics Neutron Generator	513A (part)	Operational	FA-14	CDP: RC-2015 [A17]	150
Waste Management Areas	B596, 591, 591A, 599A, 599B. LDA, WMA B, C, D, H, A, E, F, G, Thorium Nitrate Dispersal, Ammonium Nitrate Plant, Glass Blocks	Operational	FA-18	PDP: RC-2193 [A18]	2,197
MDS MAPLE-1 Isotope Reactor	110	Commissioning	N/A	CDP: 6400-01702-DWP-001, Rev. 2, May 1999 [A19]	832
MDS MAPLE-2 Isotope Reactor	111	Commissioning	N/A	CDP: 6400-01702-DWP-001, Rev. 2, May 1999 [A19]	833
New Processing Facility (Mo-99)	260	Commissioning	N/A	CDP: 6400-01702-DWP-001, Rev. 2, May 1999 [A19]	1,378
Pool Test Reactor	145 (part)	Decommissioning	N/A	PDP: RC-1681 [A20]	164
Plutonium Recovery Laboratory	220	Decommissioning	N/A	PDP: RC-2229 [A21]	1,489
Plutonium Tower	223	Decommissioning	N/A	PDP: RC-2392 [A22]	130
Waste Water Evaporator	228	Decommissioning	N/A	PDP: RC-2395 [A23]	137
PHELA/IMPELA Accelerators	610 (part)	Decommissioned No longer listed	N/A	End-State Report: IMPPHE-01600-PD-1 [A24]	N/A
Tandem Accelerator, Super-Conducting Cyclotron	137	Decommissioned No longer listed	N/A	Safe Shutdown End-State Document: TASCC-01609-1-PD [A25]	N/A

Facility	Scope (Building(s) or Area)	Facility Status (as of 2005 January	Documentation		Floor Area (m^2) (Buildings only)
			Facility Authorization	PDP/DDP	
				Approximate Total Floor Area =	46,407

Table A-2: Planning Envelope 2 – Radiochemical Laboratories & Other Buildings Where Radioactive Materials have been or are being Handled

Building Number	Use/Description	Status	Floor Area (m^2)
107	Physics & General Chemistry	Operational	3,530
160	LOCA Filter House	Operational	276
172	Decontamination Skid Storage For NRU	Operational	25
174	Storage shack for NRU	Operational	22
175	Storage shack for NRU	Operational	25
202	Active Laundry Building	Operational	899
226	Active Area Maintenance Shop	Operational	431
250	Chemical Eng. Building.	Operational	4,653
300A	Corrosion Laboratory (includes a trailer, 300T)	Operational	2,773
320	Chemistry & Materials Building	Operational	1,931
322	Garbage Can Storage.	Operational	4
330	Chemistry & Materials Building	Operational	2,090
375	Metallurgy Building	Operational	3,247
468	R&IS Vehicle Decontamination	Operational	254
469	Fuel Engineering	Operational	1,639
507	Decontamination	Operational	717
539	Materials	Operational	283
554	Decontamination Storage Building	Operational	69
591T	Q2 Trailer - WMA 'B'	Operational	37
594	Spring B Facility	Operational	90
		Approximate Total Floor Area:	**22,995**

Table A-3: Planning Envelope 3 – Low-Hazards Nuclear Structures (Generally CA-2)

Building Number	Use/Description	Status	Floor Area (m^2)
100A	NRX Annex - DIF Offices	Operational	881
102	Drum Cleaning Building	Operational	125
102X	Drum Cleaning Building	Operational	84
125	Process Water Line Valve House	Operational	35
135	Generator Building	Operational	186
138	Major Facilities Services and Storage	Operational	932
143	Maintenance & Storage (includes a shed, 143C)	Operational	504
145	Research Building	Operational	4,163
150T	NRU License Extension Project	Operational	994
168	Waste Disposal Sorting Building	Operational	20
171	CHF Electrical Test Bldg.	Operational	171
200	Reactor & Processing Facilities Commissioning	Operational	1,344
201	Filter Storage & Maintenance Shop	Operational	147
210T	MMIR Project Trailer	Operational	22
211T	MMIR Project Trailer	Operational	22
211	Underground Storage	Operational	58
212 (part)	ASME Section 3 pipe fabrication shop	Operational	132
227	Nuclear Facilities Operations	Operational	791
300B	Fuel Engineering & Offices	Operational	145
321	Gas Bottle Storage	Operational	10
323	Service Building For B320/330	Operational	149
380	Materials Laboratories	Operational	1,936
420	Power House & Related Facilities (includes 420A, B, C)	Operational	4,218
423	Sewage Pump House	Operational	8
433	CA-2 Maintenance Shop	Operational	615
440	Water Treatment & Filtration Plant (includes 441 tank)	Operational	48
442	Filtered Water Storage	Operational	28
444	Filter Water Head	Operational	27
451	Restricted Storage	Operational	510
456	Engineering Technology, OD&T, Decommissioning Planning (designated A, B, C)	Operational	6,588
458	Carpenter Shop CA-2	Operational	427
464	Health Sciences & Dosimetry	Operational	911
466	Thermalhydraulics and CA-2 Workshop (includes B434 CO_2)	Operational	4,228
467	Accelerator Development Lab.	Operational	852
491	Heavy Equipment Storage	Operational	575
493	Quonset-Construction Storage	Operational	450
513	Health Sciences & Environmental Research (includes 431 A, E)	Operational	4,684
515	Emergency Equipment Storage	Operational	145
527	Ammonia/Hydrogen/Amine Tower (designated A, B)	Operational	186
529	Burst Test Lab	Operational	68
541	NRU Storage	Operational	535
557	Active Equipment Storage	Operational	223
558	Hydrogen/ H_2O Exchange Tower (designated A, B, C)	Operational	131

Building Number	Use/Description	Status	Floor Area (m^2)
575	Uranium And Thorium	Operational	108
600	Electronics Building	Operational	3,230
		Approximate Total Floor Area:	**41,646**

Table A-4: Planning Envelope 4 – Non-Contaminated Buildings (Generally Supervised Area & CA-1)

Building Number	Use/Description	Status	Floor Area (m^2)
114	Administration	Operational	1,849
137	Former TASCC Facility	Operational	4,421
401	Gate House	Operational	1,308
406	Garage	Operational	2,193
407	Fire Hall & Garage	Operational	381
408	Lead Shop	Operational	90
409	Glassblowing Shop	Operational	1,115
412	CA-1 Area Machine Shop	Operational	2,699
413	Carpenter Shop & Storage	Operational	925
414	Carpenter Shop Storage.	Operational	178
417	Aggregate Storage Building	Operational	242
418	Lubricant & Scaffolding Storage	Operational	85
419	Spare Parts	Operational	156
422	HEPC Substation	Operational	167
426	Service water tank	Operational	N/A
432	Main Library	Operational	2,568
457	Purchasing, Stores, Photography	Operational	3,425
459	Neutron & Solid State Physics	Operational	1,022
485	Salt Storage	Operational	159
492	Reactors Tooling Storage	Operational	561
500	Cafeteria	Operational	2,409
501	Pickling Building	Operational	103
508	IT and Communication	Operational	2,811
512	Fire water tank	Operational	N/A
514	Emergency Storage Building	Operational	69
517	Sheet Metal Shop	Operational	113
519	Auxiliary Auto Parts Storage	Operational	101
522	Temporary PCB Storage Building	Operational	54
523	Reactors Tool Storage	Operational	541
524	Animal Facility	Operational	2,880
533	Storage Shed For Reinforced Steel	Operational	90
536	Storage Building	Operational	296
540	Misc. Bulk Storage	Operational	626
542	Environmental Research Structures	Operational	100
543	Visitors Centre	Operational	856
552	Carport	Operational	135
553	Storage Building	Operational	177
555	Vehicle Storage Building	Operational	313
560	Low Background Laboratory	Operational	310

Building Number	Use/Description	Status	Floor Area (m^2)
566	Fire & Impact Test Facility	Operational	86
567	New water treatment plant	Not commissioned	600
568	New Sewage Treatment (includes 447, A, B, D, E, F, G)	Operational	164
576	Mechanical Services	Operational	191
580	Evacuation Monitoring Building	Operational	500
581	Guard Entrance House	Operational	100
610	Accelerator Development (former)	Operational	1,540
701	New Gatehouse	Operational	1,807
		Approximate Total Floor Area:	**40,516**

Summary of Planning Envelopes 1 to 4

The total floor areas of structures within each of the four Planning Envelopes on the CRL site are summarized in Figure A1.

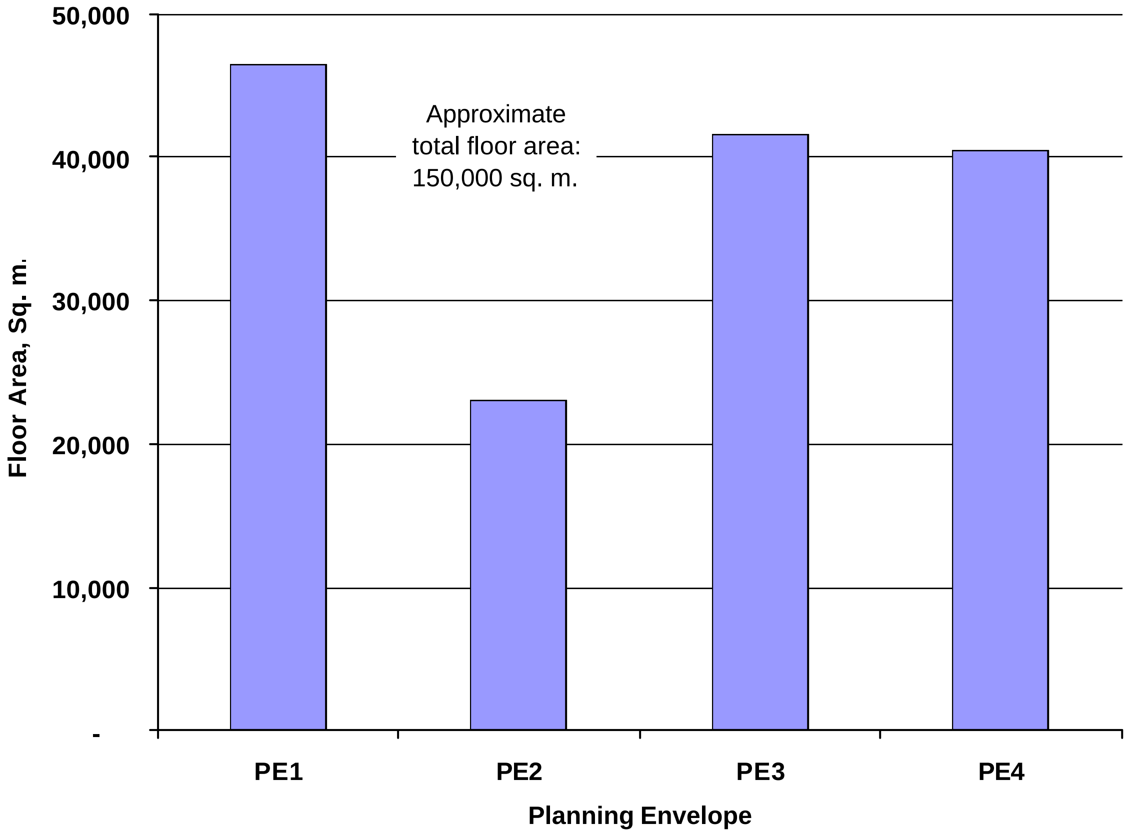

Figure A1: Summary of Aboveground Structures at CRL

Reference Documents

[A1] AECL, "NRU Reactor Facility, Chalk River Laboratories: Preliminary Decommissioning Plan", RC-2434, **PROTECTED-Proprietary**.

[A2] AECL, "*NRX Reactor and Building 100: Preliminary Decommissioning Plan*", 3611-01610-PDP-004, **PROTECTED**.

[A3] AECL, "*Building 204 A/B Fuel Rod and Storage Handling Bays, Chalk River Laboratories: Detailed Decommissioning Plan*", RC-2593, **PROTECTED**.

[A4] AECL, "*NRX Ancillary Buildings, Chalk River Laboratories: Detailed Decommissioning Plan*", RC-2735, (in preparation).

[A5] AECL, "*Heavy Water Upgrading Plant Building 210, Chalk River Laboratories: Preliminary Decommissioning Plan*", B210-05270-PD-1 **PROTECTED-Proprietary**.

[A6] AECL, "*Detailed Decommissioning Plan for the Chalk River Laboratories Heavy Water Upgrading Plant*", HWUP-01690-DDP-1 RC-2720 **PROTECTED-Proprietary**.

[A7] AECL, "*The ZED-2 Research Reactor Facility, CRL Building 145: Conceptual Decommissioning Plan*", RC-1938, **PROTECTED-Proprietary**.

[A8] AECL, "The Nuclear Fuel Fabrication Facility, CRL Building 405: Preliminary Decommissioning Plan", RC-1964, **PROTECTED - Proprietary**.

[A9] AECL, "*The Nuclear Fuel Fabrication Building 429A and 429B: Preliminary Decommissioning Plan*", RC-1965, **PROTECTED - Proprietary**.

[A10] AECL, "Re*cycle Fuel Fabrication Laboratories at CRL: Conceptual Decommissioning Plan*", RC-1693.

[A11] AECL, "*Tritium Laboratory Located in CRL Building 250 Preliminary Decommissioning Plan*", EVALPN-01610-PLA-001, **PROTECTED**.

[A12] AECL, "*CECEUD Conceptual Decommissioning Plan*", CECEUD-9000-1-PD RC-1759.

[A13] AECL, "*Conceptual Decommissioning Plan for the WTC*", WTC-01602-1-PD.

[A14] AECL, "*Universal Cells, CRL Building 234 Preliminary Decommissioning Plan*", EVALPN-01610-PLA-002, **PROTECTED**.

[A15] AECL, "*Fuels & Materials Cells, Located in CRL Building 375: Preliminary Decommissioning Plan*", EVALPN-01610-PLA-003, **PROTECTED**.

[A16] AECL, "*The Molybdenum-99 Production Facility, CRL Buildings 225, 225A & 229: Conceptual Decommissioning Plan*", RC-01933, **PROTECTED-Proprietary**.

[A17] AECL, "*The Health Physics Neutron Generator, CRL Building 513: Conceptual Decommissioning Plan*", RC-2015.

[A18] AECL, "*The Waste Management Areas at Chalk River Laboratories: Conceptual Decommissioning Plan*", RC-2193.

[A19] AECL, "Conceptual Decommissioning Plan for the Dedicated Isotope Facilities", 6400-01702-DWP-001, Rev. 2

[A20] AECL, "Pool Test Reactor Conceptual Decommissioning Plan", RC-1681.

[A21] AECL, "*The Plutonium Recovery Laboratory CRL Building 220: Preliminary Decommissioning Plan*", RC-2229.

[A22] AECL, "*The Plutonium Tower, CRL Building 223: Preliminary Decommissioning Plan*", RC-2392.

[A23] AECL, "*The Waste Water Evaporator, CRL Building 228: Preliminary Decommissioning Plan*", RC-2395.

[A24] *End-State Report - Industrial Materials Processing Electron Linear Accelerator (IMPELA) and Pulsed High Energy Linear Accelerator (PHELA)*, CRL Building 610, Decommissioning Project, IMPPHE-01600-PD-1.

[A25] *TASCC Facility Safe Shutdown End-State Document*, TASCC-01609-1-PD.

Attachment B

Distributed Services on the CRL Site – Planning Envelope 5

The following two tables, B1 and B2, summarize the Civil and Electrical Services that are distributed throughout the CRL site. The services are buried except where noted. In general, water, sewer and high voltage services are deeper than non-liquid or low voltage services.
These data have been assembled from quantity take-offs from CRL site drawings in the E-4444 series that show all services in a series of 500m-square grids (32 in total to cover CA-1, CA-2 and the Supervised Area).

Table B1: Distributed Civil Services on the CRL Site

Service	Length (m)				Comments
	CA-2	CA-1	Supervised	Total	
Underground Thermal Column Exhaust Duct	770	0	1,107	1,878	1.2 m diameter shielded active duct. Now used by MMIR.
Active Drain (old)	8,500	0	1,684	10,184	Active drain replacement project is ongoing. Approximately 40% of the old lines are still in service, 30% have been removed and 30% are out of service but still in place.
Active Drain (new)	3,176	0	1,684	4,860	
Acid Waste	92	0	0	92	A single 2” plastic line running from B145
Condensate	4,549	1,495	0	6,044	A network of lines running from buildings that use plant steam to return condensate to the Power House. A mix of below - and above-ground lines, 2” to 6” diameter, mostly steel.
Disposal Sewer	0	37	0	37	54” diameter steel pipe from the Power House to the river.
Fire Water	4,748	4,048	229	9,026	Distributed below-ground throughout the plant from the Power House. Mostly cast iron, diameters starting at 12” and reducing to 4” or 6” for entry into buildings.
Heating Water	2,010	69	0	2,079	Mostly PVC, 12” to 3” diameter. System is now largely out of service
Helium Line	336	0	0	336	Two line, 1½” S/S and 1” copper. Serves NRU and B375
Heating Drain	1,669	70	0	1,739	Return lines for old heating water system. 21” to 2” diameter PVC. Now largely out of service.
Pneumatic Line	2,675	125	0	2,800	Below-ground system to transfer samples from NRU to the Universal Cells.
Process Sewer	3,274	0	0	3,274	10”, 12” and 36” cast iron, vitrified clay and steel lines leading to 48” pipe to the river. System includes 26 manholes.
Process Water	2,012	90	0	2,102	Distributed throughout the plant from the Power House. Starts off as 48” diameter steel and down to 2” for entry into the buildings.
Raw Water	144	239	0	384	One 54” and two 30” intakes from river to the Power House plus one 24” intake to B440.
Refrigeration Line	21	140	0	162	Dedicated insulated line serving B250 and B375

Service	Length (m)				Comments
	CA-2	CA-1	Supervised	Total	
Sanitary Sewer	4,524	2,691	0	7,214	Mainly vitrified clay, cast iron and Transite, 4" to 12" diameter, distributed throughout the plant. System includes 80 Manholes, 2 pumping stations & a single septic system for both CA-1 & CA-2.
Service Air	5,739	2,320	75	8,134	Distributed throughout the plant from the Power House. Starts off at 6" steel and reduces to as small as ¼" for entry into buildings.
Service Water	3,826	2,119	0	5,944	Also (previously) known as process water. Wide variety of materials (including cast iron, steel and PVC) and diameters from 1" to 16". System has been extensively modified and updated over the life of the plant. Many lines replaced and old ones abandoned in place. System includes 165 shutoff valves, 3 hydrants and one water tank.
Steam	4,785	3,072	75	7,932	Distributed throughout the plant from the Power House. Mostly steel, 3" to 16" diameter and includes ~1,220 m of overhead line. Note: Steam/air/condensate system incorporates 40 manholes, 40 steam meters, 215 m of underground steam tunnel & 23 expansion joints.
Storm Sewer	4,302	7,256	901	12,459	Surface drains feed into several below-ground culverts (mostly concrete up to 72" diameter) to drain to the river. The system consists of 195 catch basins.
Active Exhaust Duct	336	0	0	336	0.45 m diameter buried stainless steel vent from Building 225A to Building 205.
Miscellaneous	924	743	0	1,668	Assorted lines such as weeping pipes, distilled water, nitrogen, conduit etc.

Table B2: Distributed Electrical Services on the CRL Site

GIS Level	Service	Length (m)		
		CA-2	CA-1	Total
18	2.4 kV Overhead Cable Run	740	2,345	3,085
19	2.4 kV Underground	15,940	18,217	34,157
22	Class 4 (Normal) 600V Cable Run	12,727	9,918	22,645
26	Class 3 (Emergency) 600V Cable Run	15,281	11,063	26,344
30	Plant Ground Run	30,530	24,152	54,682
34	Common Control Cable Run	22,416	20,081	42,497
38	Fire Signal Cable Run	11,365	12,611	23,976
42	Telephone Cable Run	15,284	21,622	36,906
46	Fibre Optic Cable Run	5,378	3,922	9,300
49	Ethernet Cable Run	1,990	594	2,584
54	Security Cable Run	7,708	7,519	15,227

Attachment C

Affected Lands on the CRL Site – Planning Envelope 6

1. GENERAL

All lands within CA-1 and CA-2 are considered as having been affected by nuclear R&D/Industrial operations over the years. Some lands have been specifically documented as containing specific radiological and non-radiological substances and have been quantified and assigned identifying designations. The great majority of the lands in the Supervised Area are unaffected with the obvious exception of the Waste Management Areas (which are designated as CA-2). Past operations within the WMAs have resulted in groundwater plumes that extend beyond the defined boundaries of some of the WMAs. Additionally, some smaller areas have been identified as being affected – physically or radiologically – as a result of routine operations or accidental spills.

2. ROADS

The CRL site includes ~40 km of roads, which can be divided into two broad groups, those open year round and those, which have seasonal use. The year round access roads (~20 km) are, in turn, either paved or gravel with seasonal roads being primarily gravel or forest path. In terms of area, the roads provide access and therefore impact a significant portion of the CRL site. The two primary concerns regarding roads on the CRL site are use of road salt (year round access roads) and historically, application of dust suppressant oils (sub fraction of the gravel roads). Several areas near the Plant Highway have elevated chloride concentrations resulting directly from winter road salt application. Neither of these concerns is in any way unique to the CRL site. For the purposes of the CRL Site PDP, no specific actions are proposed but they can be revisited in future revisions to the document, as required.

The primary intent with respect to roads (salt and dust suppressant) is that as this problem has solutions and approaches developed for use outside of AECL, similar solutions will be applied for the same situations on the CRL site.

3. SITE SUPPORT AREAS

3.1 General

Site support areas include several different types of items ranging from Aggregate Borrow Pits to Snow Dumps, Forest-Slash Lay-Down Areas and also an on-Site Target Range used by CRL Security Personnel. Additional items like septic fields, which service some of the outer area buildings, will be included with the appropriate building or structure.

3.2 Aggregate Borrow Pits

Aggregate extraction on the CRL site has taken place from the earliest days of site development (and the start of some of these activities pre-date both AECL and the initial development of CRL). This has resulted in the presence of several sand pits on the site. All the pit areas are considered to be in operational use, but the frequency of their use depends largely on their proximity to current operations requiring aggregate. The total land area under use as aggregate borrow pit is less than 8 hectares.

Although currently considered to be in operational use, as site operations no longer requires them, several steps will be taken to provide for pit reclamation:

- Slope stabilization will be achieved;
- Excavations extending below the water table will be in-filled; and
- If required, re-vegetation will be implemented (areas larger than 2 acres).

The cost of reclamation is estimated to be low for these items.

3.3 Snow Dumps

There are two sites at CRL that are used as snow-dumping areas. The primary concern with snow dumping is the same concern that exists with use of road salt. Again, this concern is not unique to CRL and these Snow Dumps are noted so that if there is a strategy developed outside of AECL to manage the reclamation of these areas it can be captured in future revisions of this PDP. These Snow Dumps have associated with them elevated groundwater chloride concentrations.

3.4 Target Range

CRL Security personnel have a target range that has been in use over the last four decades. The primary concern for the area is from lead, which has been deposited from spent munitions. The target range is small in area, less than an acre and continues to be in active use. Reclamation is scheduled in the 11 to 25 year time frame, with an estimated volume of material requiring removal of $< 2\ m^3$, additional reclamation activities would be the same as required for a Borrow Pit (the areas original use), namely slope stabilization and infilling for water-table exposure, if required.

3.5 Forest Slash Areas

On the CRL site there are several areas that have been used to accumulate forest slash from site and road development activities. These areas continue to be in operational use by Site Operations and there are no plans to cease these operations in the next 25 years. Over time, the accumulated vegetation degrades to a mulch/organic layer so no future measures are currently seen as necessary, but these areas have been identified so that they can be considered in future revisions of this CPDP.

3.6 Meteorological Stations

The CRL Supervised Area is host to five meteorological stations. These are expected to be in use over the next 20 years and then upgraded/replaced as part of ongoing site operations.

3.7 Electrical Supply Power Lines & Corridors

Electrical supply lines will require replacement and upgrading over the lifetime of the CRL site.

3.8 NRX Emergency Pipeline

Following the NRX accident of 1952, a temporary pipeline was constructed from NRX to WMA A. This pipeline was operated only for several years but during this period the pipeline leaked at a number of locations. Remedial actions included the removal of the pipeline and the contaminated soils, but minor residual contamination is present along the pipeline route. Although further characterization work is needed to confirm this, the existing data indicates that no contamination is present that would require removal. This forms the basis of the PDP assumption that no further remedial work will be required at this site.

Other pipelines (e.g. the waste effluent lines from Building 240 to the Liquid Dispersal Area) are included in Planning Envelope 7.

3.9 Sanitary Landfill

AECL operates a sanitary landfill on the CRL site. The landfill is used for non-radioactive and chemically non-hazardous wastes resulting from operations on the CRL site. Present day operating procedures are in-line with current regulations governing the use of sanitary landfills. The landfill site is part of a ground-water monitoring program and the landfill and monitoring program are expected to continue operation for many decades. Landfill closure will be conducted in-line with current Provincial regulations and involve final site contouring and re-vegetation and continued post-closure monitoring. Ongoing monitoring has occasionally detected low levels of radionuclides, primarily tritium and strontium (at concentrations generally less than Drinking Water Quality Objectives), but these are expected to be below levels of concern following the site operational period.

3.10 Grey Crescent

The Grey Crescent is a crescent shaped area outside the southern portion of the laboratory's Controlled Area 1 and was previously described in Reference [C1]. The planning assumption is that ongoing monitoring of the Grey Crescent will be in effect up to 2050. It is further assumed that no recovery of materials (soils or construction type debris) will be required, although limited recovery of discrete objects may be required and would be confirmed by the monitoring.

4. EXPERIMENTAL AREAS

The CRL site Supervised Area continues to serve as a host for a variety of experimental areas including: Glass Block sites; Twin Lake Tracer Experiment area; Perch Lake Canopy Tower; Waste Lysimeters; O-Nest pumping test area, etc.

Each of these areas has been assessed on an individual basis since they are each unique. In general, all of the experimental areas have been developed to study the migration and fate of radionuclides so they involve both source areas and plumes or dispersion areas. However, with the exception of the two glass block sites short half-life tracers were used so there is no long-term contamination issue associated with any of these other experimental facilities. The removal of the glass block experimental facilities is estimated to yield 1.5 m^3 of LLRW.

5. BOREHOLES

5.1 General

Boreholes on the CRL site can be subdivided into two categories of: deep bedrock boreholes and shallow overburden boreholes. The deep bedrock boreholes number approximately 25. The deep boreholes are exploratory/experimental in nature as opposed to the shallow holes, which were also installed for monitoring contaminant migration from a variety of facilities.

5.2 Deep Boreholes

Closure of deep boreholes will involve sealing of the boreholes to prevent cross-linking of aquifers. Cementitious grouts will be injected into the boreholes and casings will be extracted or terminated as close to surface as practical. No radiological/non-radiological contamination issues exist with respect to the boreholes. The timeframes for deep borehole sealing are shown in Table C1.

5.3 Shallow Overburden Boreholes

Shallow overburden holes are very numerous on the CRL site and number approximately two thousand. Closure of the shallow boreholes is planned to involve removal of casings to a minimum depth 1.5 metres (greater if practical) and filling (with native materials) of remaining holes. The timeframes for shallow borehole closure are shown in Table C1.

6. PLUMES

6.1 WMA Plumes

The WMA plumes are discussed in Section 2 of Attachment D.

6.2 Other Plumes

The plumes originating from facilities within CA-2 and not originating from the WMAs are:

- Building 204 Fuel Storage Bays (strontium and tritium);
- NRU (2 plumes; one from the IX transfer line and the other from the north side of NRU (tritium)); and
- Tank 240 (tritium).

In general, the strategy for the plumes will be continued monitoring and assessment of the need for capture, although based on current information no provision is seen as necessary for capture and treatment. The purpose of continued monitoring is intended to be confirmatory in nature providing data showing that the plumes are evolving as expected and that impacts are acceptable.

7. RIVER SEDIMENTS

Historical discharges from the CRL Process Sewer system to the Ottawa River, dating back to the 1940s and 1950s, have produced concentrations of radionuclides and non-radiological substances in the river sediment that are elevated above background levels. Preliminary characterization data indicate that these sediments are limited to a relatively small area, and that the deposition is related to the operation of the CRL site. The size of the affected area is roughly 200 m by 400 m. The anthropogenic deposits are within the upper 15 cm of sediment. There appears to be a trend of decreasing deposition of radionuclides toward the sediment surface, perhaps indicative of the much cleaner conditions since NRX was last in operation (1991). As the bulk of the activity (estimated to be 40 GBq in total) is from radionuclides with half-lives shorter than 30 years, negligible levels of radioactivity will remain after the site operational and the institutional control periods. Activity appears to be partly in the form of active particles within the area, and AECL is currently characterizing the activity in terms of nuclides and particle size. Contaminated sediments in the Ottawa River associated with the CRL process sewer outfall will be remediated. The extent and nature of the remedial activities will be dictated by an assessment of the potential environmental impacts associated with various options for managing the sediments.

References

[C1] AECL, Letter to CNSC (B. Howden), "Historic Areas of Contamination in the Supervised Area at CRL", 1999 November 30.

Table C1: Affected Lands Matrix

Facility/Item Description	Location	Timeframe	Planning Assumption Requirement	Notes & Waste Estimates (As Applicable)
Inner Area Plumes	CA	Long	Ongoing Monitoring No retrieval required, source removed with facility/structure	5 to 10 boreholes + twice per year sampling ongoing for 50 years
Grey Crescent General Area Used for Landfill/Backfill Activities	SA	Long	Ongoing Monitoring and assessment Small selective retrieval may be required (monitoring to confirm)	10 to 15 boreholes + twice per year sampling ongoing for 50 years
Road Salt & Oiled CRL Roads	SA	Long	Continued use expected - No Action Required	NA
River Sediment	SA	Long	No Action Required	NA
Snow Dumps (2)	SA	Long	Continued use expected	Re-vegetating
Meteorological Towers	SA	Long	Continued use expected, no contamination, thereby allowing conventional removal	NA
Landfill Attenuation Zones	SA	Long	Continued use - No Action Required	NA
Dawson City	SA	Long	No Action Required – construction debris used for landfill – confirmatory monitoring	Sampling requirements included in Grey Crescent
Target Range	SA	Long	Recovery of lead fragments & re-vegetating	No radioactive waste – lead contamination
1953 NRX Pipeline Route	SA	Long	Confirmatory Survey of No Action Required – potential for residual contaminations exists, but short in-use period was in early 1950's	Pipeline recovered some years after 1953 usage
On-site Sanitary Landfill	SA	Long	No recovery of materials assumed to be required – to be confirmed by continued monitoring	5 acres closure document and ongoing annual monitoring

CA - Controlled Area 1 and/or 2

SA - Supervised Area

Table C1 (continued): Affected Lands Matrix

Experimental Sites

Facility/Item Description	Location	Timeframe	Planning Assumption Requirement	Notes & Waste Estimates (As Applicable)
Perch Lake Hydro-Meteorological Study Area	SA	Short	Recovery of redundant equipment, no residual contamination	
Waste Lysimeters	SA	Short	Recovery of waste materials (minor contamination) and extraction of facility structure	5 m^3 LLRW
O-Nest	SA	Short	Shallow boreholes – covered elsewhere	NA
Twin Lake Tracer	SA	Short	Shallow boreholes – covered elsewhere	NA
Glass Blocks	SA	Short	Recovery of Blocks and soils in immediate vicinity	1.5 m^3 LRW
Deep Boreholes	SA	Long	Grouting of boreholes and removal of protruding casings – no contamination anticipated	50 boreholes
Shallow Boreholes	SA	Long	Extraction of (mostly PVC) casings to 1 metre below grade – no contamination anticipated	2,500 boreholes

CA - Controlled Area 1 and/or 2

SA - Supervised Area

Attachment D

Waste Management Areas on the CRL Site – Planning Envelope 7

1. CONSTRUCTION & OPERATING HISTORY

1.1 General

Detailed descriptions of construction and operating histories for the CRL waste management facilities are presented in a Safety and Hazards Analysis Report [D1]. Additional information on the facilities in continued operation is presented in a Facility Description Document [D2]. A summary, supplemented with additional information, is presented in this section.

A summary of the information in this attachment is presented in tabular format in Table D1. Included in the table are references to facility drawings from which definitive information is available for facility dimensions.

1.2 WMA 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 referred to as **Waste Management Area (WMA) A**. These emplacements took the form of direct disposal of solids and liquids to excavated trenches into 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 (9,000 Ci) 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. The active liquid disposal tank received bottled liquids and, based on recorded observations, it is assumed the bottles were intentionally broken at the time of emplacement. Additions to inventory terminated following the 1955 dispersal.

1.3 Liquid Dispersal Area

Development of the **Liquid Dispersal Area (LDA)** commenced in 1953 when the first of several infiltration pits was established to receive active liquids via pipeline from Building 204 (the NRX Rod Bays). The pits are located on a small dune, in an area bounded on the east and south by wetlands (the East and South Swamps, respectively) and by WMA A to the west.

Reactor Pit #1 was a natural closed depression used between 1953 and 1956 for radioactive aqueous solutions; dispersals included an estimated 74 TBq (2,000 Ci) of ^{90}Sr, 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 and vehicles previously stored in WMA A plus potentially contaminated soils from excavations in the Active Area.

Reactor Pit #2 was established in 1956 to succeed Reactor Pit #1. A pipeline from Building 240 was used for transfers of NRX Rod Bay water. Samples of water from the holding tank are analyzed for soluble and total alpha, soluble and total beta, ^{90}Sr, ^{3}H, ^{137}Cs, ^{60}Co, and uranium.

Two sources of data were used to develop an estimate for the radionuclide inventory in Reactor Pit #2:

1. annual records of liquid waste inputs compiled from monthly records of radiochemical composition and discharge rates from the holding tank that discharges to the reactor pits; and

2. radiochemical analysis of cobble samples taken from the pits in 1996.

The **Chemical Pit** was also established in 1956 to receive radioactive aqueous wastes from active laboratories on site (other than the reactors). Its construction is similar to that of Reactor Pit #2, namely an excavation backfilled with gravel and supplied by a pipeline from Building 240. The reference inventories for the Chemical Pit are shown in Table D1.

The last facility in the Liquid Dispersal Area is the **Laundry Pit**, again installed in 1956. As its name implies, it was used for wastewater from the active area laundry and the Decontamination Centre, but was only employed for that purpose for a year. The recorded inventory is 100 GBq of mixed fission products and 0.1 g ^{239}Pu.

1.4 WMA B

WMA B was established in 1953 to succeed WMA A as the site for solid waste management. The site is located on a sand covered upland approximately 750 m west of WMA A. Early waste storage practices for Low Level Radioactive Waste (LLRW) continued those 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 (ILRW) from 1955 to 1959 when they were superseded by concrete bunkers constructed below grade but above the water table in the site's sands. Use of sand trenches in WMA B for LLRW was discontinued in 1963 in favour of concrete bunkers and WMA C.

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 concrete bunkers**. These were superseded in 1977 by the currently used cylindrical structures.

Cylindrical bunkers are formed with 25 cm thick corrugated reinforced concrete walls on a 15 cm thick concrete pad by using removable metal forms. The bunkers have a 6.1 metre inside diameter and are 3.8 metres deep. The maximum volume of a cylindrical concrete bunker is 110 m^3, but typical volumes of stored waste average about 60 m^3. The base is sloped to a centre sump pit and a liquid detection tube runs from the sump pit to ground level.

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 fission product waste from the molybdenum-99 production process.

Tile Holes used for the storage of irradiated uranium and other fissionable material differ from the standard Tile Holes in that they consist of a standard Tile Hole into which a steel pipe, closed at the bottom is inserted and the annulus between the pipe and the Tile Hole is filled with poured concrete. When full, the Tile Holes are closed in an arrangement that typically includes a steel-encased concrete shield plug and sealed by a gasketted closure plate, which is bolted to the steel pipe flange. A vent pipe in the closure plate prevents the build-up of pressure in the Tile Hole. These Tile Holes are commonly known as Irradiated Material Disposal (IMD) or Irradiated Fuel Elements (IFE) Tile Holes, depending on their size.

1.5 Waste Tank Farm

The **Waste Tank Farm** was established in 1961 to store high- and intermediate-level liquid wastes resulting from operation of facilities at the CRL plant site. It consists of seven tanks, some of which are housed in stainless steel-lined concrete bunkers. Water level sensors in the concrete bunkers are wired to alarms at the CRL Fire Hall and Waste Treatment Centre Operations maintain periodic testing. The inventories are well characterized and contained. Also, the inventories can be recovered for treatment such as immobilization. The Waste Tank Farm is included in FA-16, Revision 5 [D3].

1.6 WMA C

WMA C was established in 1963 to receive low-level wastes with hazardous lifetimes less than 150 years and wastes that cannot be confirmed to be uncontaminated. It is located about 3 km west of the plant area and covers an area of approximately 4.5 hectares. Early operations consisted of emplacements in parallel trenches separated by intervening wedge shaped strips of undisturbed sand. In 1982, this was changed to the current method of a Continuous Trench to make more efficient use of available space. Part of the original parallel trenches were covered with an impermeable membrane of High Density Polyethylene (HDPE) in 1983.

As the Continuous Trench and/or its extension is backfilled and landscaped, material from the suspect soil stock-pile is used for grading purposes to ensure that the surface of WMA C is suitable for travel by heavy equipment. Material placed in the stock-pile must satisfy specific acceptance criteria. In addition some waste materials are held in **surface storage** at WMA C, which includes items like the NRX stack sections and some wastes contained in 200 litre drums.

The **Area C Extension** was constructed adjacent to the south end of WMA C in 1993 and began accepting wastes in 1995.

1.7 WMA D & Bulk Storage Area

WMA D was established in 1976 to store obsolete or surplus equipment and components that are known or suspected to be contaminated but do not require enclosure (pipes, vessels, heat exchangers, etc.) plus closed marine containers containing drums of contaminated oils and Liquid Scintillation Cocktails (LSCs). These latter pose more of a short-term chemical hazard than a radiological hazard. The site consists of a fenced compound enclosing a gravel-surfaced area in which the components are placed. If the components have surface contamination they must be appropriately packaged such that the package is free of surface contamination. The Low Level Radioactive Waste Management Office (LLRWMO) maintains two buildings for the storage of slightly contaminated material from non-AECL sites.

All storage in WMA D is above ground: no burials are authorized.

The **Bulk Storage Area** was used prior to 1973 for storage of large pieces of equipment from Controlled Area 2, which were believed to be free of contamination. The compound is in a 'U' shaped configuration with fencing and locked gates to control access. Recent radiological surveys have detected low levels of contamination on equipment as well as vegetation. The contaminated equipment has been identified and represents a small fraction of the overall inventory of equipment stored there.

1.8 WMA E

WMA E is an area near the Waste Tank Farm that received suspect and slightly contaminated soils and building materials and other bulk soils and building debris from approximately 1977 to 1984. The waste materials were used to construct a roadway to a site, which was intended to become a waste management area for suspect contaminated materials to be used in place of WMA C for this type of waste. The plans for the creation of the site for storage of suspect materials were dropped when concerns were raised about the location. The general area adjacent to the tank farm has been used in recent years for deposition of clean construction rubble. Some suspect materials were placed here and then removed during 1999. Records indicate that the volume of suspect materials located at WMA E is small.

1.9 WMA F

A new area was established in 1976 to accommodate contaminated soils and slags from Port Hope, Albion Hills and Ottawa. This site is designated **WMA F**. The stored materials are known to contain low levels of ^{226}Ra, uranium and arsenic. Emplacement was completed in 1979 and the site is now considered closed, although subject to monitoring and surveillance to assess possible migration of radioactive and chemical contaminants.

1.10 WMA G

WMA G was established in 1988 to store the entire inventory of irradiated fuel from the NPD prototype CANDU® power reactor in aboveground concrete canisters. The canisters are founded on bedrock within a fenced compound.

1.11 WMA H

The Modular Above Ground Storage (MAGS) facility consists of two components. Located in WMA B, adjoining the existing Waste Reception Centre (WRC), the Waste Handling Building (WHB) prepares compactable and other LLRW for storage in WMA H. The new WMA H, consisting of storage buildings for waste packages and open areas for the storage of luggers, is situated north of the Plant Road from the WHB on a 3.4-hectare area (159 m by 214 m). The WMA H site has the capacity to store the volume of compacted and packaged LLRW that is expected during the next 20 years. This waste will be removed as part of operations prior to the start of decommissioning. At the time of decommissioning, WMA H will comprise:

- up to 10 empty prefabricated metal storage buildings (approximately 18 m x 23 m) on reinforced concrete floors;
- outdoor gravel pads which supported luggers (removed by operations prior to the start of decommissioning);

- connecting gravel roadways; and
- a perimeter fence with padlocked gates.

A separate Preliminary Decommissioning Plan (PDP) for MAGS (WMA H) was submitted to the Canadian Nuclear Safety Commission (CNSC).

1.12 Acid, Chemical & Solvent Pits

A series of three small pits are located north of WMA C and are collectively known as the **Acid, Chemical and Solvent (ACS) Pits**. The pits were constructed in 1982 and remained in operation up to 1987 and used (one each) for inactive chemical, acid and solvent wastes [D4]. The acid pit received on the order of 11,000 litres of liquid wastes (hydrochloric, sulphuric and nitric acids) and a small amount of solid wastes (potassium carbonate powder, acid batteries and citric acid). The solvent pit received approximately 5,000 litres of mixed solvents, oils, varsol, acetone, etc. The chemical ACS pit received smaller volumes of wastes.

1.13 Above Grade Buildings & Structures

Many of the WMAs have as part of the operations buildings or surface structures. They include buildings such as gatehouses, treatment facilities or smaller structures used for housing sampling equipment. These buildings will remain in use until declared redundant and then will be put into a safe and stable state until dismantlement is warranted.

1.14 Construction & Operating History Summary

The information presented above provides a brief summary of the significant features of the WMAs and other facilities with radiological inventories in the CRL Supervised Area. Several of these facilities have resulted in contamination migration beyond the original emplacement areas. Table D1 is a condensed summary of the preceding descriptions and provides information, which is necessary to link to the WMAs. The operating histories of the Waste Management Areas are illustrated in time-line form in Figure D1.

2. WMA PLUMES

The non-engineered WMA facilities have permitted some radiological and chemical substances to escape from their boundaries, primarily via groundwater transport. This has led to several plumes that are the subject of characterization and monitoring programs. Section 8.6.3 of this report provides a more detailed discussion of the plumes along with interventions that have been implemented. The monitoring programs, which are intended to provide confirmatory data that the plumes are behaving as expected, will continue for the indefinite future and will guide intervention and remediation programs designed to ensure continued public safety.

The plumes originating from WMA A and the Liquid Dispersal Area are illustrated in Figure D2. The plumes originating from WMA B are illustrated in Figure D3 and those originating from WMA C, the Nitrate Plant and the Thorium Pit are shown in Figure D4. The plumes are further documented in the WMA Safety and Hazards Analysis Report [D1], including some projections for their potential future extent. A brief summary, extracted from Reference [D1] and supplemented, is presented in Table D2. There is only minor external soil contamination arising from the engineered WMA, concrete facilities.

In general, these plumes do not represent a potential direct external exposure hazard to operating personnel or the public.

The surface waters noted in the above table are not accessible to the general public and therefore do not represent a direct exposure pathway to the public. The annual discharges into the two relevant drainage basins have been, and are projected to continue to be, well below annual Derived Release Limits (DRLs) for CRL. This is documented in [D5].

3. REFERENCES

[D1] AECL, "A Safety and Hazards Analysis of the Chalk River Laboratories Waste Management Areas", AECL-MISC-306, Rev. 2, **PROTECTED-Proprietary**, 1995 July.

[D2] AECL, "AECL Research Waste Management Areas Facility Description Document", WMS-TM-30, 1993 October.

[D3] AECL, "Facility Authorization for the Operation of the Waste Treatment Centre and Associated Facilities at The Chalk River Laboratories", AECL-FA-16, Revision5, 1999 November.

[D4] AECL, "An Assessment of Chemical and Radiological Contamination in the Vicinity of the Acid-Chemical & Solvent Pits", TR-550, April 1992.

[D5] AECL, "2002 Annual Report of Radiological Monitoring Results for the Chalk River and Whiteshell Laboratories Sites Volume 3 - Environmental Monitoring - Chalk River", AECL-MISC-362-02-CRL Volume 3, Revision 0, 2003 April.

Table D1: Summary of Waste Management Areas at CRL & Estimates of Waste Volumes & Radioactivity Content

Area Designation	Period of Operation	Description	Waste Volume (1) (m^3) Solid	Waste Volume (1) (m^3) Liquid	Major Activity (2) Type	Major Activity (2) TBq	Notes
Waste Management Area A							Drawing: E-4500-2S5W-12
Liquid Wastes		Liquid wastes discharged into trenches in 1953 (4,500 m^3), 1954 September (7.2 m^3) and 1955 February (50 m^3).	n.a.	4,500 7.2 50	Mixed FP Mixed FP Mixed FP	330 6.3 34	Dilute aqueous Nitric acid / ammonium nitrate solution. Nitric acid solution. Source of a groundwater plume.
Solid Wastes	1946-1955	Solid wastes emplaced in unlined trenches and a variety of buried structures. Various drummed and bottled liquids emptied into below-grade concrete structures.	N/A	Misc. liquids	N/A	N/A	Limited records for solid wastes and drummed/bottled liquids buried prior to 1952. Source of a groundwater plume.
Liquid Dispersal Area							Drawing: E-4500-2S5W
Reactor Pit #1	1953-1998	Liquid waste discharged to natural depression between 1953 and 1956. Lightly contaminated equipment and suspect soils later used to fill depression.	n.a.	230,000	β/γ α	100 0.1	Estimated disposal of 74 TBq ^{90}Sr plus 100 g (Pu equivalent) of alpha-emitters. Source of a groundwater plume.
Laundry Pit	1956-1957	Aqueous waste from Decontamination Centre and Laundry discharged to engineered pit.	n.a.	680	β/γ α	0.06 0.0003	Small inventory compared with other LDA pits.
Chemical Pit	1956 - present	Liquid aqueous waste from site labs and chemical operations discharged to a gravel-filled pit.	n.a.	330,000	β/γ α Tritium	230 0.4 70	Source of a groundwater plume. Groundwater from Chemical Pit plume is subject of pump and treat program.
Reactor Pit #2	1956 - present	Lightly contaminated water from Rod Storage Bays, and NRX & NRU operations.	n.a.	1,500,000	β/γ α Tritium	500 0.5 1,000	Source of a groundwater plume.

Waste Management Area B							Drawing: E-4500-2S7W-26
Sand Trenches	1953 - 1963	Solid wastes in unlined trenches covered with sand: Intermediate Level Radioactive Waste (ILRW) emplaced prior to 1956 August, only Low Level Radioactive Waste (LLRW) emplaced after 1956 September.	9,000	Misc. bottled liquids	Mixed LLRW and ILRW	~75	Use discontinued in favour of engineered structures. Limited inventory data. Source of two separate groundwater plumes.
Asphalt-lined trenches	1955 - 1959	Intermediate-level solid wastes, i.e. wastes having external fields >100 mR/h at 30 cm, that were emplaced in asphalt-lined and-capped trenches.	1,300	Misc. bottled liquids	ILRW	N/A	Estimated to contain 0.6 TBq of ^{239}Pu.
Rectangular concrete bunkers	1959 - 1979	Low level solid wastes in rectangular concrete bunkers. (Below grade but above the water table)	8,500	Residual	LLRW	A	
Special burials	1955 - 1973	Various materials including the NRU and the second NRX calandrias.	*	*	*	*	* See Reference 1 for details.
Circular concrete bunkers	1979 - present	Low level solid wastes. (Below grade but above the water table)	6,850	Residual	LLRW	A	
Tile Holes - Nuclear Reactor Fuels	1956 - present	Reactor Fuel high-level wastes in vertical, below-grade facilities.	1,187	n.a.	HLRW	A	Estimates available for fissile material quantities. Fuel-bearing structures are the subject of a remediation program.
Tile Holes - ^{99}Mo wastes	1970 - present	High-level wastes arising from ^{99}Mo production.	A	n.a.	HLRW	N/A	Estimates available for fissile material quantities.
Tile Holes - other wastes	1956 - present	A variety of high level wastes including reactor components.	A	n.a.	HLRW	N/A	Cell wastes, reactor components, Rod Bay wastes.
Waste Management Area C							Drawing: E-4500-0S11W
Surface Storage	1963 - present	Surface storage of limited amounts of drummed wastes, NRX Stack sections, drummed aqueous liquids, solidified oils, bulk suspect soils and other bulk items.	N/A	81	LLRW	N/A	Stock-piled soils may be re-used elsewhere in WMAs.
C Extension	1993 - present	Low level solid waste (external fields <100 mR/h at 30 cm) in unlined trenches. Higher proportion of drummed waste than Area C.	2,600	Residual	LLRW	A	Characterization data available for some radionuclide inventories. Source of groundwater plume. Drawing: D-4500-36
Sand Trenches	1963 - present	Low-level solid waste (external fields <100 mR/h at 30 cm) in unlined trenches. Total area is approx. 4.5 ha; impermeable cover installed on 0.7 ha in 1983 November. Waste is half from CRL and half from across Canada including NPD.	88,000	Drummed & bottled liquids	LLRW	N/A	Limited characterization data for radionuclide inventories. Source of a groundwater plume. Some waste retrievals have taken place. Drawing: OS11W-9 (slit trenches) Drawing: OS11W-12 (bulk trench)

Waste Management Area D	1976 to present	Fenced gravel compound used for aboveground storage of potentially contaminated equipment, materials and drummed liquids. Not a burial site.	585	200	LLRW	A	The drummed liquids (lightly contaminated aqueous wastes and waste oils) are stored in marine containers. Drawing: E-4500-OS7W-15
Acid, Chemical and Solvents Pits	1982 - 1987	Small fenced compound containing three small pits, which as the names imply were used for different non-active liquid wastes and very small quantities of solid wastes.	Acid: minor	Acid: 11.2 Chem.: 2.7 Sol.: 5.3			Acid: Hydrochloric, Sulphuric, Nitric, Chromic acids, potassium carbonate powder, citric powder and acid batteries. Chemical: Scintillation fluids, Alconox and other cleaning agents, ammonia, alkylating agents, others. Solvent: Mixed solvents, oils, scintillation solutions, ammonia, varsol, acetone, others. Drawing: E-4500-2N11W-11
Bulk Storage Area	prior to 1973	Fenced compound used for the storage of uncontaminated equipment intended for re-use. Some contaminated materials were also stored there.	N/A	n.a.	LLRW	N/A	Field surveys of the compound have located and identified contaminated items.
Waste Management Area E	1977 - 1984	Used for disposition of lightly contaminated & suspect bulk materials (building debris and soils) from the CRL Active Area.	N/A	n.a.	Suspect slightly contaminated	N/A	The volume of suspect contaminated materials is believed to be a small fraction of the total volume of materials stored here.
Tank Farm	1961 - 1968	Tank Farm with intermediate to high-level wastes in tanks in concrete vaults with leak-detection systems. Intermediate - T-40F (secondary concrete containment), T-40E (empty), T-40D (concrete pad) High level - T-283A, B, C, D (all with secondary concrete containment)	n.a.	68	β/γ α	150	Monitoring & surveillance confirms containment of these wastes and the facility includes emergency transfer lines. Drawing: E-4500-2N5W-16
Waste Management Area F	1976 - 1979	Contaminated soils and slags from Port Hope, Albion Hills and Ottawa stored above the water table in sand valley. Unsuccessful clay cover.	120,000 (Mg)	zero	Radium	0.5	Approx. 515 GBq Total ^{226}Ra, 4 - 13 Mg Arsenic, 80 Mg U. Drawing: E-4500-2S11W-9
Waste Management Area G	1989 - present	NPD spent fuel dry storage facility - aboveground concrete canisters.	4,921 (bundles)	zero	Irrad. U		Complete inventory data available. Monitoring & surveillance confirms containment within structures. Drawing: OS9W-3

Waste Management Area H (MAGS)	2001 - present	Prefabricated metal storage buildings with capability of storing 865 m^3 each of compacted LLRW in B-1000 compactor boxes, 45-gallon drums, wooden crates, boxes and B-25 "blue bins".	n.a.	n.a.	Mixed FP	N/A	All LLRW will be removed by Operations prior to turnover to Decommissioning. Some residual contamination may be present as a result of operational activities.
Nitrate Plant	1953 - 1954	Discharges of mixed fission products in salt solutions to limed pit following a process accident. Decontaminating solutions also released. Contaminated rubble from Building 233 demolition.	N/A	200	β/γ	60	Estimated 60 TBq of β/γ activity (35% ^{90}Sr) in liquid releases - small α inventories. Plant demolished and buried on-site, no data for solid waste inventories. Drawing: E-4500-2N11W-11
Thorium Pit	1955 - 1960	Reprocessing wastes from operation of the ^{233}U extraction facility.	n.a.	20	Nat. Th, ^{233}U and mixed FP	A	Approximate total of 45 m^3 reprocessing solution discharged in separate dispersals to crib containing ammonium carbonate (~4,000 kg of nat. Th, 27 g ^{233}U). Drawing: E-4500-2N11W-11
Above Ground Buildings and Structures in Waste Management Areas							
Buildings and Structures in WMAs	1953 - present	Various buildings/gatehouses.	N/A	n.a.	N/A	N/A	See individual drawings listed above.

(1) Inventories as of 1997
(2) Activity at time of emplacement - not corrected for decay
(3) N/A - no quantitative data available
(4) A - quantitative data available
(5) n.a. - not applicable

Table D2: Summary of Radioactive Plumes in the CRL Supervised Area

Drainage Basin	Area	Structure/Source of Radionuclide	Main Radionuclides in Plumes
Perch Lake	WMA A	Sand trench, reprocessing solutions	^{137}Cs, ^{90}Sr areal extent 38,000 m^2
	LDA	Chemical Pit, active drain discharges	^{90}Sr, ^{60}Co, Alpha areal extent 8,000 m^2
		Reactor Pit #1, miscellaneous aqueous discharges	^{90}Sr areal extent 9,000 m^2
		Reactor Pit #2, Rod Bay water discharges	Tritium areal extent 200,000 m^2 ^{90}Sr areal extent 18,000 m^2
	WMA B	Sand trench	Tritium
		Sand and/or Asphalt trenches	^{90}Sr areal extent 8,500 m^2
Maskinonge Lake	WMA C	Mixed low level wastes	Tritium areal extent 38,000 m^2
	Nitrate Plant	Reprocessing wastes process upsets	^{90}Sr, ^{137}Cs areal extent 16,000 m^2
	Thorium Pit	Reprocessing waste direct-to-ground discharge	^{90}Sr areal extent 6,000 m^2

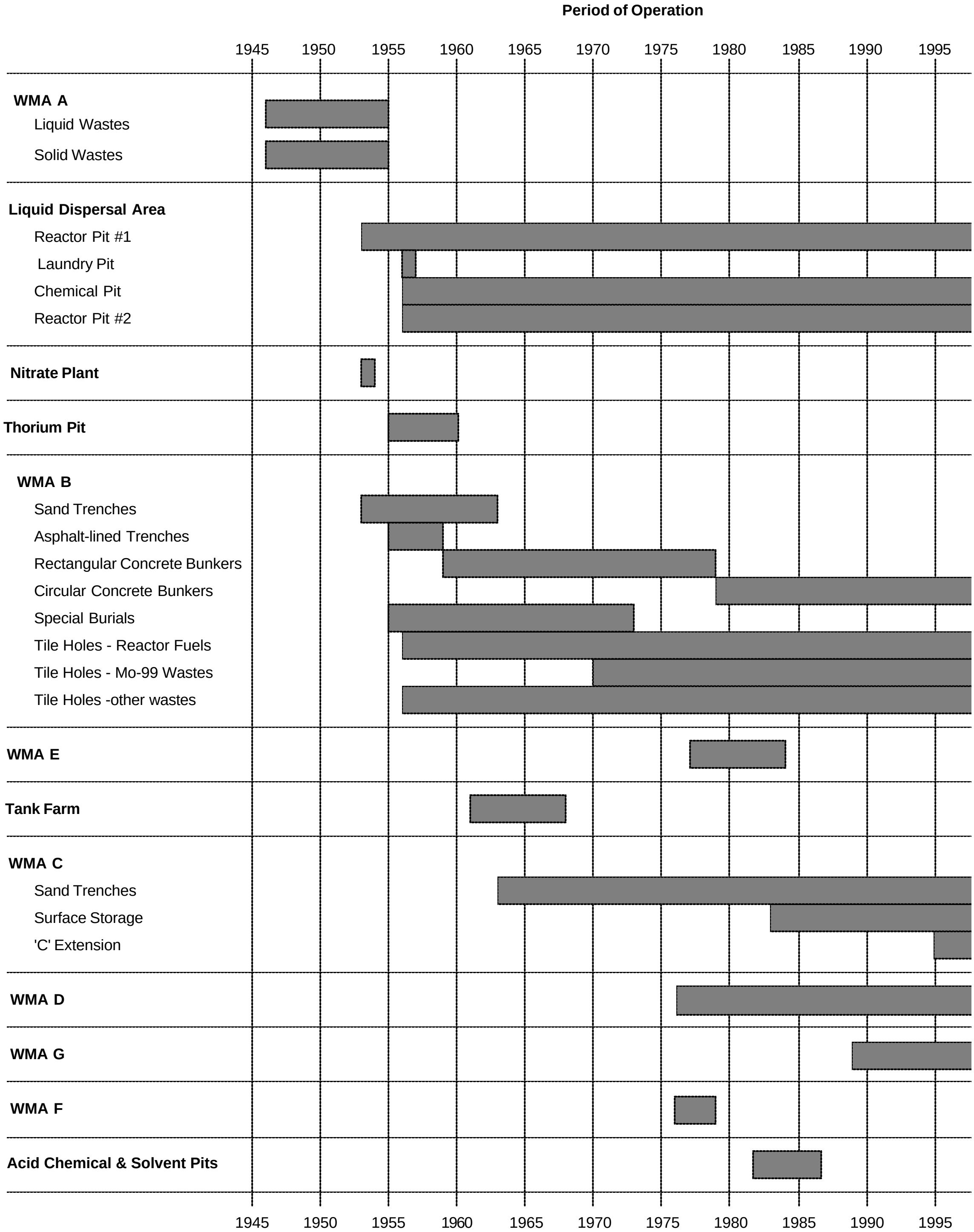

Figure D1: Summarized Operational History of Waste Management Facilities at CRL

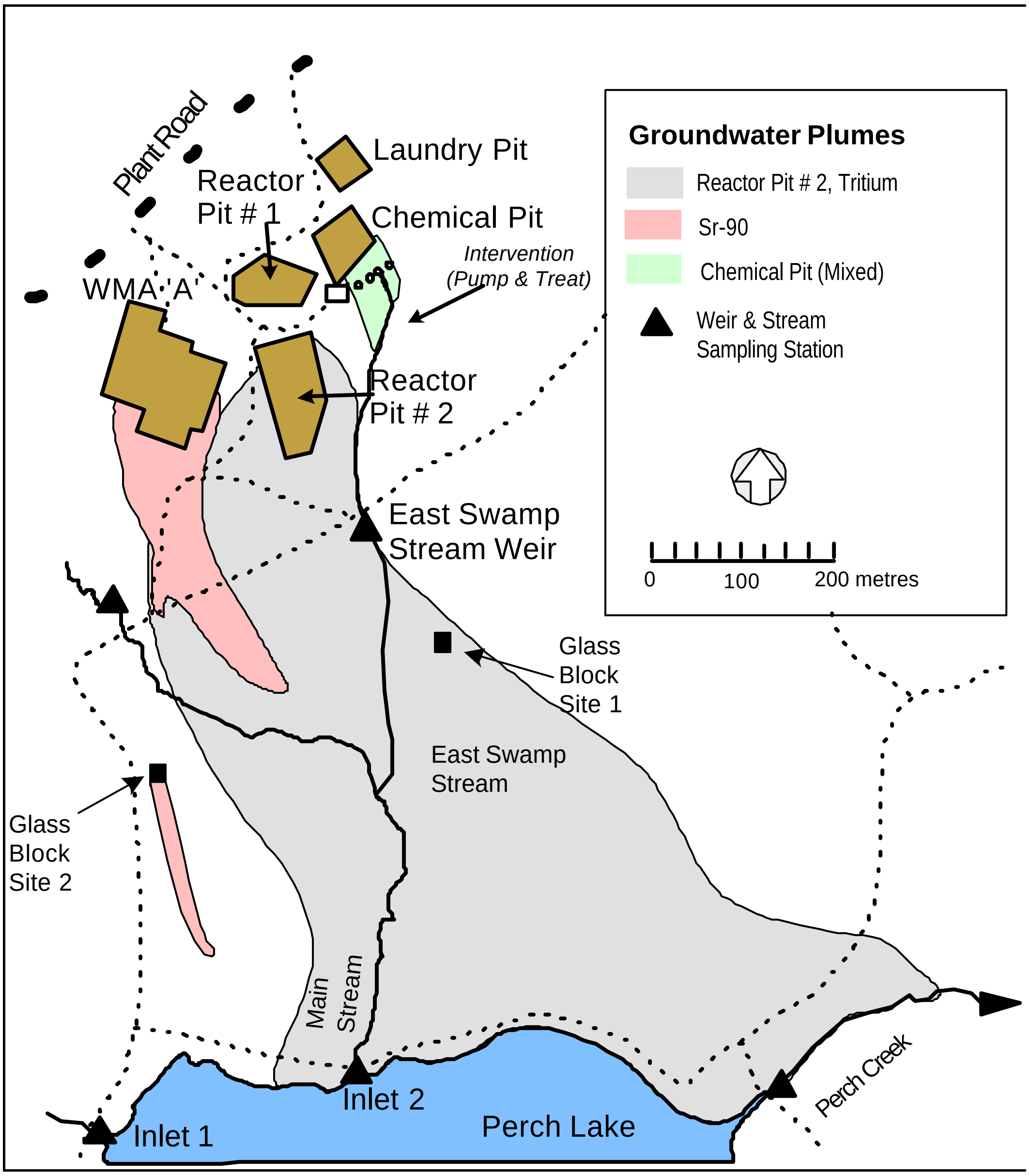

Figure D2: Subsurface Plumes Originating from WMA A & the LDA

Note: The plume from Glass Block Site 2 has been well studied as part of an ongoing experiment and is shown here for completeness. Strontium concentrations in this plume [Killey 1995] are well below drinking water guidelines and therefore this plume is not discussed further in this report.

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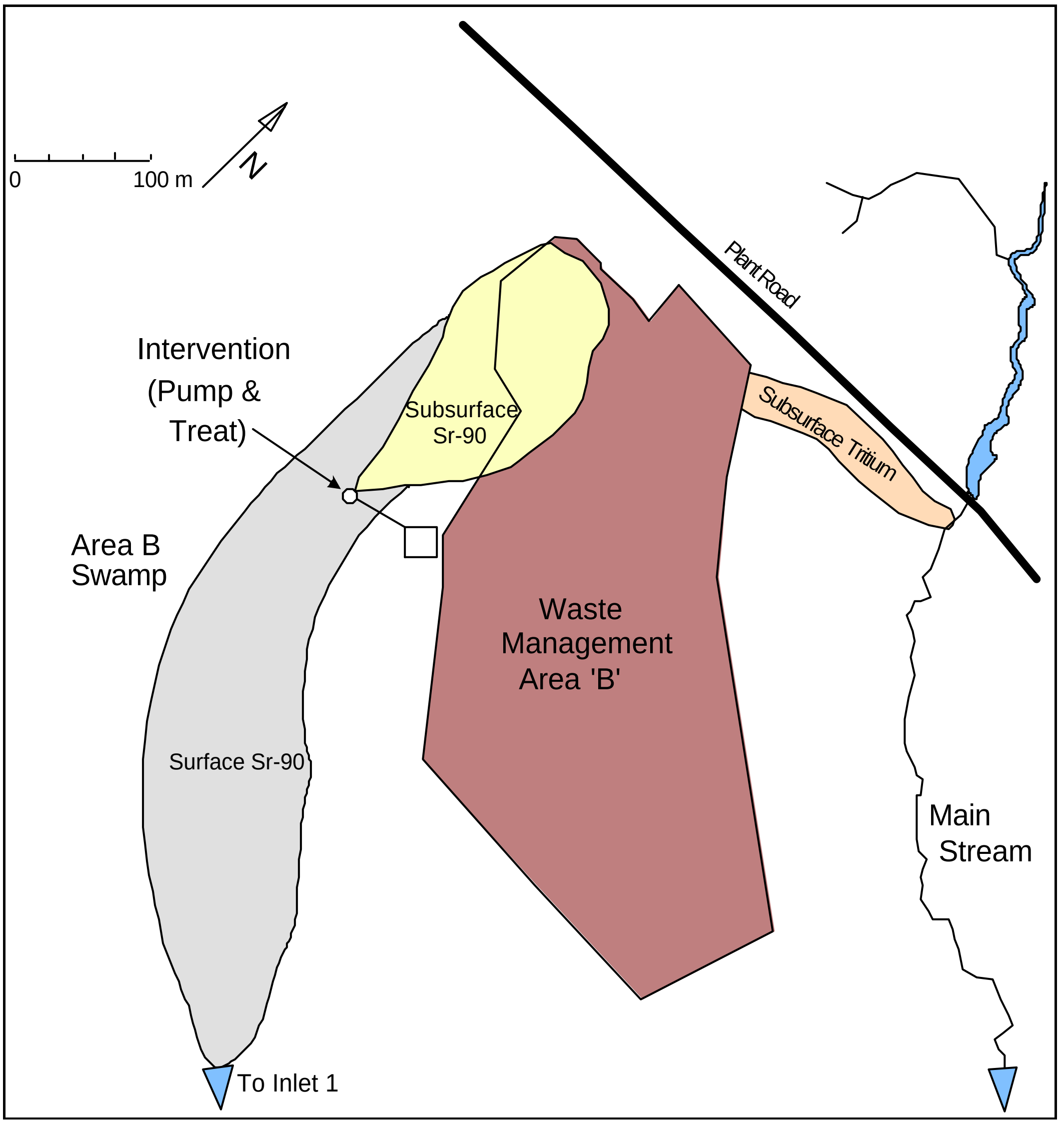

Figure D3: Subsurface Plumes Originating from WMA B

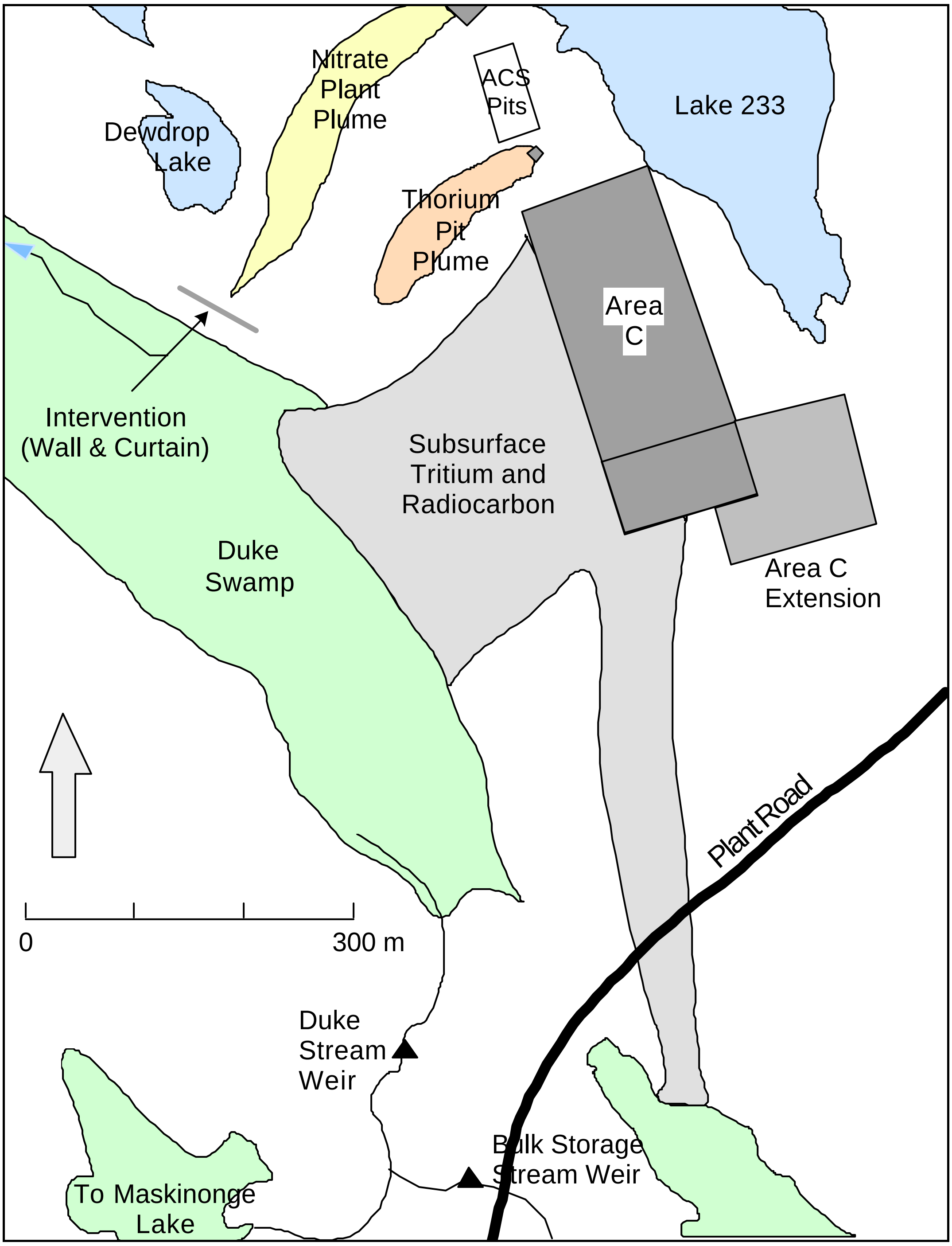

Figure D4: Plumes Originating from WMA C, the Nitrate Plant & the Thorium Pit

Attachment E

Tables & Figures

Table E1: Summary of CRL Building Area by Usage

General Use Classification	**Area (1,000 m^2)**	**Area (%)**
Laboratory	22	14
Office	19	13
Storage	26	17
Work Shop	9	6
Process Service	31	21
Building Service	15	10
Common Areas	28	18
Total	**150**	**100**

Table E2: Planning Envelopes for the CRL Site Preliminary Decommissioning Plan

Planning Envelope	Attributes	Details
1. Listed Nuclear Facilities (excluding the Waste Management Areas)	Nuclear facilities listed in Appendix A (Operational) or C (Permanently Shutdown) to the CRL Site Licence. These facilities have their own, facility-specific PDPs. The Waste Management Areas are considered separately as Planning Envelope 7 (Attachment D).	Attachment A
2. Radiochemical Laboratories	Laboratories and other structures that have been or are being used primarily for work with radioactive materials and are known to contain contaminated components from planned activities and unplanned events. All PE 2 structures are located in CA-2.	Attachment A
3. Low Hazard Contaminated Structures	Laboratories and other structures that have been or are being used for activities that may involve small quantities of radioactive materials under controlled conditions. Local areas of low hazard contamination may be present as a result of spills or process upsets. Buildings in CA-2, other than those in Planning Envelopes 1 and 2, are assigned to this Planning Envelope. Also, a few buildings in CA-1 are assigned to this planning envelope because of their operational history.	Attachment A
4. Non-Contaminated Structures	Buildings that have no record of being used for activities involving radioactive materials. These structures can be presumed – with a high level of confidence – to be free of contamination. Most buildings in CA-1 are assigned to this Planning Envelope. (See PE 3 for the exceptions)	Attachment A
5. Distributed Services	Services installed throughout the CRL site, including buried and overhead power, steam, gas, water, active and inactive drains and ventilation ducts, etc.	Attachment B
6. Affected Lands	All lands and water bodies that have been affected in any way by the establishment, operation and maintenance of the CRL site. Note: affected lands within 1 metre of a building or structure are considered to be part of that building or structure.	Attachment C
7. Waste Management Areas (WMAs)	All areas within the Waste Management Areas that have been used for aboveground storage and burial of current and historical wastes since the establishment of the CRL site. The buildings and structures in the WMAs are considered in PE 2.	Attachment D

Table E3: Summary of Typical Work Packages in Decommissioning Cost Elements

Cost Element	Objective	Work Packages (Typical)	Schedule for Element by Planning Envelope (Year after S/D)[1]			
			1	2	3	4
0. Establish SSS W0 – Manage SSS Wastes	Qualify the structure for turnover to Decommissioning	Remove process inventories, chemicals, furniture, loose or reusable items, etc. Carry out and document a hazards characterization. This is performed at the Facility Operator's expense.	-	-	-	-
1. Documentation	Secure acceptance for the structure-specific decommissioning plan/process	Prepare DDP (PE 1) or equivalent plans (PE 2) and supporting documents. Submit to appropriate authorities for review and approval (PE & 2). PE 3 & 4 documentation is an internal requirement. Scope and approval level will depend on the specific structure/facility involved.	1	1	1	1
2. SWS-1 (Optional)	Planned deferral of large-scale removals or demolition pending natural decay of (radioactive) hazards, availability of waste repositories and/or business drivers.	Storage with Surveillance of the structure following establishment of SSS. Components include provision of heat, light & power, routine/seasonal inspections & maintenance and periodic repairs.	1 - 5 (2)	1 - 5 (2)	1 - 3 (2)	1 - 2 (2)

Notes:

(1) Year that element is implemented. The model reference is that each element (other than SWS) takes one year to complete.

(2) The cost model assumes that decommissioning and demolition proceed in a timely manner, subject to management and regulatory approvals. The costs associated with SWS-1, therefore, extend from year 1 until the structure is ready for demolition (2 to 5 years depending on Planning Envelope).

(3) The general assumption in the cost model is that SWS-2 will be invoked only for a limited number of structures, e.g. reactors, where delay will be advantageous in reducing radiological hazards during final demolition. It is not considered likely that PE 4 structures will have SWS-2. It can be applied to other structures if the model is used for real-life planning and scheduling.

Table E3 (continued): Summary of Typical Work Packages in Decommissioning Cost Elements

Cost Element	Objective	Work Packages (Typical)	Schedule for Element by Planning Envelope (Year after S/D)[1]			
			1	**2**	**3**	**4**
3. Remove Process/Lab. Equipment (Optional) W1 – Manage Process/Lab Wastes	Further stabilization of the structure if required to qualify for a longer period of SWS.	Targeted removal of all process and laboratory equipment including fume hoods, glove boxes, components in hot cells etc., sometimes referred to as decontamination. Services that are integral to the building's structure or difficult to access, such as ventilation systems and active drains, may remain.	4	4	N/A	N/A
4. SWS-2 (Optional)	As for SWS-1. Note: SWS-1 and SWS-2 are alternatives.	Similar to SWS-1 but some modest cost reduction may be possible since process/laboratory equipment has been removed.	(3)	(3)	(3)	N/A
5. Pre-Demolition W2 – Manage Decontamination of. Wastes	1. Provision of a "clean" empty shell for demolition. 2. Segregation of LLRW wastes from "potentially clearable" structural materials.	Extensive – and aggressive – removal of remaining hazards including ventilation systems, shielded facilities and active drains, sometimes referred to as decontamination. Surfaces will be decontaminated using appropriate techniques. Crawl spaces will be remediated as far as possible but it is recognized that complete decontamination may not be practicable until the building is demolished.	5	5	3	2

Notes:

(1) Year that element is implemented. The model reference is that each element (other than SWS) takes one year to complete.

(2) The cost model assumes that decommissioning and demolition proceed in a timely manner, subject to management and regulatory approvals. The costs associated with SWS-1 therefore extend from year 1 until the structure is ready for demolition (2 to 5 years depending on Planning Envelope).

(3) The general assumption in the cost model is that SWS-2 will be invoked only for a limited number of structures, e.g. reactors, where delay will be advantageous in reducing radiological hazards during final demolition. It is not considered likely that PE 4 structures will have SWS-2. It can be applied to other structures if the model is used for real-life planning and scheduling.

Table E3 (continued): Summary of Typical Work Packages in Decommissioning Cost Elements

Cost Element	Objective	Work Packages (Typical)	Schedule for Element by Planning Envelope (Year after S/D)[1]			
			1	2	3	4
6. Demolition W3 – Manage Demolition Wastes	Establish final end-state.	Dismantling of all structures to the designated end-state accompanied by recovery of any usable components or materials. Scope includes services and affected lands within a 1 metre zone beyond the original building perimeter. Foundations and footings will be removed, as required, up to a depth of 1.5 metres.	6	6	4	3

Notes:

(1) Year that element is implemented. The model reference is that each element (other than SWS) takes one year to complete.

(2) The cost model assumes that decommissioning and demolition proceed in a timely manner, subject to management and regulatory approvals. The costs associated with SWS-1 therefore extend from year 1 until the structure is ready for demolition (2 to 5 years depending on Planning Envelope).

(3) The general assumption in the cost model is that SWS-2 will be invoked only for a limited number of structures, e.g. reactors, where delay will be advantageous in reducing radiological hazards during final demolition. It is not considered likely that PE 4 structures will have SWS-2. It can be applied to other structures if the model is used for real-life planning and scheduling.

Table E4: Estimated Waste Arisings from the Decommissioning of the CRL Site

Planning Envelope	Short-Term - up to 2010 (m^3)			Long-Term - post 2010 (m^3)			Total Program (m^3)
	"Potentially Clearable"(1)	LLRW	Total(3)	"Potentially Clearable"(1)	LLRW	Total	
1. Listed Nuclear Facilities (2)	600	600	1,200	52,600	11,600	64,200	**65,400**
2. Radiochemical Laboratories	1,500	200	1,700	19,000	3,000	22,000	**23,700**
3. Low-hazard, Potentially Contaminated Structures	4,500	300	4,800	35,000	1,800	36,800	**41,600**
4. Non-Contaminated Structures	8,000	0	8,000	12,300	0	12,300	**20,300**
5. Distributed Services	0	0	0	2,600	200	2,800	**2,800**
6. Affected Lands		<100	<100		<100	<100	**<200**
7. Waste Management Areas	See Table D1 in Attachment D	See Table D1 in Attachment D		See Table D1 in Attachment D	See Table D1 in Attachment D		
Total Volumes	**14,600**	**1,200**	**15,800**	**122,000**	**16,600**	**138,200**	**154,000**

<u>Notes:</u>

(1) "Potentially clearable" includes scrap/recycle, clearance waste and approved landfill.

(2) The CRL Waste Management Areas are considered separately in Planning Envelope 7.

(3) The LLRW waste generation rate from decom. activities is on the order of 200m^3/a, along with clearable waste generation of 3,000 m^3/a, these rates are similar to the generation rate experienced over the last several years, and is within the capacity of AECL on-site facilities and off-site landfill and recycling as appropriate

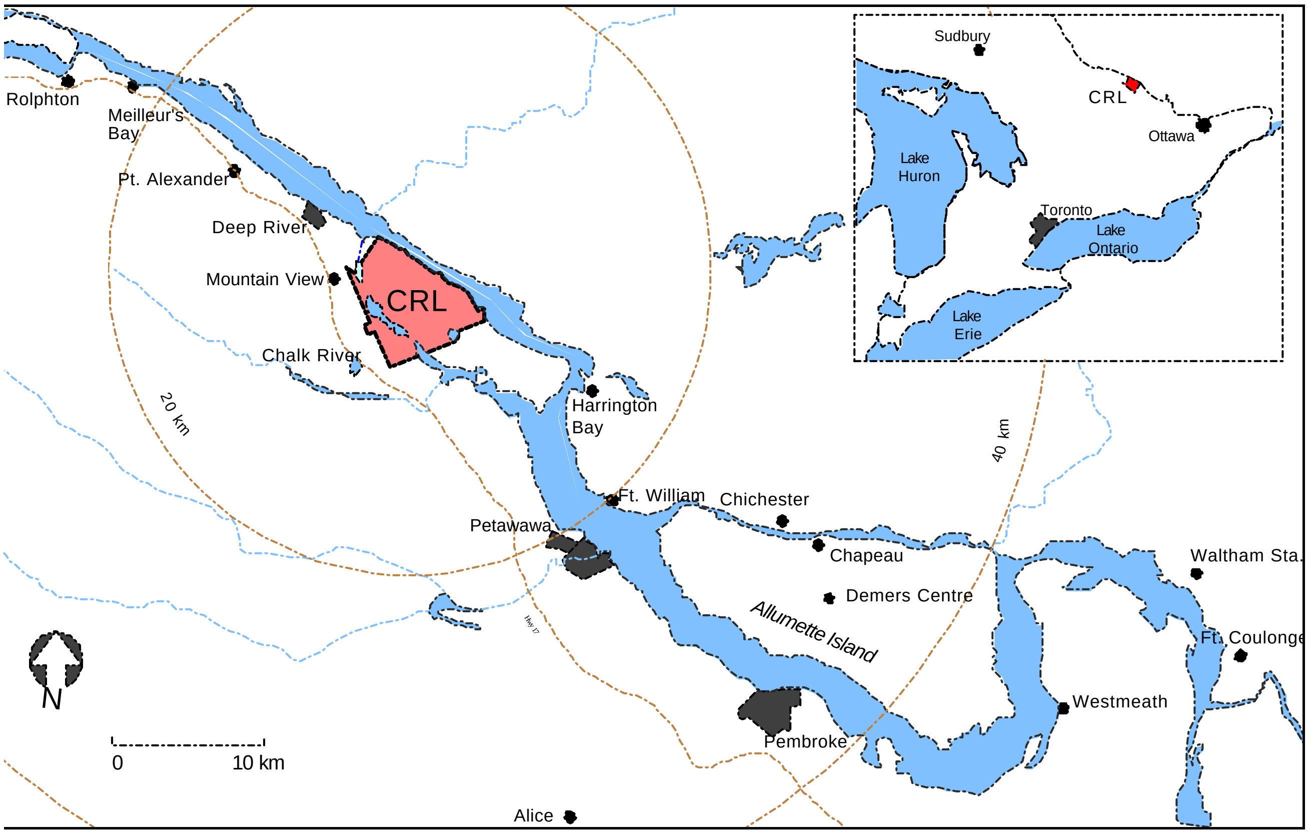

Figure E1: Location of the Chalk River Laboratories

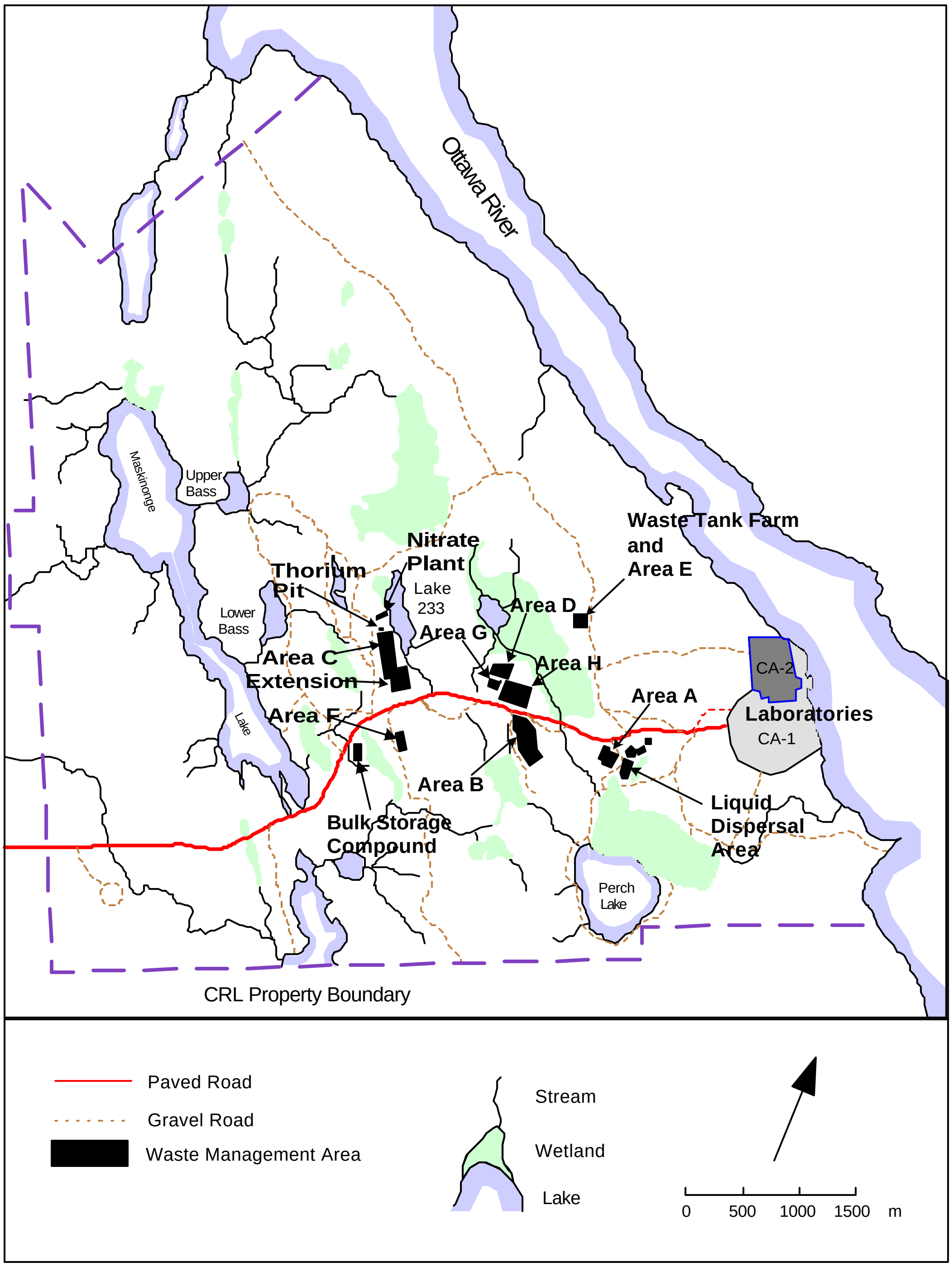

Figure E2: The CRL Site Boundary & Supervised Area

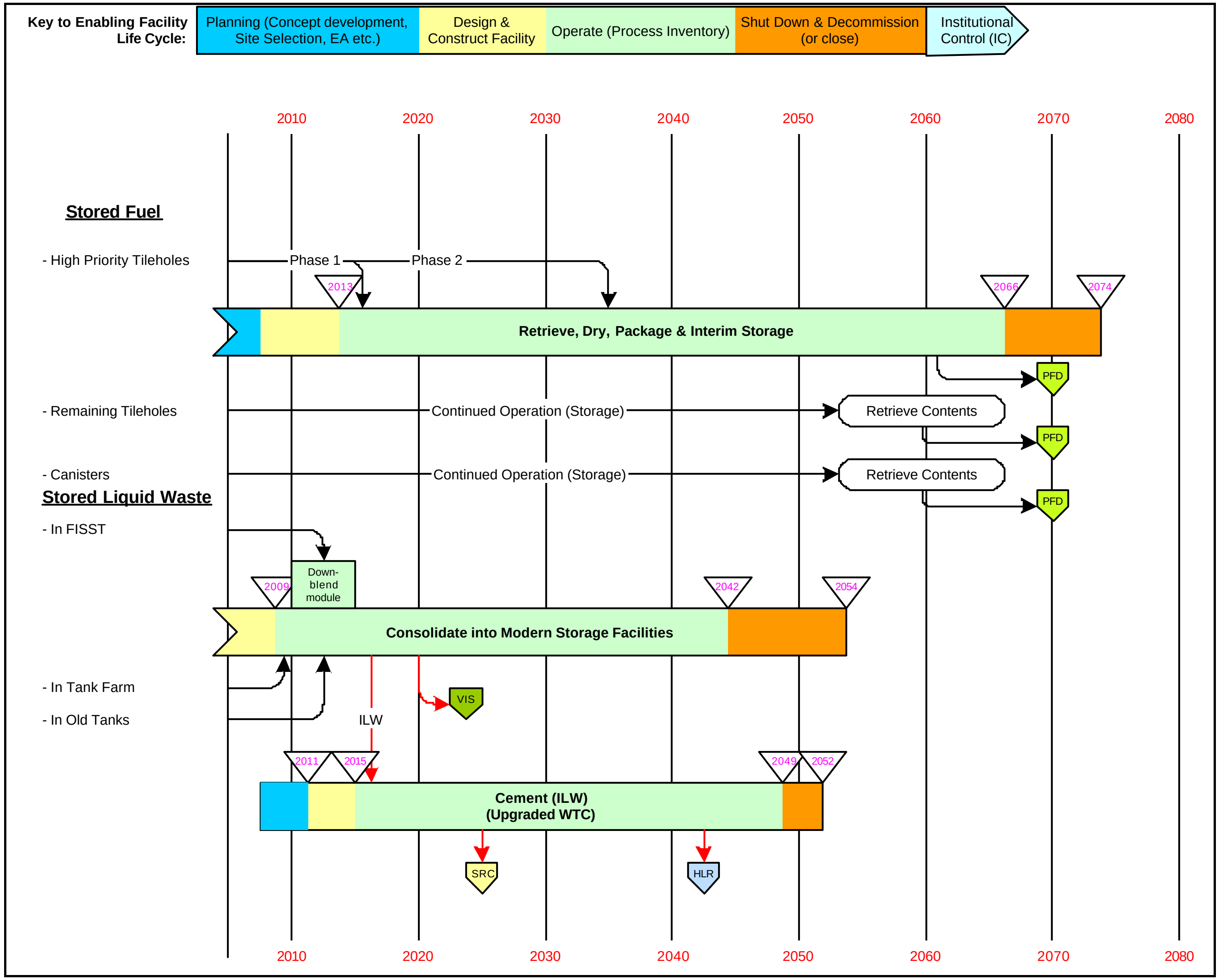

Figure E3: Operating Plan for Decommissioning of the CRL Site showing Major Activities and Enabling Facilities
A: Stored Fuels and Liquid Wastes

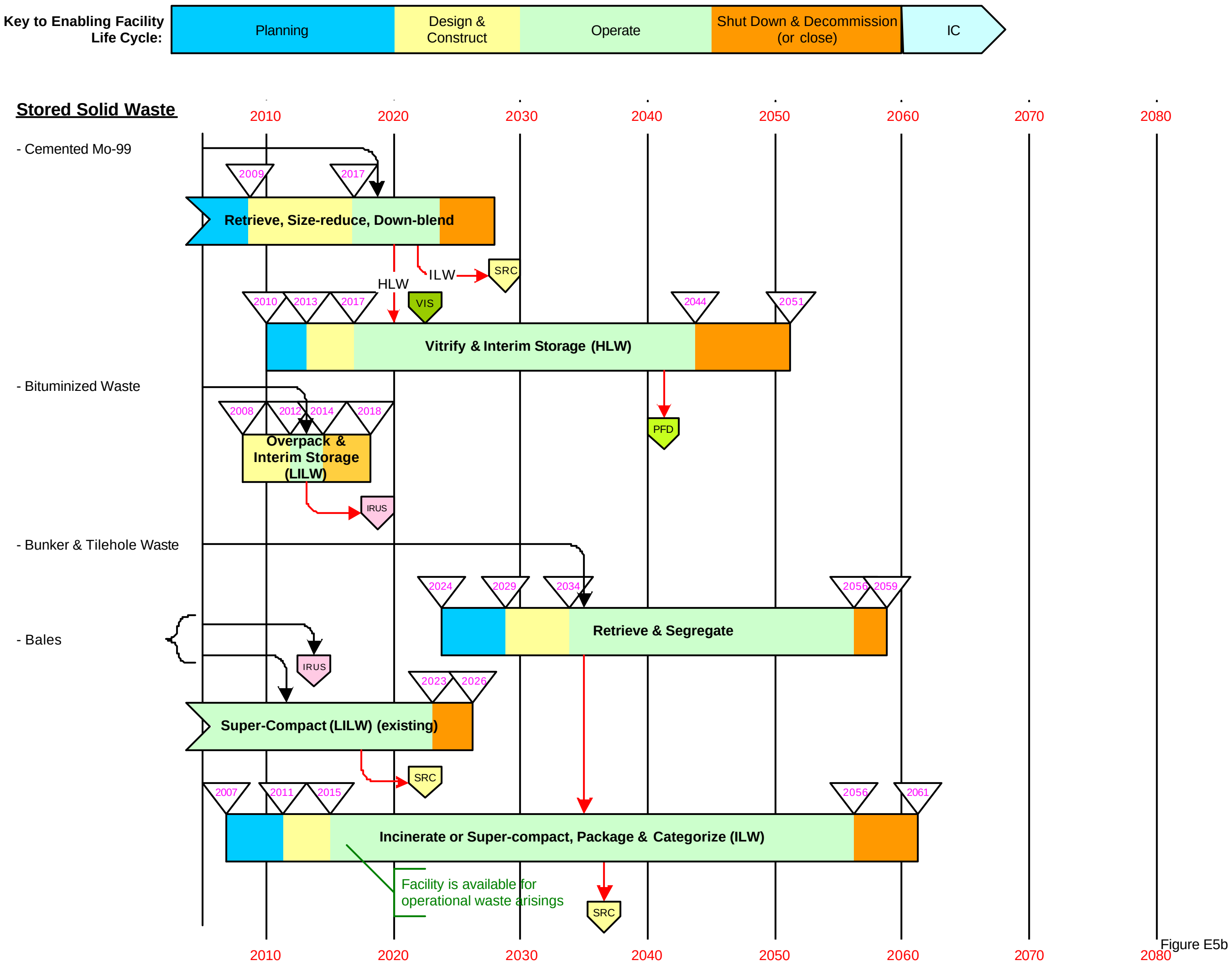

Figure E3: Operating Plan for Decommissioning of the CRL Site showing Major Activities and Enabling Facilities
B: Stored Solid Wastes

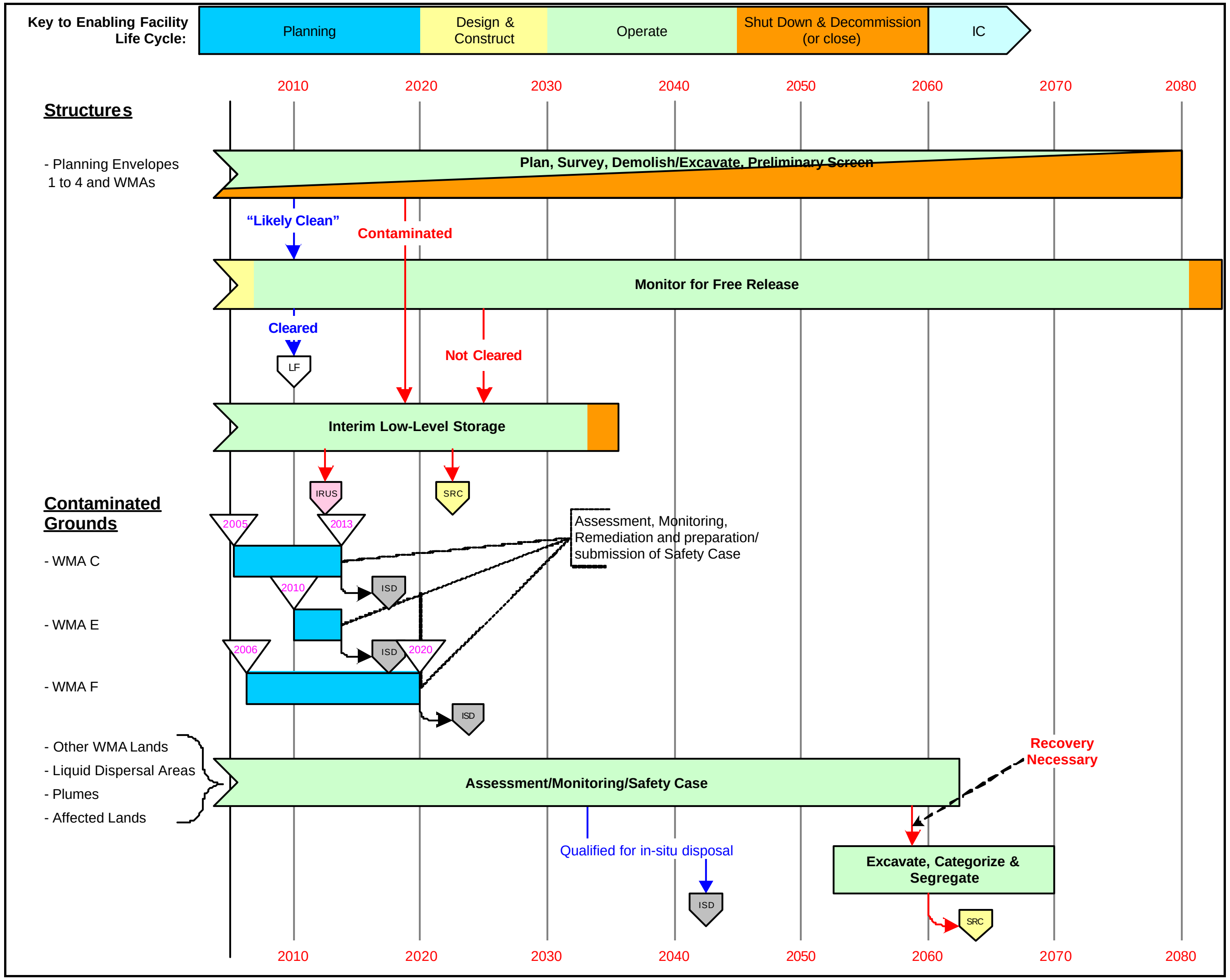

Figure E3: Operating Plan for Decommissioning of the CRL Site showing Major Activities and Enabling Facilities C: Structures and Contaminated Grounds

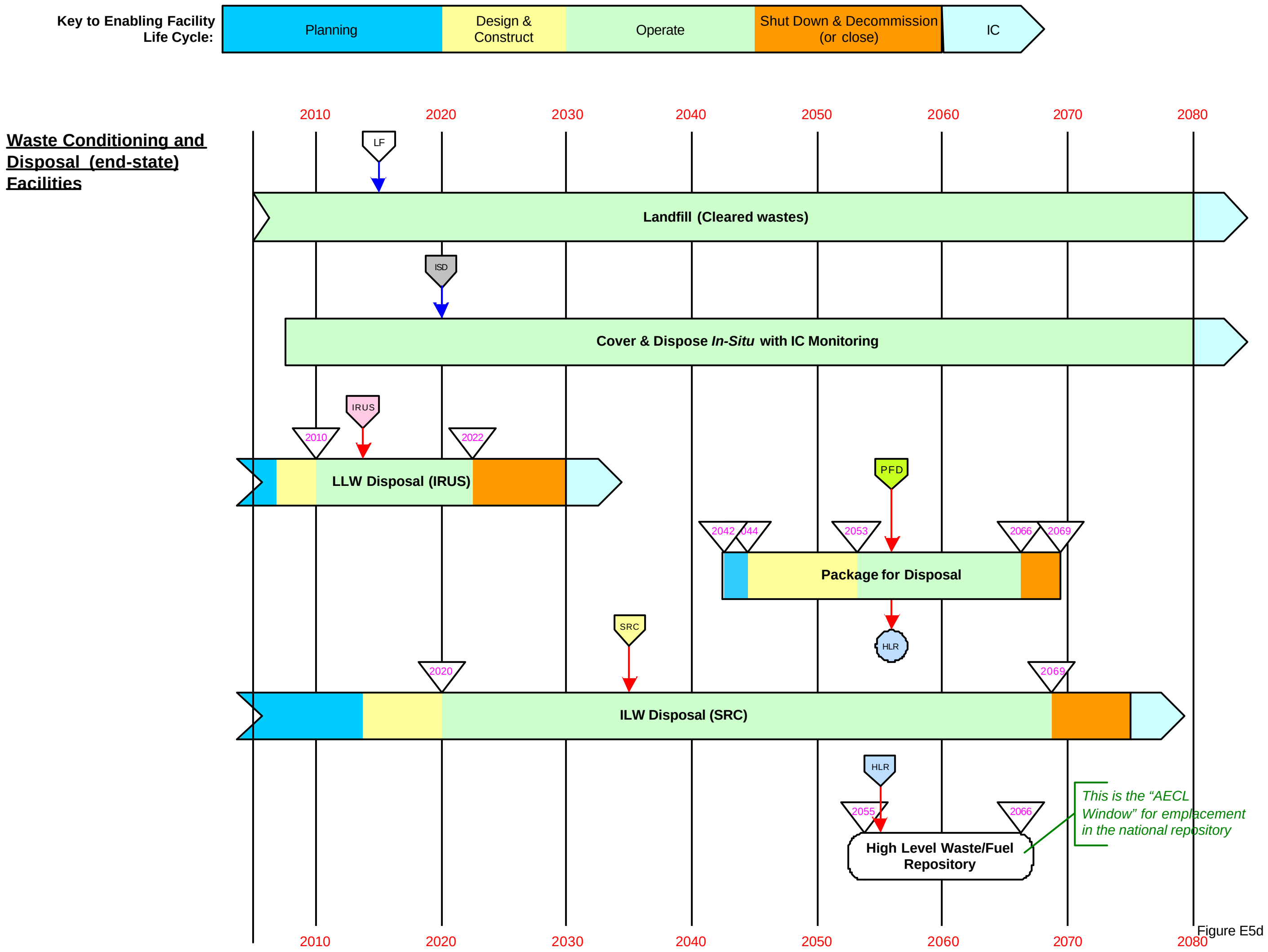

Figure E3: Operating Plan for Decommissioning of the CRL Site showing Major Activities and Enabling Facilities D: Waste Conditioning and Disposal (end-state) Facilities

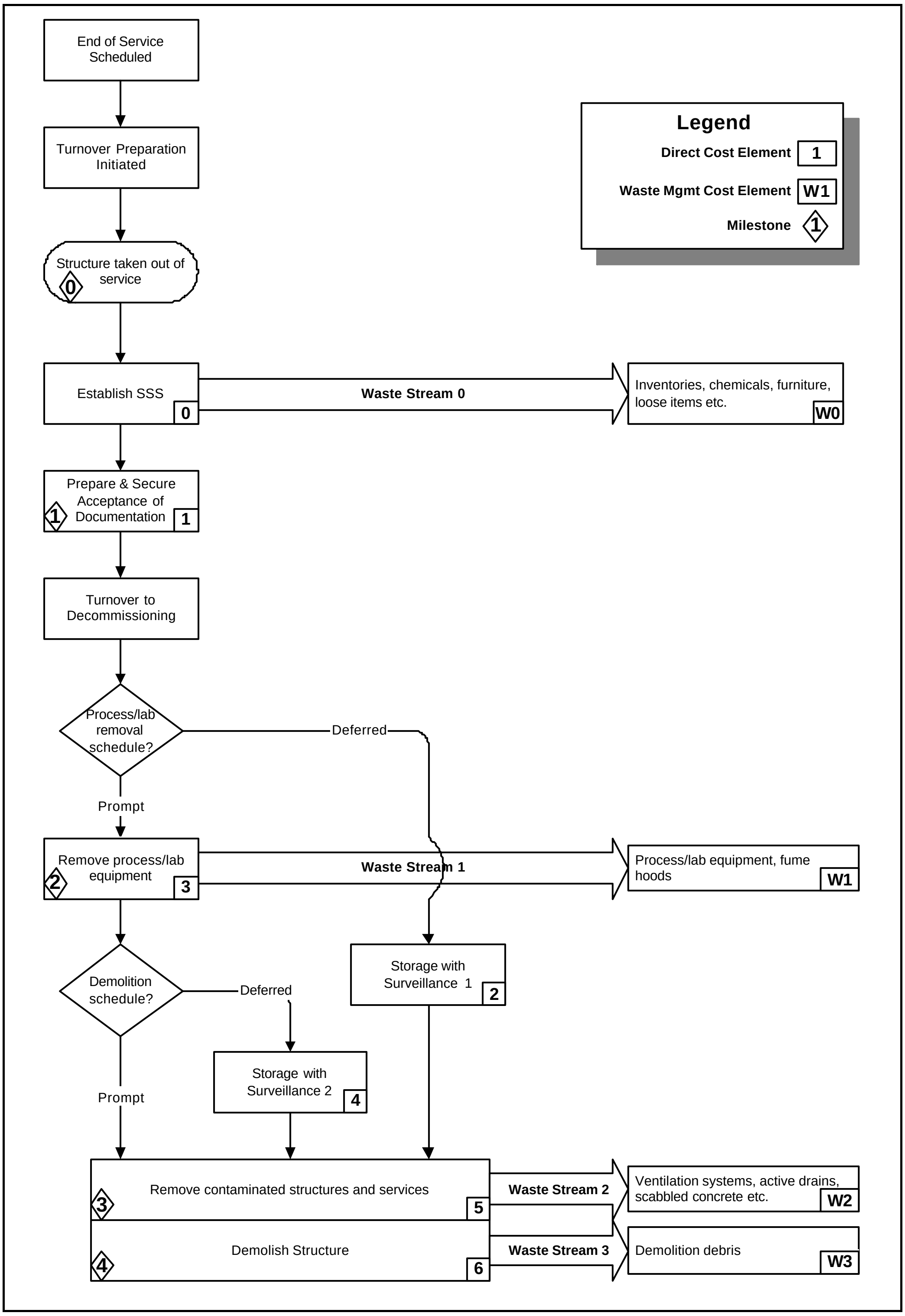

Figure E4: Generic Cost, Schedule & Waste Model for Decommissioning of Structures on the CRL Site (Planning Envelopes 1, 2 & 7)

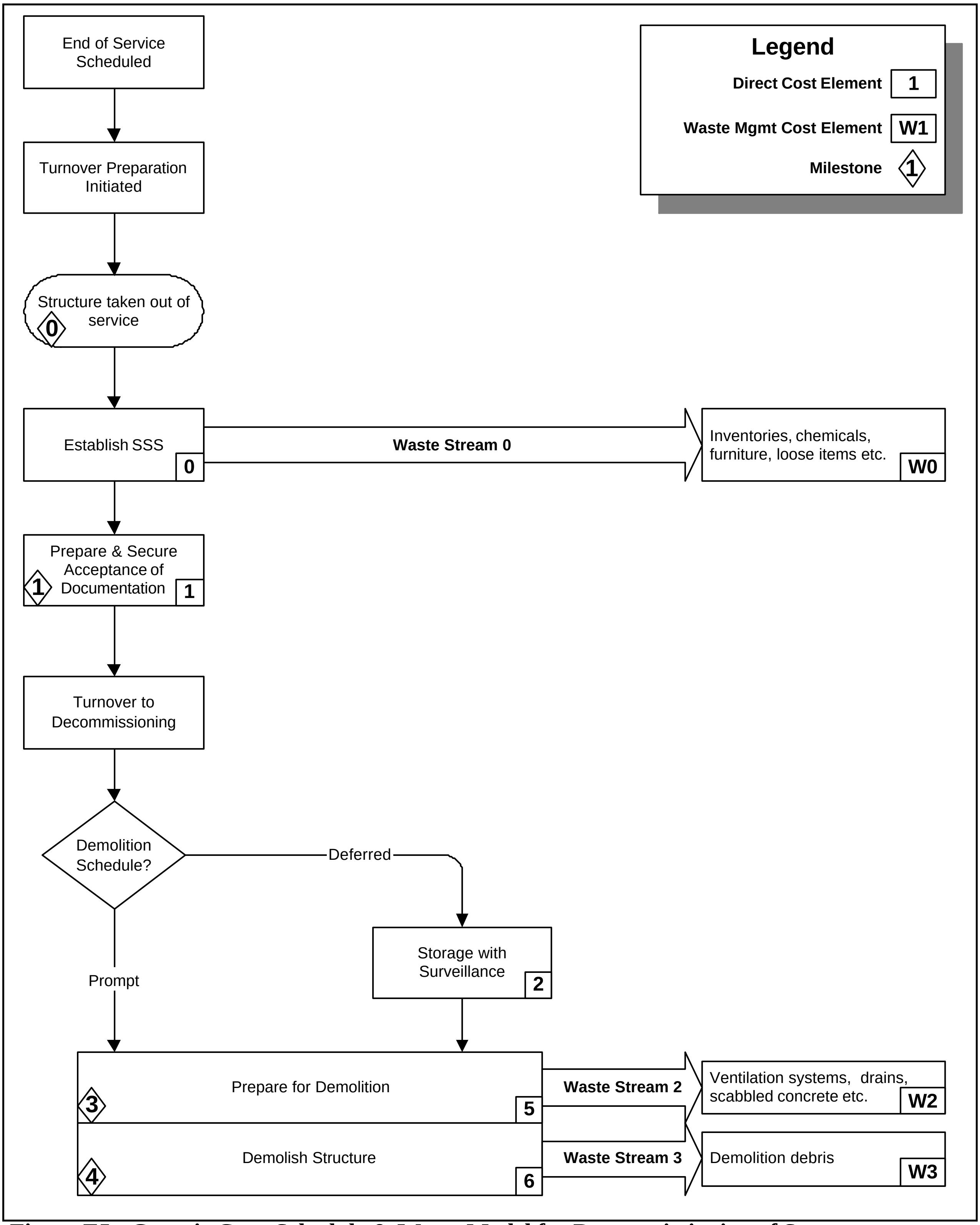

Figure E5: Generic Cost, Schedule & Waste Model for Decommissioning of Structures on the CRL Site (Planning Envelope 3)

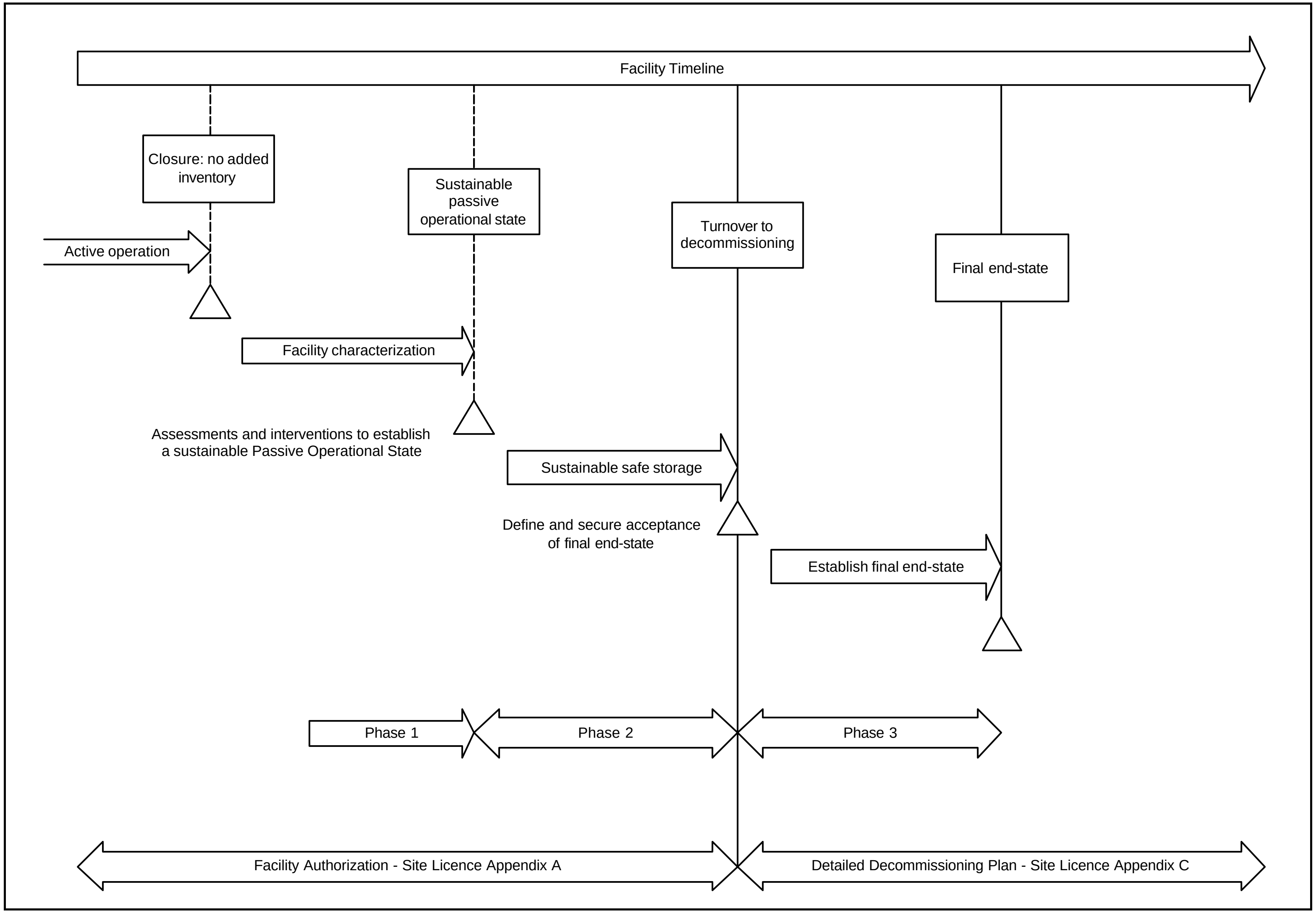

Figure E6: CRL WMA Conceptual Decommissioning Plan Timeline

Models for Decommissioning Decision Processes

The following models depict a simplified decision making process related to the planning envelopes described in this PDP. Table E4 provides a guide as to which decision processes are applicable to a given planning envelope (PE).

All Planning Envelopes

Figure E7: Assignment of Planning Envelope

The first step in the planning process for a decommissioning item is to determine which PE it is part of. The goal with PE assignment is to establish a grouping of items to which common planning assumptions can be applied, given the anticipated hazards associated with the item. In this sense, some items fall directly into one PE, for example distributed services have a unique planning envelope. For buildings/facilities at the CRL site, four PEs have been established and in Figure E7 much of the decision making process depicted is determining which PE a particular building is within.

In general, current conditions and knowledge about individual items in a planning envelope are used to predict the condition expected at turnover from operations to decommissioning. For a building, as an example, current and past use, radiological zoning information, type and nature of existing hazards are all used as indicators of potential conditions at the future point of turnover. Facility classification, whether the facility is a licensed listed facility on the CRL site license, the location CA1 or CA2 are both considered to be important factors in the anticipated hazards associated with a PE item.

PE1 consists of the licensed listed facilities on the CRL site. PE2, includes the main radioisotope laboratories, which are, mainly, located in CA2. Other buildings/facilities which may have had previous use of radioisotopes, but where no significant contamination (of systems, fumehoods etc) has occurred or remains are assigned to PE3. Buildings or facilities in CA1, where there has been no evidence or history of work involving radioactive materials (library, cafeteria, office space) are included in PE4.

Distributed services, Affected Lands and Waste Management Areas are each assigned to their specific PEs.

Characterization is a fundamental component of each of the decision processes described in the following sections. During the operational phase of a facility records are kept of facility events and performance (as described in section 11 of the main body of this report). These operational records are used to help determine the appropriate decommissioning strategy to be used for a facility.

When the facility reaches the end of its operational life the operational records are summarized and as required “gaps” are filled by additional characterization work. This may include radiological surveys, structural assessments, examination of records from other facilities which may have had “inputs” to the facility. In the case of WMAs as wastes are recovered from storage they could be analyzed for radiological and non-radiological constituents. Similarly for buildings as “actual” wastes are generated during decommissioning they are also characterized.

Therefore there are typically three layers of characterization information which are used in decommissioning:

- Existing operational records
- Confirmatory characterization at the end of service life in support of decommissioning activities
- Characterization of wastes that are generated during decommissioning.

Planning Envelopes 1-5

Figure E8: Model for Determining Decommissioning Strategy

For buildings and structures PE1-4 and distributed Services PE5 on the CRL site the decision to promptly decommission the facility, or to put the facility into a SWS for a time period after it has been turned over to decommissioning is depicted is Figure E8.

The decision process has two main components. First, it is determined whether there is a primary driver for prompt decommissioning, e.g., HSSE, Cost or Business. Where one or more primary drivers exist the second component of the decision process is engaged where it is determined whether all necessary items in place to allow a project to take place, i.e., the ability to manage the wastes resulting from decommissioning, as well as available financial, technical and human resources then prompt decommissioning will be pursued. It is important to note that priority is given to management of decommissioning items with HSSE concerns above all other concerns.

Planning Envelope 6

Figure E9: Model for Determining Management of Affected Lands

The decision process for determining what is required for Affected Lands first involves determining whether a "disturbance" is apparent (i.e., whether an area has been affected by past human activities). This is accomplished through an initial screening where records are reviewed and field reconnaissance takes place (i.e. through a Phase I site assessment). If the site is determined to have been "disturbed" further investigation is warranted. The order of investigation is surface or buried contamination or contaminated objects, followed by groundwater investigation. Where there is an immediate HSSE risk, remediation is implemented and material is removed promptly, generating solid or liquid waste to be managed in accordance to Figures E12 and E13.

If subsurface contamination or plume is present (whether as primary contamination, or resulting contaminant migration as a plume), the lower portion of the diagram is used. The level and nature of plume contamination is assessed. Treatment of contaminated groundwater may be recommended and implemented, if current or projected impacts are unacceptable.

While assessing projected impacts the operational period as well as the institutional control period are considered.

The possible endpoints for affected lands are a combination of confirmed clean, or in the case of remedial measures, generation of solid or liquid wastes.

Planning Envelope 6 and 7

Figure E10: Model for Determining Management Option for WMA or Contaminated Area

This decision process would be used in the case of WMAs or a portion of a WMA and would also be applicable to an affected land determined to be contaminated. The decision made by way of this process is to determine whether *in situ* management or recovery is the appropriate route for the item under consideration.

Initially, a site is characterized through assembly and examination of site maps and drawings, inventory and previous environmental records. Examples of these could include operational records of emplacement, RP surveyor logs, WM inventory data, Groundwater Monitoring Program data. This information is used to establish the correct scope – defining the extent of the study area, what the contaminants of concern are. These steps could also be termed "site identification and historical review". In some cases it could be determined that in order to enable assessments additional field data is required. If this was required additional characterization of the site would be conducted. Using this information initial assessments would be performed. The focus of these assessments is to determine what portion of the wastes or "site" would need to be recovered vs what could be left in situ. A central part of the decision is whether or not *in situ* disposal is practical, and this question has two facets: an economic facet, where the question of applying resources to the preparation of a safety case is assessed; and the second facet of whether it is reasonably possible for the area under consideration to be considered for *in situ* disposal.

The first part of the diagram focuses on establishing the correct scope – defining the extent of the study area. A central part of the decision is whether or not *in situ* disposal is practical, and this question has two facets: an economic facet, where the question of applying resources to the preparation of a safety case is assessed; and the second facet of whether it is reasonably possible for the area under consideration to be considered for *in situ* disposal.

For those items where *in situ* disposal is proposed, internal assessments followed by regulatory approvals are required to reach the endstate. If either of those requirements are not met the area can be "re-scoped", either in terms of defining what is under consideration, or by active intervention (recovery/remediation) (see the right side of the diagram). The endpoints of the diagram are solid and/or liquid waste generation and/or *in situ* disposal.

Planning Envelope 7

Figure E11: Model for Determining the Management of HLW and UNF

The decision process begins with retrieval of waste from existing storage facilities. In some cases used nuclear fuel (UNF) and high-level waste (HLW) are stored with non-fuel materials. This would require a characterization step. Non-fuel solid or liquid wastes are diverted for management as described in Figures E12 and E13. HLW and UNF proceed into the diagram. The basic decision processes are directed at satisfying the requirements of Nuclear Waste Management Organization (NWMO) for long-term management of UNF and HLW. AECL CANDU fuel, and research fuels with very similar characteristics to CANDU fuel will be conditioned and packaged (potentially resized) to meet NWMO waste acceptance criteria. Other research fuels may need to have a variety of physical or chemical processes applied to them in order to be qualified for acceptance into the NWMO long-term management facility.

The endpoints of this diagram are a combination of liquid or solid wastes, or HLW and UNF material packaged to meet NWMO repository requirements.

All Planning Envelopes

Figure E12: Model for Management of Solid Waste Arisings

This flowchart depicts the management of solid wastes resulting from decommissioning activities. The application of this flowchart assumes that UNF and HLW are managed according to Figure E12. The first steps in this process are to retrieve the waste and size it appropriately for characterization. The characterization information feeds into the first decision, which concerns radiological free release criteria (clearance criteria). Much of the waste generated from decommissioning is anticipated to be conventional construction materials either free of any radiological contamination or containing trace levels of residual activity and therefore suitable for re-use, recycle or landfill disposal. The practice of segregating and releasing wastes with minor residual levels of contamination (i.e., below release criteria) is recognized in regulatory guide G-219 as a necessary element in optimizing the decommissioning process.

If the waste materials meet the clearance criteria (refer to the left side of the diagram) but where conventional hazardous materials are a factor in its further management, a number of steps are implemented to ensure the waste is managed appropriately. If hazardous materials are present and can be removed; they will be segregated/removed. The intent is to economically maximize the amount of material suitable for re-use, recycle or landfill. This portion of the diagram can result in the following endpoints, re-use, recycle or landfill, hazardous waste facility, or generation of liquid wastes from segregation of materials followed by return to characterization.

On the right side of the diagram, materials with activity above radiological release criteria are addressed. The goal is to decontaminate to the extent practicable and then to direct the remaining radiologically contaminated material to the appropriate repository (either LLW or ILW). The goal is to maximize, through economic application of decontamination and segregation techniques, the amount of material for release, LLW or ILW in that order.

The endpoints for this section of the diagram result in materials sent to interim storage pending repository availability, or decontaminated/segregated and returned to the characterization stage. Any liquid wastes generated by decontamination or segregation are directed to the liquid waste flowchart.

All Planning Envelopes

Figure E13 Model for Management of Liquid Waste Arisings

This flowchart displays the management process for liquid wastes arising from decommissioning activities. Liquids are defined to include sludges and the first step in the process is to characterize/inspect liquids and sludges to make a decision regarding whether solids can be separated and managed according to Figure E12

The next decision step determines whether accountable quantities of fissile/fertile material are present and if so, whether recovery, downblending or storage is most appropriate. Storage would be of an interim nature, until a waste repository or repository WACs were available to permit further processing. The endpoints to the right side of the diagram are either disposition in a repository, or material recovery, which would result in the non-recovered liquid fraction being returned back into the characterize/inspect stage.

The other branch of the flowchart, the left side of the diagram, results in processing in the Waste Treatment Centre (WTC), provided WTC acceptance criteria are satisfied, or otherwise storage until repository criteria are available, followed by processing to meet those criteria. The endpoint for the left side of this flowchart is eventual disposition to a repository, when that repository exists.

All Planning Envelopes

Enabling Facilities

The following list summarizes the types of new or upgraded facilities that are expected to be required to support the decommissioning activities at the CRL site as indicated in figures E3 and E7-E13. Abbreviations used in Figure E3 are included with the following summaries i.e., (LF) for landfill.

- **Landfill for inactive and cleared wastes**. (LF)

  This disposal facility will be for the major fraction of demolition debris that is not significantly contaminated, and has met free release criteria.

- **Intrusion Resistant Underground Structure (IRUS) for low-level radioactive waste disposal**. (IRUS)

  A CRL disposal facility for shorter-lived decommissioning wastes produced before disposal is available in the Shallow Rock Cavity.

- **Shallow Rock Cavity (SRC) for low and intermediate-level radioactive waste disposal.** (SRC)

  A geologic disposal facility for most CRL and WL decommissioning wastes as well as wastes from other operations.

- **Interim long-term and buffer storage for low and intermediate-level waste (ILW).**

  Facilities used to store solid wastes awaiting the next processing step or transfer to a disposal facility. These facilities may comprise Modular Above Ground Storage (MAGS) and/or Shielded Modular Above Ground Storage (SMAGS).

- **Interim long-term and buffer storage for radioactive liquid wastes.**

  Facilities used to store liquid wastes awaiting the next processing step. The Liquid Waste Transfer and Storage Project is currently developing such a facility for liquid wastes.

- **Waste Analysis Facility – Clearance Module**

  A facility to confirm likely clean wastes are safe to release unconditionally for reuse, recycle or disposal.

- **Solids processing facilities**

  Incinerator

  Equipment for the combustion of wastes to reduce their volume, stabilize their form and facilitate their characterization and preparation for disposal.

Concrete conditioning facility

Equipment for size reduction, characterization and segregation of concrete wastes to facilitate their handling and disposal.

Processing and conditioning facility for cemented Mo-99 waste

Equipment for the conversion of the CRL stored inventory of immobilized Mo-99 isotope production wastes to a form suitable for further processing and/or permanent disposal.

Drying and Storage Facility for High Priority Fuels

A facility to enable the recovery, drying and storage of high priority fuels currently in tileholes. This facility represents one of the current Waste Remediation and Enhancement Projects (WREP).

Fuel Packaging Facility (PFD)

A facility that would include provision for packaging fuels (package for disposal) recovered from storage for shipment to a High level waste repository (HLR). This facility would allow for cutting of fuel as required and determined by waste acceptance criteria.

Cementation and grouting facility

Equipment for the immobilization in a container of solid or liquid wastes via their incorporation in a cementitious mortar.

Bitumen overcoating facility

Equipment to overpack drums of WTC-bituminized liquid wastes to enhance the water resistance and thus qualify them for disposal.

Decontamination facility

A facility providing a selection of process equipment for reducing the level of surface contamination of materials to facilitate their reuse or management as wastes.

Soil segregation facility

Although soil and other material excavated from decommissioning sites is often largely uncontaminated it may contain pockets of radioactivity that, if removed, will permit the bulk of the material to be cleared for release.

- **Fluids processing facilities**

  Incinerator for oils and solvents

  The incinerator used for combustible solids may be fitted to accept liquid feed, perhaps by injection into its afterburner.

  Low-level liquid waste treatment centre

  The existing CRL Waste Treatment Centre (WTC), although currently undergoing an upgrade, is expected to require further upgrading or replacement in a decade or so as disposal acceptance criteria become better established.

Bituminization and cementation

Immobilization of low- and intermediate-level liquid wastes can involve a variety of solidification matrices, for example, bitumen in the existing WTC and cementitious material for higher specific activity liquids.

Vitrification for liquid wastes and cemented Mo-99 wastes (VIS)

Incorporation in a glass matrix is a preferred disposal form for radioactive wastes, particularly those containing fissile or high-level contaminants. Pre-processing to down-blend the HEU and/or separate hazardous components such as mercury may be done for specific wastes. This facility would incorporate necessary storage requirements.

Mercury removal

Some wastes contain hazardous components other than radioactivity, such as mercury, that may be more easily managed if separated from the waste.

- **Shielded Facilities**

  Hot-Cell facilities, such as B234 and B375 currently in operation at CRL require upgrading if they are to service a variety of needs associated with the decommissioning of nuclear reactors and Waste Management Areas at CRL.

Table E4: Decision Models and Flowcharts Applicable to each Decommissioning Planning Envelope

Planning Envelope	**Description**	**Applicable Decision Models/Flowcharts**		
PE1-PE4	Buildings/Structures	Figure E7: Assignment of Planning Envelopes	Figure E8: Model for Determining Decommissioning Strategy	Figure E12: Model for Management of Solid Waste Arisings. Figure E13: Model for Management of Liquid Waste Arisings
PE5	Distributed Services	Figure E7: Assignment of Planning Envelopes	Figure E8: Model for Determining Decommissioning Strategy	Figure E12: Model for Management of Solid Waste Arisings. Figure E13: Model for Management of Liquid Waste Arisings
PE6	Affected Lands	Figure E7: Assignment of Planning Envelopes	Figure E9: Model for Determining Management of Affected Lands Figure E10: Model for Determining Management Option for WMA or Contaminated Area	Figure E12: Model for Management of Solid Waste Arisings. Figure E13: Model for Management of Liquid Waste Arisings
PE7	Waste Management Areas	Figure E7: Assignment of Planning Envelopes	Figure E10: Model for Determining Management Option for WMA or Contaminated Area Figure E11: Model for Determining the Management of HLW and UNF	Figure E12: Model for Management of Solid Waste Arisings. Figure E13: Model for Management of Liquid Waste Arisings

The following three symbols are used on the following figures:

Enclosed “S” representing solid wastes which are generated as a result of indicated actions and then also managed as shown on Figure E12.

Enclosed “L” representing liquid wastes which are generated as a result of indicated actions and then also managed as shown on Figure E13.

Enclosed “C” which is a connector used to indicate a “tie-in” on that same page

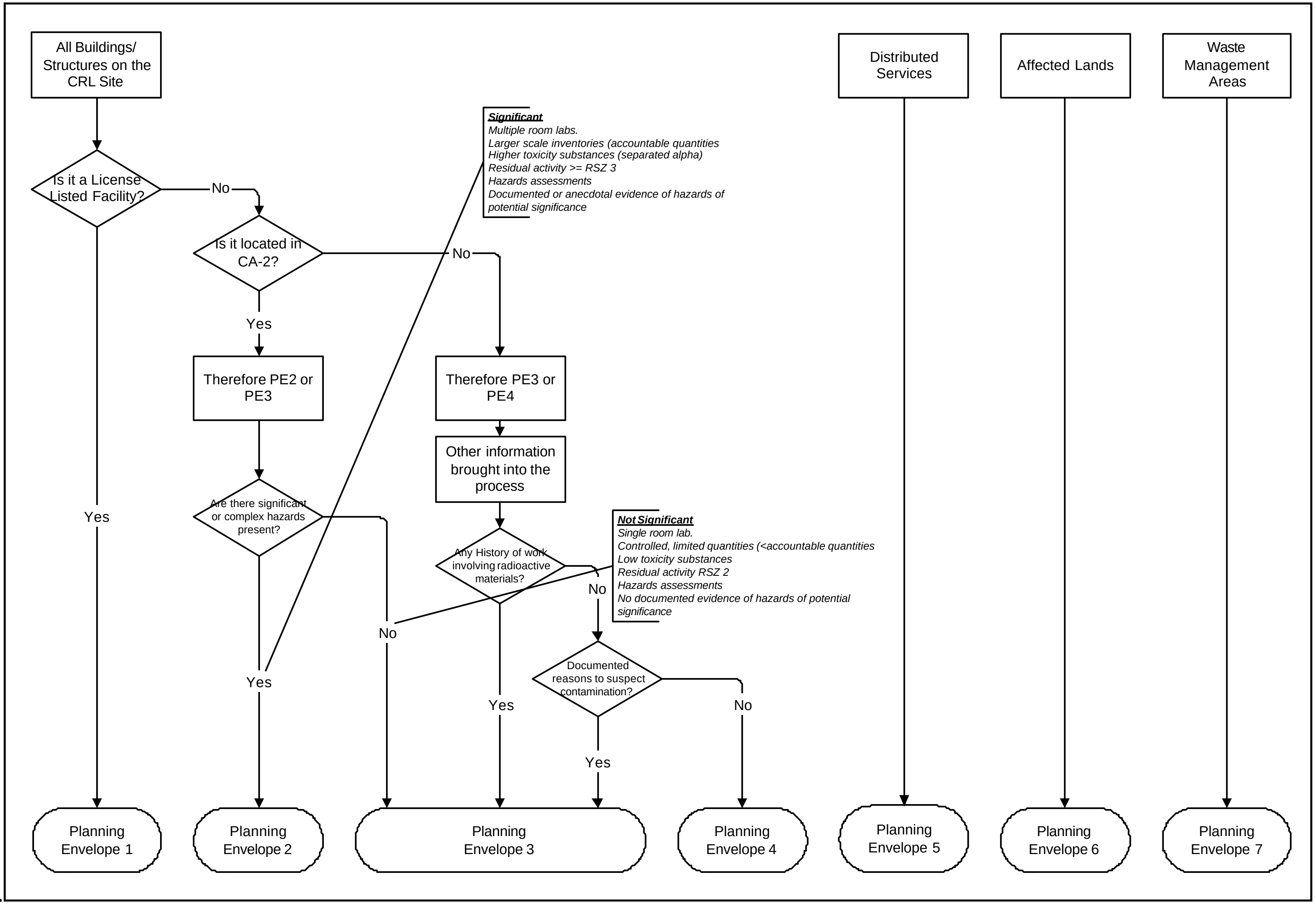

Figure E7: Assignment of Planning Envelopes

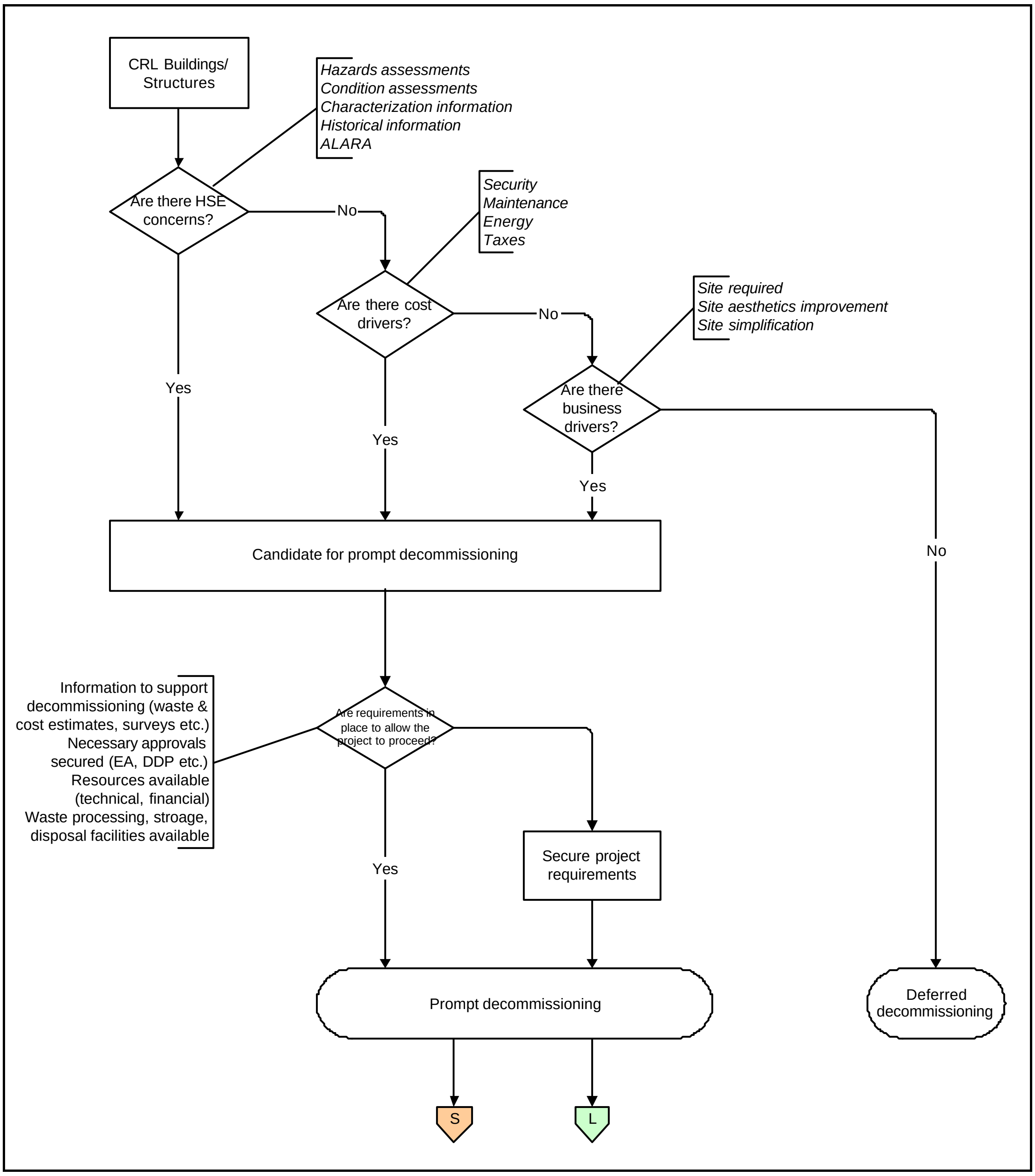

Figure E8: Model for Determining Decommissioning Strategy

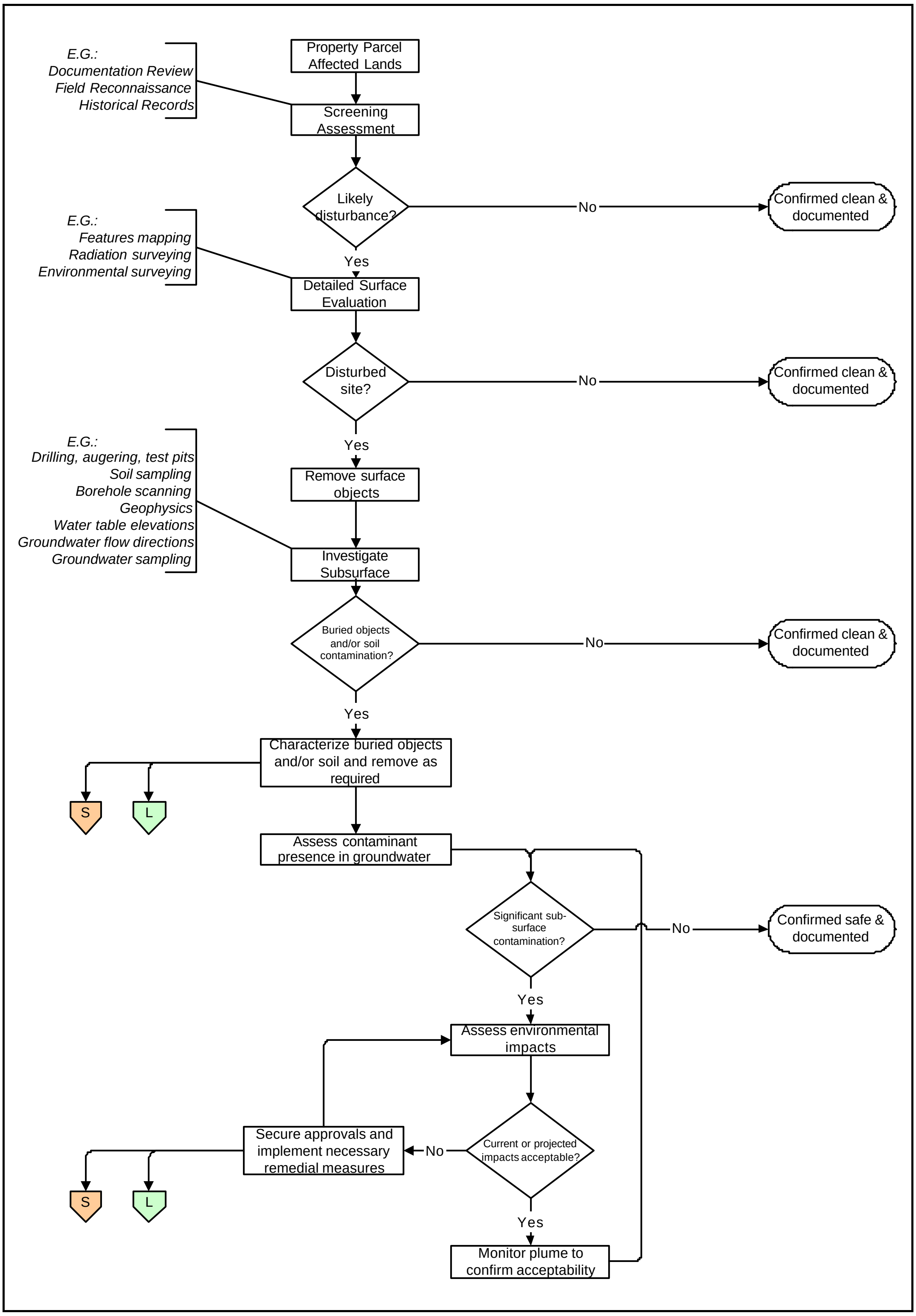

Figure E9: Model for Determining Management of Affected Lands

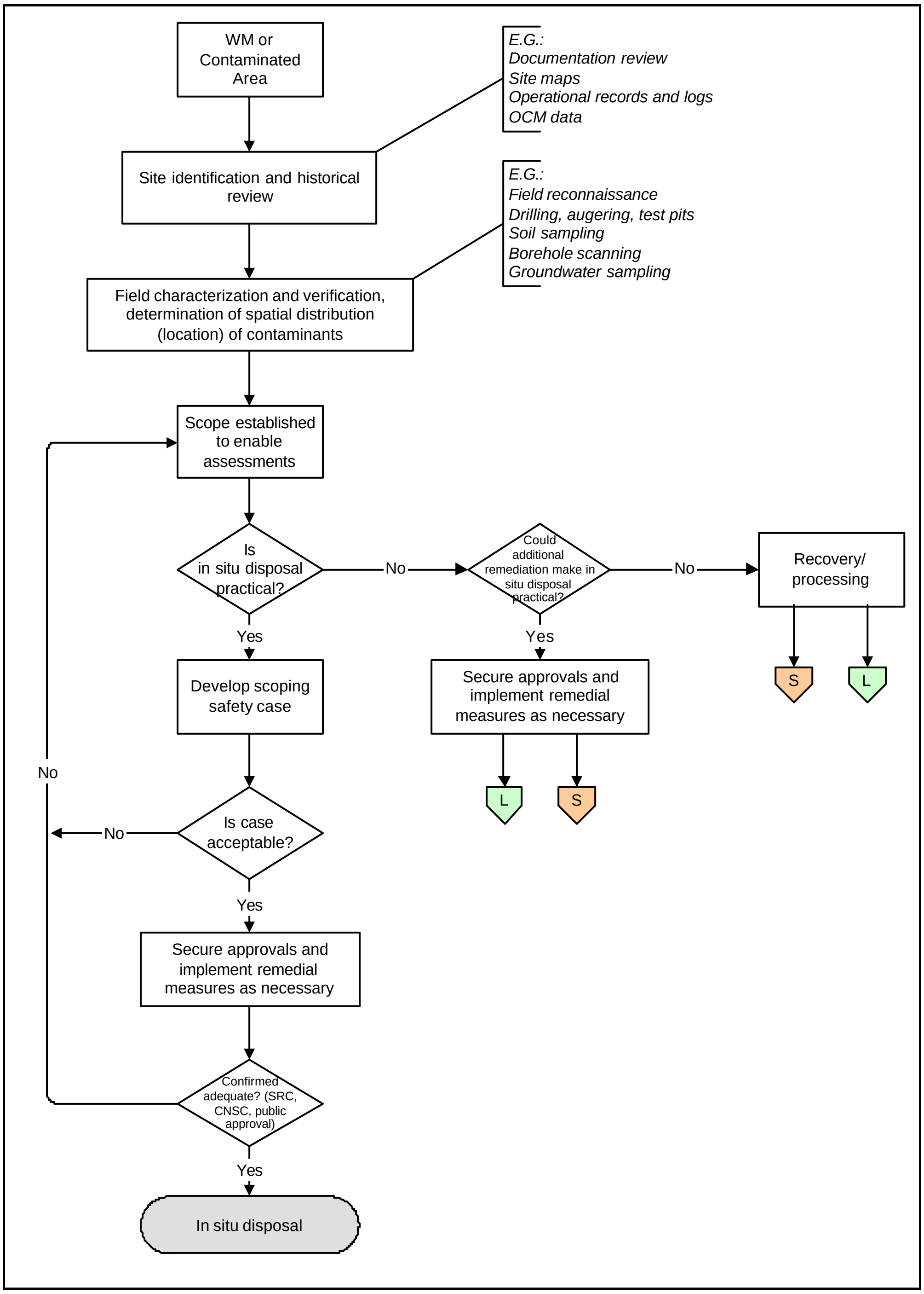

Figure E10: Model for Determining Management Option for WMA or Contaminated Area

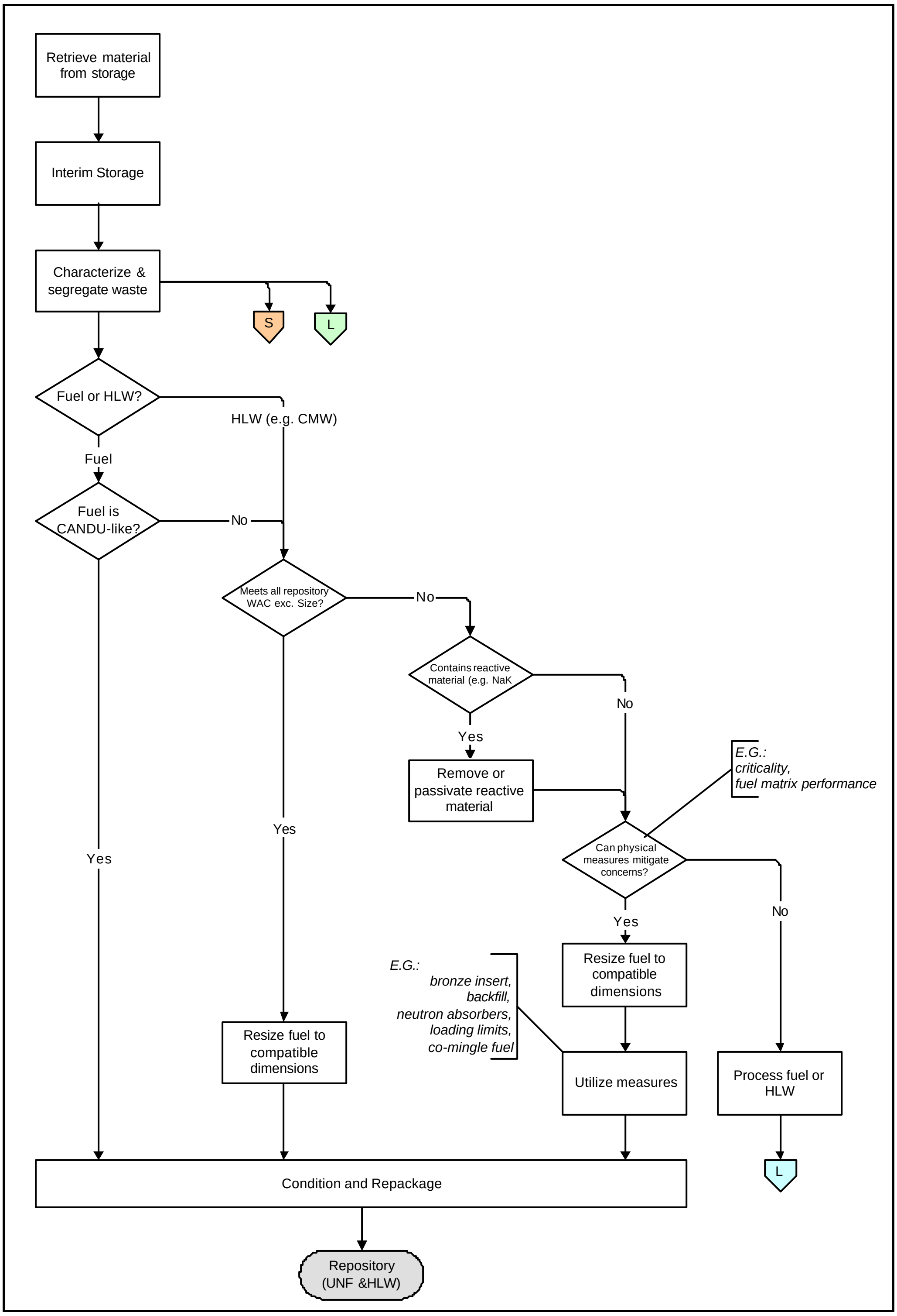

Figure E11: Model for Determining the Management of HLW and UNF

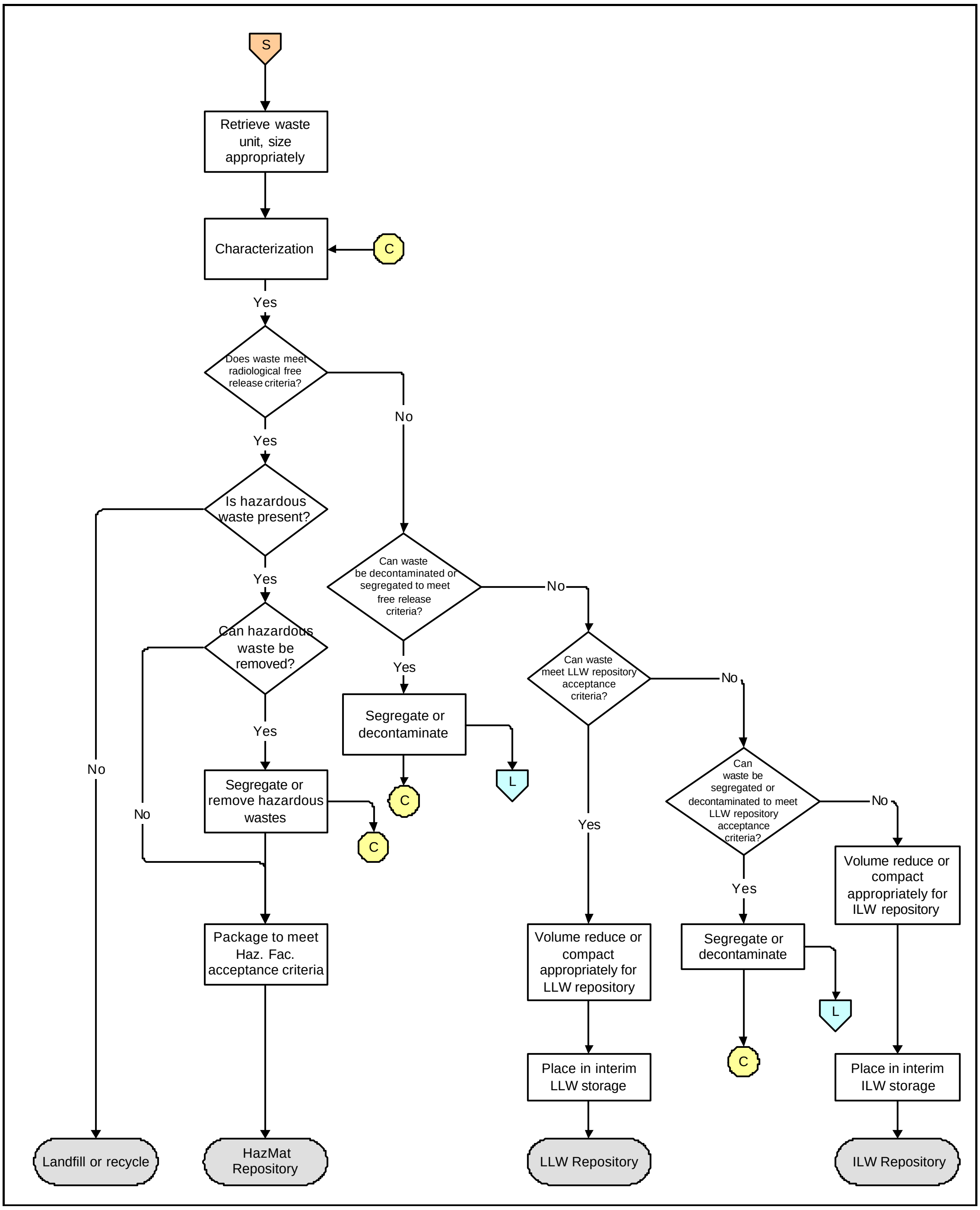

Figure E12: Model for Management of Solid Waste Arisings.

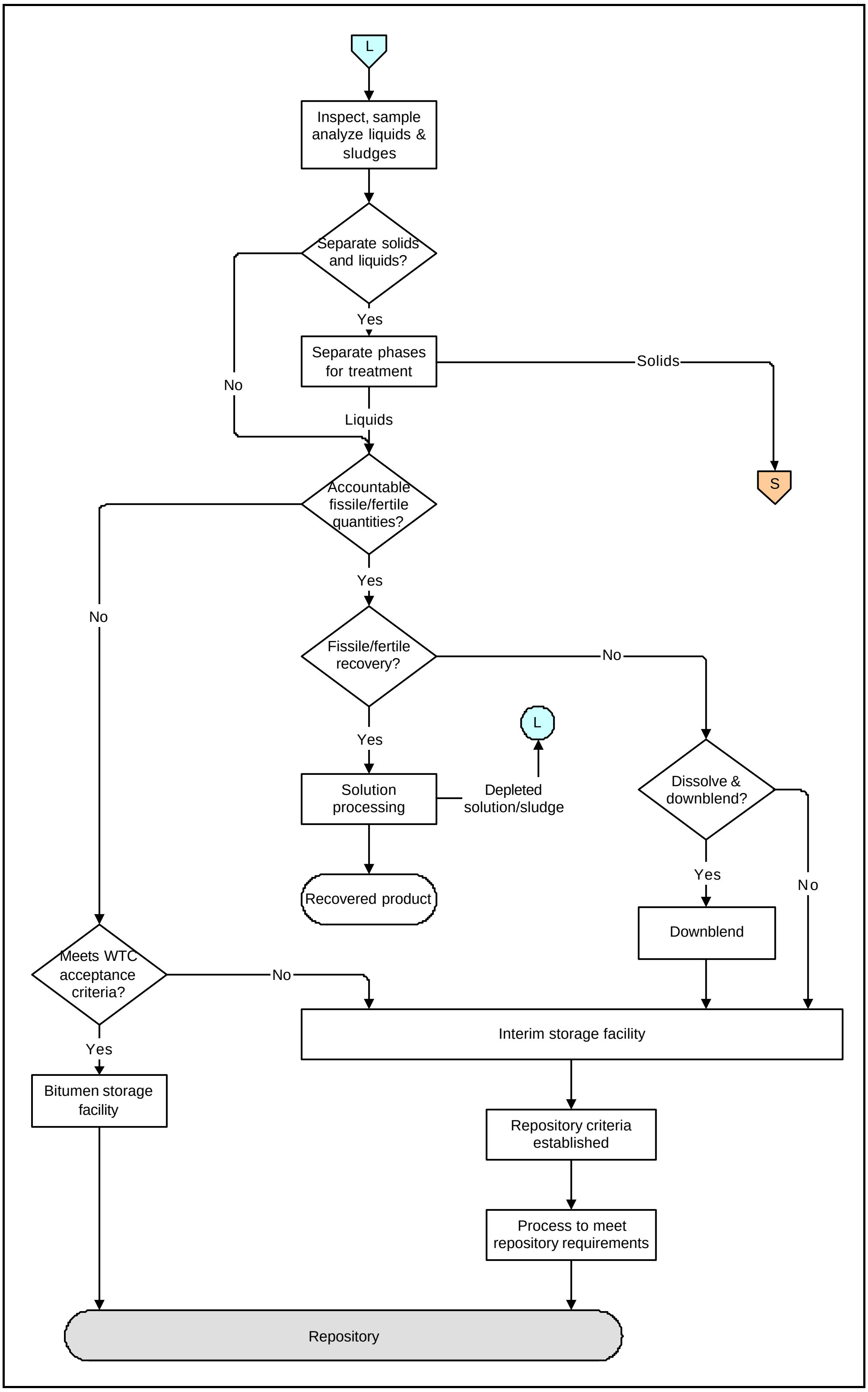

Figure E13: Model for Management of Liquid Waste Arisings