INTRUSION RESISTANT UNDERGROUND STRUCTURE (IRUS)

Design and Operations

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1. IRUS WASTE STREAMS AND INVENTORY

1.1 INTRODUCTION

The safety case for the IRUS low-level radioactive waste disposal facility is based on the fact that IRUS will contain three specific types of waste only. Any applications to modify the types of waste will be the subject of separate regulatory submissions.

1.2 DESCRIPTIONS OF THE WASTE STREAMS

The three specific waste streams that will be emplaced in the IRUS facility are:

(i) baled waste (1740 m^3);
(ii) bituminized incinerator ash (30 m^3); and
(iii) bituminized reverse osmosis concentrate (142 m^3).

1.2.1 Baled Waste

The various activities carried out at AECL's Chalk River Laboratories (CRL) site generate solid wastes which are first placed in 40 L plastic bags and then picked up and transported to the Waste Treatment Centre (WTC) for compaction. The bags are segregated at source into incinerable, non-incinerable, and non-processible categories. Bags with external radiation fields in excess of 1 $mGy{\cdot}h^{-1}$ at 30 cm are not accepted for processing at the WTC.

The solid waste typically consists of contaminated items such as paper, wood, cardboard, wet mops, rags, gloves, and plastics. The records compiled over the past 11 years indicate that 1000 to 2000 such bags are generated per month, and that most of these bags (94%) have radiation levels less than 10 $\mu Gy{\cdot}h^{-1}$ on contact.

The baling process involves placing a corrugated fibreboard box with a plastic liner inside the chamber of the baler, and then placing the bags of waste into the chamber where they are compressed at a pressure of (typically) 930 kPa. The process is repeated until the bale is fully formed, at which time strapping is placed around the bale. The final bale is therefore composed of waste material that is partially encapsulated inside the remnants of the plastic trash collection bags which are, in turn, contained within the plastic liner of the bale box.

Each bale resulting from the compaction process contains approximately 65 bags, weighs 290 kg, and has a volume of approximately 0.4 m^3. In the period 1982 to 1993, 2757 bales (1100 m^3) were sent for storage in circular concrete bunkers on the CRL site, and the average generation rate for bales from 1989 to 1995 was 305 (122 m^3) bales per year. The on-contact radiation fields from waste bales vary widely from 20 $\mu Gy{\cdot}h^{-1}$ to 20 $mGy{\cdot}h^{-1}$ with an average value of 250 $\mu Gy{\cdot}h^{-1}$.

1.2.2 Bituminized Incinerator Ash

150 drums (30 m^3) of bituminized incinerator ash were generated from the operation of the CRL low-level radioactive waste incinerator, which was used between 1982 and 1989. The predominant waste feed to the incinerator was uncompacted and compacted wastes of the type discussed in Section 1.2.1. The waste package resulting from the subsequent ash immobilization process was a 210-L galvanized steel drum containing a 50:50 mixture by weight of the ash and bitumen and weighing approximately 270 kg. A ribbon blender was used to mix the ash and molten (oxidized) bitumen. The average on-contact radiation field for the 150 drums was 0.6 $mGy{\cdot}h^{-1}$ with a standard deviation of 0.5 $mGy{\cdot}h^{-1}$.

1.2.3 Bituminized Reverse Osmosis Concentrate

The CRL site is equipped with a chemical active drain system that is intended for use in collecting and transferring the radioactive waste liquids that arise from the large and diverse number of research activities and radioisotope production facilities on the site. The CRL programs that typically generate these liquid wastes include fuel engineering, fuel and pressure tube examination, catalyst development, chemical engineering, metallurgy, isotope production, and chemical analysis, and between 1991 and 1994 the average amount of liquid collected through the chemical active drain system was 1432 $m^3{\cdot}a^{-1}$. In addition, the liquid wastes generated during CRL decontamination operations have a dedicated drain line; between 1990 and 1994, the average amount of liquid originating from the Decontamination Centre was 1307 $m^3{\cdot}a^{-1}$.

The radioactive liquids collected by these drain systems are routed to the Waste Treatment Centre (WTC), where they are passed through microfiltration units and reverse osmosis membranes to concentrate the contaminants by a factor of 20 to 30. This concentrate is subsequently combined with direct distilled bitumen that has been emulsified with water (40%) to reduce its viscosity. The residual water in the concentrate and bitumen feed material is removed in a thin film evaporator, and the resulting product fed into 210-L galvanized steel drums. Approximately 50 drums (11.4 m^3) of bituminized reverse osmosis concentrate is sent for storage in circular concrete bunkers on the CRL site each year, and as of 1994 December, there were about 40 m^3 of this material in storage. Each drum weighs approximately 270 kg, and the on-contact radiation fields vary between 3 and 50 $mGy{\cdot}h^{-1}$ with a typical field being 30 $mGy{\cdot}h^{-1}$.

1.3 WASTE CONTAMINANT INVENTORY

A detailed knowledge of the waste inventory is of fundamental importance when preparing the safety case for waste disposal. AECL has characterized the waste in a pragmatic and organized fashion by:

(i) systematically identifying on-site and off-site waste streams and waste blocks;
(ii) employing inference methods (based on process knowledge) to predict the content of the wastes;

(iii) applying analytical methods specifically developed at CRL for the determination of radionuclide levels in CRL waste streams;
(iv) carrying out analyses on the identified wastes;
(v) applying administrative systems and databases to meet auditing, reporting, and inventory control requirements; and
(vi) educating producers of waste about the importance of waste characterization and waste control.

The nature of CRL operations is such that a wide variety of wastes are generated, and the variability in the wastes exceeds that associated with the routine operation of, for example, a large power reactor or an isotope user or producer. In recognition that a major effort will be required to characterize the AECL waste streams and waste blocks for future disposal on a major scale, an approach was taken that permits proceeding with disposal into the IRUS facility, while at the same time accommodating the fact that the characterization of all waste streams or waste blocks would take years. That approach was to restrict the inventory in IRUS, for the purposes of this safety case, to the three waste streams described in Section 1.2.

These three waste streams have been extensively characterized, and the results of that characterization used in predicting the final inventory of IRUS.

Table 1.3-1
Total Radionuclide Inventory for IRUS

Nuclide	Nuclide Inventory in 1912 m^3 of Waste (Bq)	Nuclide	Nuclide Inventory in 1912 m^3 of Waste (Bq)
Ag-110m	4.77E+10	Pd-107[2]	2.30E+06
Am-241	3.27E+10	Pu-238	8.67E+10
C-14	1.23E+10	Pu-239	1.34E+10
Ce-144	5.39E+12	Pu-240	2.19E+10
Cl-36[1]	3.48E+08	Pu-241[2]	1.76E+12
Cm-244[2]	2.12E+09	Pu-242[2]	7.70E+07
Co-60	2.31E+12	Ra-226	9.09E+07
Cr-51	2.33E+14	Ru-103	3.08E+13
Cs-134	5.89E+11	Ru-106	7.22E+11
Cs-135[2]	8.62E+06	Sb-125	4.29E+10
Cs-137	4.79E+12	Se-79[2]	6.01E+06
Eu-152	2.22E+10	Sn-126[1]	1.08E+07
Eu-154	1.43E+11	Sr-90	3.34E+11
Eu-155	8.53E+10	Tc-99[1]	1.84E+09
H-3	3.25E+13	Th-230	1.44E+05
I-129	1.50E+06	U-233[2]	2.05E+02
Nb-94	8.69E+09	U-234	2.56E+09
Nb-95	3.11E+13	U-235	1.10E+08
Ni-59	1.39E+08	U-238[1]	4.94E+08
Ni-63	3.19E+10	Zn-65	2.66E+11
Np-237	3.12E+07	Zr-93[2]	2.17E+08
		Zr-95	4.91E+13

[1] Inventories based on minimum detectable activity from measurements.

[2] Inventories inferred.

Table 1.3-2

Non-Radiological Contaminant Inventories in IRUS, by Waste Stream and Total

Element	Inventory in 30 m^3 of Bituminized Incinerator Ash (g)	Inventory in 142 m^3 of Bituminized Reverse Osmosis Concentrate (g)	Inventory in 1740 m^3 of Baled Waste (g)	Total Predicted Inventory in 1912 m^3 of Waste (g)
Na	9.39E+05	9.23E+06	2.38E+06	1.25E+07
K	3.88E+05	1.44E+05	9.08E+05	1.44E+06
Ca	1.66E+06	2.95E+05	3.89E+06	5.85E+06
Mg	2.95E+05	5.99E+04	6.89E+05	1.04E+06
Fe	2.24E+06	3.05E+05	5.25E+06	7.79E+06
Mn	4.43E+04	3.37E+04	1.04E+05	1.82E+05
Al	1.65E+06	4.70E+05	3.86E+06	5.98E+06
Ni	7.98E+04	1.12E+04	1.87E+05	2.78E+05
Co	3.26E+03	2.49E+02	7.63E+03	1.11E+04
Cd	1.96E+04	1.25E+03	4.59E+04	6.68E+04
Pb	3.03E+05	3.78E+04	7.08E+05	1.05E+06
Cr	1.16E+05	1.15E+04	2.71E+05	3.99E+05
Hg	6.33E+02	2.31E+03	1.48E+03	4.42E+03
Te	2.39E+03	7.44E+02	5.59E+03	8.72E+03
As	3.17E+03	6.54E+02	7.41E+03	1.12E+04
NO_3^-	1.43E+06	1.40E+07	3.61E+06	1.90E+07
PO_4^{3-}	5.62E+05	5.52E+06	1.42E+06	7.50E+06

2. WASTE FORM PERFORMANCE

2.1 BALED WASTES

There are insufficient data that can be used to estimate time scales for radionuclide release from bales. A certain amount of release will occur by diffusion and perhaps advection (i.e., contact with infiltration). Bale decomposition, which is a process that is estimated to occur on a time scale of several hundred years, may also lead to the release of radionuclides.

For this reason, radionuclide release from baled waste is based on the following, very conservative, assumptions:

i) No credit is taken for sorption onto the refuse that makes up the bales.
ii) Radionuclide release occurs over a ten year period. Hence, the radionuclide inventory in bales is released and distributed uniformly throughout the backfill within the first ten years of the postclosure period.

These assumptions are conservative because (i) the bale liner, the remnants of the plastic trash collection bags and the refuse itself will restrict radionuclide mass transfer, (ii) the bales are less permeable to flow than is the backfill, hence, even after the onset of infiltration, diffusion should still limit radionuclide releases from bales, and (iii) the bale matrix (i.e., the refuse) will sorb radionuclides.

2.2 BITUMEN

Two types of bituminized waste will be emplaced in IRUS: 30 m^3 of bituminized ash from the incineration of bales, and 142 m^3 of bituminized RO concentrate. The bituminized ash is about 50 wt % ash that is largely insoluble solids (refractory oxides). The bituminized RO concentrate is about 35 wt % waste solids, which are mainly soluble salts. Incinerator ash is solidified in oxidized bitumen and the RO concentrate is being solidified in distilled bitumen. Distilled bitumen is sometimes referred to as emulsified bitumen, because waste solids are blended with an emulsion of distilled bitumen during waste processing.

Each drum of bituminized RO concentrate to be emplaced in IRUS will be coated with about 5 cm of "cold" bitumen inside a steel overpack (cold bitumen is oxidized bitumen that does not contain any radioactive waste). The cold bitumen coating is an additional barrier that is expected to delay and limit the release of contaminants from bituminized RO concentrate for hundreds of years.

For this safety case, the assumption is made that the contents of the bituminized waste will be released at a uniform rate over a period of 500 years.

3. VAULT DESIGN AND CONSTRUCTION

3.1 INTRODUCTION

IRUS will be a below-ground vault consisting of an open bottom reinforced-concrete structure (approximate dimensions 30 m x 20 m x 8 m) with a reinforced-concrete roof. The vault will contain waste packages separated and surrounded by permeable sand/clinoptilolite backfill. The vault has a capacity of about 1900 m^3 of waste packages and an equal volume of backfill.

The vault roof consists of a 1 m thick reinforced-concrete slab designed to resist infiltration of water and to deter inadvertent intruders. The roof will be covered by a multi-layer earthen cover engineered to limit infiltration down to the roof, and to isolate the roof and vault structure from freeze-thaw cycles. The walls and footings of the vault are made of 0.61 m thick reinforced-concrete. The floor of the vault is constructed of two 0.3 m thick layers of permeable sorbing buffer mixtures. The engineered permeable floor is designed to be free-draining, which is one of the features of the IRUS facility.

The vault structure is required to meet its functional requirements for 500 years until most of the radioactivity in the waste has decayed. Therefore, the durability of the structural materials used in the construction and the long-term behaviour of the structure are important considerations in the design of the vault. The details are discussed briefly in the following sections.

3.2 FUNCTIONAL REQUIREMENTS

The IRUS disposal facility is designed to meet the following functional requirements:

(i) minimize contact of water with the waste;
(ii) ensure long-term structural integrity;
(iii) prevent inadvertent intrusion into the waste;
(iv) restrict the loss of radionuclides from the vault; and
(v) minimize the need for long-term maintenance.

3.3 DESCRIPTION OF THE IRUS STRUCTURE

3.3.1 Vault Foundation and Walls

The vault will be 31.6 m long x 21.65 m wide x 8.6 m high from the base of the foundation to the underside of the concrete roof at the outer wall location. The foundation width is proportioned such that the bearing capacity of the soil will not be exceeded under any load or combination of loads. The foundation pressures are kept below the allowable bearing pressures (6000 psf - 290 kPa) at all locations, as recommended by a geotechnical consultant. The total maximum settlement corresponding to this pressure would be of the order of 25 mm, resulting in very little differential settlement of the foundation.

The base and walls are made of 0.61 m thick reinforced-concrete. To take advantage of the material properties of concrete, the outer walls are arch-shaped in plan view. This shape helps the walls to resist the external soil pressure by inducing direct compressive stresses in the concrete walls and minimizing the bending stresses (i.e. compression on one side and tension on the other side in a conventional trench-type design). This reduces the quantity of reinforcing steel (a potential cause of concrete degradation), and also provides a stress field that would counteract tension cracks produced in the concrete walls due to the effects of other loadings.

The walls are also provided with construction and isolation joints to help minimize drying and plastic shrinkage cracks in the concrete during construction. The inside and outside surfaces of the outer walls will be treated with a waterproofing coating. Even though the waterproofing material will provide protection of the concrete from infiltration for a number of years, the longevity of the waterproof coating is not quantifiable and hence no credit is given for the coating in the assessment of concrete longevity.

Internal walls divide the vault into six cells. The top of the centre wall is 0.61 m higher than the outside walls, thus providing the concrete roof with a slope from the centre towards the edges to facilitate natural drainage to the sides. The internal floor area of the vault is 525 m^2, providing a total inside volume from the top of the foundation to the underside of the concrete roof cap, of 3,900 m^3, exclusive of the buffer layers at the bottom and the sand layer placed on top of the waste packages prior to closure.

3.3.2 Vault Roof

After the vault is filled with waste, a compacted sand layer will be placed over the waste in each cell, over which 150 mm of lean concrete (low-strength concrete) will be poured in place. The roof slab will be poured in place on top of the vault walls such that the reinforcing steel continues from the exterior walls into the roof, making the walls and roof into one integral structure. The roof and walls are designed to resist the loads from the earthen cover, including loads from equipment to be used for the construction, without counting on any support from the waste and backfill inside the vault.

The outside surface of the concrete roof will be treated with a waterproofing coating and covered with bentonite panels, which will seal the surface and resist any infiltration of water and any water contact with the concrete surface. To further enhance the resistance to infiltrating water and facilitate drainage away from the vault, the earthen cover will contain a gravel drainage layer. Water collected by the drainage layer will flow into drains placed on both sides of the vault along the length of the vault, to be discharged away from the unit so that its infiltration through the soil will not affect the water table elevation under the vault. The drainage layer will be covered with a geotextile fabric and topped with layers of decreasing particle size and well-consolidated sand. The geotextile will prevent sand entering the drainage layer, thereby reducing drainage efficiency during the postclosure period. The site surface will be graded, covered with topsoil, and planted with hardy vegetation to enable precipitation to run off without causing erosion.

3.3.3 Floor Buffer and Backfill Layers

The vault will have a permeable bottom to allow any water that has infiltrated into the vault to discharge readily, thus minimizing the time it will remain in contact with the waste and decreasing any leaching of the radionuclides. The permeable bottom will avoid the accumulation of water inside the cells (the bathtub effect).

The vault floor will consist of a 610 mm thick layer of buffer materials applied in two layers. The bottom layer will be 300 mm thick and will be composed of 90% sand and 10% Dochart clay by weight, and the top layer 310 mm in thickness will be made of 90% sand and 10% clinoptilolite by weight. These buffer layers will be topped by 75 mm of compacted sand which will form the floor of the unit. Both Dochart clay and clinoptilolite have the ability to sorb cationic radionuclides from aqueous solution, and thus reduce radionuclide escape from the vault. The backfill placed around the waste packages will comprise a mixture of sand and clinoptilolite to increase the absorption of radionuclides.

3.3.4 Monitoring Shaft

A system has been included to monitor the performance of the stored waste material. The monitoring system requires access to the base of the IRUS unit for instrumentation and sampling. Access will be in the form of a vertical shaft to an underground monitoring room located adjacent to the IRUS base. The monitoring shaft will be independent of the IRUS unit and will be backfilled after the monitoring period is ended.

The monitoring shaft and room are designed to meet the following functional requirements:

(i) provide access to the probes and sample tubes located in the buffer layers and the underlying sand;
(ii) provide sufficient working space and a suitable working environment for placing probes, taking samples, and storing equipment;
(iii) be available during operational (waste emplacement) phase and the initial part of the post-closure phase; and
(iv) provide access to the underlying soil through the monitoring room floor, if required.

The monitoring shaft will be a reinforced-concrete structure designed to the same standards of construction and same level of quality assurance as the IRUS unit.

3.4 SEISMIC DESIGN OF THE IRUS STRUCTURE

3.4.1 Seismic Design Parameters

The IRUS facility is designed for long-term structural integrity and therefore seismic safety is one of the major considerations. An earthquake event equivalent to the Design Basis Earthquake (DBE) defined for the CRL site is employed for the seismic qualification of IRUS. The values of the ground motion parameters necessary for the definition of the DBE are determined using the probabilistic approach recommended in CSA Standard N289.2. The DBE is chosen at 10^{-3} probability of exceedance per annum (i.e. 1000 year return period). The DBE parameters for the CRL site are as follows:

At bedrock or firm strata level:

Peak Horizontal Acceleration (PHA) = 0.24 g
Peak Horizontal Velocity (PHV) = 0.130 $m \cdot s^{-1}$

An alternative seismic event having a probability of exceedance of 0.0021 per annum at the CRL site (return period of 475 years), is defined by the following parameters:

At bedrock or firm strata level:

Peak Horizontal Acceleration (PHA) = 0.17 g
Peak Horizontal ground Velocity (PHV) = 0.086 $m \cdot s^{-1}$

There is an adequate factor of safety to ensure overall stability of the sand ridge under the DBE condition. Furthermore, the post-seismic stability of the soil slope was also examined and found to be satisfactory against ground movement due to aftershocks following the DBE.

3.4.2 Seismic Design Requirements

The IRUS structure is designed to meet the following requirements:

(i) the repository structure must be capable of meeting the strength and serviceability requirements, during and following the postulated seismic event;
(ii) the probability of exceedance of the seismic design parameter values must be very low; and
(iii) in the unlikely occurrence that a seismic event exceeds the selected seismic design parameter values, the consequence of exceedance must not be severe enough to cause a total structural failure.

3.5 DESIGN FEATURES FOR LONG-TERM INTEGRITY

To achieve the long service life requirement for the IRUS facility, a number of aspects were given special consideration. These include: seismic qualification, durability of concrete, and earthen cover design.

3.5.1 Seismic Design

The structure is designed to perform well during and after an anticipated seismic event. Steel reinforcement for the concrete structure is designed and detailed to satisfy both the strength and serviceability criteria, including the special provisions for seismic design stipulated in CSA Standards N287.3 and A23.3. To meet the functional requirement of minimizing water infiltration, the crack width on the exterior surface of the concrete roof and walls, is limited by design to less than 0.33 mm, and for interior walls to less than 0.40 mm, under all load combinations including the seismic loads.

3.5.2 Concrete Durability

3.5.2.1 Introduction

The durability of concrete has been studied for many years. The processes that affect the long-term integrity of concrete structural elements are known. However, few studies are available to predict the longevity of reinforced-concrete structures over hundreds of years. Very little information in the literature quantitatively relates the rate of degradation of concrete subjected to aggressive environmental agents.

To remedy this situation, as part of the IRUS licensing support effort, in 1987 AECL initiated a research program on concrete durability. The objective of the program was to develop a method for designing a concrete mix for IRUS that would have a long service life. The experimental work in the program was performed by the National Research Council (NRC) under contract to AECL. Durability and qualities of a wide variety of concrete types were evaluated under a range of environmental exposure conditions.

3.5.2.2 Conclusions

The main focus of the NRC experimental work for AECL was the diffusion studies designed to set a lower bound on the time required for corrosion of reinforcing steel, the process that is expected to limit the lifetime of IRUS structural concrete elements. Measurements were also made on other degradation mechanisms (e.g., carbonation, sulphate attack, freeze-thaw cycling).

The following conclusions can be drawn from the program:

(i) Blended cements yield diffusivities up to 25 times lower than equivalent Type 10 Portland cements.
(iii) The requirement of a 500 year service life for IRUS concrete can be met by:

   a) using a special concrete containing blended cement,
   b) covering the reinforcing steel with concrete to a depth of 75 mm in the foundations, walls and roof of the vault, and
   c) continuing moist curing of the concrete for at least two weeks

3.5.3 Cover Design

3.5.3.1 Introduction

Contemporary near-surface disposal facilities generally incorporate multi-layered engineered barriers. These include an earthen cover over the entire facility, as well as the waste form, backfill material, and the concrete structure in which the waste is emplaced.

The essential design requirements of an earthen cover are:

(i) A stable, benign environment for the vault and its contents by stabilizing the surface soil, protecting the roof from water contact, and providing frost protection;
(ii) Resistance to inadvertent intrusion;
(iii) Minimise water infiltration.

3.5.3.2 Design Features of a Possible Earthen Cover for IRUS

The conceptual cover above the reinforced-concrete roof of the vault contains the following layers:

(i) Hardy vegetation and rock mulch - for surface stabilization;
(ii) Topsoil - the growth medium for the vegetation;
(iii) Fine sand - for frost protection, and part of a capillary break (in combination with the cobbles below);
(iv) Geotextile - an installation aid for the establishing the capillary break;
(v) Cobbles - a barrier to burrowing animals and plant roots, and a capillary break (in combination with the fine sand above);
(vi) Gravel - for infiltration drainage;
(vii) Geomembrane - an infiltration barrier;
(viii) Sand - for frost protection;
(ix) Bentonite panels - a self-sealing infiltration barrier that will also seal cracks in the concrete roof below.

The design details are conceptual, and a design of a satisfactory cover and an evaluation of its expected performance will be submitted as part of the Final Safety Analysis Report (FSAR), or in the application to close IRUS.

The eventual design will have sufficient redundancy to continue to perform adequately even if the individual features function less well than expected. The main layers will be made of natural geologic materials; long experience with them gives confidence that their long-term behaviour is well understood.

3.6 WEATHERSHIELD BUILDING

During the waste emplacement period, which may last 5 to 7 years, a temporary building will be constructed over the concrete vault. This building meets the following functional requirements:

- protect the concrete structure and waste packages from the outside elements and provide a dry area for the waste emplacement operation;
- provide support for the building crane;
- provide enclosed space for the control room, a truck unloading area, and storage of waste handling equipment.

The overall building size is 27.4 m x 51.5 m, with a minimum roof height of 8.25 m above grade. The building encloses a truck unloading area, control room for crane operation, and material handling equipment storage area.

The building is a pre-engineered structure with structural steel framing and pre-finished, metal sandwich panel cladding. Steel columns are supported on reinforced-concrete footings set 1.65 m below grade for frost protection, with a pier height extending 1.0 m above grade. Within the building, the floor is covered with gravel, including the end bay areas for truck

4. OPERATIONAL FEATURES

4.1 RADIATION PROTECTION

The prime sources of radiation are the waste packages, which must be handled with care during the various operations, from receipt to emplacement and, finally, closure of the facility. Full knowledge of the radiation fields present at each stage is vital, and these can be obtained either by external monitoring or prior knowledge of the package contents.

Waste packages will be managed in a manner that is consistent with the practice of ALARA. Where practical, time, distance, and shielding will be utilized to minimize exposures to radiation fields. The more radioactive packages (e.g. bituminized wastes) will be placed near or at the bottom of a cell and overlaid by less radioactive wastes to minimize radiation fields to operators and workers during subsequent operations and closure. This will also help to minimize the impact of any inadvertant intrusion after closure.

The radiation protection program will involve the direct measurement of radiation fields by Radiation Protection personnel using hand-held measuring devices, and by the use of area monitoring devices placed strategically inside the IRUS weathershield building. In addition to this, all personnel working in the IRUS facility will wear personal dosimetry devices (e.g. thermoluminescent dosimeters). Continuously operating air monitors will permit the measurement of particulate and gaseous emissions from waste packages within the IRUS weathershield building. The area monitoring devices will warn of abnormal radiation fields and the air monitors will warn of the presence of airborne radioactive particles or gases. The set points of these monitoring devices will be dictated by their actual locations and will be specified during commissioning. The normal response to monitor alarms will be to evacuate the area until the hazard has been evaluated. The emplacement procedures will also provide direction for minimizing the spread of contamination and the necessary controls to prevent contamination of equipment and personnel during normal and abnormal operations.

4.2 WASTE RECEIPT AND INSPECTION

A Waste Reception Center (WRC) is equipped to off-load the three IRUS waste streams directly from transport vehicles by trained personnel. It also has areas to inspect incoming packages, to temporarily store packages in a safe manner, to monitor packages on a selective basis and to sample individual low-activity packages for detailed destructive examination.

Packages arriving at the WRC will be visually inspected and checked with hand-held radiation meters to determine external radiation fields. Package identification will be recorded and cross-referenced to the manifest completed by the waste generator. Manifests are required to have all of the pertinent information on the physical and radiological characteristics of the wastes. WRC operators will check the completeness of the manifest data before the waste packages are shipped to IRUS. If there are any "non-qualifying" aspects of either the accompanying documentation, or the package itself, it will be rejected from emplacement into IRUS.

Monitoring packages will principally involve measuring the gamma-ray emissions from the packages and interpreting the data to estimate the radionuclide inventory. Waste characterization using destructive analysis will be performed in analytical facilities within the active area at the Chalk River Laboratories.

4.3 WASTE TRANSPORTATION, HANDLING, AND INTERIM STORAGE

The three IRUS wastes will be transported to and from the WRC or the various waste management facilities using AECL vehicles. Handling will be minimized to reduce exposures and reduce the risk of mishaps. The WRC is intended to serve as the control point for wastes destined for the Chalk River Laboratories waste management facilities, including IRUS. The WRC has a truck ramp and shipping doors to facilitate loading and unloading. Within the WRC there are areas for temporary storage of packages prior to transportation to an appropriate waste management facility.

Waste packages will be transported and handled in a fashion consistent with present practice. The more active wastes, including wastes stabilized in bitumen, and about one percent of the bales, will be transported in reusable shielded containers.

4.4 WASTE EMPLACEMENT

Waste emplacement operations at the IRUS facility will be conducted on a schedule consistent with waste volumes and the availability of resources and staff. Waste emplacements at the IRUS facility will be conducted using a gantry crane. The crane will lift waste packages from the transport vehicle and emplace them into the IRUS cells.

Placement of the wastes is expected to be guided by the contact radiation field and by the waste type. The higher activity waste packages will be placed near the bottom of the IRUS cells to minimize radiation exposure to operations personnel. Cells will be loaded with packages and backfill, layer by layer, to maintain stability. To avoid the possibility of a package being accidently dropped on the control room, the crane will be provided with limit switches that will prevent the hoist from passing over the control room.

The operator will record the location of each waste package and its identity code on an XYZ coordinate system. For each particular waste item, the information will be entered into the IRUS inventory database.

4.5 BACKFILL PREPARATION, HANDLING AND EMPLACEMENT

Dry backfill material will be added to cover each layer of waste packages emplaced in the cells. This process will fill the voids between the packages and provide a stable base for the placement of the next package layers. The backfill layer will provide some shielding and will serve as a fire retardant.

The backfill will be placed in a variable flow hopper and moved by crane to the cell where it will be deposited in a controlled manner. With the material freeflowing in the dry state, voids are expected to be filled. Extra material will be levelled in the cell using the crane with remote tamping as necessary. Once the cell has been filled to the desired level with waste, a final thick layer of backfill will be tamped into place.

4.6 DECONTAMINATION AND MAINTENANCE

During the transport and handling of waste packages there is the possibility of damage to the packages and release of radioactive material. The Radiation Protection Branch (RPB) at Chalk River Laboratories has experience in dealing with waste spillage, and the subsequent cleanup and expertise and resources for decontamination lies within their mandate. The Supervisor of the IRUS facility will have responsibility for notifying RPB of the need for decontamination. Radiation Protection Branch personnel will be responsible for assessing the hazard and taking the appropriate actions.

The IRUS facility has been designed to contribute to the ease of decontamination; for example, should an event release contamination to the working area around the concrete wall of the unit, the floor area is overlaid with gravel to facilitate removal of the contaminated material. Fresh gravel can be installed when necessary, and the contaminated material packaged and disposed of accordingly.