OPG's DEEP GEOLOGIC

REPOSITORY

FOR LOW & INTERMEDIATE LEVEL WASTE

Reference Low and Intermediate Level Waste Inventory for the Deep Geologic Repository

August 2008

Prepared by:
Ontario Power Generation

OPG 00216-REP-03902-00003-R01

Preliminary

ONTARIO POWER GENERATION

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DOCUMENT HISTORY

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Notes:	• Basis for 2052 and 2062 dates clarified. Projected inventory at 2035 deleted. • Definition of LM and LD provided in Appendix D. • Updated Tables B-1 to B-3 with new specific activity data, and forecast radionuclide inventories in Tables 2.4-2.7, 3.2 and 3.3 based on new data. • Updated Table C-1 with new chemical composition data, and forecast inventories of chemical species in L&ILW in Table 2.8 based on new data. • Minor adjustments to inventories in Tables 2.8-2.12, and 4.1 • CANDECON resins grouped with ILW resins in tables. • Updated waste inventories in Tables 2.1, 3.1, 4.2, and Figure 4.4 to reflect new disposal assumptions for resin liners, T-H-E liners and steam generators. • Added Table 4.4, Table C-7, Table D-3 and Section D.3. • Updated Section 5 to reflect new waste container processing and transfer assumptions.		
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EXECUTIVE SUMMARY

Ontario Power Generation is proposing to build a Deep Geologic Repository (DGR) for low and intermediate level radioactive waste (L&ILW). The purpose of this report is to describe the reference waste package inventory and waste characteristics for emplacement in the DGR, taking into consideration the current and potential future waste, including reactor retube and steam generator refurbishment waste.

The waste forecasts provided in this report are based on “Scenario B”, which considers refurbishment of all reactor units (except Pickering A) with operation for a further nominal 30 calendar years after refurbishment. It includes the effects of current nuclear unit layups, re-start dates, and end-of-life dates.

The projected total disposal volume will be about 196,000 m^3 of operational L&ILW and refurbishment waste, based on approximately 166,000 m^3 of stored volume. The corresponding total number of containers to be handled would be about 50,000.

The reference planning assumption is that L&ILW will be retrieved from various waste structures at the Western Waste Management Facility (WWMF) and transferred to the DGR for emplacement following facility in-service. In this concept, no extra processing/packaging will be required with the exception of shielding of most of the ILW and overpacking of a small portion of the LLW. L&ILW at the nuclear generating stations will be shipped to the WWMF for processing, if required, and then directly to the DGR, bypassing storage. In order to estimate the total volume for disposal in the DGR, it is also assumed that the future operational L&ILW will be shipped in containers similar to those currently used to store the L&ILW.

Ash containers, low level resin boxes, ALW sludge boxes, and 10% of drum racks containing drummed non-processible waste are expected to be packaged in LLW container overpacks. Disposable concrete shields will be used for most of the inventory of ILW resins, filters, IX columns, and core components. Large component wastes such as steam generators and heat exchangers are assumed to be size reduced to pieces that meet physical constraints and/or weight limits of the repository material handling systems.

The total operational and refurbishment L&ILW radionuclide inventory is estimated to be 17,000 TBq at repository closure (assumed here to be 2062), attributed mostly to H-3, Sr-90, Cs-137, C-14, Nb-94, Co-60, Ni-59, and Ni-63. Total thermal decay power is estimated to be less than 2 kW at repository closure, primarily from Nb-94, Sr-90/Y-90 and Co-60.

GLOSSARY

Arising, Waste: amount of waste produced at the stations, prior to any processing.

CANDECON: a chemical decontamination process for nuclear heat transport systems. Wastes produced from this process are contaminated resins and filters, which contain high levels of chelating agents such as EDTA.

Compactible Waste: wastes which can be processed by medium force compaction, such as light metal objects, insulation materials, hoses, cables, metal fillings and turnings etc. with a contact dose rate less than 2 mSv/h (200 mrem/hr).

Conditioning (Waste): those operations that produce a waste package suitable for handling, transport, storage and/or disposal. Conditioning may include the conversion of the waste to a solid waste form, enclosure of the waste in containers, and, if necessary, providing an overpack.

Decommissioning: transforming a facility and its site, after the operational period is concluded, into a safe and socially acceptable state.

Disposal: The emplacement of waste in an appropriate facility without the intention of retrieval.

Disposal Volume: the external volume of the package for disposal which includes the storage container, overpack, and/or shield.

Filter: depending on each specific station system, filter waste may consist of disposable vessels along with the exhausted filter cartridges contained therein, or filter cartridges from systems employing permanent vessels.

Intermediate Level Waste (ILW): Radioactive non-fuel waste, containing sufficient quantities of long-lived radionuclides (generally refers to half-lives greater than the 30 year half-life of Cs-137) that deep geological disposal is a suitable alternative for providing isolation from the environment in the long-term.

Incinerable Waste: radioactive waste materials generally consisting of paper, plastic, wood, cardboard etc. which can be incinerated. The contact dose rate of such waste is less than 0.6 mSv/h (60 mrem/hr).

In-Ground Storage: storage of waste in in-ground storage containers (ICs) generally used for intermediate level waste. All ICs with the exception of those used for heat exchangers (HXs) consist of steel liners fixed with concrete inside bore-holes in the ground. IC-HXs use limestone gravel for the backfill.

In-Service Date: the date on which the facility is put into service or made available for operation.

IX-Resin: ion-exchange resin used to maintain the water quality in station process systems (e.g. moderator and PHT heavy water systems, and light water auxiliary systems such as the Active Liquid Waste Treatment System).

Irradiated Core Components: Radioactive waste such as flux detectors and liquid zone control rods resulting from the routine replacement of irradiated core components during the operation of reactor units.

Liquid waste: radioactive waste in liquid form, which may contain dissolved, colloidal or dispersed solids. Because liquids are mobile and dispersible, treatment by incineration, drying or solidification is generally carried out prior to storage and disposal.

Low Level Waste (LLW): Radioactive waste in which the concentration or quantity of radionuclides is above the clearance levels established by the regulatory body (CNSC). This waste does not necessarily require disposal in a deep geologic repository. It contains primarily short-lived radionuclides (half-lives shorter than or equal to the 30-year half-life of Cs-137).

Low Level Storage Building: buildings at the WWMF used for storing low level radioactive waste.

Net Volume: the internal volume of the container in which the waste is stored.

Non-processible Waste: wastes that are neither incinerable nor compactible, such as heavy gauge metal objects, glass, concrete, tools, heavy slings and cables. Maximum dose rate is 10 mSv/h (1 rem/hr) at 30 cm for storage in LLSBs, or 150 mSv/h (15 rem/h) for storage in trenches. Greater than 150 mSv/h requires storage in IC-18s.

Retubing Waste: radioactive waste produced from the fuel channel replacement (retubing) program i.e. pressure tubes, calandria tubes, end fittings, yokes and studs.

Repository: The underground portion of the deep geologic repository facility for low and intermediate level waste. Initially, the repository includes the access-ways (shafts, ramps and/or tunnels), underground service areas and installations, and emplacement rooms. In the postclosure phase it also includes the engineered barrier systems. The repository excludes the waste emplaced within the rooms and the excavation damage zone.

Scaling Factor: a ratio relating the activity of “difficult-to-measure” radionuclide (e.g. Pu-239, Pu-241) to the activity of “easy-to-measure” radionuclide (e.g. Co-60, Cs-137).

Storage: the placement of waste in a nuclear facility where isolation, environmental protection and human control, i.e., monitoring, are provided with the intent that the waste will be retrieved for processing and/or disposal at a later time.

Stored Volume: the external volume of the storage container in which the waste is currently stored. This volume does not include overpacks or concrete shields which may be required for repository emplacement.

Used Fuel: fuel that has undergone fission in the nuclear reactor and has been discharged from the reactor.

Waste Acceptance Criteria (WAC): formal criteria which define the qualities of waste packages (including the waste) that are accepted for disposal in the repository.

Waste Characterisation: activities to define the physical, chemical and radiological characteristics of the radioactive waste.

Waste Management: all activities, administrative and operational, that are involved in the handling, pre-treatment, treatment, conditioning, transportation, storage and disposal of waste from a nuclear facility.

Waste Volume Reduction Building: the building at the WWMF containing waste volume reduction equipment (i.e. incinerator and compactor).

Western Waste Management Facility: the centralized processing and storage facility for OPG's low and intermediate level radioactive wastes, and the dry storage facility for used fuel from the Bruce nuclear generating stations.

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1. INTRODUCTION

1.1 PURPOSE

Ontario Power Generation (OPG) is proposing to build a Deep Geologic Repository (DGR) for low and intermediate level radioactive waste (L&ILW) near its Western Waste Management Facility (WWMF) on the Bruce site. The purpose of this report is to define and describe the reference waste package inventory and reference waste characteristics for emplacement in the DGR, taking into consideration the current inventory and potential future waste arisings, including reactor retube and steam generator refurbishment waste.

1.2 BACKGROUND

OPG's reference planning assumption is that L&ILW from the operation and maintenance of its nuclear power stations will be sent to the DGR for disposal.

L&ILW will be retrieved from various waste structures at the WWMF and transferred to the DGR, once it is place into service. No extra processing/packaging is required, with the exception of shielding for most of the ILW and overpacking for a small portion of the LLW. L&ILW at the nuclear generating stations will be shipped to the WWMF for processing, if required, and then directly to the DGR, bypassing storage. In order to estimate the total volume for disposal in the DGR, it is also assumed that the future operational L&ILW will be shipped in containers similar to those currently used to store the L&ILW.

This report describes the reference inventory of waste packages to be placed in the DGR and their waste characteristics. Information on existing waste generation rates and package characteristics has been compiled from a number of sources and used to project the future inventory of wastes that will be generated during the period up to the shutdown of the last Darlington unit.

The L&ILW inventory projections and repository emplacement periods are based on "Scenario B" (see Appendix A) which assumes refurbishment of all reactor units (except Pickering A) at or near the end of their initial life, with operation for a further 30 years after refurbishment. This is a conservative scenario for generation of waste.

As background, this report also describes current storage practices at the WWMF, and the proposed methods by which waste will be retrieved from storage, packaged for emplacement, and then transferred to the above-ground waste receipt area of the DGR facility.

For planning purposes, the L&ILW inventory consists of operational waste and reactor refurbishment wastes. The operational L&ILW inventory includes bulk incinerable, compactible, and non-processible wastes, bulk low-level ion-exchange resins from station auxiliary systems, Active Liquid Waste Treatment System (ALW) resins and sludges, bulk low-level resins from historical CANDECON, miscellaneous large objects such as heat exchangers, intermediate-level resins, disposable IX columns, irradiated core components, filters and filter elements, and miscellaneous ILW resulting from the routine maintenance of nuclear stations. Reactor refurbishment waste is comprised of large scale retube waste (pressure tubes, calandria tubes and/or end fittings) and/or steam generators replaced during refurbishment.

1.3 OBJECTIVES AND SCOPE

The major objectives of this report are to:

(a) Describe the physical, chemical, and radiological characteristics of operational L&ILW and reactor refurbishment waste currently in storage and projected for the future.

(b) Document the reference inventory of operational L&ILW and refurbishment waste packages (numbers and types) that will be sent to the DGR, including assumptions used to calculate the inventory.

(c) Describe current storage practices at the WWMF, and the proposed methods by which waste will be retrieved from storage, and packaged for emplacement.

(d) Provide information on the containers currently used to store operational L&ILW and that will likely be used for emplacement.

Decommissioning wastes are not included in this report.

Waste projections from any proposed new-build reactors in Ontario are not included in this report.

This report will be revised and re-issued as additional or more up-to-date waste inventory and characterization data becomes available.

2. PROJECTED OPERATIONAL L&ILW INVENTORY AND CHARACTERISTICS

2.1 WASTE VOLUMES AND PACKAGE INVENTORY

The amount of waste and number of packages projected over the life of Ontario's nuclear program is calculated based on the existing inventory [Anderson et al, 2005] and assumed future production and processing scenarios. Table 2.1 summarizes the forecast operational L&ILW inventory by waste type, including reference assumptions for disposal based on "Scenario B" (see Appendix A). "Scenario B" assumes refurbishment of all reactor units (except Pickering A) at or near the end of their initial life, with operation for a further 30 years after refurbishment. This is conservative scenario for generation of waste. Tables 2.2 and 2.3 describe the various L&ILW types listed in Table 2.1.

The major sources of uncertainty in the projections of L&ILW are summarized as follows:

(i) Impacts on waste volume stored if different waste processing methods are used in future.
(ii) Unplanned-for wastes, such as unforeseen major maintenance activities.
(iii) Long term generation rates of low level spent IX resins and sludges from the active liquid waste treatment systems installed at the stations to meet MISA discharge requirements are not known for certain at this time

2.2 RADIONUCLIDE INVENTORY

Radionuclide activity concentrations in L&ILW are presented in Appendix B. They are a result of either fixed (inherent to the material) or surface contamination. The data are based on direct measurements, scaling factors, used fuel ratios, and neutron activation calculations. Scaling factors were adopted to calculate the concentrations of difficult-to-measure radionuclides such as pure beta emitters, which cannot be measured by non-intrusive methods in waste packages. The scaling factor methodology is widely used internationally and is described in reference [ISO, 2007]. The data based on actual measurements were generally obtained from gamma spectrometry of waste packages and/or samples of waste, or scaling factors derived from analytical data collected for each of the individual waste streams [Husain, 2005a, 2005b]. Scaling factors were also developed from predicted data from fission product release and activation models (i.e., Cl-36, Se-79, Tc-99, and I-129) [Lewis and Husain, 2003, Lewis et al. 2003]. The exceptions are tritium estimates for bulk LLW which are based on C-14/H-3 ratios derived from incinerator emissions data. The used fuel data are calculated from scaling factors based on used fuel radionuclide inventories and other miscellaneous relationships [Tait et al, 2000]. The activity data for direct measurements and scaling factors are best estimates based on log-mean averages.

Tables 2.4-2.7 summarize the estimated total decay corrected radionuclide inventory of projected operational L&ILW at 2 future dates: 1) 2018, the earliest possible in-service date of the repository, and 2) 2062, the earliest repository closure date (based on 10 years after the 2052 forecast shutdown date of the last reactor unit). They are based on the existing operational L&ILW characteristics given in Appendix B, and the projected operational L&ILW volumes calculated for those years. For the purposes of simplicity of display, short-lived radionuclides (half-life less than 1 year) are excluded from the body of the table. Their inventories, however, are included in the totals at the bottom of each column.

Table 2.1: Scenario B Operational L&ILW Forecast Summary by Waste Type

Waste Stream	Net Volume (m^3)	Number of Disposal Containers	Disposal Volume (m^3)	Reference Assumptions for DGR
Bottom Ash	864	269	2,286	Overpack 100% in DGR ready LLW container overpack .
Baghouse Ash	71	47	400	Overpack 100% in DGR ready LLW container overpack .
Bottom Ash (New)	1,470	816	6,936	Overpack 100% in DGR ready LLW container overpack .
Baghouse Ash (New)	242	134	1,139	Overpack 100% in DGR ready LLW container overpack .
Compact Bales	2,445	1,491	5,069	Assume 25% are incinerated, and remainder overpacked in a container to be determined.
Box Compacted	12,185	5,298	14,834	Transfer containers to DGR as-is.
Non-processible*	47,364	19,035	65,975	Transfer containers to DGR as-is.
Feeder Pipes	3,253	1,301	4,163	Transfer containers to DGR as-is.
Non-pro Other^	2,396	148	2,396	Assume 25% of HXs are cut into 2 segments and seal plates are welded similar to SGs; transfer remainder to DGR as-is. ETHs will be transferred to DGR as is.
Non-processible Drummed	11,736	6,276	20,858	Overpack 10% of drum racks in DGR ready LLW container overpack; transfer remainder to DGR as-is. Transfer drum bins to DGR as-is.
CANDECON Resin	2,154	480	5,318	Assumptions same as moderator IX resin.
LL Resin~	1,513	2,171	6,203	Overpack 100% of LL resin boxes in DGR ready LLW container overpack.
ALW Resin~	1,937			Resin pallet tanks to be overpacked in container to be determined and transferred to DGR..
ALW Sludge	3,375	1,534	13,039	Overpack 100% in DGR ready LLW container overpack.
Moderator IX Resin	2,264	504	5,585	28% of resin liners (including 400 in SS overpacks) are expected to meet the dose rate limits of the DGR and will be emplaced without a shield, 53 % will be placed into a standard cylindrical concrete shield (250 mm thick wall)) , and 19% will be placed in concrete shields having a wall thickness of 350 mm.
PHT IX Resin	1,595	355	3,941	Assumptions same as moderator IX resin.
Miscellaneous IX Resin+	2,126	473	5,245	Assumptions same as moderator IX resin.
IX Columns#	561	8,048	11,323	IC-18 T-H-E liners and IC-2 liners will be retrieved into a re-usable shielded transfer bell and transported to DGR. Tile hole liners and ILW shields will be transferred to DGR as is.
Irradiated Core Components#	25			
Filters and Filter Elements#	1,453			
Totals	99,029	48,380	174,710	

Note: Old and new bottom and baghouse ash refer to ash collected from old and new incinerators respectively.
* Includes miscellaneous LLW and miscellaneous trench waste packed in NPB47 and shield plugs
^ Includes heat exchangers and encapsulated tile holes
~ LL resin also stored in resin pallet tanks (used also for ALW resin)
+ Comprised of station auxiliary system resins
# Stored in IC-18 T-H-E liners, IC-2 liners, tile hole liners, and ILW shields

Table 2.2: Low Level Waste Categories

Waste Category	Description
Bottom ash	Heterogeneous ash and clinker from waste incineration.
Baghouse ash	Fine homogeneous ash from waste incineration.
Compact Bales	Compacted empty waste drums, rubber hoses, rubber area floor matting, light gauge metals, welding rods, plastic conduit, fire blankets and fire retardant material, metal cans, insulation, ventilation filters, air hoses, metal mop buckets and presses, electric cable (<1/4" dia), lathe turnings, metal fillings, glass, plastic suits (MarK III/IV), rubbers, Vicraft hoods, rubber gloves, etc.
Box Compacted	Same as compact bales.
Non-Processible	Comfo respirator filters, heavy gauge metal (e.g., beams, IX vessels, angle iron, plate metal, etc.), concrete and cement blocks, metal components (e.g., pipe, scaffolding pipes, metal planks, motors, flanges, valves, etc.), wire cables and slings, electric cables (>1/4" dia), tools, paper, plastic, absorbent products, etc.
Non-Processible Drummed	Floor sweepings, Dust Bane, Stay Dry, etc., metal fillings, glassware, light bulbs, etc.
Non-Processible Other	Large and irregularly shaped objects such as heat exchangers, encapsulated tile holes, and other miscellaneous large objects (e.g., fume hoods, glove boxes, processing equipment).
LL Resin	Spent IX resin arising from Bruce A/B auxiliary systems.
ALW Resin	Spent IX resin arising from Active Liquid Waste Treatment Systems.
ALW Sludge	Sludge from a two-stage Active Liquid Waste Treatment System at Bruce A.

Table 2.3: Intermediate Level Waste Categories

Waste Category	Description
Moderator resin	Spent IX resin arising from moderator purification systems.
PHT resin	Spent IX resin arising from PHT purification systems.
IX Columns	Spent IX resin arising from Pickering PHT purification system.
Misc. resin	Spent IX resin arising from station auxiliary systems (e.g. heavy water upgraders).
CANDECON Resin	Spent IX resin from the chemical decontamination process for nuclear heat transport systems.
Irradiated core components	Includes flux detectors and liquid zone control rods.
Filters and filter elements	Filters and filter elements from various station process systems.

The short-lived radionuclide data may be important for personnel exposure considerations, but will not be a factor in the long term.

The results for the assumed repository closure date of 2062 indicate that the total radioactivity will be dominated at closure by H-3, C-14, Cs-137, and Sr-90.

The uncertainties associated with the radionuclide inventories are presented in Appendix D.

2.3 CHEMICAL INVENTORY

The inventories of non-radioactive components in L&ILW at 2052 (shutdown date of last reactor unit) are summarized in Table 2.8. As these are stable elements, their inventory will not change prior to assumed repository closure at 2062. The data are based on L&ILW chemical properties presented in Appendix C, and net volumes for each of the individual waste streams documented in Table 2.1. The uncertainties associated with the chemical compositions are presented in Appendix D.

2.4 BULK MATERIAL INVENTORY

The physical characteristics of L&ILW and the containers in which they are stored are important considerations for waste handling and emplacement. They are also important parameters in evaluating the long-term degradation of the L&ILW.

The inventory of L&ILW container materials at 2052, in terms of mass of metal and plastic associated with the containers, and total surface area is summarized in Tables 2.9 and 2.10. The inventory is based on the weight of steel and plastic in each container, and container numbers listed in Table 2.1. The surface areas are calculated based on container dimensions provided in Appendix E, and container numbers listed in Table 2.1.

The estimated inventories of cellulose (including cloth), plastics (including rubber), resin, steel, and concrete in L&ILW at 2052 are presented in Tables 2.11 and 2.12. They are based on characterisation data and estimated bulk densities of various L&ILW streams documented in Appendix C, and net volumes listed in Table 2.1.

The total inventory of steel in L&ILW package materials, including the iron in concrete shield rebar is estimated to be approximately 2.3×10^7 kg. The estimated weight of concrete shielding that will be required is 3.6×10^7 kg based on the current assumptions for ILW shielding design.

The total estimated inventory of steel in L&ILW is estimated to be 7.5×10^6 kg. The total organic component, consisting of cellulose, plastic materials, and ion exchange resins is estimated to be 2.9×10^7 kg.

Table 2.4: Estimated Operational LLW Radionuclide Inventory at 2018

		Decay Corrected Radionuclide Inventory (Bq)											
		Bottom Ash	Baghouse Ash	Compact Bales	Box Compacted	Non-pro	Feeder Pipes	Non-pro Other	Non-pro Drummed	LL Resin	ALW Resin	ALW Sludge	Total
Net Volume (m^3)		1,457	193	2,445	8,195	34,849	2,823	2,302	8,016	805	760	1,605	63,450
Nuclide	T-1/2 (yrs)												
Ag-108m	1.3E+02	6.5E+05	5.5E+05	6.2E+05	3.0E+06	1.5E+07		1.0E+06	3.5E+06	9.2E+07	8.0E+04	1.2E+05	1.2E+08
Am-241	4.3E+02	7.0E+08	4.9E+07	2.1E+08	1.3E+09	8.6E+08	2.7E+11	5.1E+07	1.9E+05	2.0E+10	1.1E+08	8.8E+06	2.9E+11
Am-243	7.4E+03	8.7E+05	5.0E+04	3.3E+05	1.9E+06	1.1E+06		6.7E+04	3.0E+02	1.7E+07	1.4E+04	1.3E+04	2.1E+07
C-14	5.7E+03	9.7E+09	4.3E+08	1.3E+10	5.8E+10	2.7E+10	9.3E+12	2.6E+09	1.2E+11	1.1E+13	4.8E+09	3.5E+09	2.1E+13
Cl-36	3.0E+05	4.1E+05	3.1E+04	1.5E+05	6.9E+05	7.2E+05		4.8E+04	3.6E+05	2.0E+07	8.4E+03	8.5E+03	2.2E+07
Cm-244	1.8E+01	6.7E+07	3.8E+06	3.4E+07	3.8E+08	1.5E+08	9.4E+10	8.5E+06	1.5E+04	2.0E+09	2.4E+06	2.2E+06	9.7E+10
Co-60	5.3E+00	6.0E+10	4.6E+08	2.9E+09	1.3E+11	1.5E+11	2.7E+14	9.5E+09	8.2E+10	5.2E+12	3.9E+09	3.0E+09	2.8E+14
Cs-134	2.1E+00	9.6E+07	3.9E+07	6.5E+05	3.6E+09	1.0E+09	4.6E+11	4.9E+07	2.6E+09	3.6E+11	1.3E+07	1.2E+09	8.3E+11
Cs-135	2.3E+06	7.3E+04	6.0E+04	7.1E+04	3.2E+05	1.6E+06		1.1E+05	3.8E+05	1.0E+07	7.6E+03	1.2E+04	1.3E+07
Cs-137	3.0E+01	4.1E+10	3.2E+10	3.4E+10	2.2E+11	1.1E+12	3.2E+12	7.2E+10	2.4E+11	6.6E+12	6.5E+09	9.5E+09	1.2E+13
Eu-152	1.3E+01	1.6E+06				1.1E+06			1.6E+08	6.1E+08			7.7E+08
Eu-154	8.8E+00	6.0E+08	5.4E+07	3.9E+08	6.5E+09	9.3E+05	1.3E+12		1.3E+08	4.8E+08			1.3E+12
Eu-155	5.0E+00	2.2E+07		1.4E+07	7.4E+08					2.0E+09			2.8E+09
Fe-55	2.7E+00	2.2E+11	6.3E+08	2.0E+08	2.3E+10	3.9E+11	5.9E+14	2.1E+10	9.3E+10	4.5E+12	1.1E+10	5.9E+09	6.0E+14
H-3	1.2E+01	1.5E+10		3.9E+13	6.3E+14	4.3E+14		1.8E+13	2.1E+15	1.5E+14	6.9E+10	2.9E+12	3.4E+15
I-129	1.6E+07	4.9E+03	1.4E+03	2.7E+02	2.4E+04	5.0E+05		4.1E+02	1.2E+05	4.4E+04	2.7E+03	4.3E+01	7.0E+05
Nb-94	2.0E+04	2.5E+09	1.4E+06	1.9E+09	8.3E+09	4.9E+06			9.0E+08	1.7E+08		6.7E+07	1.4E+10
Ni-59	7.5E+04	1.7E+08	5.1E+06	1.0E+07	4.7E+07	2.5E+08		1.3E+07	4.6E+07	1.3E+10	1.4E+06	1.4E+06	1.4E+10
Ni-63	9.6E+01	1.1E+11	5.9E+08	1.1E+09	5.9E+09	3.3E+10	1.5E+12	1.6E+09	5.7E+09	1.6E+12	1.9E+08	1.9E+08	3.3E+12
Np-237	2.1E+06	4.2E+04	2.5E+03	1.6E+04	9.1E+04	5.5E+04		3.3E+03	1.4E+01	8.0E+05	7.1E+02	6.4E+02	1.0E+06
Pu-238	8.8E+01	2.1E+08	1.2E+07	4.0E+07	2.6E+08	1.6E+08	8.6E+10	8.9E+06	2.6E+04	4.4E+09	2.2E+06	1.9E+06	9.1E+10
Pu-239	2.4E+04	2.7E+08	1.6E+07	1.0E+08	6.1E+08	3.4E+08	1.6E+11	2.1E+07	9.6E+04	1.1E+10	4.6E+06	4.2E+06	1.7E+11
Pu-240	6.5E+03	4.0E+08	2.3E+07	1.5E+08	8.6E+08	5.1E+08	2.4E+11	3.1E+07	1.4E+05	1.6E+10	6.6E+06	5.9E+06	2.6E+11
Pu-241	1.4E+01	1.0E+10	3.2E+08	9.4E+08	1.3E+10	8.8E+09	3.0E+12	5.0E+08	2.0E+06	1.4E+12	1.5E+08	1.2E+08	4.4E+12
Pu-242	3.8E+05	4.0E+05	2.3E+04	1.5E+05	8.6E+05	5.1E+05		3.1E+04	1.4E+02	8.0E+06	6.7E+03	6.1E+03	1.0E+07
Ru-106	1.0E+00	8.8E+07	7.3E+05	1.4E+03	1.8E+10	2.0E+09	1.3E+13	4.9E+07	3.9E+08	2.3E+08			1.3E+13
Sb-125	2.8E+00	1.7E+09	1.0E+08	1.6E+07	1.0E+10	3.3E+09	1.6E+12	1.9E+08	1.5E+09	2.2E+11		1.0E+09	1.8E+12
Se-79	1.1E+06	2.5E+03	2.1E+03	2.5E+03	1.2E+04	5.6E+04		3.8E+03	1.3E+04	3.5E+05	2.7E+02	4.3E+02	4.4E+05
Sm-151	9.0E+01	2.0E+05	1.6E+05	1.9E+05	9.6E+05	4.8E+06		3.3E+05	1.1E+06	3.0E+07	2.5E+04	3.9E+04	3.8E+07
Sn-126	2.1E+05	3.8E+05	3.2E+05	3.8E+05	1.7E+06	8.3E+06		5.7E+05	2.0E+06	5.3E+07	4.2E+04	6.4E+04	6.7E+07
Sr-90	2.9E+01	2.4E+10	4.0E+08	1.3E+09	8.7E+09	1.1E+10	3.0E+13	8.7E+08	4.6E+10	5.5E+11	4.4E+08	2.4E+08	3.1E+13
Y-90	7.3E-03	2.4E+10	4.0E+08	1.3E+09	8.7E+09	1.1E+10	3.0E+13	8.7E+08	4.6E+10	5.5E+11	4.4E+08	2.4E+08	3.1E+13
Tc-99	2.1E+05	5.0E+04	1.0E+03	3.1E+04	1.4E+05	1.4E+05		9.3E+03	7.3E+04	3.9E+06	1.7E+03	1.8E+03	4.3E+06
U-234	2.5E+05	4.5E+05	2.5E+04	1.7E+05	9.6E+05	5.8E+05		3.3E+04	1.5E+02	8.7E+06	7.5E+03	6.7E+03	1.1E+07
U-235	7.0E+08	7.4E+03	4.1E+02	2.9E+03	1.6E+04	9.6E+03		5.7E+02	2.5E+00	1.4E+05	1.2E+02	1.1E+02	1.8E+05
U-236	2.3E+07	8.6E+04	4.7E+03	3.1E+04	1.8E+05	1.1E+05		6.4E+03	2.9E+01	1.6E+06	1.4E+03	1.3E+03	2.0E+06
U-238	4.5E+09	5.6E+05	3.1E+04	2.1E+05	1.2E+06	7.2E+05		4.3E+04	1.9E+02	1.1E+07	9.1E+03	8.3E+03	1.4E+07
Zr-93	1.5E+06	2.2E+04	1.7E+02	7.8E+03	3.5E+04	7.6E+04		5.2E+03	6.0E+03	4.9E+04		6.1E+02	2.0E+05
Totals	T-1/2 >1 yr	5.2E+11	3.6E+10	3.9E+13	6.3E+14	4.3E+14	9.5E+14	1.8E+13	2.1E+15	1.8E+14	9.6E+10	2.9E+12	3.4E+15
	incl. short lived	5.4E+11	3.6E+10	3.9E+13	6.3E+14	4.3E+14	1.0E+15	1.8E+13	2.1E+15	2.3E+14	9.6E+10	2.9E+12	4.5E+15

Note: Nuclides with half lives greater than 1 yr and Y-90 shown only.

Table 2.5: Estimated Operational LLW Radionuclide Inventory at 2062

		Decay Corrected Radionuclide Inventory (Bq)											
		Bottom Ash	Baghouse Ash	Compact Bales	Box Compacted	Non-pro	Feeder Pipes	Non-pro Other	Non-pro Drummed	LL Resin	ALW Resin	ALW Sludge	Total
Net Volume (m^3)		2,334	313	2,445	12,185	47,364	3,253	2,396	11,736	1,513	1,937	3,375	88,851
Nuclide	T-1/2 (yrs)												
Ag-108m	1.3E+02	7.0E+05	4.6E+05	4.9E+05	3.4E+06	1.8E+07		1.0E+06	4.3E+06	1.4E+08	1.7E+05	2.1E+05	1.7E+08
Am-241	4.3E+02	1.6E+09	7.8E+07	2.0E+08	2.1E+09	1.2E+09	2.9E+11	5.8E+07	2.7E+05	3.4E+10	2.6E+08	1.7E+07	3.3E+11
Am-243	7.4E+03	1.8E+06	8.4E+04	3.3E+05	3.1E+06	1.6E+06		8.1E+04	4.5E+02	3.0E+07	3.7E+04	2.8E+04	3.7E+07
C-14	5.7E+03	1.3E+10	5.4E+08	1.3E+10	7.8E+10	3.9E+10	1.1E+13	3.2E+09	1.8E+11	2.0E+13	1.2E+10	7.3E+09	3.1E+13
Cl-36	3.0E+05	5.8E+05	3.1E+04	1.5E+05	9.4E+05	1.0E+06		5.8E+04	5.4E+05	3.6E+07	2.1E+04	1.8E+04	3.9E+07
Cm-244	1.8E+01	4.7E+07	2.3E+06	6.2E+06	2.0E+08	6.8E+07	2.1E+10	2.4E+06	7.3E+03	1.3E+09	2.1E+06	1.6E+06	2.3E+10
Co-60	5.3E+00	6.3E+09	5.6E+06	9.0E+06	8.7E+09	1.2E+10	1.0E+12	1.1E+08	6.0E+09	6.5E+11	5.2E+08	3.7E+08	1.7E+12
Cs-134	2.1E+00	5.3E+05	6.8E+04	2.4E-01	1.9E+07	6.3E+06	2.5E+05	6.2E+02	1.0E+07	3.8E+09	1.4E+05	1.2E+07	3.8E+09
Cs-135	2.3E+06	9.5E+04	6.3E+04	7.1E+04	4.4E+05	2.3E+06		1.3E+05	5.6E+05	1.8E+07	1.9E+04	2.6E+04	2.2E+07
Cs-137	3.0E+01	2.6E+10	1.3E+10	1.2E+10	1.4E+11	7.5E+11	1.4E+12	3.6E+10	1.8E+11	6.3E+12	8.4E+09	1.0E+10	8.9E+12
Eu-152	1.3E+01	1.7E+05				2.6E+05			5.5E+07	3.2E+08			3.8E+08
Eu-154	8.8E+00	1.1E+08	1.7E+06	1.2E+07	9.8E+08	1.1E+05	4.8E+10		2.5E+07	1.5E+08			4.9E+10
Eu-155	5.0E+00	4.7E+04		2.9E+04	4.3E+07					2.2E+08			2.6E+08
Fe-55	2.7E+00	3.6E+09	3.1E+06	2.5E+03	1.3E+07	6.4E+09	1.0E+10	3.7E+06	1.0E+09	1.1E+11	2.9E+08	1.5E+08	1.3E+11
H-3	1.2E+01	5.8E+09		3.3E+12	2.2E+14	1.3E+14		2.7E+12	6.5E+14	6.7E+13	3.9E+10	1.4E+12	1.1E+15
I-129	1.6E+07	1.3E+04	2.4E+03	2.7E+02	6.3E+04	7.4E+05		5.0E+02	1.9E+05	8.4E+04	6.8E+03	9.0E+01	1.1E+06
Nb-94	2.0E+04	4.7E+09	3.8E+06	1.9E+09	1.1E+10	6.5E+06			1.3E+09	3.4E+08		1.4E+08	1.9E+10
Ni-59	7.5E+04	1.7E+08	5.3E+06	1.0E+07	6.7E+07	3.7E+08		1.6E+07	6.9E+07	2.4E+10	3.5E+06	3.0E+06	2.5E+10
Ni-63	9.6E+01	2.2E+11	4.5E+08	8.2E+08	6.5E+09	3.8E+10	1.3E+12	1.5E+09	6.7E+09	2.4E+12	3.8E+08	3.2E+08	4.0E+12
Np-237	2.1E+06	8.9E+04	4.1E+03	1.6E+04	1.5E+05	8.0E+04		4.1E+03	2.2E+01	1.4E+06	1.8E+03	1.3E+03	1.7E+06
Pu-238	8.8E+01	3.7E+08	1.6E+07	2.9E+07	3.3E+08	1.8E+08	7.0E+10	8.0E+06	3.0E+04	6.3E+09	4.5E+06	3.1E+06	7.7E+10
Pu-239	2.4E+04	5.8E+08	2.6E+07	1.0E+08	1.0E+09	5.0E+08	1.9E+11	2.6E+07	1.4E+05	2.0E+10	1.2E+07	8.7E+06	2.1E+11
Pu-240	6.5E+03	8.5E+08	3.8E+07	1.5E+08	1.4E+09	7.5E+08	2.8E+11	3.8E+07	2.0E+05	2.9E+10	1.7E+07	1.2E+07	3.1E+11
Pu-241	1.4E+01	6.1E+09	1.4E+08	1.1E+08	5.2E+09	3.2E+09	4.3E+11	1.0E+08	7.4E+05	7.5E+11	1.0E+08	6.9E+07	1.2E+12
Pu-242	3.8E+05	8.5E+05	3.8E+04	1.5E+05	1.4E+06	7.5E+05		3.8E+04	2.0E+02	1.4E+07	1.7E+04	1.3E+04	1.7E+07
Ru-106	1.0E+00	8.7E+03	6.4E+01	1.1E-10	1.7E+06	2.8E+05	1.8E+00	5.2E-03	2.6E+04	6.4E+04			2.1E+06
Sb-125	2.8E+00	3.0E+07	5.0E+05	2.7E+02	1.5E+08	5.8E+07	3.5E+07	4.1E+04	1.8E+07	6.1E+09		2.8E+07	6.4E+09
Se-79	1.1E+06	3.3E+03	2.2E+03	2.5E+03	1.6E+04	8.1E+04		4.7E+03	2.0E+04	6.4E+05	7.0E+02	9.0E+02	7.7E+05
Sm-151	9.0E+01	2.1E+05	1.2E+05	1.4E+05	1.0E+06	5.5E+06		3.0E+05	1.3E+06	4.3E+07	5.1E+04	6.3E+04	5.2E+07
Sn-126	2.1E+05	5.1E+05	3.3E+05	3.8E+05	2.4E+06	1.2E+07		7.0E+05	2.9E+06	9.6E+07	1.1E+05	1.3E+05	1.2E+08
Sr-90	2.9E+01	2.0E+10	2.8E+08	4.6E+08	5.7E+09	7.4E+09	1.2E+13	4.3E+08	3.3E+10	5.2E+11	5.6E+08	2.5E+08	1.3E+13
Y-90	7.3E-03	2.0E+10	2.8E+08	4.6E+08	5.7E+09	7.4E+09	1.2E+13	4.3E+08	3.3E+10	5.2E+11	5.6E+08	2.5E+08	1.3E+13
Tc-99	2.1E+05	8.5E+04	1.1E+03	3.1E+04	1.9E+05	2.0E+05		1.1E+04	1.1E+05	7.1E+06	4.3E+03	3.7E+03	7.7E+06
U-234	2.5E+05	9.6E+05	4.3E+04	1.7E+05	1.6E+06	8.5E+05		4.1E+04	2.3E+02	1.6E+07	1.9E+04	1.4E+04	2.0E+07
U-235	7.0E+08	1.6E+04	7.0E+02	2.9E+03	2.6E+04	1.4E+04		7.0E+02	3.7E+00	2.5E+05	3.1E+02	2.3E+02	3.1E+05
U-236	2.3E+07	1.8E+05	7.9E+03	3.1E+04	2.9E+05	1.6E+05		7.9E+03	4.3E+01	2.9E+06	3.5E+03	2.6E+03	3.6E+06
U-238	4.5E+09	1.2E+06	5.3E+04	2.1E+05	2.0E+06	1.1E+06		5.2E+04	2.9E+02	2.0E+07	2.3E+04	1.7E+04	2.5E+07
Zr-93	1.5E+06	4.3E+04	1.8E+02	7.8E+03	4.8E+04	1.1E+05		6.4E+03	8.9E+03	8.8E+04		1.3E+03	3.1E+05
Totals	T-1/2 >1 yr	3.3E+11	1.5E+10	3.3E+12	2.2E+14	1.3E+14	4.1E+13	2.8E+12	6.5E+14	9.8E+13	6.2E+10	1.4E+12	1.1E+15
	incl. short lived	3.3E+11	1.5E+10	3.3E+12	2.2E+14	1.3E+14	4.1E+13	2.8E+12	6.5E+14	9.8E+13	6.2E+10	1.4E+12	1.1E+15

Note: Nuclides with half lives greater than 1 yr and Y-90 shown only.

Table 2.6: Estimated Operational ILW Radionuclide Inventory at 2018

		Decay Corrected Radionuclide Inventory (Bq)							
		Moderator IX Resin	PHT IX Resin	Misc. IX Resin	CANDECON Resin	IX Columns	Irradiated Core Components*	Filters & Filter Elements	Total
Net Volume (m^3)		1,338	925	1,254	1,434	327	21	684	5,983
Nuclide	T-1/2 (yrs)								
Ag-108m	1.3E+02		4.8E+08	1.6E+08	1.7E+07	1.6E+08		1.0E+06	8.2E+08
Am-241	4.3E+02		9.0E+07	3.4E+10	9.7E+10	3.2E+07		1.4E+10	1.5E+11
Am-243	7.4E+03		1.1E+06	4.3E+06	7.5E+07	3.9E+05		2.1E+07	1.0E+08
C-14	5.7E+03	3.6E+15	8.1E+13	1.9E+13	1.4E+11	2.9E+13	1.7E+12	7.9E+12	3.7E+15
Cl-36	3.0E+05	4.5E+08	2.8E+06	3.4E+07	9.8E+06	9.8E+05		4.9E+06	5.0E+08
Cm-244	1.8E+01		2.4E+09	3.5E+09	3.8E+10	7.6E+08		6.9E+10	1.1E+11
Co-60	5.3E+00	1.6E+13	6.9E+11	8.1E+12	5.7E+13	2.4E+11	5.5E+12	1.4E+12	8.9E+13
Cs-134	2.1E+00	5.8E+10	2.7E+12	5.3E+11	3.9E+11	1.1E+12			4.8E+12
Cs-135	2.3E+06		5.1E+07	1.8E+07	1.7E+06	1.8E+07		1.1E+05	8.9E+07
Cs-137	3.0E+01	1.7E+11	3.5E+13	1.1E+13	1.6E+12	1.1E+13		7.5E+10	5.9E+13
Eu-152	1.3E+01	7.8E+11	2.2E+12	6.1E+08	1.7E+10	6.9E+11			3.7E+12
Eu-154	8.8E+00	3.1E+11		4.6E+08	9.0E+11				1.2E+12
Eu-155	5.0E+00	1.5E+10		3.1E+09	2.8E+10				4.6E+10
Fe-55	2.7E+00	2.5E+12	4.5E+10	5.7E+12	2.1E+14	1.7E+10	1.4E+13	2.2E+12	2.3E+14
H-3	1.2E+01	8.7E+13	4.8E+13	2.3E+14	9.5E+13	6.8E+12	2.8E+09		4.7E+14
I-129	1.6E+07		6.0E+07	5.9E+06	6.5E+04	2.1E+07		2.5E+04	8.7E+07
Ir-192m	2.4E+02						4.4E+07		4.4E+07
Mo-93	3.5E+03						3.6E+08		3.6E+08
Nb-93m	1.4E+01						1.1E+11		1.1E+11
Nb-94	2.0E+04		1.0E+10	1.9E+08	2.4E+09	3.6E+09	4.5E+06	5.0E+10	6.6E+10
Ni-59	7.5E+04	1.9E+10	5.5E+07	2.0E+10	2.2E+10	1.9E+07	2.1E+11	1.8E+09	2.7E+11
Ni-63	9.6E+01	2.4E+12	6.8E+09	2.8E+12	3.1E+12	2.3E+09	3.0E+13	2.3E+11	3.9E+13
Np-237	2.1E+06		5.5E+04	2.0E+06	3.6E+06	1.9E+04		1.0E+06	6.7E+06
Pt-193	5.0E+01						4.1E+09		4.1E+09
Pu-238	8.8E+01		2.3E+08	7.6E+09	9.8E+09	7.8E+07		4.4E+09	2.2E+10
Pu-239	2.4E+04		3.5E+08	1.9E+10	2.3E+10	1.2E+08		6.5E+09	4.9E+10
Pu-240	6.5E+03		5.1E+08	2.8E+10	3.3E+10	1.8E+08		9.5E+09	7.1E+10
Pu-241	1.4E+01		5.2E+08	2.4E+12	2.7E+12	1.6E+08		1.9E+10	5.1E+12
Pu-242	3.8E+05		5.2E+05	2.0E+07	3.4E+07	1.8E+05		9.5E+06	6.4E+07
Ru-106	1.0E+00	1.1E+11	7.6E+11	2.2E+08	6.9E+12	3.0E+11			8.1E+12
Sb-125	2.8E+00	1.8E+11	1.2E+11	3.2E+11	2.3E+12	4.5E+10	1.3E+13	2.9E+11	1.6E+13
Se-79	1.1E+06	1.5E+04	1.8E+06	6.1E+05	6.6E+03	6.2E+05		3.8E+03	3.1E+06
Sm-151	9.0E+01		1.6E+08	5.2E+07	5.6E+06	5.3E+07		3.3E+05	2.7E+08
Sn-121m	5.5E+01						7.3E+11		7.3E+11
Sn-126	2.1E+05		2.7E+08	9.2E+07	8.9E+06	9.5E+07		5.6E+05	4.7E+08
Sr-90	2.9E+01	1.3E+10	1.9E+11	9.6E+11	3.4E+13	6.0E+10	2.4E+09	3.6E+10	3.5E+13
Y-90	7.3E-03	1.3E+10	1.9E+11	9.6E+11	3.4E+13	6.0E+10	2.4E+09	3.6E+10	3.5E+13
Tc-99	2.1E+05		1.9E+08	6.8E+06	2.0E+06	6.9E+07	3.4E+08	9.8E+05	6.1E+08
U-234	2.5E+05		5.8E+05	2.1E+07	3.9E+07	2.1E+05		1.1E+07	7.2E+07
U-235	7.0E+08		9.3E+03	3.6E+05	6.2E+05	3.3E+03		1.8E+05	1.2E+06
U-236	2.3E+07		1.1E+05	4.0E+06	7.0E+06	3.9E+04		2.0E+06	1.3E+07
U-238	4.5E+09		7.2E+05	2.8E+07	4.7E+07	2.6E+05		1.3E+07	8.9E+07
Zr-93	1.5E+06	6.0E+05	1.8E+06	8.4E+04	6.5E+06	6.2E+05	5.4E+11	7.5E+05	5.4E+11
Totals	T-1/2 >1 yr	3.7E+15	1.7E+14	2.8E+14	4.5E+14	4.9E+13	6.6E+13	1.2E+13	4.7E+15
	incl. short lived	3.8E+15	1.7E+14	3.7E+14	5.1E+14	5.0E+13	6.6E+13	1.3E+13	5.0E+15

Note: Nuclides with half lives greater than 1 yr. and Y-90 shown only.
* Based on 6 flux detectors per core component liner

Table 2.7: Estimated Operational ILW Radionuclide Inventory at 2062

		Decay Corrected Radionuclide Inventory (Bq)							
		Moderator IX Resin	PHT IX Resin	Misc. IX Resin	CANDECON Resin	IX Columns	Irradiated Core Components*	Filters & Filter Elements	Total
Net Volume (m^3)		2,264	1,595	2,126	2,154	561	25	1,453	10,178
Nuclide	T-1/2 (yrs)								
Ag-108m	1.3E+02		6.9E+08	2.3E+08	2.0E+07	2.4E+08		1.8E+06	1.2E+09
Am-241	4.3E+02		1.5E+08	5.5E+10	1.4E+11	5.2E+07		3.0E+10	2.3E+11
Am-243	7.4E+03		1.9E+06	7.2E+06	1.1E+08	6.7E+05		4.6E+07	1.7E+08
C-14	5.7E+03	6.1E+15	1.4E+14	3.2E+13	2.1E+11	4.9E+13	2.0E+12	1.6E+13	6.3E+15
Cl-36	3.0E+05	7.7E+08	4.8E+06	5.7E+07	1.5E+07	1.7E+06		1.0E+07	8.6E+08
Cm-244	1.8E+01		1.5E+09	2.0E+09	1.1E+10	4.9E+08		5.7E+10	7.2E+10
Co-60	5.3E+00	1.8E+12	7.5E+10	8.8E+11	3.0E+11	4.9E+08	3.2E+11	2.2E+11	3.6E+12
Cs-134	2.1E+00	4.0E+08	1.9E+10	3.6E+09	3.1E+05	4.7E+09			2.8E+10
Cs-135	2.3E+06		8.8E+07	3.0E+07	2.6E+06	3.1E+07		2.3E+05	1.5E+08
Cs-137	3.0E+01	1.5E+11	3.1E+13	9.9E+12	9.1E+11	1.0E+13		8.8E+10	5.2E+13
Eu-152	1.3E+01	3.4E+11	9.9E+11	2.6E+08	2.7E+09	3.4E+11			1.7E+12
Eu-154	8.8E+00	8.0E+10		1.2E+08	4.6E+10				1.3E+11
Eu-155	5.0E+00	1.4E+09		3.0E+08	1.0E+08				1.8E+09
Fe-55	2.7E+00	4.7E+10	8.5E+08	1.1E+11	5.1E+09	2.4E+08	1.5E+11	6.7E+10	3.8E+11
H-3	1.2E+01	3.5E+13	2.0E+13	9.3E+13	1.3E+13	3.0E+12	5.7E+08		1.6E+14
I-129	1.6E+07		1.0E+08	1.0E+07	9.7E+04	3.6E+07		5.7E+04	1.5E+08
Ir-192m	2.4E+02						4.6E+07		4.6E+07
Mo-93	3.5E+03						4.2E+08		4.2E+08
Nb-93m	1.4E+01						2.5E+10		2.5E+10
Nb-94	2.0E+04		1.8E+10	3.2E+08	3.7E+09	6.2E+09	5.2E+06	1.1E+11	1.4E+11
Ni-59	7.5E+04	3.2E+10	9.4E+07	3.4E+10	3.2E+10	3.3E+07	2.5E+11	3.8E+09	3.5E+11
Ni-63	9.6E+01	3.2E+12	9.4E+09	3.8E+12	3.4E+12	3.2E+09	2.7E+13	3.9E+11	3.8E+13
Np-237	2.1E+06		9.4E+04	3.4E+06	5.4E+06	3.3E+04		2.2E+06	1.1E+07
Pt-193	5.0E+01						2.8E+09		2.8E+09
Pu-238	8.8E+01		3.1E+08	1.0E+10	1.1E+10	1.1E+08		7.8E+09	2.9E+10
Pu-239	2.4E+04		6.1E+08	3.2E+10	3.4E+10	2.1E+08		1.4E+10	8.1E+10
Pu-240	6.5E+03		8.7E+08	4.7E+10	4.9E+10	3.1E+08		2.1E+10	1.2E+11
Pu-241	1.4E+01		2.5E+08	1.1E+12	5.2E+11	8.6E+07		1.3E+10	1.6E+12
Pu-242	3.8E+05		8.9E+05	3.4E+07	5.2E+07	3.1E+05		2.1E+07	1.1E+08
Ru-106	1.0E+00	1.4E+07	9.2E+07	2.7E+04	1.7E+00	1.2E+07			1.2E+08
Sb-125	2.8E+00	3.7E+09	2.5E+09	6.7E+09	7.5E+07	7.2E+08	1.6E+11	9.4E+09	1.8E+11
Se-79	1.1E+06	2.5E+04	3.0E+06	1.0E+06	9.9E+03	1.1E+06		8.0E+03	5.1E+06
Sm-151	9.0E+01		2.1E+08	7.0E+07	6.1E+06	7.3E+07		5.6E+05	3.6E+08
Sn-121m	5.5E+01						5.3E+11		5.3E+11
Sn-126	2.1E+05		4.6E+08	1.6E+08	1.3E+07	1.6E+08		1.2E+06	7.9E+08
Sr-90	2.9E+01	1.1E+10	1.6E+11	8.2E+11	1.8E+13	5.5E+10	1.2E+09	4.2E+10	1.9E+13
Y-90	7.3E-03	1.1E+10	1.6E+11	8.2E+11	1.8E+13	5.5E+10	1.2E+09	4.2E+10	1.9E+13
Tc-99	2.1E+05		3.3E+08	1.1E+07	3.0E+06	1.2E+08	4.0E+08	2.0E+06	8.7E+08
U-234	2.5E+05		1.0E+06	3.6E+07	5.8E+07	3.5E+05		2.3E+07	1.2E+08
U-235	7.0E+08		1.6E+04	6.2E+05	9.3E+05	5.6E+03		3.9E+05	2.0E+06
U-236	2.3E+07		1.9E+05	6.8E+06	1.1E+07	6.7E+04		4.4E+06	2.2E+07
U-238	4.5E+09		1.2E+06	4.7E+07	7.1E+07	4.4E+05		2.9E+07	1.5E+08
Zr-93	1.5E+06	1.0E+06	3.0E+06	1.4E+05	9.7E+06	1.1E+06	6.2E+11	1.6E+06	6.2E+11
Totals	T-1/2 >1 yr	6.1E+15	1.9E+14	1.4E+14	5.5E+13	6.3E+13	3.1E+13	1.7E+13	6.6E+15
	incl. short lived	6.1E+15	1.9E+14	1.4E+14	5.5E+13	6.3E+13	3.1E+13	1.7E+13	6.6E+15

Note: Nuclides with half lives greater than 1 yr.and Y-90 shown only.
*Based on 6 flux detectors per core component liner

Table 2.8: Inventory of Non-Radioactive Components in Operational L&ILW

Contaminant	Estimated Inventory at 2052 (kg)													
	Bottom Ash (Old)	Baghouse Ash (Old)	Bottom Ash (New)	Baghouse Ash (New)	Compact Bales and Box Compacted	Non-pro*	Heat Exchangers	CANDECON Resin	LL Resin & Misc. IX Resin	ALW Resin	ALW Sludge	PHT IX Resin/IX Columns	Moderator IX Resin	Core Components#
Aluminum	1.9E+04		3.4E+04	1.2E+02	3.7E+04	1.9E+05		2.2E+01	3.5E+02	1.7E+01	9.1E+01	1.3E+02	1.1E+01	
Antimony	5.9E+02		6.8E+02	8.6E+01	1.1E+03	4.7E+02		1.1E-01	7.4E-01	4.9E-02	3.0E-01	9.0E-01	8.3E-01	
Arsenic	7.1E+01		5.3E+00	4.0E-01	1.3E+02	5.9E+01		1.2E+00	4.6E+00	2.0E-01	7.6E-02	9.5E+00	5.4E-01	
Barium	1.8E+03		3.0E+03	4.2E+00	3.4E+03	1.5E+03		4.9E-01	3.8E+01	3.8E+01	4.9E+01	1.4E+02	1.1E+01	
Beryllium			1.2E+00	1.1E-01				6.6E-01	1.0E+00	1.7E-01	7.6E-02	2.2E+01	9.6E-01	
Bismuth			2.9E+00	3.0E-01				3.1E+00	5.7E-01	2.8E-02	7.6E-02	9.3E-01	9.6E-01	
Boron	3.2E+02		2.1E+02	3.3E+00	6.0E+02	2.6E+02	5.8E+00	7.4E+01	4.9E+02	7.3E-01	3.4E+01	4.6E+01	8.1E+02	
Bromine								1.9E-01	4.4E-01	7.3E+01				
Cadmium	3.6E+00		9.7E+00	1.7E+00	7.2E+03	3.1E+03		3.8E+00	5.5E+00	3.3E-01	1.4E-01	1.3E-01	1.4E+01	
Calcium	3.2E+04	9.7E+01	1.1E+05	2.8E+04	6.0E+04	5.8E+04	5.8E+00	2.1E+01	7.6E+03	3.1E+04	1.1E+03	1.7E+02	1.3E+02	
Cerium										7.3E-02			9.6E-02	
Carbon	6.5E+04	1.2E+04	2.7E+04	2.4E+04	4.4E+06	2.3E+05	1.3E+03	5.5E+05	9.8E+05	5.2E+05		6.6E+05	6.9E+05	
Cesium			5.1E-01	4.2E-02				1.9E-02	2.1E-01	1.6E-02	7.6E-02	1.0E-01		
Chlorine	2.4E+03	2.7E+03	1.9E+04	1.3E+04	7.8E+03	5.4E+04		1.2E+00	1.8E+02	2.5E+03		4.2E+02	1.2E+03	
Chromium	4.1E+03		3.0E+03	1.0E+01	7.6E+03	3.8E+05	2.0E+02	1.6E+01	2.2E+01	1.6E+00	1.1E+00	2.9E+01	2.5E+01	4.8E+02
Cobalt	7.1E+01		5.8E+01	4.9E-01	1.3E+02	5.8E+01		1.7E+01	6.3E+00	1.0E+00	1.2E-01	2.7E-01	1.2E+00	
Copper	1.4E+04		6.4E+03	1.8E+01	2.5E+04	1.9E+06	9.9E+05	1.3E+02	6.3E+03	9.3E+01	4.5E+00	2.6E+01	8.7E+02	
Fluorine													1.6E+02	
Gadolinium								1.2E-01	1.7E+01				5.2E+03	
Iodine								4.6E-02	1.3E-01	3.8E+01				
Iron	2.6E+04	9.7E+01	7.4E+04	2.5E+02	3.8E+06	3.1E+06	1.9E+05	3.3E+04	3.8E+03	1.3E+02	1.0E+02	6.4E+02	9.2E+02	2.4E+02
Lead	7.6E+03		8.9E+02	6.3E+01	1.4E+04	6.3E+05	5.7E+02	7.8E+01	1.9E+02	4.5E+00	2.8E+00	1.2E+01	1.1E+02	
Lithium			4.4E+01	7.0E-01				1.2E+01	3.8E+02	1.2E+00	7.2E-01	6.0E+03	4.6E+02	
Magnesium	4.7E+03		2.3E+04	3.8E+02	8.6E+03	9.3E+03	2.9E+02	9.7E+00	1.7E+03	3.2E+03	2.8E+02	3.8E+01	1.6E+01	
Manganese	2.4E+03		1.5E+03	8.6E+00	4.0E+04	2.4E+04	1.6E+04	5.0E+02	1.5E+02	2.3E+01	9.8E+00	1.0E+02	2.9E+01	
Mercury	1.2E+01		1.6E+00	4.2E-02	3.1E+01	1.3E+01		7.7E-02	6.6E-02	1.7E-01	7.6E-02	1.2E-01	7.3E-02	
Molybdenum			2.3E+02	2.4E+00				2.7E+00	7.6E+00	1.3E+00	1.0E-01	4.4E+01	3.1E+00	
Nickel	1.2E+03		1.1E+03	1.0E+01	2.2E+03	2.4E+04	4.4E+05	4.1E+03	6.6E+02	2.2E+01	9.1E+00	1.2E+01	5.4E+03	1.7E+03
Niobium	2.4E+01				5.1E+01	2.3E+01								
Nitrate ion	3.1E+04				5.7E+04	2.4E+04		9.5E-01	6.6E+01				7.3E+02	
Nitrogen								1.1E+04	5.5E+04	3.3E+04		3.7E+04	3.8E+04	
Oxygen								9.5E+05	1.3E+06	7.0E+05		8.8E+05	9.2E+05	
Phosphorus	1.8E+03	1.1E+03	1.4E+04	1.9E+02	1.9E+04	7.5E+04		1.4E+02	5.7E+02	4.8E+01	2.3E+01	1.8E+02	3.1E+02	
Potassium	1.8E+03		5.0E+03	1.5E+02	3.2E+03	1.7E+03		2.4E+02	2.2E+03	1.2E+02	2.5E+02	1.8E+02	4.2E+01	
Rubidium										1.4E-01				

Table 2.8: Inventory of Non-Radioactive Contaminants in Operational L&ILW (cont'd)

Contaminant	Estimated Inventory at 2052 (kg)													
	Bottom Ash	Baghouse Ash	Bottom Ash (New)	Baghouse Ash (New)	Compact Bales and Box Compacted	Non-pro*	Heat Exchangers	CANDECON Resin	LL Resin & Misc. IX Resin	ALW Resin	ALW Sludge	PHT IX Resins/IX Columns	Moderator IX Resin	Core Components#
Scandium	2.4E+01												6.5E-02	
Selenium			8.1E-01	1.5E+00	5.1E+01	2.3E+01		6.3E-01	5.2E+00	4.5E-01	5.3E-01	9.2E-01	9.6E-01	
Silicon	2.1E+04	2.2E+02	6.7E+04	8.1E+02	3.8E+05	2.6E+06	9.9E+02	3.1E+01	2.2E+02	3.6E+01	2.4E+02	2.0E+02	2.9E+01	
Silver			2.6E+00	1.7E-01				1.1E-01	4.4E-01	5.4E-01	9.5E-02	2.0E-01	5.4E-01	
Sodium	3.5E+03	1.2E+03	1.1E+04	9.4E+02	8.0E+03	1.6E+05		1.6E+02	5.5E+03	7.7E+02	2.3E+04	3.7E+02	1.6E+02	
Strontium	5.9E+02		3.2E+02	1.5E+01	1.1E+03	5.9E+02		1.6E-01	6.3E+01	3.2E+02	1.2E+01	1.8E+00	6.4E-01	
Sulphur	1.2E+03	1.8E+03	9.7E+03	1.0E+03	5.1E+03	3.8E+04	2.8E+02	1.5E+05	8.4E+04	7.8E+04		6.0E+04	6.0E+04	
Tellurium	5.3E+01				1.0E+02	4.4E+01								
Thallium			1.8E-01	1.9E-02				8.5E-02	6.0E-02	2.2E-02	7.6E-02	9.2E-02	9.6E-02	
Thorium			7.5E+00	4.2E-02				1.4E+00	2.0E-01	2.2E-02	6.4E-02	9.2E-02	9.6E-02	
Tin			1.5E+02	5.5E+00				7.1E+00	2.7E+00	3.5E-01	2.5E-01	6.0E+00	1.9E+00	
Titanium	9.4E+03		4.8E+04	3.6E+01	1.8E+04	7.0E+04	1.2E+02	2.0E+00	6.0E+01	6.2E-02	1.9E+00	7.9E-01	2.1E-01	
Tungsten			8.9E+01	5.7E-01				1.4E-01	3.5E+00	6.2E-01	7.6E-02	9.2E+00	1.9E-01	
Uranium			3.3E+00	1.7E-01				2.0E+01	3.3E+00	1.6E-01	7.6E-02	2.0E+00	1.1E-01	
Vanadium			1.1E+02	1.3E+01				5.3E-02	3.8E+00	1.6E-01	7.6E-02	2.6E+00	9.6E-02	
Zinc	2.4E+04	1.2E+03	1.6E+04	3.6E+02	4.5E+04	4.4E+04	1.1E+04	6.5E+01	3.0E+03	7.3E+01	1.1E+02	7.0E+01	4.8E+02	
Zirconium	1.6E+02		1.2E+02	2.2E+00	2.9E+02	1.3E+02		6.0E-02	1.5E+00	2.3E-01	3.6E-01	2.0E-01	2.7E-01	
EDTA								4.8E+04						
PAH	1.3E+00	2.4E-03	1.8E+00	9.4E-03										
Cl-Benzenes & Cl-Phenols	1.9E+00	6.3E-01	2.7E+00	2.5E+00										
Dioxins & Furans	4.5E-02	1.9E-03	6.1E-02	7.4E-03										
PCB	1.2E-01	2.4E-03	1.6E-01	9.4E-03										

Note: Data for filters not yet developed
Resin inventory does not include water
*Includes feeder pipes, encapsulated tile holes, and drummed non-pro waste
#Based on 138 liners containing 690 flux detectors, and avg. flux detector mass for Pickering

Table 2.9: Inventory of LLW Container Materials

Container Type	Container Count	Total Mass (kg)					Total External Surface Area (m^2)	
		Carbon Steel (Container)	Carbon Steel (Overpack)	Copper Alloy	Plastics	Concrete	Carbon Steel (Container)	Carbon Steel (Overpack)
Ash Bin (Old) - bottom ash	269	1.8E+05	4.3E+05				4.3E+03	6.8E+03
Ash Bin (New) - bottom ash	816	3.1E+05	1.3E+06				8.9E+03	2.1E+04
Drum Rack - baghouse ash (Old)	47	2.0E+04	7.5E+04				7.5E+02	1.2E+03
Ash Bin (New) – baghouse ash	134	5.1E+04	2.1E+05				1.5E+03	3.4E+03
Compactor Box	5,298	2.6E+06					6.3E+04	
Bale Rack	1,491	2.2E+05					4.2E+03	
Drum Rack - non-processible drums	2,959	1.2E+06	4.7E+05				8.5E+04	7.5E+03
Drum Bin	3,317	1.9E+06					3.9E+04	
Non-Pro Container (47" High)	20,327	5.7E+06					2.6E+05	
Low Level Resin Box (90")	45	5.3E+04	7.2E+04				7.2E+02	1.1E+03
Low Level Resin Pallet Tank	2,126	4.7E+05			2.1E+05		8.1E+03	
ALW Sludge Box	1,534	5.8E+05	2.4E+06				1.8E+04	3.9E+04
Shield Plug Container	9	1.2E+05					2.5E+02	
Heat Exchanger	66	1.7E+05		1.5E+06				
Encapsulated Tile Hole	66	1.1E+05				1.5E+06	1.4E+03	
TOTAL	38,504	1.4E+07	5.0E+06	1.5E+06	2.1E+05	1.5E+06	5.0E+05	7.9E+04

Note: Feeder pipes are included in the non-pro container inventory and will be stored in non-pro high capacity containers similar to the NPB47s, but sturdier

Table 2.10: Inventory of ILW Container Materials

Container Type	Container Count	Total Mass (kg)					Total External Surface Area (m²)			
		Carbon Steel (Container)	Stainless Steel (Container)	Stainless Steel (Overpack)	Concrete (Shield)	Carbon Steel (rebar in shield)*	Carbon Steel (Container)	Stainless Steel (Container)	Stainless Steel (Overpack)	Concrete (Shield)
Resin Liner#	2,712	5.3E+05	1.6E+06	5.8E+05	2.1E+07	4.2E+05	9.0E+03	2.7E+04	5.7E+03	3.9E+04
IC-2 Liner	20	2.0E+04					3.0E+02			
IC-18 T-H-E Liner - filters, IX columns, etc.	422	5.9E+05					8.8E+03			
IC-18 T-H-E Liner - core components	22	3.1E+04					4.6E+02			
ILW Shield	7,383				1.5E+07	3.0E+05				5.1E+04
Tile Hole Liner	201	9.1E+04					1.2E+03			
TOTAL	10,760	1.3E+06	1.6E+06	5.8E+05	3.6E+07	7.2E+05	1.9E+04	2.7E+04	5.7E+03	9.0E+04

Note: CANDECON resins are included in the resin liner inventory

*Rebar in shield construction is assumed to be 2% of empty weight

2042 are stainless steel liners, and 670 are carbon steel liners, 400 of which are packed in stainless steel overpacks

Table 2.11: Inventory of Bulk Materials in LLW

Waste Stream	Container Count	Total Organic Materials (kg)							Concrete (kg)	Carbon Steel (kg)	Stainless Steel (kg)
		Paper	Cotton	Wood	Rubber	Plastics~	Resins	Absorbent^			
Bottom Ash (old + new)	1,085										
Baghouse Ash (old + new)	181										
Compact Bales	1,491	4.5E+05	7.5E+04		1.3E+05	7.3E+05				2.8E+05	
Box Compacted	5,298	2.9E+06	4.9E+05		8.5E+05	4.7E+06				1.8E+06	
Non-Pro*	20,327	9.2E+05	3.5E+05	5.8E+05	2.3E+05	6.8E+05		1.6E+06	6.9E+05	1.1E+06	1.2E+06
Non-pro Other	132						1.6E+04			2.1E+04	
Non-pro Drummed	6,276	3.0E+05	1.1E+05	1.9E+05	7.6E+04	1.9E+05		5.3E+05	2.3E+05	3.8E+05	3.8E+05
LL Resin	45						1.2E+05				
LL Resin/ALW Resin#	2,126						2.4E+06				
ALW Sludge	1,534						2.8E+06				
TOTAL	38,504	4.6E+06	1.0E+06	7.7E+05	1.3E+06	6.3E+06	5.3E+06	2.1E+06	9.2E+05	3.6E+06	1.6E+06

Note: Weight of resins does not include weight of interstitial water
* Includes shield plugs and feeder pipes
# Utilize same storage container
~Includes plastic bag inventory
^Includes both clay-based and organic absorbents

Table 2.12: Inventory of Bulk Materials in ILW

Waste Type	Total Mass (kg)		
	Resins	Carbon Steel	Stainless Steel
ILW Resin (PHT, Moderator, Misc., CANDECON)	6.9E+06		
IX Columns	3.2E+05	4.1E+05	
Filters and Filter Elements		1.8E+06	
Irradiated Core Components*		1.3E+04	4.8E+02
TOTAL	7.2E+06	2.3E+06	4.8E+02

Note: Weight of resins does not include weight of interstitial water
* Assumes 1 PNGSB vertical flux detector in a flux detector liner

3. PROJECTED RETUBE AND STEAM GENERATOR REFURBISHMENT WASTE INVENTORY AND CHARACTERISTICS

3.1 WASTE VOLUMES AND PACKAGE INVENTORY

Reactor refurbishment consists of large scale retube (replacing the pressure tubes, calandria tubes and/or endfittings) and/or replacing the steam generators. By virtue of their radiological properties, retube components and steam generators are classified as ILW and LLW respectively.

Table 3.1 summarizes the forecast refurbishment waste inventory, including reference assumptions for disposal based on "Scenario B". Two types of boxes are envisioned for retube component waste: one for volume reduced components (pressure tubes, calandria tubes and calandria tube inserts), and one for uncut end fittings. Historic retube waste from the Pickering A retube is not included in the inventory. This waste is assumed to be retrieved from Dry Storage Modules at Pickering at the time of station decommissioning, and then cut and repackaged and co-disposed with the Pickering decommissioning ILW.

The waste volume forecasts are subject to changes to the nuclear operating and refurbishment program; improvements to waste storage technology; standardization across stations; and disposal technology. There are also uncertainties related to storage technologies for newer "hotter" pressure tube wastes that will arise from future refurbishment activities.

Table 3.1: Scenario B Reactor Refurbishment Waste Forecast Summary by Waste Type

Waste Stream	Net Volume (m^3)	Number of Disposal Containers	Disposal Volume (m^3)	Reference Assumptions for DGR
Retube Waste (Pressure Tubes)	196	245	1,887	From PWMF and DWMF, put in re-usable transport overpack and transport to DGR as is. From WWMF, transfer as-is by forklift.
Retube Waste (End Fittings)	2,479	918	10,038	Assumptions same as pressure tube re-tube waste.
Retube Waste (Calandria Tubes)	134	168	1,294	Assumptions same as pressure tube re-tube waste.
Retube Waste (Calandria Tube Inserts)	36	45	347	Assumptions same as pressure tube re-tube waste.
Steam Generators (SG)	7,673	512	7,673	Assume each SG from Bruce-A will be cut into 5 segments, each SG from Bruce-B will be cut into 8 segments, and each SG from Pick-B will be cut into 6 segments. Seal plates to be welded prior to transfer/transport to DGR.
Totals	10,518	1,888	21,239	

3.2 RADIONUCLIDE INVENTORY

Activation calculations for Pickering B pressure tubes and calandria tubes, calandria tube sleeve inserts, and the “hot” ends of end fittings were performed using the isotope generation and depletion code ORIGEN-S [Hermann and Westfall 1995] for a 25 year irradiation period at 100% full power. The code calculates time-dependent concentrations and source terms for a large number of isotopes, which are simultaneously generated through neutronic transmutation, fission, and radioactive decay.

The radionuclide activity concentrations for the significant nuclides present in retube components are reported in Appendix B for a decay period of 270 days, which represents the average decay time of the waste before it is transferred to storage. The Pickering B data is applied for reactor units at Bruce Power and Darlington – reactor unit design differences are not a significant factor, but the actual irradiation period and period of shutdown prior to retubing would influence the inventories sent to the DGR.

The activity concentrations are based on activation of the base metal. The active particulate from surface contamination is not included as the contribution is expected to be minimal. A previous study on the characterization of Bruce A calandria swabs indicated the presence of mainly corrosion products, and primarily zirconium alloy debris, with very little C-14 or fission product contamination.

Tables 3.2 and 3.3 present the radionuclide inventories for refurbishment wastes for “Scenario B” at 2018 and 2062 respectively. In pressure tubes, Zr-95, Nb-95 and Fe-55 are initially dominant, with a portion of the Nb-95 inventory attributable to the 2.5% Nb-93 present in the initial composition. However, Zr-95, Nb-95, and Fe-55 decay significantly after that, and by 2062 (Table 3.3), the most significant nuclides are Nb-94, Co-60, C-14, Ni-59, and Ni-63. Similarly for the calandria tubes, the nuclides with the highest inventory are Nb-95 and Zr-95. However, in the long term, the other nuclides assume greater significance. Both components are comprised of Zr-based materials.

For stainless steel components (calandria tube inserts/end fittings), the same nuclides predominate, with Fe-55, Co-60, and Ni-63 among the most significant nuclides from 2018 to 2062. Nuclides with relatively short half lives, such as Cr-51, Fe-59, and Mn-54, are significant initially, but decay to low levels by 2062.

The specific activities for steam generators are based on data for Bruce A tube sections (see Appendix B), and are considered to apply to steam generators at Bruce B and Pickering B. The activities were based on measurements of the internal oxide at several locations along the length of these tubes. Comparatively, the overall radionuclide inventory associated with this waste is relatively small compared to the retube inventory.

Table 3.2: Estimated Reactor Refurbishment Radionuclide Inventory at 2018

		Decay Corrected Radionuclide Inventory (Bq)					
		Retube Waste Pressure Tubes*	Retube Waste End Fittings*	Retube Waste Calandria Tubes*	Retube Waste Calandria Tube Inserts*	Steam Generators	Total
Net Volume (m^3)		145	1,828	99	26	7,673	9,771
Nuclide	T-1/2 (yrs)						
Ag-108m	1.3E+02	1.1E+13	4.5E+11	6.4E+12	3.0E+10	1.8E+06	1.8E+13
Ag-110m	6.8E-01	1.9E+11	1.6E+12	1.1E+11	1.7E+10	2.9E+10	2.0E+12
Am-241	4.3E+02					4.6E+11	4.6E+11
Am-243	7.4E+03					3.0E+08	3.0E+08
C-14	5.7E+03	3.8E+14	3.3E+13	2.4E+13	2.4E+12	5.9E+11	4.4E+14
Cl-36	3.0E+05	7.7E+11	3.5E+09	8.6E+10	2.2E+08	1.1E+08	8.6E+11
Cm-244	1.8E+01					9.6E+10	9.6E+10
Co-60	5.3E+00	1.1E+15	4.7E+16	6.7E+14	3.3E+15	6.4E+12	5.2E+16
Cr-51	7.6E-02	7.4E+11	1.7E+14	2.1E+12	1.2E+13	2.7E+11	1.8E+14
Cs-134	2.1E+00	1.3E+12	5.3E+11	1.6E+10	2.4E+10	7.2E+09	1.9E+12
Cs-135	2.3E+06	2.0E+08	1.2E+05	2.5E+06	5.6E+04	1.7E+05	2.1E+08
Cs-137	3.0E+01	5.5E+09	3.8E+02	7.2E+07	1.6E+04	1.6E+11	1.6E+11
Eu-152	1.3E+01	5.9E+01		1.6E+01	8.1E-03	1.2E+10	1.2E+10
Eu-154	8.8E+00	9.2E+05		2.7E+05	1.8E+00	9.7E+10	9.7E+10
Eu-155	5.0E+00	4.8E+05		1.4E+05	6.7E-01	1.6E+11	1.6E+11
Fe-55	2.7E+00	7.2E+15	7.2E+17	3.4E+15	5.3E+16	2.5E+13	7.8E+17
Fe-59	1.2E-01	1.1E+13	1.5E+14	5.6E+12	1.3E+13	3.8E+11	1.8E+14
H-3	1.2E+01	1.5E+12	2.7E+13	3.3E+11	6.2E+11		3.0E+13
I-129	1.6E+07	2.6E+05	2.6E+04	3.7E+04	1.7E+03	4.9E+04	3.7E+05
Ir-192m	2.4E+02	8.1E+09	1.7E+05	2.5E+08	1.5E+06		8.1E+09
Mn-54	8.6E-01	1.8E+13	3.6E+15	6.0E+12	2.8E+14	5.5E+11	3.9E+15
Mo-93	3.5E+03	2.2E+10	4.2E+11	1.3E+10	3.1E+10		4.9E+11
Nb-93m	1.4E+01	3.4E+13	1.1E+11	1.4E+13	8.4E+09		4.7E+13
Nb-94	2.0E+04	3.3E+15	3.5E+11	2.0E+11	2.3E+10	2.3E+09	3.3E+15
Nb-95	9.5E-02	5.6E+16	6.2E+10	2.1E+16	9.6E+09	5.2E+12	7.7E+16
Nb-95m	1.0E-02	2.8E+14	2.9E+08	1.1E+14	2.3E+07		4.0E+14
Ni-59	7.5E+04	2.0E+11	1.8E+13	2.0E+12	9.7E+11	1.6E+09	2.1E+13
Ni-63	9.6E+01	7.6E+13	1.9E+15	7.1E+14	1.4E+14	2.2E+11	2.9E+15
Np-237	2.1E+06					1.4E+07	1.4E+07
Pt-193	5.0E+01	1.2E+13	6.0E+10	3.9E+11	5.3E-10		1.2E+13
Pu-238	8.8E+01					7.6E+10	7.6E+10
Pu-239	2.4E+04					2.3E+11	2.3E+11
Pu-240	6.5E+03					2.3E+11	2.3E+11
Pu-241	1.4E+01					3.6E+12	3.6E+12
Pu-242	3.8E+05					1.3E+08	1.3E+08
Ru-106	1.0E+00	5.9E-03		3.8E-03	1.1E-06	2.3E+12	2.3E+12
Sb-125	2.8E+00	2.1E+13	7.3E+13	6.8E+15	8.8E+11	9.0E+10	6.9E+15
Se-79	1.1E+06	2.3E+09	1.7E+08	5.4E+09	3.8E+07	5.9E+05	7.9E+09
Sm-151	9.0E+01	1.5E+04		4.3E+03	2.7E-01	5.8E+05	6.0E+05
Sn-113	3.2E-01	1.4E+12	5.2E+12	5.0E+14	4.0E+11	8.3E+10	5.1E+14
Sn-119m	8.0E-01	4.3E+13	1.0E+14	8.8E+15	7.9E+12		8.9E+15
Sn-121m	5.5E+01	1.9E+11	5.7E+11	8.4E+13	4.1E+10		8.5E+13
Sn-126	2.1E+05					9.3E+05	9.3E+05
Sr-90	2.9E+01	1.8E+12	3.4E+04	5.9E+11	2.2E+04	1.3E+11	2.5E+12
Y-90	7.3E-03	1.8E+12	3.4E+04	5.9E+11	2.2E+04	1.3E+11	2.5E+12
Tc-99	2.1E+05	1.4E+10	1.2E+10	4.7E+09	7.4E+08	2.2E+07	3.2E+10
Te-123m	3.3E-01	6.0E+12	3.8E+11	1.6E+14	2.2E+11		1.6E+14
Te-125m	1.6E-01	2.0E+12	7.2E+12	6.4E+14	5.3E+11		6.5E+14
U-234	2.5E+05					1.5E+08	1.5E+08
U-235	7.0E+08					2.5E+06	2.5E+06
U-236	2.3E+07					2.8E+07	2.8E+07
U-238	4.5E+09					1.9E+08	1.9E+08
Zr-93	1.5E+06	1.0E+14	8.8E+07	4.0E+13	6.6E+06	3.0E+06	1.4E+14
Zr-95	1.8E-01	2.5E+16	2.5E+10	9.8E+15	1.9E+09	2.7E+12	3.5E+16
Totals	**T-1/2>1 yr**	**9.4E+16**	**7.7E+17**	**5.3E+16**	**5.7E+16**	**4.9E+13**	**9.7E+17**
	incl. short l'vd	**9.4E+16**	**7.7E+17**	**5.3E+16**	**5.7E+16**	**5.5E+13**	**9.7E+17**

Table 3.3: Estimated Reactor Refurbishment Radionuclide Inventory at 2062

		Estimated Radionuclide Inventory (Bq)					
		Retube Waste Pressure Tubes*	Retube Waste End Fittings*	Retube Waste Calandria Tubes*	Retube Waste Cal. Tube Inserts*	Steam Generators	Total
Net Volume (m^3)		**196**	**2,479**	**134**	**36**	**7,673**	**10,518**
Nuclide	**T-1/2 (yrs)**						
Ag-108m	1.3E+02	1.2E+13	4.8E+11	6.9E+12	3.3E+10	1.4E+06	2.0E+13
Ag-110m	6.8E-01	5.8E-08	4.8E-07	3.2E-08	5.0E-09	1.2E-09	5.8E-07
Am-241	4.3E+02					4.3E+11	4.3E+11
Am-243	7.4E+03					2.9E+08	2.9E+08
C-14	5.7E+03	5.1E+14	4.4E+13	3.2E+13	3.3E+12	5.9E+11	5.9E+14
Cl-36	3.0E+05	1.0E+12	4.7E+09	1.2E+11	3.0E+08	1.1E+08	1.2E+12
Cm-244	1.8E+01					1.8E+10	1.8E+10
Co-60	5.3E+00	5.9E+12	2.4E+14	3.4E+12	1.7E+13	2.0E+10	2.7E+14
Cr-51	7.6E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cs-134	2.1E+00	1.2E+06	4.7E+05	1.4E+04	2.2E+04	2.7E+03	1.7E+06
Cs-135	2.3E+06	2.7E+08	1.6E+05	3.4E+06	7.7E+04	1.7E+05	2.8E+08
Cs-137	3.0E+01	2.8E+09	1.9E+02	3.7E+07	8.2E+03	5.7E+10	6.0E+10
Eu-152	1.3E+01	8.8E+00		2.4E+00	1.2E-03	1.2E+09	1.2E+09
Eu-154	8.8E+00	4.4E+04		1.3E+04	9.0E-02	3.0E+09	3.0E+09
Eu-155	5.0E+00	1.8E+03		5.2E+02	2.5E-03	3.3E+08	3.3E+08
Fe-55	2.7E+00	1.9E+11	1.9E+13	8.7E+10	1.4E+12	3.0E+08	2.0E+13
Fe-59	1.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
H-3	1.2E+01	1.9E+11	3.5E+12	4.2E+10	8.0E+10		3.8E+12
I-129	1.6E+07	3.5E+05	3.5E+04	5.0E+04	2.4E+03	4.9E+04	4.9E+05
Ir-192m	2.4E+02	1.1E+10	2.1E+05	2.9E+08	1.8E+06		1.1E+10
Mn-54	8.6E-01	3.0E-02	6.1E+00	1.0E-02	4.7E-01	1.8E-04	6.6E+00
Mo-93	3.5E+03	2.9E+10	5.6E+11	1.7E+10	4.2E+10		6.5E+11
Nb-93m	1.4E+01	5.3E+12	1.8E+10	2.1E+12	1.3E+09		7.4E+12
Nb-94	2.0E+04	4.5E+15	4.7E+11	2.7E+11	3.2E+10	2.3E+09	4.5E+15
Nb-95	9.5E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Nb-95m	1.0E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00
Ni-59	7.5E+04	2.7E+11	2.4E+13	2.7E+12	1.3E+12	1.6E+09	2.9E+13
Ni-63	9.6E+01	7.5E+13	1.9E+15	7.1E+14	1.4E+14	1.6E+11	2.9E+15
Np-237	2.1E+06					1.4E+07	1.4E+07
Pt-193	5.0E+01	8.7E+12	4.5E+10	2.9E+11	4.0E-10		9.0E+12
Pu-238	8.8E+01					5.3E+10	5.3E+10
Pu-239	2.4E+04					2.3E+11	2.3E+11
Pu-240	6.5E+03					2.2E+11	2.2E+11
Pu-241	1.4E+01					4.4E+11	4.4E+11
Pu-242	3.8E+05					1.3E+08	1.3E+08
Ru-106	1.0E+00	1.9E-15		1.2E-15	3.5E-19	1.8E-01	1.8E-01
Sb-125	2.8E+00	7.0E+08	2.5E+09	2.3E+11	3.1E+07	1.5E+06	2.3E+11
Se-79	1.1E+06	3.1E+09	2.3E+08	7.3E+09	5.3E+07	5.9E+05	1.1E+10
Sm-151	9.0E+01	1.5E+04		4.2E+03	2.7E-01	4.1E+05	4.3E+05
Sn-113	3.2E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Sn-119m	8.0E-01	7.1E-03	1.7E-02	1.5E+00	1.3E-03		1.5E+00
Sn-121m	5.5E+01	1.5E+11	4.5E+11	6.7E+13	3.3E+10		6.8E+13
Sn-126	2.1E+05					9.3E+05	9.3E+05
Sr-90	2.9E+01	9.0E+11	1.7E+04	2.9E+11	1.1E+04	4.5E+10	1.2E+12
Y-90	7.3E-03	9.0E+11	1.7E+04	2.9E+11	1.1E+04	4.5E+10	1.2E+12
Tc-99	2.1E+05	1.9E+10	1.7E+10	6.3E+09	1.0E+09	2.2E+07	4.3E+10
Te-123m	3.3E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00
Te-125m	1.6E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00		0.0E+00
U-234	2.5E+05					1.5E+08	1.5E+08
U-235	7.0E+08					2.5E+06	2.5E+06
U-236	2.3E+07					2.8E+07	2.8E+07
U-238	4.5E+09					1.9E+08	1.9E+08
Zr-93	1.5E+06	1.4E+14	1.2E+08	5.4E+13	9.1E+06	3.0E+06	1.9E+14
Zr-95	1.8E-01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Totals	T-1/2 > 1 yr	**5.3E+15**	**2.3E+15**	**8.8E+14**	**1.6E+14**	**2.3E+12**	**8.6E+15**
	incl. short lived	**5.3E+15**	**2.3E+15**	**8.8E+14**	**1.6E+14**	**2.3E+12**	**8.6E+15**

3.3 CHEMICAL INVENTORY

Elemental compositions, impurities, and other specific component data were taken from OPG design documents and other sources (see Appendix C). The inventories of elements integral to the material for each of the components/items are reported in Table 3.4. The estimates are based on "Scenario B" at 2052. The steam generator data are documented again as part of the bulk material inventory in Table 3.5.

Table 3.4: Elemental Inventory in Reactor Refurbishment Waste

Element	Pressure Tubes* (kg)	End Fittings~ (kg)	Calandria Tubes# (kg)	Calandria Tube Inserts+ (kg)	Steam Generators (kg)
Zr	4.4E+05		1.7E+05		
Nb	1.2E+04				
Sn			1.7E+03		
Cr		1.7E+05		1.5E+03	3.8E+05
Fe		2.2E+06		1.9E+04	8.9E+06
C					1.9E+05
Mn					1.5E+05
Ni					1.6E+06
Others	1.8E+02	3.4E+04	3.4E+02	2.9E+02	2.2E+04
Total	**4.5E+05**	**2.4E+06**	**1.7E+05**	**2.1E+04**	**1.1E+07**

* Based on weight of 61 kg/PT and 30 PT/box
~ Based on weight of 163 kg/EF and 16 EF/box
\# Based on weight of 23 kg/CT and 44 CT/box
\+ Based on weight of 1.2 kg/CTI and 384 CTI/box

3.4 BULK MATERIAL INVENTORY

The inventory of reactor refurbishment container materials, in terms of mass of metal and concrete associated with the containers, and total surface area based on "Scenario B" at 2052 is summarized in Table 3.5. The inventory is based on the weight of steel and concrete in each container. The surface areas are calculated based on container dimensions provided in Appendix E. The carbon steel surface area totals for retube waste containers include the internal surface area as the boxes are of steel-concrete-steel construction. The total mass of concrete includes the grout that will be used to fill the steam generators. The Inconel 600 inventory is attributed to the tube weight inside of the steam generators.

The total estimated inventory of steel in container materials including the rebar in concrete shielding is 2.4×10^{7} kg. The total weight of concrete is estimated to be 3.2×10^{7} kg.

Table 3.5: Inventory of Reactor Refurbishment Container Materials

Container Type	No. of Containers/ #Items	Total Mass* (kg)					Total Surface Area* (m^2)				
		Carbon Steel	Stainless Steel	Inconel 600	Concrete	Carbon Steel (rebar in container)	Carbon Steel^	Stainless Steel (External)	Stainless Steel (Internal)	Inconel 600+	Concrete
Retube Waste Container (PT) - Pressure Tubes	245		1.1E+06		5.7E+06	1.4E+05		5.8E+03	2.9E+03		5.8E+03
Retube Waste Container (PT) – Calandria Tubes	168		7.6E+05		4.0E+06	9.7E+04		3.9E+03	2.0E+03		3.9E+03
Retube Waste Container (PT) - Calandria Tube Inserts	45		2.0E+05		1.1E+06	2.7E+04		1.1E+03	5.3E+02		1.1E+03
Retube Waste Container (EF)	918		5.9E+06		1.9E+07	5.0E+05		2.2E+04	1.1E+04		2.2E+04
Steam Generator (Bruce A)	32	2.1E+06		6.9E+05	4.9E+05		3.1E+03			7.6E+04	
Steam Generator (Bruce B)	32	3.3E+06		1.1E+06	7.5E+05		4.2E+03			7.7E+04	
Steam Generator (Pickering)	48	3.1E+06		1.0E+06	7.1E+05		4.1E+03			8.8E+04	
TOTAL	1,488	8.4E+06	7.9E+06	2.8E+06	3.2E+07	7.6E+05	1.1E+04	3.2E+04	1.6E+04	2.4E+05	3.2E+04

Note: Unless otherwise documented, surface areas cover outside areas only

* Container only

^ Surface area for steam generator shell

+ Surface are for steam generator tubes

4. TOTAL OPERATIONAL AND REFURBISHMENT L&ILW INVENTORY FOR DISPOSAL

This section provides a summary of the waste volume and radiological inventory data presented in sections 2 and 3. The projected inventories are based on historical waste production rates, expected impact of waste minimization initiatives, and current plans to bring laid-up reactor units back to service (“Scenario B”).

4.1 TOTAL L&ILW VOLUME

Approximately 166,229 m^3 of stored volume (after processing by compaction and incineration as applicable and recovery of space occupied by backlogged wastes) of operational L&ILW and reactor refurbishment waste is expected to be generated from the committed nuclear program. Table 4.1 provides a summary of stored waste volumes for the major container groups. The projected volumes by waste type are depicted in Figures 4.1-4.3. The totals by this calculation are somewhat less than the stored volume reported by container type because of items such as filters, IX columns, and core components, which occupy a volume less than the liners and shields in which they are stored or projected to be stored in.

Table 4.1: Scenario B Forecast Container Stored Volume

Container Group	Stored Volume (m^3)
Boxed LLW	123,020
Boxed ILW*	9,969
Resin Liners	8,139
Tile Holes, Tile Hole Liners, T-H-E Liners, and ETHs	1,969
Heat Exchangers & Steam Generators	9,566
Retube Waste Containers	13,566
Total	**166,229**

* Comprised of shield plug containers and ILW shields

Table 4.2 summarizes the forecast L&ILW package inventory for disposal as it would arrive at the receiving area of the DGR. The table also documents the expected range of package sizes and weights. Figure 4.4 provides a breakdown of the wastes for disposal in the LLW and ILW rooms of the repository.

Assuming overpacking of 100% of ash bins, LL resin boxes, and ALW sludge boxes, and 10% of drum racks into LLW container overpacks, and packaging of 72% of the ILW resin liners, and IC-18 T-H-E, and IC-2 T-H-E waste generated after 2018 in concrete shields, then approximately 50,000 packages representing a gross disposal volume of about 196,000 m^3 will be sent to the DGR for disposal. This volume could be reduced by the incineration of compact bales which is expected to occur when available incineration capacity permits. Further reduction of the total volume may be possible through sorting and processing of the currently deemed “non-processible” portion of the waste, future adoption of advanced processing techniques or aggressive station waste minimization programs.

Similar to operational ILW resin liners, CANDECON IX resin liners are assumed to be packaged in cylindrical concrete shields if they fail to meet the dose rate limits for the DGR. This waste is included in the resin liner inventory.

After 2018, it is assumed that IC-18 T-H-E wastes will be packaged in ILW shields.

Large component wastes, such as heat exchangers and steam generators, are assumed to be low-level wastes for disposal purposes. However, in the future, some opportunities may be found to decontaminate and scrap some items. The remaining items would be size-reduced to pieces that meet physical constraints and/or weight limits of the repository material handling systems.

As part of reactor lifecycle management activities, some or all of the feeder pipes may require replacement. The current assumption is that replaced feeders will be cut into suitable lengths and packaged in non-processible waste containers. The packaged volume of feeder pipes is included in the non-processible waste totals.

Appendix E provides a description of each of the various DGR container and overpack types. There are currently in excess of 100 different waste containers that have been used for storage of L&ILW at the WWMF. For the purposes of this report, containers of similar design have been grouped and only containers typical of those found in each group have been listed. The individual container datasheets provide a description of the container including a picture and drawing, and physical, chemical, and radiological properties of the wasteform. The datasheets provide forecast package and waste inventories for “Scenario B” (the reactor life extension scenario) at 2018, and 2052.

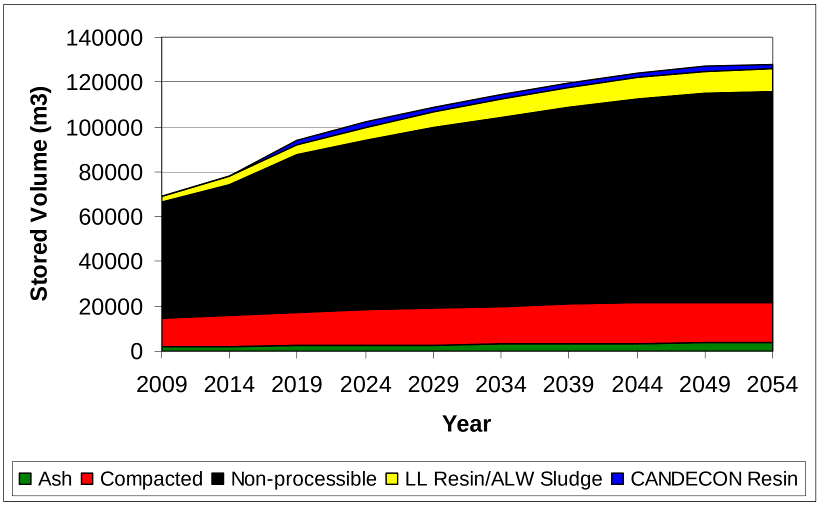


Figure 4.1: Annual Operational LLW Production Forecast

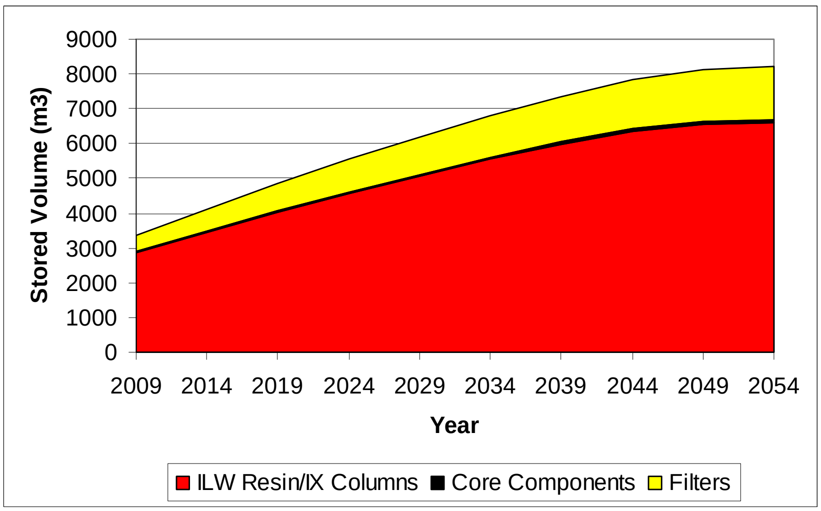


Figure 4.2: Annual Operational ILW Production Forecast

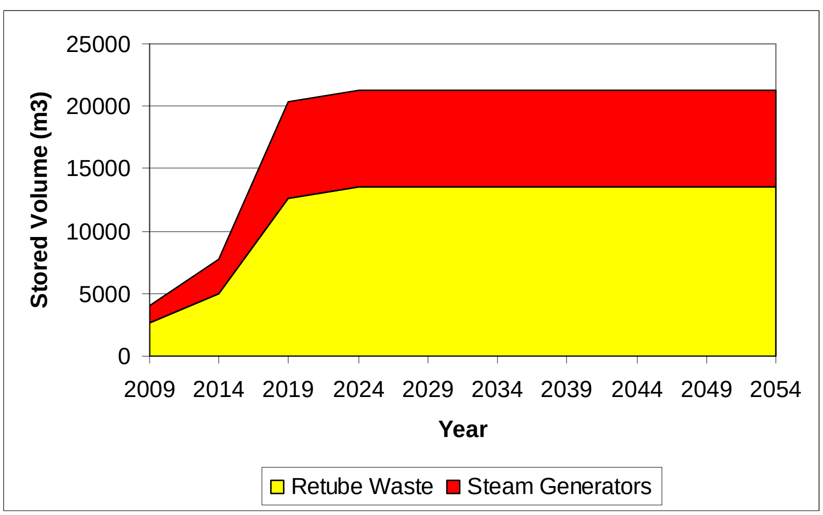
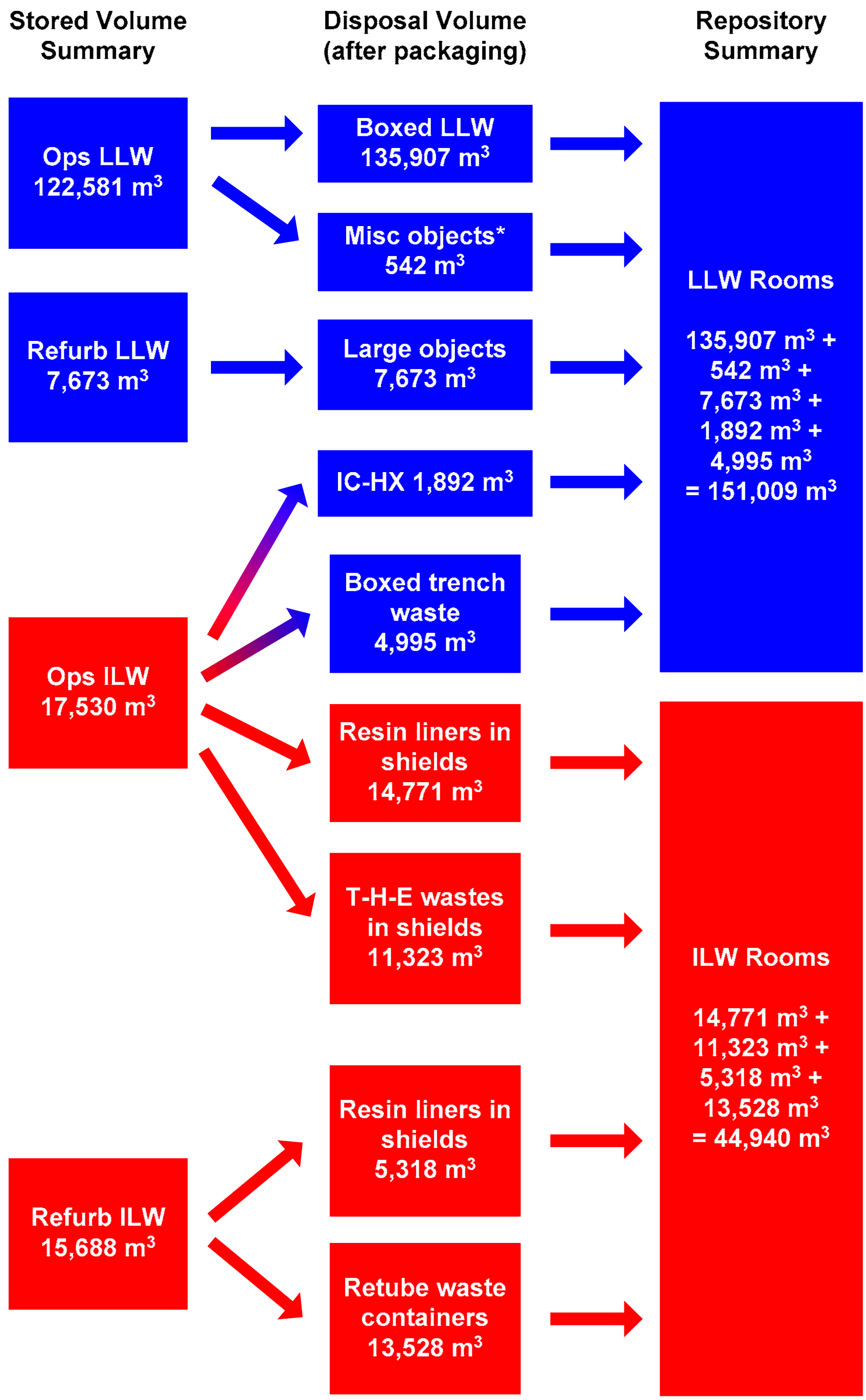


Figure 4.3: Annual Reactor Refurbishment Waste Production Forecast

Table 4.2: Operational and Refurbishment L&ILW Package Inventory for Disposal

Container Type	Number of Containers	Disposal Volume (m^3)	Dimensions LxWxH (m)	Empty Mass (kg)	Avg. Full Mass (kg)	Comments
Bale Racks	1,491	5,069	2.29 x 1.22 x 1.2	150	n/a	
Compactor Boxes	5,298	14,834	1.84 x 1.12 x 1.3	486	2,722	
Non-pro Bins (NPB47 example)	20,327	70,027	1.96 x 1.32 x 1.19	360	1,460	Includes miscellaneous LLW and miscellaneous trench ILW packed in NPB47.
Drum Racks	2,663	9,054	2.29 x 1.22 x 1.2	150	1,490	
Drum Bins	3,317	9,288	1.96 x 1.32 x 1.03	290	1,450	
LL Resin Pallet Tanks	2,126	5,820	1.24 x 1.24 x 1.68	320	2,000	
LLW Container Overpacks	3,141	26,699	2.54 x 1.78 x 1.88	1,591	5,400	Overpacking for 1,266 ash bins, 45 LL resin boxes, 1,534 ALW sludge boxes, and 296 drum racks.
Shield Plug Containers	9	111	3.0 x 1.8 x 1.8	13,000	26,000	Non-pro waste.
Heat Exchangers	82	1,892	Various	10,000 – 30,000	n/a	
Encapsulated Tile Holes	66	504	1.5 (OD) x 4.6 (OL)	n/a	25,000	
Resin Liners	359	1,077	1.63 (OD) x 1.8 (OL)	795	4,545	For Ops. IX and retube IX resin.
Resin Liner Overpacks	400	1,640	1.66 (OD) x 1.9 (OL)	1,450	6,000	
Resin Liner 250 mm Shield	718	11,600	2.2 (OD) x 4.24 (OL)	17,760	26,850	Two resin liners per disposal shield.
Resin Liner 350 mm Shield	182	3,664	2.4 (OD) x 4.45 (OL)	28,556	37,646	Two resin liners per disposal shield.
Resin Liner 350 mm Shield with Steel Insert	153	2,108	2.53 (OD) x 2.74 (OL)	24,420	28,965	One resin liner per disposal shield
IC-2 Liners	20	44	0.61 (OD) x 7.6 (OL)	1,000	4,500	
IC-18 T-H-E Liners	444	1,245	0.55 (OD) x 11.8 (OL)	1,400	3,600	
Tile Hole Liners	201	176	0.61 (OD) x 3.0 (OL)	450	2,000	
Retube Waste Container (RWC(EF) example)	1,376	13,566	1.70 x 3.35 x 1.92	29,200	33,500	For Bruce A, B, PNGS B, and DNGS retube waste.
Steam Generator Segments	512	7,673	1.8-3.6 (OD) x 2.0-4.3 (OL)	n/a	25,730	
ILW Shield	7,383	9,858	1.0 (OD) x 1.7 (OL)	2,015	2,290	To replace IC-18 T-H-E Shields after 2018, and provide shielding for IX columns and filters in trenches.
Total	50,268	195,949	-	-	-	



* Large objects plus encapsulated tileholes

Figure 4.4: L&ILW and Reactor Refurbishment Waste Volumes

4.2 TOTAL RADIOACTIVITY

Figures 4.5 and 4.6 approximate the decay rate of projected operational L&ILW and refurbishment wastes. The decayed inventories were calculated by summing up the incremental increase in radionuclide inventory on an annual basis, and decay correcting for each year. As depicted, the decay of the activity in ILW is much less pronounced than LLW after 2052. This is due to the presence of C-14 in ILW resins. In LLW, the dramatic decline in the inventory is due to decay of H-3 which has a significantly shorter half life than C-14.

The projected radioactivity, and stored volumes documented in the previous section were calculated using the L&ILW waste volume and characterization data contained in Nuclear Waste Management Division's Integrated Waste Tracking System [Anderson et al, 2005]. The application was developed by Idaho National Laboratory for OPG to integrate, store, track, and provide access to large amounts of waste inventory and characterisation data. The database was installed, commissioned, and placed successfully into production status in 2004.

Table 4.3 is a summary of dose rates associated with the major operational L&ILW types. The data are obtained from dose measurements at the surface of the various L&ILW storage containers as received at the WWMF. The data is especially relevant for controlling worker dose during the operational phase of the repository. Due to the practice of mixing bulk resin types for storage, a breakdown by resin type is not available. Resin liner shields, transfer bells for IC-2 and IC-18 T-H-E liners, ILW shields, and retube containers are expected to maintain surface dose rates below 2 mSv/h during transportation and storage.

In 2007, OPG successfully completed a project to overpack and report on the radiological data of 349 of the oldest carbon steel resin liners in ICs and trenches. Table 4.4 provides a summary of measured dose rates of resin liners as originally received and during the course of the remediation work.

Using the 2062 radionuclide inventory as a basis, the thermal power output from the DGR is estimated to be less than 2 kW at repository closure. The primary sources are Nb-94 (1.2 kW), Sr-90/Y-90 (0.14 kW), and Co-60 (0.12 kW).

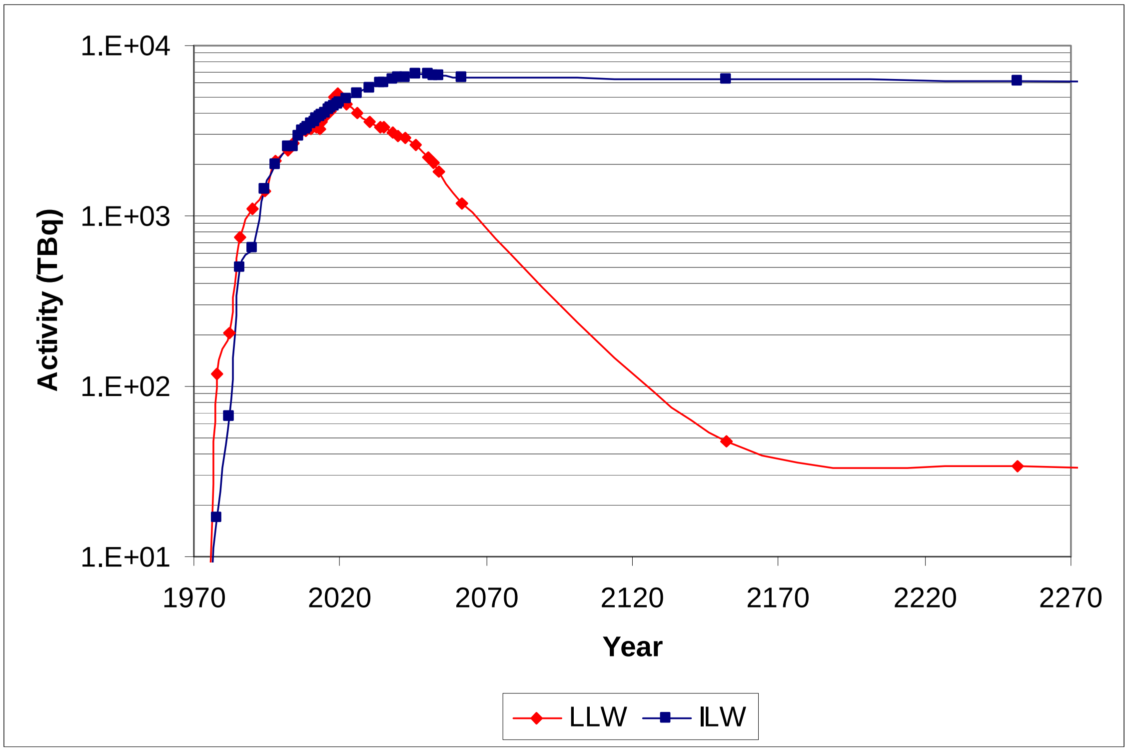


Figure 4.5: Decay Corrected Activity for Operational L&ILW

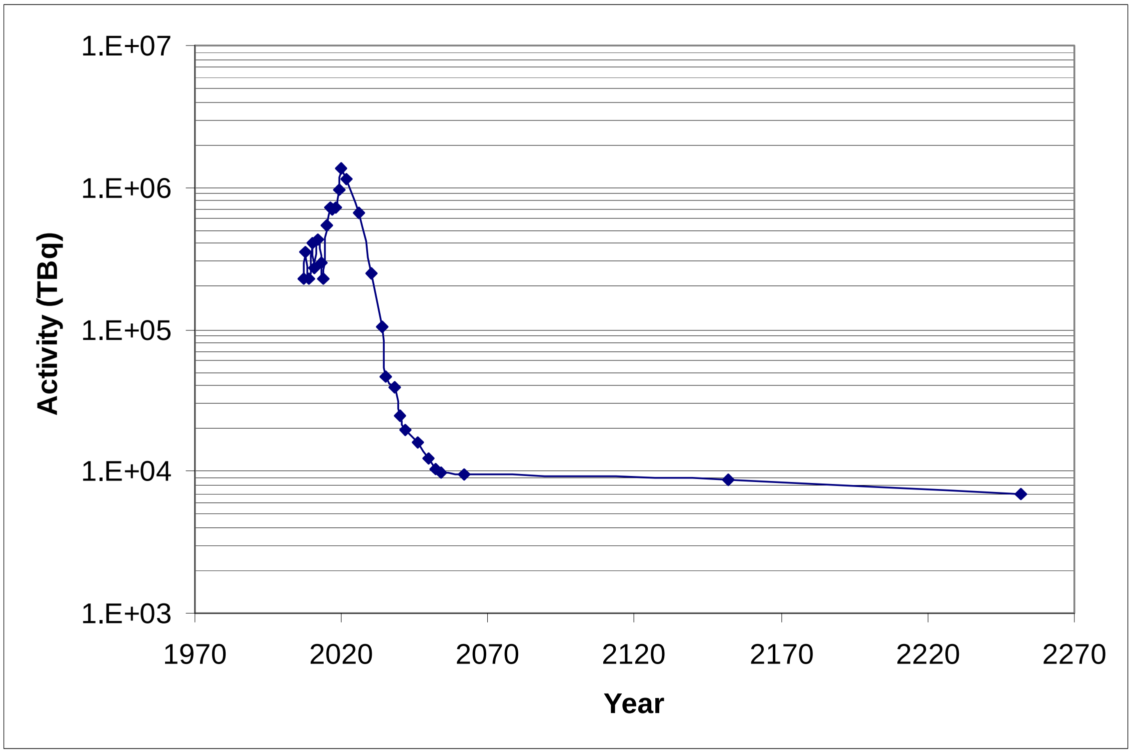


Figure 4.6: Decay Corrected Activity for Reactor Refurbishment Waste

Table 4.3: Summary of Waste Volume Fraction Handled by Waste Type and Dose Rate (As-received)

Contact Dose Rate (mSv/hr)	Volume Handled (m^3)	Overall LLW & ILW %	LLW								ILW						
			TOTAL LLW %	Ash %	Bales %	Box Comp. %	Incin. %	Non-pro %	Non-pro Drum %	LL Resin* %	TOTAL ILW %	CANDECON Resin %	ILW Resin %	Tile Hole Liners %	IX Columns %	Filters %	Misc ILW~ %
< 0.01	209,754	76.2%	77.1%	9.5%	24.6%	57.9%	91.1%	64.1%	70.7%	48.6%	5.5%	2.4%	7.0%	2.9%	2.6%	1.7%	0.0%
0.01 - 0.05	28,830	10.5%	10.8%	5.6%	25.4%	26.8%	5.9%	15.5%	13.8%	1.2%	0.9%	0.0%	0.8%	0.7%	3.1%	1.2%	0.0%
0.05 - 0.1	10,997	4.0%	4.1%	14.7%	12.7%	8.8%	1.4%	6.9%	4.9%	15.6%	3.0%	7.1%	3.5%	0.0%	1.6%	1.1%	0.0%
0.1 - 0.2	6,397	2.3%	2.3%	25.4%	9.7%	3.4%	0.7%	3.7%	2.4%	5.9%	2.1%	0.0%	2.6%	0.0%	1.2%	1.5%	0.0%
0.2 - 0.5	6,770	2.5%	2.5%	38.1%	11.6%	1.7%	0.5%	4.5%	2.2%	0.0%	5.0%	4.8%	6.1%	0.0%	4.5%	2.8%	0.0%
0.5 - 1	3,338	1.2%	1.2%	5.0%	7.5%	0.8%	0.2%	2.0%	1.6%	1.8%	4.3%	0.0%	4.5%	4.4%	4.2%	6.0%	0.0%
1 - 2	2,391	0.9%	0.8%	1.3%	4.9%	0.5%	0.3%	1.2%	1.0%	1.8%	3.7%	0.0%	3.6%	4.1%	3.9%	7.1%	0.0%
2 - 10	3,380	1.23%	0.99%	0.4%	3.1%	0.1%	0.0%	1.9%	2.9%	12.6%	22.6%	23.8%	21.4%	57.2%	15.8%	22.9%	0.0%
10 - 50	1,369	0.50%	0.12%	0.0%	0.4%	0.0%	0.0%	0.2%	0.4%	12.6%	28.5%	35.7%	31.4%	19.2%	18.7%	21.0%	18.3%
50 - 100	548	0.20%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.7%	23.8%	13.4%	5.8%	12.2%	13.5%	24.4%
100 - 500	349	0.13%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.2%	2.4%	4.9%	5.6%	21.7%	16.4%	37.2%
500 - 1000	51	0.02%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	0.0%	0.7%	0.0%	7.1%	3.5%	3.3%
1000 - 5000	22	0.01%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.1%	0.0%	3.1%	1.3%	5.7%
> 5000	985	0.36%	0.00%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.2%	0.0%	11.1%
Max. Dose Rate (mSv/hr)				5	40	3	4	30	90	30		200	1600	300	8000	5000	700000

Note: Data is as of December, 2005
* Includes ALW Resin and Sludge
~All other ILW e.g., core components

Table 4.4: Resin Liner Doses Rates "As Received" and After Decay*

Dose Rate (mSv/hr)**	"As-Received" (%)	Sept-Nov 2007 (%)
< 0.01	7.0	2.8
0.01-0.1	4.3	10.4
0.1-0.2	2.6	9.8
0.2-0.5	6.1	7.0
0.5-1	4.5	4.4
1-2	3.6	7.9
2-10	21.4	56.0
>10	50.5	1.6

* 30 cm from side
** As measured during resin liner retrieval program in 2007 at WWMF.

5. WASTE RETRIEVAL AND TRANSFER TO THE DGR

5.1 WASTE TRANSFER

All packages being transferred to the DGR from the WWMF will be shipped in a disposal-ready state on flat-bed transporters to the DGR Receiving Building adjacent to the Main Shaft of the DGR. At the Main Shaft, they will be off-loaded by forklift or mobile crane and placed into the staging area prior to being moved to the shaft cage. Waste movement will be monitored throughout the transfer process from the storage location to the DGR Receiving Building to ensure that the container being moved is free of loose radioactive surface contamination. All waste will be transferred in packages that meet the Waste Acceptance Criteria (WAC) for the DGR.

A detailed roster for the transferral will be drawn up prior to commencement of emplacement operations, which will take into account the storage locations and accessibility of the packages at the WWMF and the requirements for emplacement underground, so that groups of packages are delivered to the DGR Receiving Building in the correct order for transfer. While the emplacement room configurations have been designed to provide a certain amount of flexibility in stacking, it will still be important to define a detailed plan that recognizes uplifting and removal constraints at the WWMF as well as limitations on stacking underground.

The general steps in the handling of new waste receipts after the start of DGR operations would be as follows:

1. For LLW, receive waste at the Waste Volume Reduction Building and, where possible, volume reduce waste and then package for disposal. All wastes would be placed in disposal-ready packages, and then transferred to the DGR Receiving Building.

2. For ILW, deliver waste directly to the DGR Receiving Building. Resin liners will be removed from the transportation package and inserted into a concrete shield if necessary using a gantry crane. Tile hole equivalent liners will be transported in a shielded transfer bell secured in the cradle of a custom-made rail car, which will be mounted on a flat-bed truck. If waste is in a disposal-ready package, lift package from transport vehicle and transfer to staging area.

5.2 WASTE RETRIEVAL

The general steps in the retrieval of waste from existing storage locations at the WWMF are as follows:

1. Establish a protective environment around the area where the waste is to be retrieved.
2. For ILW, set up the lifting device to be used and connect the lifting attachments to the waste, and retrieve container. For LLW, retrieve waste containers with forklift.
3. Inspect waste containers to ensure that they meet the WAC for the DGR. Other activities such as attaching bar code tags, logging data into a tracking database, and selecting containers for further testing or analysis may also be performed at this time.
4. For LLW, containers may be staged inside Low Level Storage Buildings (LLSBs) for transfer to the DGR.

5. Lift the waste container and place either onto the transporter, or into its overpack or shielding container and then onto transporter.

The following sections provide more detailed information about how waste will be retrieved from each type of storage structure, packaged for disposal, and transferred to the DGR facility.

5.2.1 LLW CONTAINERS IN LLSBs

The LLSBs are warehouse-like structures where each building provides usable storage space for approximately 7,000 to 8000 m^3 of waste. The approximate building dimensions are 50 m long by 30 m wide by 8 m high. Wastes containers are stacked using conventional forklift type equipment. There are currently 10 LLSBs, with more planned to be built as required until the DGR is brought into service.

The LLSBs are used to store old and new style ash bins, compactor boxes, non-processible boxes, drums containing non-processible waste, resin and sludge boxes, resin pallet tanks, and miscellaneous large objects.

Containers will be retrieved from the LLSBs using a forklift similar to the ones used to place the containers into storage. The containers will be checked for radiation level before engaging the forklift as part of personnel radiation protection. Utilizing radiation protection measures appropriate to the circumstances, each container will be removed from its storage location, placed in a nearby area with space to allow access to all sides and will be surveyed for surface contamination and radiation level as well as being inspected for the condition of the container. Lids will be installed on open bin containers. If the container exhibits surface contamination or damage, it will be placed in a LLW container overpacks (see BINOPK in Appendix E).

For planning purposes, it is assumed that the following containers will be placed in LLW container overpacks at the time of retrieval to form a repository waste package:

- All ash bins
- All LL resin boxes
- All ALW sludge boxes
- 10% of drum racks

Shielded overpack containers will be used if the contact dose rates of the packages exceed the acceptable limit of 2 mSv/hr in a non-shielded overpack.

All other LLW containers in LLSB storage are assumed to be retrieved and transferred as is to the DGR. In other words these containers are assumed to meet DGR WAC, and are considered to be repository waste packages.

5.2.2 MISCELLANEOUS WASTES IN TRENCHES

There are two types of concrete trenches, a wide-type and a narrow-type. There are a total of 2 wide trenches and 13 narrow trenches with a combined storage capacity of 5,790 m^3. The wide trenches are approx 38 m long by 6.8 m wide and divided into 6 sections. The narrow trenches are approx 40 m long by 3.8 m wide and divided into 3 sections. Each trench has an internal depth of approximately 3 m. Each trench section has a removable concrete cover. There are no plans to construct more trenches. Although many of the trenches contain historic wastes similar to those now stored in LLSBs, they are now mainly used for large, heavy or otherwise difficult to handle objects such as scrap shielding casks or non-processible wastes requiring more shielding than can be provided by the LLSBs.

At the time of retrieval a large temporary frame and fabric structure will be erected over the trench area. The structure will be well ventilated with the exhaust passing through a HEPA filter to control the spread of dust or contamination. Wastes will be retrieved by removing the appropriate trench section cover and hoisting the individual waste item with a conventional mobile crane.

The containers will be checked for surface contamination and will be inspected for damage or degradation. If the inspection results are satisfactory and waste material in containers meet the WAC for the DGR, the container will be placed in a truck for direct transfer to the repository. If the container is damaged, it may be placed in an overpack or the contents may be repackaged into a new container.

Items that can be processed further by compaction or incineration will be transferred to the Waste Volume Reduction Building where they will be processed in accordance with established procedures. If items in the trenches are too large for transfer directly to the repository, they may be cut into smaller pieces and repackaged.

A similar process was utilized while transferring trench waste from RWOS1 to the Western Low and Intermediate Level Waste Storage Facility in 1992, 1997, and 1998. Where possible, many of the wastes were processed by compaction or incineration prior to re-storing.

The condition of the waste containers in trench storage is not known, therefore, for planning purposes, it is assumed that all trench wastes, with the exception of the large objects, will ultimately be repackaged into low level waste container overpacks.

5.2.3 RESIN LINERS IN QUADRICELLS

The above-ground Quadricells provide storage capacity for resin liners and filters. Each Quadricell is comprised of four independent, cylindrical, reinforced concrete shells with integral bottoms, contained within a cubic, reinforced concrete structure that is subdivided into four cells. This outer shell possesses its own integral bottom. The Quadricells are located above-ground, in line, back-to-back, covering an area 6.2 m wide by 83.2 m long. A conventional mobile crane was used to place the cylindrical steel liners inside inner concrete shells. Each shell is capped with a concrete plug. There are a total of 60 concrete shells in storage.

The Quadricells will be prepared for waste retrieval by cutting the weather-tight seals and clearing the threaded inserts in the Quadricell lids. Lifting eyes will be installed in a Quadricell lid and the lid will be removed using a crane, exposing the top of the concrete shell containing two liners. Plastic sheeting will be placed around the top of the Quadricell opening and along the movement path of the shell container to capture any dry or wet loose contamination. Lifting eyes will be installed in the shell container lid and the shell container will be lifted by the crane and placed on a low bed trailer adjacent to the Quadricell.

While resting on the trailer, the shell exterior will be checked for surface contamination and radiation level, and the surface of the shield will be inspected. If the shell meets the acceptance criteria, the shell and enclosed resin liners will be released as unit for movement to the repository using the low bed trailer.

5.2.4 RESIN LINERS IN IN-GROUND CONTAINERS

The In-ground Container (IC) design utilizes the natural shielding provided by the surrounding till. The structure possesses an inner and outer liner, both constructed from welded carbon steel pipe. There is an interspace between the inner retrievable resin liners and the outer fixed liner. This interspace is provided for routine water detection and dose rate monitoring as required. Outer liners are placed in a cylindrical hole made by vertical auguring of the soil. The annular space between the augured hole and outer liner is backfilled with a concrete material that encases the liner.

There are 20 IC-12s, each with a nominal capacity of 12 m^3, consisting of four 3 m^3 bulk resin liners stacked 4-high inside. The 3 m^3 resin liners are individually retrievable.

The current design of choice for ILW storage is the IC-18. There are currently 198 IC-18s: 33 are fitted as T.H.E. (see section 5.2.7 for details) and 165 are fitted for bulk resin storage. Additional IC-18s of both types will be constructed in the future as required. Similar to the IC-12, the bulk resin IC-18s contain individually retrievable 3 m^3 resin liners but they are stacked 6 liners high instead of 4 for the IC-12.

Currently, stainless steel liners are used, of identical dimensions to carbon steel liners. The oldest 400 carbon steel liners from IC-12s and IC-18s were recently packaged in stainless steel overpacks (see container code RLOPK in Appendix E) and re-stored (Pearson et al. 2008). A similar retrieval procedure could be used for the DGR as outlined below.

The first step in removing resin liners from ICs involves the removal of the concrete shield plug. A filtered fan will be used to withdraw air from the IC. The resulting inflow of fresh air assures that the IC interior environment will be safe from both industrial and radiological hazards.

An overhead/mobile crane with remote grapple will be used to attach to the resin liners for withdrawal from the IC. As the resin liner is withdrawn from the IC, radiation readings will be obtained using remote operated equipment. For the resin liners that require shielding, the crane will retrieve them from the ICs and place them into shields (see RLSHLD1, RLSHLD2, and RLSHLD3 in Appendix E), with either a single liner or two liners placed in a vertical stack inside each shield. After the liners are placed into the shield cylinder, the crane will be used to place the lid on the shield. The lid will then be bolted securely in place. The shield, which will have embedded forklift pockets cast into concrete, will be place on a flat-bed trailer adjacent to the IC.

For the liners that do not require shielding, the crane will be used to lift them out of the IC and onto a sacrificial forklift pallet, where they will be secured by locking mechanisms built-into the pallet. A light duty forklift will then be used to load them onto the flat-bed trailer for transfer to the DGR.

While resting on the trailer, the exterior of the liner/shield will be checked to verify satisfactory levels of surface contamination and radiation. Plastic sheeting will be installed on the ground surface to retain any loose contamination that might fall from the exterior of the package.

5.2.5 ILW IN TILE HOLES

Tile holes are an early (1970's) design used for storage of ILW. They are used for any wastes with dimensions compatible with tile holes, such as small filters and disposable ion-exchange columns. They are in-ground structures consisting of a pre-cast concrete pipe set on a concrete base. There are several variations in the details of construction of the concrete pipe and base. Shielding is provided by the surrounding backfill. There are a total of 224 tile holes.

Most tile holes incorporate a retrievable steel liner. The remaining tile holes are "grouted in place". With some variation, the tile holes are approximately 0.6 m inner diameter by 3.5 m deep.

5.2.5.1 Retrieval of Tile Hole Liners

There are a total of 181 tile holes with removable steel liners in in-ground storage at the WWMF. There are an additional 20 liners which have been retrieved and are currently stored in LLSBs and trenches.

At the time of waste retrieval, lean concrete or grout will be added to these liners to keep the contents in place and provide a shielding effect. Reinforcing will be used in the concrete at the top of the liner to assure the concrete is properly anchored to the liner. The prepared liner will be then be retrieved from the tile hole using a crane and will be placed on a low bed trailer adjacent to the tile hole location. Plastic sheeting will be installed on the ground surface to retain any loose contamination that might fall from the exterior of the liner.

While resting on the trailer, the exterior will be checked to verify satisfactory levels of surface contamination and radiation. Liners will then be released for transfer to the repository using the low bed trailer.

5.2.5.2 Retrieval of Grouted Tile Holes

There are 43 tile holes without liners at the WWMF. They are equipped with internal reinforcing cages to facilitate the grouting and removal of the tile hole. Concrete or grout was previously used to fill the empty spaces within the tile holes to form solid structures. The grouted tile holes will be removed by two possible methods.

The first method involves a larger steel pipe section or caisson that is driven or vibrated into the soil surrounding each tile hole to provide another layer of protection or encapsulation. The backfill material contained in the annulus between the tile hole and the larger pipe is vacuumed out using construction type vacuuming processes. The annulus is then filled with concrete, creating a monolithic package. A crane is used to lift the combined package and place it nearby for work to complete the processing for storage. Concrete is used to seal the bottom of the larger pipe, completing the encapsulation of the tile hole. The grouted tile hole can then be lifted with a crane and placed on a low bed trailer.

The second method involves loosening and removing the backfill surrounding the tile hole using construction excavation techniques including backhoe, hand shovelling and vacuuming. The grouted tile hole can then be lifted with a crane and placed on a low bed trailer. The exterior of the encapsulated tile hole will be inspected for surface contamination and radiation levels. After inspection the package will then be transferred to the repository.

The resultant repository waste package is identified as ETH in Appendix E. There are currently 66 ETH packages from RWOS1 stored in LLSBs.

5.2.6 IC-2 LINERS

There are currently 20 IC-2s, each with a nominal capacity of 2 m^3. The inner retrievable liner is approximately 0.6 m diameter by 7.6 m long. Similar to the tile holes, the IC-2s contain filters, ion-exchange columns, and similar small sized wastes.

The liners will be retrieved from the appropriate IC after grouting internally to stabilise the contents, utilising a shielded transfer bell. The shielded transfer bell is designed to be positioned vertically, using an overhead crane, above the open IC. The liner grappling tool, mounted through the top end cap of the transfer bell, will be lowered to engage the liner to be retrieved. The liner will then be retracted into the transfer bell and the articulated bottom end cap closed. The transfer bell with the liner inside will be rotated to the horizontal position and positioned and secured in the cradle of a custom-made rail car, which will already be mounted on a flat-bed truck that will be used for transport to the DGR Receiving Building.

5.2.7 IC-18 TILE-HOLE-EQUIVALENT (T-H-E) LINERS

There are currently 33 IC-18s fitted as T-H-E. The T-H-E IC-18s each contain 7 inner steel liners, 0.55 m diameter by 10.7 m deep. The liners were designed to be individually retrievable, and as a replacement for tile holes and IC-2s. They contain filter elements and vessels, disposable ion exchange columns, core components, and other miscellaneous wastes. Some liners are further subdivided into four quadrants, each containing a full length core component.

The T-H-E liners will then be retrieved and transferred to the DGR after grouting internally to stabilise the contents. The process will be similar to the method utilised for IC-2 liners.

After 2018, it is assumed that IC-18 T-H-E liners will not be utilized, and filter elements and vessels, disposable ion exchange columns, core components, and other miscellaneous wastes will be packaged in concrete shield boxes (see ILWSHLD in Appendix E) at the stations for shipment directly to the DGR.

5.2.8 IN-GROUND HEAT EXCHANGERS

The in-ground heat exchanger containers (IC-HXs) provide storage for scrap radioactive heat exchanger tube bundles from moderator, PHT and auxiliary systems from Ontario Power Generation stations. The diameter and depth of the augured holes can be altered to suit the various sized containers. More than one scrap radioactive heat exchanger tube bundle container may be stored in a single IC-HX. The radiation fields from the buried IC-HXs are shielded by crushed limestone backfill and the surrounding till.

Retrieval of the waste containers will be achieved by removing the crushed limestone, then hoisting or jacking the containers upwards. Some of the larger/heavier heat exchangers will be cut into 2 segments to allow transfer into the DGR. Seal plates will be welded onto the cut ends prior to transfer to the DGR.

5.2.9 RE-TUBE WASTE CONTAINERS IN STORAGE BUILDINGS

Two types of containers are currently used: one for volume reduced components (pressure tube, calandria tubes, and calandria tube inserts), or RWC(PT), and one for uncut end-fittings, or RWC(EF). The boxes are a steel-concrete-steel construction. The containers are stored in an above-ground warehouse type building, similar to the LLSBs. Subject to confirmation of shielding and heat load requirements, in principle all boxes could be stored in a single 30 m x 50 m storage building, when the RWC(EF)s are stacked 3 high and RWC(PT)s are stacked 2 high. For the Bruce retube waste, the RWCs will be transferred as is to the DGR by heavy forklift. RWCs stored at Pickering and Darlington will be placed in re-usable transport overpacks, one box per overpack, and transported to the WWMF. On arrival, they will be removed from the overpack and transferred to the DGR by heavy forklift.

5.2.10 STEAM GENERATORS IN STORAGE BUILDINGS

Steam generators from Bruce A are currently stored in an above ground warehouse building, similar to an LLSB and the Retube Waste Storage Building. Due to large size and heavy weight (and resulting transportation difficulties), current reference plans are based on storage at the site of origin. Prior to storage, the steam generators would be sealed and leak tested. They would be moved in on cradles with a multi-axled heavy load mover and rail-mounted hydraulic crane system [CH2MHILL, 2006]. At the time of station decommissioning, the steam generators would be retrieved and transferred from the storage building to a purpose-built processing facility located immediately adjacent to the building. At the processing facility, the steam generators will be off-loaded from the trailer with a gantry crane. Prior to sectioning, the steam generators will be filled with lightweight grout and then moved to the sectioning station. The purpose of the grout is to surround the tubes with a stable matrix and thereby prevent them from moving during and after the sectioning process. The steam generator will be sectioned with a diamond wire saw in a manner that results in segments of not greater than 35 tonnes that will fit within the currently proposed DGR hoist cage. The segments will have a 6.5 cm shield plate welded to each surface that was exposed by the sectioning process to produce a disposal ready package.

6. CONCLUSIONS

This report has presented the reference inventory and container characteristics for emplacement of operational L&ILW and refurbishment waste into the proposed DGR near the WWMF at the Bruce site. The forecasts are based on "Scenario B" which assumes refurbishment of all reactor units except Pickering A, with operation for a further 30 years after refurbishment. This scenario has the highest volume of waste among those presently considered for the current OPG nuclear program. Based on the currently stored waste and the Scenario B forecast, the following are some highlights regarding the characteristics of the L&ILW emplaced within the DGR:

- The projected total stored volume is approximately 166,000 m^3.
- The projected disposal volume of operational L&ILW and reactor refurbishment waste is approx. 196,000 m^3 (net volume of approx. 110,000 m^3), in 50,000 packages.
- Approximately half of the volume and number of operational L&ILW packages to be handled are comprised of "non-processible" waste.
- All ash containers, LL resin boxes, ALW sludge boxes, and 10% of drum racks containing drummed non-processible waste will be packaged in LLW container overpacks. Disposable concrete shields will be used for ILW resin liners that do not meet the dose rate limits for the DGR, and filters, IX columns, and core components generated after 2018.
- The total operational L&ILW radionuclide inventory is estimated to be 7.7×10^{15} Bq at the assumed repository closure (2062), attributed mostly to H-3, Sr-90, Cs-137, and C-14.
- The total inventory of steel in operational L&ILW container packages is estimated to be about 2.3×10^{7} kg. The weight of concrete shielding that will be required is 3.6×10^{7} kg.
- The total estimated inventory of steel in operational L&ILW is 7.5×10^{6} kg. The total organic component, consisting of cellulose and plastic materials and ion exchange resins, is estimated to be 2.9×10^{7} kg.
- Large component wastes such as steam generators and heat exchangers are assumed to be size reduced to pieces that meet physical constraints and/or weight limits of the repository material handling systems.
- The reactor refurbishment waste radionuclide inventory decays from 9.7×10^{17} Bq at 2018 to 8.6×10^{15} Bq at 2062.
- The principal radionuclides found in re-tube fuel channel waste are Zr-95, Nb-95, Fe-55, Co-60, and Ni-63 at 2018, and Nb-94, Co-60, C-14, Zr-93 and Ni-63 at 2062.
- The total inventory of steel associated with reactor refurbishment waste packages is estimated to be about 2.7×10^{7} kg.
- Total thermal decay power is estimated to be less than 2 kW at repository closure, most of which is attributed to retube waste containers.

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APPENDIX A: TECHNICAL ASSUMPTIONS

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A.1 GENERAL ASSUMPTIONS

(i) Forecasts include all L&ILW generated by the operation of OPG's nuclear reactors at Pickering, Bruce (now operated by Bruce Power), and Darlington and related facilities.

(ii) Pickering A Units 1 and 4, Pickering B, Bruce B, and Darlington continue to operate. Pickering A Units 2 and 3 will not be returned to service. Bruce A Units 3 and 4 were restarted in 2003. Bruce A Units 1 and 2 are assumed to be refurbished and restarted in 2008 and 2007, respectively.

(iii) Radioactive liquids, and decommissioning wastes are specifically excluded from the inventory. Radioactive liquids are assumed to be incinerated, and the resulting volume of ash is included in the ash inventory.

(iv) The waste generation and processing scenario(s) are based on Corporate and/or Divisional reference plans for number of operating units, and Waste Volume Reduction Building (WVRB) equipment life, enhancement, and/or replacement where available or applicable.

(v) Current volume reduction capacities are maintained as a minimum including incineration; Low Level Storage Building resorting, reprocessing and re-storing programs are maintained; continued processing of contaminated oil, and completion of RWOS#1 waste removal are assumed.

A.2 WASTE GENERATION SCENARIOS

Two scenarios for end-of-life dates are outlined in Table A-1. "Scenario A" is the proposed OPG Financial Reference Plan which excludes refurbishment and life extension of reactors except for Bruce A Units 1, 2, and 3, while "Scenario B" considers refurbishment of all reactor units (except Pickering A) with operation for a further nominal 30 calendar years after refurbishment. The decision to refurbish reactors will be made at an appropriate time in the future on a unit-by-unit basis.

The detailed assumptions for operational L&ILW and reactor refurbishment waste are:

(i) Stations produce no operational wastes after shutdown of the last unit. Any waste produced post shutdown is considered to be decommissioning waste.

(ii) The reactor operational LLW, following various minimization initiatives, will be generated at a rate of about 200 m^3 produced per reactor unit per year. The annual volumes of operational waste produced will reduce proportionately as the various units are permanently shutdown.

(iii) Non-processible, compactable, and incinerable components of LLW generally remain constant at 20%, 16% and 64%. Based on the waste received during the retubing of Pickering units in 1983-93, this ratio changes during the years that reactor retubing activities are being conducted to 33%, 10% and 57% for the units being retubed.

(iv) Reactor refurbishment is expected to produce an extra 500 m^3/unit/yr of LLW during the years that refurbishment is carried out.

(v) 30 m^3 of contaminated oil are received each year at the WWMF. Contaminated oil (including accumulated backlog) is incinerated.

(vi) Resin volumes (ILW) vary as a result of station resin consumption, including periodic CANDECON (and/or CANDEREM) campaigns, and the draw-down of station resin tanks. For the purpose of system planning, station resin tanks are assumed to remain at their Dec 2005 levels. Station tanks will be emptied and transferred to the WWMF in the year following station shutdown (Bruce stations where common tanks serve 4 units) or unit shutdown (Pickering and Darlington stations, where each unit has its own storage tank(s)). WWMF resin receipts will be based on historic average station resin

Table A-1: Forecasting Scenarios

Unit	Scenario A*			Scenario B*		
	Retubing	SG Replacement	End-of-life	Retubing	SG Replacement	End-of-life
Pickering A1	-	-	2021	-	-	2021
Pickering A2	-	-	2005	-	-	2005
Pickering A3	-	-	2005	-	-	2005
Pickering A4	-	-	2021	-	-	2027
Pickering B5	-	-	2014	2014-15	2014-15	2046
Pickering B6	-	-	2015	2015-16	2015-16	2047
Pickering B7	-	-	2014	2014-15	2014-15	2046
Pickering B8	-	-	2015	2015-16	2015-16	2047
Bruce A1**	2007-08	2007-08	2034	2007-08	2007-08	2034
Bruce A2**	2006-07	2006-07	2034	2006-07	2006-07	2034
Bruce A3**	2009-10	2009-10	2036	2009-10	2009-10	2036
Bruce A4**	-	2010-11	2017	2010-11	2010-11	2037
Bruce B5**	-	-	2011	2017-18	2017-18	2043
Bruce B6**	-	-	2011	2016-17	2016-17	2042
Bruce B7**	-	-	2012	2018-19	2018-19	2044
Bruce B8**	-	-	2013	2019-20	2019-20	2045
Darlington 1	-	-	2019	2018-19	-	2050
Darlington 2	-	-	2017	2019-20	-	2051
Darlington 3	-	-	2019	2019-20	-	2051
Darlington 4	-	-	2019	2020-21	-	2052

* conservative dates for long-term waste management planning purposes only. May differ from station lifecycle plans
** subject to Bruce Power operating plans

production. Future CANDECON/CANDEREM campaigns are expected to occur only in conjunction with reactor retubing operations.

(vii) Filters and IX columns (ILW) are received at the WWMF at a yearly rate equal to the historic average actual volumes received in past years. This is equivalent to the average station production levels (i.e. waste is shipped from the station as it is produced).

(viii) Total ILW is produced at an annual rate of 50 m^3/year total per four unit Bruce or Darlington station; 85 m^3/yr for 8 unit Pickering and then reduced consistent with station shutdowns, as in the case of LLW. The amount of ILW received at the WWMF will vary as per (vi).

(ix) Bruce A, Bruce B, Pickering B and Darlington are retubed (Pickering A was previously retubed in the 1980s/1990s). The assumed schedule is given in Table A-1, based on Pickering A style “large scale fuel channel replacement”.

(x) Bruce B CANDECON resin is stored in IC-18s (240 m^3 per reactor stored volume). No CANDECON is planned prior to the Bruce A retube.

(xi) Pickering (30 m^3 per reactor stored volume) and Darlington (240 m^3 per reactor stored volume) CANDECON resin will be shipped to the WWMF for storage in IC-18s.

(xii) Steam generators are assumed to be replaced in Bruce A, Bruce B, and Pickering B. No steam generator replacement is currently considered in the lifecycle plans for Pickering A or Darlington.

A.3 WASTE PROCESSING SCENARIOS

(i) Current volume reduction capacities are maintained, as a minimum, including incineration and compaction as well as continued processing of contaminated oil. Future programs may include LLSB resorting, reprocessing and re-storing and completion of RWOS #1 waste removal.

(ii) Annual incineration capability of at least 3,000 m^3 in 2008, 3,300 m^3 in 2009 and 3,500 m^3 in 2010 onwards at a volume reduction factor of 50:1, with the remainder of the processible LLW being compacted with a volume reduction factor of 5:1. The non-processible portion of the waste is packaged and stored, with a net volume increase of 0.8:1.

(iii) Incineration of oils started in 2003, with a net volume reduction factor of 100:1. The limit for oil incineration is included in the overall incinerator licensed limit of 2,272 kg/day. (The average processing rate for oils is assumed to be 60 m^3/yr.)

(iv) The effects of possible future installation of advanced waste processing equipment that may further reduce stored and disposed volumes are not considered.

(v) During the WVRB incinerator replacement outage, compactible and incinerable wastes were backlogged without processing (approx 5,500 m^3). During 2004, much of this waste was processed by compaction. It is assumed that any remaining backlogged wastes will also be processed. Other processible wastes previously backlogged (e.g. baled waste ~5,000 m^3 and oil ~650 m^3) will also be recovered and incinerated in the future when available incineration capacity permits.

(vi) All ash containers, low level resin boxes, and ALW sludge boxes, and 10% of all drum racks will be packaged in LLW container overpacks.

(vii) The Bruce irradiated component waste from retube will be packaged in “disposal ready” shielded boxes, and stored in an above-ground warehouse building(s) at the WWMF site. The boxes for volume reduced components (pressure tubes, calandria tubes, etc) are approx 1.85 m x 1.85 m x 2.25 m high external dimension, with a steel-concrete-steel construction. The walls contain approx 0.5 m of heavy concrete and the loaded weight is approx 30 tonnes. The containers for un-cut end fittings are of similar construction and loaded weight, with external dimensions of 1.70 m x 3.35 m x 1.92 m high and holding 16 end fittings. Approx 30 of the pressure tube style boxes and 60 of the end fitting style boxes are required per reactor unit.

(viii) Similar to the Bruce retubing waste, Pickering B and Darlington retubing waste is assumed to be packaged in “disposal ready” concrete boxes, stored in an above-ground warehouse building(s) at the PWMF and DWMF sites, respectively

(ix) Other wastes generated during reactor refurbishment, such as feeder pipes, insulation, miscellaneous hardware, etc, are packaged and handled similar to routine operational wastes.

(x) No extra processing/packaging is required with the exception of shielding of most of the ILW and overpacking of a small portion of the LLW such as incinerator ash. The estimates of the number of containers that will require overpacking is considered conservative.

A.4 WASTE CHARACTERISATION DATA

The waste radionuclide inventory, chemical and physical characterisation data, and scaling factors for “difficult to measure” radionuclides have been developed by Kinectrics Inc. and other groups (such as the CANDU Owners Group (COG) Working Party 49) over a period of many years [Husain, 2005a, 2005b].

Four types of radionuclide characterisation data have been developed:

(a) Average measured values - This data applies mostly for “easy to measure” gamma emitting radionuclides such as Co-60 and Cs-137. They are based on direct analysis of samples of different categories of wastes (incinerable, compactable, non-processible (bagged, drummed and boxed), ash from the old and new incinerators, bales, box compacted, IX resins);

(b) Scaling factors - This data applies for important but “difficult to measure” radionuclides (mostly for beta emitters such as C-14, Sr-90 and some alpha emitters such as Pu-238 and Pu-239/240). They are based on values obtained from detailed radiochemical analyses of waste samples for the radionuclide of interest and comparing it to “easy to measure” radionuclides. The ratio of the “difficult to measure” to the “easy to measure” radionuclide is used for estimating the “difficult to measure” radionuclide in wastes of a similar type, once the “easy to measure” radionuclide has been measured. In some instances, approaches based on theoretical modeling have been developed (e.g. I-129/Cs-137) to support the data obtained by experimental analysis; and

(c) Fuel inventory ratios – This applies for radionuclides that are potentially of interest (e.g. very long-lived) but are only present at low concentrations. They are based on the calculated ratios in the used CANDU fuel compared with other easier to measure radionuclides. Fuel inventory ratios are used where waste-specific scaling factors have not been developed. Reasonable agreement has been achieved between measured scaling factors and estimates from fuel inventory ratios for common radionuclide pairs (e.g. Pu-239/Cs-137) used in scaling factors.

(d) Activation calculations – This applies to refurbishment and other irradiated metals where the important radionuclides tend to be generated from neutron activation. The radionuclide inventories are calculated using ORIGEN-S or similar codes.

The radionuclide inventories in this report have been calculated based on the latest recommended specific activities, scaling factors, and radionuclide ratios in used fuel for individual radionuclides and waste categories.

APPENDIX B: SPECIFIC ACTIVITIES OF OPERATIONAL AND REFURBISHMENT L&ILW

Table B-1: Summary of Specific Activities of Operational LLW (As-received)

Nuclide	Half Life (yrs)	Estimated Specific Activity (Bq/m³)												
		Bottom Ash	Baghouse Ash	Bottom Ash(New)	Baghouse Ash(New)	Compact Bales	Box Compacted	Non-pro	Feeder Pipes*	Non-pro Other	Non-pro Drummed	LL Resin	ALW Resin	ALW Sludge
Ag-108m	1.3E+02	6.4E+02	4.9E+03	2.6E+02	2.5E+02	3.3E+02	4.0E+02	4.7E+02		4.7E+02	4.7E+02	1.4E+05	1.1E+02	7.8E+01
Am-241	4.3E+02	1.7E+05	1.6E+05	1.1E+06	2.8E+05	2.4E+05	3.0E+05	2.6E+04	9.6E+07	2.6E+04	2.4E+01	2.8E+07	1.4E+04	5.6E+03
Am-243	7.4E+03	3.2E+02	2.4E+02	1.1E+03	2.9E+02	3.3E+02	4.0E+02	3.3E+01		3.3E+01	3.8E-02	3.4E+04	1.9E+01	8.3E+00
C-14	5.7E+03	8.1E+06	3.0E+06	4.1E+06	9.2E+05	5.5E+06	6.7E+06	7.3E+05	3.3E+09	7.3E+05	1.5E+07	1.5E+10	6.3E+06	2.2E+06
Cl-36	3.0E+05	1.6E+02	4.1E+01	2.0E+02	1.0E+00	6.8E+01	8.3E+01	2.0E+01		2.0E+01	4.4E+01	2.7E+04	1.1E+01	5.3E+00
Cm-244	1.8E+01	4.9E+04	3.4E+04	1.2E+05	4.0E+04	1.1E+05	1.3E+05	7.9E+03	3.9E+07	7.9E+03	3.5E+00	4.8E+06	4.1E+03	2.0E+03
Co-60	5.3E+00	1.6E+08	4.1E+07	2.0E+08	1.0E+06	6.8E+07	8.3E+07	2.0E+07	1.4E+11	2.0E+07	4.4E+07	2.7E+10	1.1E+07	5.3E+06
Cs-134	2.1E+00	7.6E+06	5.1E+07	6.2E+05	5.9E+05	5.6E+06	6.8E+06	3.0E+05	3.4E+08	3.0E+05	2.8E+06	4.0E+09	7.4E+04	4.5E+06
Cs-135	2.3E+06	6.3E+01	4.8E+02	2.6E+01	2.4E+01	3.2E+01	3.9E+01	4.6E+01		4.6E+01	4.6E+01	1.4E+04	1.0E+01	7.7E+00
Cs-137	3.0E+01	6.1E+07	4.7E+08	2.5E+07	2.3E+07	3.1E+07	3.8E+07	4.5E+07	1.3E+09	4.5E+07	4.4E+07	1.3E+10	1.0E+07	7.4E+06
Eu-152	1.3E+01										4.4E+04	1.0E+06		
Eu-154	8.8E+00	2.8E+06	2.6E+06	8.9E+05		1.9E+06	2.3E+06		5.9E+08		4.8E+04	1.0E+06		
Eu-155	5.0E+00	6.3E+05				4.0E+05	4.9E+05					1.1E+07		
Fe-55	2.7E+00	1.0E+09	3.0E+08	1.2E+09	7.5E+06	2.6E+06	3.2E+05	9.6E+07	4.0E+11	9.6E+07	8.4E+07	3.4E+10	5.0E+07	1.8E+07
H-3	1.2E+01	2.5E+07		2.5E+07		2.3E+11	2.8E+11	3.0E+10		3.0E+10	6.1E+11	4.0E+11	1.3E+08	3.0E+09
I-129	1.6E+07	2.1E+01	1.6E+02	8.8E+00	8.2E+00	1.1E+01	1.3E+01	1.6E+01		1.6E+01	1.6E+01	4.7E+03	3.5E+00	2.7E-02
Nb-94	2.0E+04	1.4E+06		2.5E+06	2.0E+04	8.6E+05	1.0E+06				1.1E+05	1.5E+05		4.2E+04
Ni-59	7.5E+04	1.1E+06	2.1E+04	3.8E+03	1.4E+03	5.3E+03	6.5E+03	7.5E+03		7.5E+03	5.7E+03	1.6E+07	1.8E+03	9.0E+02
Ni-63	9.6E+01	1.5E+08	3.0E+06	1.9E+08	1.9E+05	7.5E+05	9.1E+05	1.1E+06	5.6E+08	1.1E+06	8.0E+05	2.5E+09	2.6E+05	1.3E+05
Np-237	2.1E+06	1.5E+01	1.2E+01	5.4E+01	1.4E+01	1.6E+01	1.9E+01	1.6E+00		1.6E+00	1.8E-03	1.6E+03	9.3E-01	4.0E-01
Pu-238	8.8E+01	6.4E+04	6.2E+04	3.2E+05	7.9E+04	5.0E+04	6.1E+04	5.4E+03	3.1E+07	5.4E+03	3.8E+00	6.9E+06	3.1E+03	1.3E+03
Pu-239	2.4E+04	1.0E+05	7.7E+04	3.5E+05	9.0E+04	1.0E+05	1.3E+05	1.0E+04	5.7E+07	1.0E+04	1.2E+01	1.5E+07	6.1E+03	2.6E+03
Pu-240	6.5E+03	1.5E+05	1.1E+05	5.1E+05	1.3E+05	1.5E+05	1.8E+05	1.5E+04	8.6E+07	1.5E+04	1.7E+01	2.2E+07	8.7E+03	3.7E+03
Pu-241	1.4E+01	2.6E+06	4.1E+06	2.2E+07	3.3E+06	4.0E+06	4.9E+06	5.4E+05	1.3E+09	5.4E+05	5.2E+02	3.8E+09	2.7E+05	1.2E+05
Pu-242	3.8E+05	1.5E+02	1.1E+02	5.1E+02	1.3E+02	1.5E+02	1.8E+02	1.5E+01		1.5E+01	1.7E-02	1.6E+04	8.8E+00	3.8E+00
Ru-106	1.0E+00	3.7E+07	1.7E+07	1.0E+06	5.4E+04	5.0E+07	6.1E+07	1.0E+06	1.3E+10	1.0E+06	7.0E+05	2.9E+06		
Sb-125	2.8E+00	1.6E+07	4.2E+07	8.9E+06	1.1E+06	1.2E+07	1.4E+07	7.8E+05	1.1E+09	7.8E+05	1.3E+06	1.9E+09		3.0E+06
Se-79	1.1E+06	2.2E+00	1.7E+01	9.1E-01	8.4E-01	1.1E+00	1.4E+00	1.6E+00		1.6E+00	1.6E+00	4.9E+02	3.6E-01	2.7E-01
Sm-151	9.0E+01	2.1E+02	1.6E+03	8.8E+01	8.2E+01	1.1E+02	1.3E+02	1.6E+02		1.6E+02	1.6E+02	4.7E+04	3.5E+01	2.6E+01
Sn-126	2.1E+05	3.3E+02	2.5E+03	1.4E+02	1.3E+02	1.7E+02	2.1E+02	2.4E+02		2.4E+02	2.4E+02	7.3E+04	5.5E+01	4.0E+01
Sr-90	2.9E+01	4.1E+07	4.0E+06	2.7E+07	2.3E+06	1.5E+06	1.8E+06	4.5E+05	1.2E+10	4.5E+05	8.4E+06	1.1E+09	6.8E+05	1.9E+05
Tc-99	2.1E+05	3.3E+01	8.3E+00	4.0E+01	2.1E-01	1.4E+01	1.7E+01	3.9E+00		3.9E+00	8.9E+00	5.4E+03	2.2E+00	1.1E+00
U-234	2.5E+05	1.6E+02	1.2E+02	5.8E+02	1.5E+02	1.7E+02	2.0E+02	1.7E+01		1.7E+01	1.9E-02	1.7E+04	9.9E+00	4.2E+00
U-235	7.0E+08	2.7E+00	2.0E+00	9.4E+00	2.4E+00	2.7E+00	3.3E+00	2.8E-01		2.8E-01	3.1E-04	2.9E+02	1.6E-01	6.9E-02
U-236	2.3E+07	3.1E+01	2.3E+01	1.1E+02	2.7E+01	3.1E+01	3.8E+01	3.2E+00		3.2E+00	3.6E-03	3.2E+03	1.8E+00	7.8E-01
U-238	4.5E+09	2.0E+02	1.5E+02	7.2E+02	1.8E+02	2.1E+02	2.5E+02	2.1E+01		2.1E+01	2.4E-02	2.2E+04	1.2E+01	5.2E+00
Zr-93	1.5E+06	1.0E+01	1.3E+00	2.4E+01	9.4E-02	3.5E+00	4.2E+00	2.2E+00		2.2E+00	7.3E-01	6.7E+01		3.8E-01
TOTALS	T-1/2 life >1 yr	1.5E+09	9.4E+08	1.7E+09	4.1E+07	2.3E+11	2.8E+11	3.0E+10	5.8E+11	3.0E+10	6.1E+11	5.0E+11	2.1E+08	3.0E+09
	incl. short lived	2.0E+09	1.0E+09	2.0E+09	4.4E+07	2.3E+11	2.8E+11	3.0E+10	5.8E+11	3.0E+10	6.3E+11	2.7E+12	2.1E+08	3.0E+09

Note: Data in black based on direct measurement. Data in blue and red based on scaling factors and used fuel ratios respectively.
Nuclides with half lives greater than 1 yr.shown only.

* Activities decay corrected back to feeder removal dates

Table B-2: Summary of Specific Activities of Operational ILW (As-received)

		Estimated Specific Activity(Bq/m^3)						
Nuclide	**Half Life (yrs)**	**Moderator IX Resin***	**PHT IX Resin***	**Misc. IX Resin***	**CANDECON Resin**	**IX Columns~**	**Irradiated Core Components+**	**Filters & Filter Elements**
Ag-108m	1.3E+02		5.6E+05	1.4E+05	1.2E+04	5.6E+05		1.6E+03
Am-241	4.3E+02		1.0E+05	2.8E+07	6.8E+07	1.0E+05		2.9E+07
Am-243	7.4E+03		1.2E+03	3.4E+04	5.2E+04	1.2E+03		4.2E+04
C-14	5.7E+03	2.7E+12	8.8E+10	1.5E+10	1.0E+08	8.8E+10	7.9E+10	7.7E+09
Cl-36	3.0E+05	3.4E+05	3.0E+03	2.7E+04	6.8E+03	3.0E+03		4.5E+03
Cm-244	1.8E+01		4.5E+06	4.8E+06	2.9E+07	4.5E+06		2.2E+08
Co-60	5.3E+00	5.1E+10	3.0E+09	2.7E+10	4.9E+10	3.0E+09	2.7E+12	4.5E+09
Cs-134	2.1E+00	4.1E+08	2.7E+10	4.0E+09	3.9E+08	2.7E+10		
Cs-135	2.3E+06		5.5E+04	1.4E+04	1.2E+03	5.5E+04		1.6E+02
Cs-137	3.0E+01	1.8E+08	5.3E+10	1.3E+10	1.2E+09	5.3E+10		1.5E+08
Eu-152	1.3E+01	1.2E+09	4.9E+09	1.0E+06	1.3E+07	4.9E+09		
Eu-154	8.8E+00	6.4E+08		1.0E+06	7.3E+08			
Eu-155	5.0E+00	4.8E+07		1.1E+07	2.4E+07			
Fe-55	2.7E+00	1.4E+10	3.5E+08	3.4E+10	2.0E+11	3.5E+08	1.4E+13	1.5E+10
H-3	1.2E+01	1.4E+11	1.1E+11	4.0E+11	7.5E+10	1.1E+11	4.7E+08	
I-129	1.6E+07		6.5E+04	4.7E+03	4.5E+01	6.5E+04		5.4E+01
Ir-192m	2.4E+02						2.2E+06	
Mo-93	3.5E+03						1.7E+07	
Nb-93m	1.4E+01						1.7E+10	
Nb-94	2.0E+04		1.1E+07	1.5E+05	1.7E+06	1.1E+07	2.1E+05	6.7E+07
Ni-59	7.5E+04	1.4E+07	5.9E+04	1.6E+07	1.5E+07	5.9E+04	1.0E+10	1.8E+06
Ni-63	9.6E+01	2.0E+09	8.2E+06	2.5E+09	2.2E+09	8.2E+06	1.7E+12	2.6E+08
Np-237	2.1E+06		5.9E+01	1.6E+03	2.9E+03	5.9E+01		2.0E+03
Pt-193	5.0E+01						2.7E+08	
Pu-238	8.8E+01		2.8E+05	6.9E+06	7.0E+06	2.8E+05		9.7E+06
Pu-239	2.4E+04		3.8E+05	1.5E+07	1.6E+07	3.8E+05		1.3E+07
Pu-240	6.5E+03		5.5E+05	2.2E+07	2.3E+07	5.5E+05		1.9E+07
Pu-241	1.4E+01		1.1E+06	3.8E+09	2.1E+09	1.1E+06		2.5E+07
Pu-242	3.8E+05		5.6E+02	1.6E+04	2.4E+04	5.6E+02		1.9E+04
Ru-106	1.0E+00	1.4E+09	1.3E+10	2.9E+06	8.1E+09	1.3E+10		
Sb-125	2.8E+00	9.9E+08	9.2E+08	1.9E+09	2.2E+09	9.2E+08	1.3E+13	2.2E+09
Se-79	1.1E+06	1.1E+01	1.9E+03	4.9E+02	4.6E+00	1.9E+03		5.6E+00
Sm-151	9.0E+01		1.9E+05	4.7E+04	4.0E+03	1.9E+05		5.4E+02
Sn-121m	5.5E+01						4.7E+10	
Sn-126	2.1E+05		2.9E+05	7.3E+04	7.0E+06	2.9E+05		8.3E+02
Sr-90	2.9E+01	1.4E+07	2.9E+08	1.1E+09	1.6E+07	2.9E+08	2.0E+08	1.0E+08
Tc-99	2.1E+05		2.1E+05	5.4E+03	2.3E+07	2.1E+05	1.6E+07	9.0E+02
U-234	2.5E+05		6.3E+02	1.7E+04	2.1E+09	6.3E+02		2.1E+04
U-235	7.0E+08		1.0E+01	2.9E+02	2.4E+04	1.0E+01		3.5E+02
U-236	2.3E+07		1.2E+02	3.2E+03	8.1E+09	1.2E+02		4.0E+03
U-238	4.5E+09		7.8E+02	2.2E+04	3.3E+04	7.8E+02		2.6E+04
Zr-93	1.5E+06	4.5E+02	1.9E+03	6.7E+01	4.5E+03	1.9E+03	2.5E+10	1.4E+03
TOTALS	**T-1/2 >1 yr**	**2.9E+12**	**3.0E+11**	**5.0E+11**	**3.7E+11**	**3.0E+11**	**3.2E+13**	**3.0E+10**
	incl. short lived	**3.6E+12**	**3.5E+11**	**2.7E+12**	**4.4E+11**	**3.5E+11**	**3.2E+13**	**6.0E+10**

Note: Data in blue, red, and magenta based on scaling factors, used fuel ratios, and neutron activation calculations respectively.
Data not highlighted based on actual measurements.
Nuclides with half lives greater than 1 yr.shown only.

* Activiities decay corrected back to the time resin was assumed to have been emptied into the station resin storage tanks

~ IX Columns are Pickering PHT IX resin waste form

\+ Based on 6 flux detectors per core component liner

Table B-3: Summary of Specific Activities of Reactor Refurbishment Wastes

Nuclide	Half Life (yrs)	Estimated Specific Activity (Bq/m^3)				
		Re-tube Waste Pressure Tubes*	Re-tube Waste End Fittings*	Re-tube Waste Calandria Tubes*	Re-tube Waste Calandria Tube Inserts*	Steam Generators[@]
Ag-108m	1.3E+02	8.0E+10	2.5E+08	6.6E+10	1.2E+09	2.3E+02
Ag-110m	6.8E-01	5.8E+09	3.8E+09	4.7E+09	2.7E+09	
Am-241	4.3E+02					5.9E+07
Am-243	7.4E+03					3.8E+04
C-14	5.7E+03	2.6E+12	1.8E+10	2.4E+11	9.5E+10	7.6E+07
Cl-36	3.0E+05	5.3E+09	1.9E+06	8.6E+08	8.6E+06	1.4E+04
Cm-244	1.8E+01					1.4E+07
Co-60	5.3E+00	1.3E+13	4.2E+13	1.1E+13	2.1E+14	1.2E+09
Cr-51	7.6E-02	2.9E+10	5.2E+11	1.2E+11	2.5E+12	
Cs-134	2.1E+00	2.3E+10	7.4E+08	4.0E+08	2.4E+09	1.9E+06
Cs-135	2.3E+06	1.4E+06	6.3E+01	2.5E+04	2.2E+03	2.2E+01
Cs-137	3.0E+01	4.2E+07	2.3E-01	8.1E+05	6.9E+02	2.2E+07
Eu-152	1.3E+01	5.1E-01		2.0E-01	4.0E-04	1.8E+06
Eu-154	8.8E+00	8.8E+03		3.7E+03	1.0E-01	1.6E+07
Eu-155	5.0E+00	5.6E+03		2.4E+03	4.4E-02	3.0E+07
Fe-55	2.7E+00	1.1E+14	8.7E+14	7.5E+13	4.6E+15	5.8E+09
Fe-59	1.2E-01	4.3E+11	4.5E+11	3.2E+11	2.7E+12	
H-3	1.2E+01	1.3E+10	1.9E+10	4.2E+09	3.1E+10	
I-129	1.6E+07	1.8E+03	1.4E+01	3.7E+02	6.8E+01	6.3E+00
Ir-192m	2.4E+02	5.6E+07	9.5E+01	2.5E+06	6.0E+04	
Mn-54	8.6E-01	4.8E+11	7.7E+12	2.4E+11	4.1E+13	
Mo-93	3.5E+03	1.5E+08	2.3E+08	1.3E+08	1.2E+09	
Nb-93m	1.4E+01	2.9E+11	7.7E+07	1.7E+11	4.1E+08	
Nb-94	2.0E+04	2.3E+13	1.9E+08	2.0E+09	9.1E+08	2.9E+05
Nb-95	9.5E-02	2.2E+15	1.9E+08	1.2E+15	2.0E+09	
Nb-95m	1.0E-02	1.1E+13	9.0E+05	6.5E+12	4.8E+06	
Ni-59	7.5E+04	1.4E+09	9.8E+09	2.0E+10	3.8E+10	2.0E+05
Ni-63	9.6E+01	5.4E+11	1.1E+12	7.4E+12	5.5E+12	2.9E+07
Np-237	2.1E+06					1.8E+03
Pt-193	5.0E+01	8.5E+10	3.5E+07	4.2E+09	2.2E-11	
Pu-238	8.8E+01					1.0E+07
Pu-239	2.4E+04					1.2E+07
Pu-240	6.5E+03					1.7E+07
Pu-241	1.4E+01					5.5E+08
Pu-242	3.8E+05					1.7E+04
Ru-106	1.0E+00	1.5E-04		1.4E-04	1.5E-07	8.4E+08
Sb-125	2.8E+00	3.1E+11	8.8E+10	1.5E+14	7.5E+10	2.1E+07
Se-79	1.1E+06	1.6E+07	9.1E+04	5.4E+07	1.5E+06	7.6E+01
Sm-151	9.0E+01	1.1E+02		4.5E+01	1.1E-02	7.6E+01
Sn-113	3.2E-01	5.3E+10	1.5E+10	2.7E+13	7.8E+10	
Sn-119m	8.0E-01	1.2E+12	2.3E+11	3.6E+14	1.2E+12	
Sn-121m	5.5E+01	1.4E+09	3.3E+08	9.0E+11	1.7E+09	
Sn-126	2.1E+05					1.2E+02
Sr-90	2.9E+01	1.4E+10	2.1E+01	6.6E+09	9.7E+02	1.8E+07
Tc-99	2.1E+05	9.6E+07	6.8E+06	4.7E+07	2.9E+07	2.8E+03
Te-123m	3.3E-01	2.2E+11	1.1E+09	8.4E+12	4.4E+10	
Te-125m	1.6E-01	7.6E+10	2.2E+10	3.6E+13	1.1E+11	
U-234	2.5E+05					1.9E+04
U-235	7.0E+08					3.2E+02
U-236	2.3E+07					3.6E+03
U-238	4.5E+09					2.4E+04
Zr-93	1.5E+06	6.9E+11	4.8E+04	4.0E+11	2.6E+05	3.8E+02
Zr-95	1.8E-01	9.6E+14	7.6E+07	5.5E+14	4.0E+08	
TOTALS	**T-1/2 >1 yr**	**1.5E+14**	**9.1E+14**	**2.4E+14**	**4.8E+15**	**8.7E+09**
	incl. short l'vd	**3.3E+15**	**9.2E+14**	**2.4E+15**	**4.8E+15**	**1.6E+10**

Note: Data in blue, red, and magenta based on scaling factors, used fuel ratios, and neutron activation calculations respectively.
Data not highlighted based on actual measurements.
Decay period of 270 days applied to retube wastes, but cooling period may be as long as 5 years before transfer to DGR

*Activated metal only, based on Pickering B retube components, decay corrected 270 days

[@] Activities based on Bruce A tube sections at shutdown

APPENDIX C: CHEMICAL AND PHYSICAL CHARACTERISTICS OF OPERATIONAL AND REFURBISHMENT L&ILW

Table C-1: Chemical Composition of L&ILW

Contaminant	Bottom Ash Old (µg/g)	Baghouse Ash Old (µg/g)	New Bottom Ash (µg/g)	New Baghouse Ash (µg/g)	Compacted* (µg/g)	Non-pro^ (µg/g)	Heat Exchangers (kg/unit)	CANDECON Resin (µg/g)	LL Resin & Misc. IX Resin (µg/g)	ALW Resin (µg/g)	ALW Sludge (µg/g)	PHT IX Resin/IX Columns (µg/g)	Moderator IX Resin (µg/g)	Core Components# (µg/g)
Aluminum	3.3E+04		4.2E+04	1.3E+03	2.5E+03	1.1E+04		1.2E+01	1.3E+02	1.2E+01	2.4E+01	7.3E+01	5.9E+00	
Antimony	1.0E+03		8.4E+02	9.1E+02	7.4E+01	2.7E+01		5.9E-02	2.7E-01	3.4E-02	7.9E-02	4.9E-01	4.3E-01	
Arsenic	1.2E+02		6.5E+00	4.2E+00	9.0E+00	3.4E+00		6.5E-01	1.7E+00	1.4E-01	2.0E-02	5.2E+00	2.8E-01	
Barium	3.0E+03		3.7E+03	4.4E+01	2.3E+02	8.4E+01		2.7E-01	1.4E+01	2.6E+01	1.3E+01	7.9E+01	5.9E+00	
Beryllium			1.5E+00	1.2E+00				3.6E-01	3.8E-01	1.2E-01	2.0E-02	1.2E+01	5.0E-01	
Bismuth			3.6E+00	3.2E+00				1.7E+00	2.1E-01	1.9E-02	2.0E-02	5.1E-01	5.0E-01	
Boron	5.5E+02		2.6E+02	3.5E+01	4.1E+01	1.5E+01	8.8E-02	4.1E+01	1.8E+02	5.0E-01	8.9E+00	2.5E+01	4.2E+02	
Bromine								1.0E-01	1.6E-01	5.0E+01				
Cadmium	6.2E+00		1.2E+01	1.8E+01	4.9E+02	1.8E+02		2.1E+00	2.0E+00	2.3E-01	3.8E-02	7.1E-02	7.1E+00	
Calcium	5.5E+04	4.0E+03	1.3E+05	3.0E+05	4.1E+03	3.3E+03	8.8E-02	1.1E+01	2.8E+03	2.1E+04	2.9E+02	9.1E+01	6.8E+01	
Cerium										5.0E-02			5.0E-02	
Carbon	1.1E+05	4.8E+05	3.4E+04	2.5E+05	3.0E+05	1.3E+04	2.0E+01	3.0E+05	3.6E+05	3.6E+05		3.6E+05	3.6E+05	
Cesium			6.3E-01	4.5E-01				1.0E-02	7.7E-02	1.1E-02	2.0E-02	5.6E-02		
Chlorine	4.0E+03	1.1E+05	2.4E+04	1.4E+05	5.3E+02	3.1E+03		6.7E-01	6.6E+01	1.7E+03		2.3E+02	6.2E+02	
Chromium	7.0E+03		3.7E+03	1.1E+02	5.2E+02	2.2E+04	3.1E+00	8.8E+00	7.9E+00	1.1E+00	2.8E-01	1.6E+01	1.3E+01	2.0E+05
Cobalt	1.2E+02		7.2E+01	5.2E+00	9.0E+00	3.3E+00		9.1E+00	2.3E+00	7.1E-01	3.2E-02	1.5E-01	6.1E-01	
Copper	2.3E+04		7.9E+03	1.9E+02	1.7E+03	1.1E+05	1.5E+04	6.9E+01	2.3E+03	6.4E+01	1.2E+00	1.4E+01	4.5E+02	
Fluorine													8.2E+01	
Gadolinium								6.7E-02	6.1E+00				2.7E+03	
Hydrogen														
Iodine								2.5E-02	4.6E-02	2.6E+01				
Iron	4.5E+04	4.0E+03	9.1E+04	2.7E+03	2.6E+05	1.8E+05	2.9E+03	1.8E+04	1.4E+03	8.9E+01	2.7E+01	3.5E+02	4.8E+02	1.0E+05
Lead	1.3E+04		1.1E+03	6.7E+02	9.6E+02	3.6E+04	8.6E+00	4.3E+01	7.1E+01	3.1E+00	7.5E-01	6.8E+00	5.6E+01	
Lithium			5.4E+01	7.4E+00				6.6E+00	1.4E+02	8.0E-01	1.9E-01	3.3E+03	2.4E+02	
Magnesium	8.0E+03		2.9E+04	4.0E+03	5.9E+02	5.3E+02	4.4E+00	5.3E+00	6.3E+02	2.2E+03	7.3E+01	2.1E+01	8.3E+00	
Manganese	4.0E+03		1.8E+03	9.1E+01	2.7E+03	1.4E+03	2.4E+02	2.7E+02	5.6E+01	1.6E+01	2.6E+00	5.6E+01	1.5E+01	
Mercury	2.0E+01		2.0E+00	4.4E-01	2.1E+00	7.5E-01		4.2E-02	2.4E-02	1.2E-01	2.0E-02	6.8E-02	3.8E-02	
Molybdenum			2.9E+02	2.5E+01				1.5E+00	2.8E+00	8.7E-01	2.7E-02	2.4E+01	1.6E+00	
Nickel	2.0E+03		1.4E+03	1.1E+02	1.5E+02	1.4E+03	6.6E+03	2.2E+03	2.4E+02	1.5E+01	2.4E+00	6.6E+00	2.8E+03	7.0E+05
Niobium	4.0E+01				3.5E+00	1.3E+00								
Nitrate ion	5.3E+04				3.9E+03	1.4E+03		5.2E-01	2.4E+01				3.8E+02	
Nitrogen								6.1E+03	2.0E+04	2.2E+04		2.0E+04	2.0E+04	
Oxygen								5.2E+05	4.8E+05	4.8E+05		4.8E+05	4.8E+05	
Phosphorus	3.0E+03	4.6E+04	1.7E+04	2.0E+03	1.3E+03	4.3E+03		7.8E+01	2.1E+02	3.3E+01	6.1E+00	1.0E+02	1.6E+02	
Potassium	3.0E+03		6.2E+03	1.6E+03	2.2E+02	9.5E+01		1.3E+02	8.0E+02	8.2E+01	6.5E+01	1.0E+02	2.2E+01	
Rubidium										9.6E-02				

Table C-1: Chemical Composition of L&ILW (cont'd)

Contaminant	Old Bottom Ash (µg/g)	Old Baghouse Ash (µg/g)	New Bottom Ash (µg/g)	New Baghouse Ash (µg/g)	Compacted* (µg/g)	Non-pro^ (µg/g)	Heat Exchangers (kg/unit)	CANDECON Resin (µg/g)	LL Resin & Misc. IX Resin (µg/g)	ALW Resin (µg/g)	ALW Sludge (µg/g)	PHT IX Resin/IX Columns (µg/g)	Moderator IX Resin (µg/g)	Core Components[#] (µg/g)
Scandium	4.0E+01												3.4E-02	
Selenium			1.0E+00	1.6E+01	3.5E+00	1.3E+00		3.4E-01	1.9E+00	3.1E-01	1.4E-01	5.0E-01	5.0E-01	
Silicon	3.6E+04	9.0E+03	8.3E+04	8.6E+03	2.6E+04	1.5E+05	1.5E+01	1.7E+01	7.9E+01	2.5E+01	6.3E+01	1.1E+02	1.5E+01	
Silver			3.2E+00	1.8E+00				5.8E-02	1.6E-01	3.7E-01	2.5E-02	1.1E-01	2.8E-01	
Sodium	6.0E+03	4.8E+04	1.3E+04	1.0E+04	5.5E+02	9.1E+03		8.9E+01	2.0E+03	5.3E+02	6.1E+03	2.0E+02	8.2E+01	
Strontium	1.0E+03		3.9E+02	1.6E+02	7.4E+01	3.4E+01		8.7E-02	2.3E+01	2.2E+02	3.2E+00	1.0E+00	3.3E-01	
Sulphur	2.0E+03	7.6E+04	1.2E+04	1.1E+04	3.5E+02	2.2E+03	4.2E+00	8.0E+04	3.1E+04	5.4E+04		3.3E+04	3.1E+04	
Tellurium	9.0E+01				6.9E+00	2.5E+00								
Thallium			2.2E-01	2.0E-01				4.7E-02	2.2E-02	1.5E-02	2.0E-02	5.0E-02	5.0E-02	
Thorium			9.3E+00	4.5E-01				7.7E-01	7.3E-02	1.5E-02	1.7E-02	5.0E-02	5.0E-02	
Tin			1.9E+02	5.8E+01				3.9E+00	1.0E+00	2.4E-01	6.6E-02	3.3E+00	1.0E+00	
Titanium	1.6E+04		5.9E+04	3.8E+02	1.2E+03	4.0E+03	1.8E+00	1.1E+00	2.2E+01	4.3E-02	5.1E-01	4.3E-01	1.1E-01	
Tungsten			1.1E+02	6.0E+00				7.4E-02	1.3E+00	4.3E-01	2.0E-02	5.0E+00	9.7E-02	
Uranium			4.1E+00	1.8E+00				1.1E+01	1.2E+00	1.1E-01	2.0E-02	1.1E+00	5.6E-02	
Vanadium			1.3E+02	1.4E+02				2.9E-02	1.4E+00	1.1E-01	2.0E-02	1.4E+00	5.0E-02	
Zinc	4.1E+04	5.1E+04	2.0E+04	3.8E+03	3.1E+03	2.5E+03	1.7E+02	3.5E+01	1.1E+03	5.0E+01	3.0E+01	3.8E+01	2.5E+02	
Zirconium	2.8E+02		1.5E+02	2.3E+01	2.0E+01	7.7E+00		3.3E-02	5.5E-01	1.6E-01	9.5E-02	1.1E-01	1.4E-01	
EDTA								2.6E+04						
PAH	2.3E+00	1.0E-01	2.3E+00	1.0E-01										
Cl-Benzenes & Cl-Phenols	3.3E+00	2.6E+01	3.3E+00	2.6E+01										
Dioxins & Furans	7.6E-02	7.9E-02	7.6E-02	7.9E-02										
PCB	2.0E-01	1.0E-01	2.0E-01	1.0E-01										
Total	4.7E+05	8.3E+05	5.8E+05	7.4E+05	6.1E+05	5.6E+05	2.5E+04	6.7E+05	5.7E+05	6.1E+05	6.7E+03	5.6E+05	5.6E+05	1.0E+06

Note: Data for filters not yet developed
Data for resins includes contribution from resin backbone comprised of C, H, O, N, S, 2% Other not included
Resin composition does not include water
*Includes box compacted and compact bales
^Includes feeder pipes, ETHs, and drummed non-pro waste
[#]Based on Pickering flux detectors

Table C-2: Pressure Tube Elemental Composition

Element	PPM	wt%	Partial density (g/cm^3)	Atomic Mass (mol)	Atomic Number	ORIGEN-S Input for 1Kg of material
Li	2.00E-03	2.00E-07	1.31E-08	6.94E+00	3	2.00E-06
Be	1.00E-03	1.00E-07	6.55E-09	9.01E+00	4	1.00E-06
B	7.00E-02	7.00E-06	4.58E-07	1.08E+01	5	7.00E-05
C	8.80E+01	8.80E-03	5.76E-04	1.20E+01	6	8.80E-02
N	5.40E+01	5.40E-03	3.54E-04	1.40E+01	7	5.40E-02
O	3.06E+03	3.06E-01	2.00E-02	1.60E+01	8	3.06E+00
F	1.70E-01	1.70E-05	1.11E-06	1.90E+01	9	1.70E-04
Na	4.50E-02	4.50E-06	2.95E-07	2.30E+01	11	4.50E-05
Mg	1.20E-01	1.20E-05	7.86E-07	2.43E+01	12	1.20E-04
Al	4.50E+01	4.50E-03	2.95E-04	2.70E+01	13	4.50E-02
Si	3.60E+01	3.60E-03	2.36E-04	2.81E+01	14	3.60E-02
P	9.00E+00	9.00E-04	5.89E-05	3.10E+01	15	9.00E-03
S	7.00E+00	7.00E-04	4.58E-05	3.21E+01	16	7.00E-03
Cl	6.00E+00	6.00E-04	3.93E-05	3.91E+01	17	6.00E-03
K	4.00E-02	4.00E-06	2.62E-07	3.91E+01	19	4.00E-05
Ca	3.00E-02	3.00E-06	1.96E-07	4.01E+01	20	3.00E-05
Sc	1.00E+00	1.00E-04	6.55E-06	4.50E+01	21	1.00E-03
Ti	9.00E+00	9.00E-04	5.89E-05	4.79E+01	22	9.00E-03
V	5.00E-01	5.00E-05	3.27E-06	5.09E+01	23	5.00E-04
Cr	4.70E+01	4.70E-03	3.08E-04	5.20E+01	24	4.70E-02
Mn	3.00E+00	3.00E-04	1.96E-05	5.49E+01	25	3.00E-03
Fe	4.94E+02	4.94E-02	3.23E-03	5.58E+01	26	4.94E-01
Co	3.00E-01	3.00E-05	1.96E-06	5.89E+01	27	3.00E-04
Ni	1.00E+01	1.00E-03	6.55E-05	5.87E+01	28	1.00E-02
Cu	7.00E+00	7.00E-04	4.58E-05	6.35E+01	29	7.00E-03
Zn	7.00E-02	7.00E-06	4.58E-07	6.54E+01	30	7.00E-05
Ga	1.00E-01	1.00E-05	6.55E-07	6.97E+01	31	1.00E-04
Ge	1.00E-02	1.00E-06	6.55E-08	7.26E+01	32	1.00E-05
As	4.00E-02	4.00E-06	2.62E-07	7.49E+01	33	4.00E-05
Se	4.00E-02	4.00E-06	2.62E-07	7.90E+01	34	4.00E-05
Br	4.00E-02	4.00E-06	2.62E-07	7.99E+01	35	4.00E-05
Rb	2.00E-01	2.00E-05	1.31E-06	8.55E+01	37	2.00E-04
Sr	6.00E-02	6.00E-06	3.93E-07	8.76E+01	38	6.00E-05
Y	2.00E-01	2.00E-05	1.31E-06	8.89E+01	39	2.00E-04
Zr	9.71E+05	9.71E+01	6.36E+00	9.12E+01	40	9.71E+02
Nb	2.50E+04	2.50E+00	1.64E-01	9.29E+01	41	2.50E+01
Mo	2.00E+00	2.00E-04	1.31E-05	9.59E+01	42	2.00E-03
Ag	1.00E+00	1.00E-04	6.55E-06	1.08E+02	47	1.00E-03
Cd	1.00E+00	1.00E-04	6.55E-06	1.12E+02	48	1.00E-03
In	3.00E+02	3.00E-02	1.96E-03	1.15E+02	49	3.00E-01
Sn	1.10E+01	1.10E-03	7.20E-05	1.19E+02	50	1.10E-02
Sb	1.00E+00	1.00E-04	6.55E-06	1.22E+02	51	1.00E-03
Te	4.00E-02	4.00E-06	2.62E-07	1.28E+02	52	4.00E-05
I	3.00E-03	3.00E-07	1.96E-08	1.27E+02	53	3.00E-06
Cs	4.00E-02	4.00E-06	2.62E-07	1.33E+02	55	4.00E-05
Ba	3.00E-03	3.00E-07	1.96E-08	1.37E+02	56	3.00E-06
La	2.00E-03	2.00E-07	1.31E-08	1.39E+02	57	2.00E-06
Ce	2.00E-03	2.00E-07	1.31E-08	1.40E+02	58	2.00E-06
Hf	3.80E+01	3.80E-03	2.49E-04	1.78E+02	72	3.80E-02
Ta	3.50E+01	3.50E-03	2.29E-04	1.81E+02	73	3.50E-02
W	7.00E+00	7.00E-04	4.58E-05	1.84E+02	74	7.00E-03
Pt	4.00E-02	4.00E-06	2.62E-07	1.95E+02	78	4.00E-05
Au	7.00E-03	7.00E-07	4.58E-08	1.97E+02	79	7.00E-06
Hg	3.00E-02	3.00E-06	1.96E-07	2.01E+02	80	3.00E-05
Tl	7.00E-03	7.00E-07	4.58E-08	2.04E+02	81	7.00E-06
Pb	2.00E+00	2.00E-04	1.31E-05	2.07E+02	82	2.00E-03
Bi	1.00E-02	1.00E-06	6.55E-08	2.09E+02	83	1.00E-05
Th	1.90E-01	1.90E-05	1.24E-06	2.32E+02	90	1.90E-04
U	3.00E-01	3.00E-05	1.96E-06	2.38E+02	92	3.00E-04
Sum	1.00E+06	1.00E+02	6.55E+00	-	-	1.00E+03

Table C-3: Calandria Tube Elemental Composition

Element	PPM	wt%	Partial density (g/cm^3)	Atomic Mass (mol)	Atomic Number	ORIGEN-S Input for 1Kg of material
Li	1.13E-03	1.13E-07	7.40E-09	6.94E+00	3	1.13E-06
Be	6.67E-04	6.67E-08	4.37E-09	9.01E+00	4	6.67E-07
B	4.00E-02	4.00E-06	2.62E-07	1.08E+01	5	4.00E-05
C	5.78E+01	5.78E-03	3.78E-04	1.20E+01	6	5.78E-02
N	8.50E+00	8.50E-04	5.57E-05	1.40E+01	7	8.50E-03
O	1.00E+03	1.00E-01	6.55E-03	1.60E+01	8	1.00E+00
F	7.83E-02	7.83E-06	5.13E-07	1.90E+01	9	7.83E-05
Na	2.00E-02	2.00E-06	1.31E-07	2.30E+01	11	2.00E-05
Mg	5.50E-02	5.50E-06	3.60E-07	2.43E+01	12	5.50E-05
Al	4.08E+01	4.08E-03	2.67E-04	2.70E+01	13	4.08E-02
Si	1.80E+01	1.80E-03	1.18E-04	2.81E+01	14	1.80E-02
P	4.67E+00	4.67E-04	3.06E-05	3.10E+01	15	4.67E-03
S	1.72E+00	1.72E-04	1.13E-05	3.21E+01	16	1.72E-03
Cl	1.32E+00	1.32E-04	8.64E-06	3.91E+01	17	1.32E-03
K	2.67E-02	2.67E-06	1.75E-07	3.91E+01	19	2.67E-05
Ca	2.33E-02	2.33E-06	1.53E-07	4.01E+01	20	2.33E-05
Sc	4.33E-01	4.33E-05	2.83E-06	4.50E+01	21	4.33E-04
Ti	4.83E+00	4.83E-04	3.16E-05	4.79E+01	22	4.83E-03
V	4.00E-01	4.00E-05	2.62E-06	5.09E+01	23	4.00E-04
Cr	3.62E+02	3.62E-02	2.37E-03	5.20E+01	24	3.62E-01
Mn	1.37E+00	1.37E-04	8.97E-06	5.49E+01	25	1.37E-03
Fe	5.83E+02	5.83E-02	3.82E-03	5.58E+01	26	5.83E-01
Co	3.00E-01	3.00E-05	1.96E-06	5.89E+01	27	3.00E-04
Ni	2.50E+02	2.50E-02	1.64E-03	5.87E+01	28	2.50E-01
Cu	3.50E+00	3.50E-04	2.29E-05	6.35E+01	29	3.50E-03
Zn	2.03E-01	2.03E-05	1.33E-06	6.54E+01	30	2.03E-04
Ga	8.17E-01	8.17E-05	5.35E-06	6.97E+01	31	8.17E-04
Ge	2.00E-02	2.00E-06	1.31E-07	7.26E+01	32	2.00E-05
As	8.50E-01	8.50E-05	5.57E-06	7.49E+01	33	8.50E-04
Se	2.50E-02	2.50E-06	1.64E-07	7.90E+01	34	2.50E-05
Br	9.00E-03	9.00E-07	5.89E-08	7.99E+01	35	9.00E-06
Rb	2.00E-02	2.00E-06	1.31E-07	8.55E+01	37	2.00E-05
Sr	1.67E-02	1.67E-06	1.09E-07	8.76E+01	38	1.67E-05
Y	5.33E-02	5.33E-06	3.49E-07	8.89E+01	39	5.33E-05
Zr	9.88E+05	9.88E+01	6.47E+00	9.12E+01	40	9.88E+02
Nb	3.83E+00	3.83E-04	2.51E-05	9.29E+01	41	3.83E-03
Mo	2.98E+00	2.98E-04	1.95E-05	9.59E+01	42	2.98E-03
Ag	1.50E+00	1.50E-04	9.82E-06	1.08E+02	47	1.50E-03
Cd	6.67E-01	6.67E-05	4.37E-06	1.12E+02	48	6.67E-04
In	1.33E+00	1.33E-04	8.71E-06	1.15E+02	49	1.33E-03
Sn	1.00E+04	1.00E+00	6.55E-02	1.19E+02	50	1.00E+01
Sb	1.33E+00	1.33E-04	8.71E-06	1.22E+02	51	1.33E-03
Te	1.33E-02	1.33E-06	8.71E-08	1.28E+02	52	1.33E-05
I	3.00E-03	3.00E-07	1.96E-08	1.27E+02	53	3.00E-06
Cs	1.33E-03	1.33E-07	8.71E-09	1.33E+02	55	1.33E-06
Ba	4.50E-03	4.50E-07	2.95E-08	1.37E+02	56	4.50E-06
La	1.00E-03	1.00E-07	6.55E-09	1.39E+02	57	1.00E-06
Ce	1.33E-03	1.33E-07	8.71E-09	1.40E+02	58	1.33E-06
Hf	5.58E+01	5.58E-03	3.65E-04	1.78E+02	72	5.58E-02
Ta	0.00E+00	0.00E+00	0.00E+00	1.81E+02	73	0.00E+00
W	5.50E-01	5.50E-05	3.60E-06	1.84E+02	74	5.50E-04
Pt	4.50E-02	4.50E-06	2.95E-07	1.95E+02	78	4.50E-05
Au	4.83E-02	4.83E-06	3.16E-07	1.97E+02	79	4.83E-05
Hg	2.33E-02	2.33E-06	1.53E-07	2.01E+02	80	2.33E-05
Tl	7.17E-03	7.17E-07	4.69E-08	2.04E+02	81	7.17E-06
Pb	3.50E+00	3.50E-04	2.29E-05	2.07E+02	82	3.50E-03
Bi	2.50E-01	2.50E-05	1.64E-06	2.09E+02	83	2.50E-04
Th	1.03E-01	1.03E-05	6.74E-07	2.32E+02	90	1.03E-04
U	1.33E+00	1.33E-04	8.71E-06	2.38E+02	92	1.33E-03
Sum	1.00E+06	1.00E+02	6.55E+00	-	-	1.00E+03

Table C-4: Calandria Tube Inserts Elemental Composition

Element	PPM	wt%	Partial density (g/cm^3)	Atomic Mass (mol)	Atomic Number	ORIGEN-S Input for 1kg of material
Li	5.00E-03	5.00E-07	3.90E-08	6.94E+00	3	5.00E-06
Be	2.00E-03	2.00E-07	1.56E-08	9.01E+00	4	2.00E-06
B	1.00E+00	1.00E-04	7.80E-06	1.08E+01	5	1.00E-03
C	1.10E+03	1.10E-01	8.58E-03	1.20E+01	6	1.10E+00
N	9.80E+01	9.80E-03	7.64E-04	1.40E+01	7	9.80E-02
O	9.10E+01	9.10E-03	7.10E-04	1.60E+01	8	9.10E-02
F	1.00E+00	1.00E-04	7.80E-06	1.90E+01	9	1.00E-03
Na	3.00E-02	3.00E-06	2.34E-07	2.30E+01	11	3.00E-05
Mg	2.00E+00	2.00E-04	1.56E-05	2.43E+01	12	2.00E-03
Al	1.70E+01	1.70E-03	1.33E-04	2.70E+01	13	1.70E-02
Si	3.30E+03	3.30E-01	2.57E-02	2.81E+01	14	3.30E+00
P	2.60E+02	2.60E-02	2.03E-03	3.10E+01	15	2.60E-01
S	8.90E+01	8.90E-03	6.94E-04	3.21E+01	16	8.90E-02
Cl	7.00E-02	7.00E-06	5.46E-07	3.91E+01	17	7.00E-05
K	3.00E-02	3.00E-06	2.34E-07	3.91E+01	19	3.00E-05
Ca	1.00E+01	1.00E-03	7.80E-05	4.01E+01	20	1.00E-02
Sc	2.00E-02	2.00E-06	1.56E-07	4.50E+01	21	2.00E-05
Ti	3.60E+01	3.60E-03	2.81E-04	4.79E+01	22	3.60E-02
V	4.10E+02	4.10E-02	3.20E-03	5.09E+01	23	4.10E-01
Cr	7.00E+04	7.00E+00	5.46E-01	5.20E+01	24	7.00E+01
Mn	4.70E+03	4.70E-01	3.67E-02	5.49E+01	25	4.70E+00
Fe	9.16E+05	9.16E+01	7.14E+00	5.58E+01	26	9.16E+02
Co	1.20E+02	1.20E-02	9.36E-04	5.89E+01	27	1.20E-01
Ni	1.70E+03	1.70E-01	1.33E-02	5.87E+01	28	1.70E+00
Cu	1.30E+03	1.30E-01	1.01E-02	6.35E+01	29	1.30E+00
Zn	7.00E+00	7.00E-04	5.46E-05	6.54E+01	30	7.00E-03
Ga	2.90E+01	2.90E-03	2.26E-04	6.97E+01	31	2.90E-02
Ge	1.30E+01	1.30E-03	1.01E-04	7.26E+01	32	1.30E-02
As	5.60E+01	5.60E-03	4.37E-04	7.49E+01	33	5.60E-02
Se	7.00E-02	7.00E-06	5.46E-07	7.90E+01	34	7.00E-05
Br	1.00E-02	1.00E-06	7.80E-08	7.99E+01	35	1.00E-05
Rb	2.00E-02	2.00E-06	1.56E-07	8.55E+01	37	2.00E-05
Sr	6.00E-02	6.00E-06	4.68E-07	8.76E+01	38	6.00E-05
Y	2.00E-02	2.00E-06	1.56E-07	8.89E+01	39	2.00E-05
Zr	1.30E+01	1.30E-03	1.01E-04	9.12E+01	40	1.30E-02
Nb	1.50E+01	1.50E-03	1.17E-04	9.29E+01	41	1.50E-02
Mo	4.00E+02	4.00E-02	3.12E-03	9.59E+01	42	4.00E-01
Ag	2.00E-01	2.00E-05	1.56E-06	1.08E+02	47	2.00E-04
Cd	1.00E-01	1.00E-05	7.80E-07	1.12E+02	48	1.00E-04
In	3.00E-01	3.00E-05	2.34E-06	1.15E+02	49	3.00E-04
Sn	2.80E+02	2.80E-02	2.18E-03	1.19E+02	50	2.80E-01
Sb	9.00E+00	9.00E-04	7.02E-05	1.22E+02	51	9.00E-03
Te	2.00E-02	2.00E-06	1.56E-07	1.28E+02	52	2.00E-05
I	3.00E-03	3.00E-07	2.34E-08	1.27E+02	53	3.00E-06
Cs	3.00E-03	3.00E-07	2.34E-08	1.33E+02	55	3.00E-06
Ba	4.00E-03	4.00E-07	3.12E-08	1.37E+02	56	4.00E-06
La	1.00E-02	1.00E-06	7.80E-08	1.39E+02	57	1.00E-05
Ce	3.00E-02	3.00E-06	2.34E-07	1.40E+02	58	3.00E-05
Hf	1.00E+02	1.00E-02	7.80E-04	1.78E+02	72	1.00E-01
Ta	0.00E+00	0.00E+00	0.00E+00	1.81E+02	73	0.00E+00
W	5.80E+01	5.80E-03	4.52E-04	1.84E+02	74	5.80E-02
Pt	2.00E-01	2.00E-05	1.56E-06	1.95E+02	78	2.00E-04
Au	4.00E-02	4.00E-06	3.12E-07	1.97E+02	79	4.00E-05
Hg	3.00E-02	3.00E-06	2.34E-07	2.01E+02	80	3.00E-05
Tl	8.00E-03	8.00E-07	6.24E-08	2.04E+02	81	8.00E-06
Pb	1.00E+00	1.00E-04	7.80E-06	2.07E+02	82	1.00E-03
Bi	4.00E-03	4.00E-07	3.12E-08	2.09E+02	83	4.00E-06
Th	5.00E-03	5.00E-07	3.90E-08	2.32E+02	90	5.00E-06
U	3.00E-03	3.00E-07	2.34E-08	2.38E+02	92	3.00E-06
Sum	1.00E+06	1.00E+02	7.80E+00	-	-	1.00E+03

Table C-5: End Fittings Elemental Composition

Element	PPM	wt%	Partial density (g/cm^3)	Atomic Mass (mol)	Atomic Number	ORIGEN-S Input for 1kg of material
Li	5.00E-03	5.00E-07	3.90E-08	6.94E+00	3	5.00E-06
Be	2.00E-03	2.00E-07	1.56E-08	9.01E+00	4	2.00E-06
B	1.00E+00	1.00E-04	7.80E-06	1.08E+01	5	1.00E-03
C	1.10E+03	1.10E-01	8.58E-03	1.20E+01	6	1.10E+00
N	9.80E+01	9.80E-03	7.64E-04	1.40E+01	7	9.80E-02
O	9.10E+01	9.10E-03	7.10E-04	1.60E+01	8	9.10E-02
F	1.00E+00	1.00E-04	7.80E-06	1.90E+01	9	1.00E-03
Na	3.00E-02	3.00E-06	2.34E-07	2.30E+01	11	3.00E-05
Mg	2.00E+00	2.00E-04	1.56E-05	2.43E+01	12	2.00E-03
Al	1.70E+01	1.70E-03	1.33E-04	2.70E+01	13	1.70E-02
Si	3.30E+03	3.30E-01	2.57E-02	2.81E+01	14	3.30E+00
P	2.60E+02	2.60E-02	2.03E-03	3.10E+01	15	2.60E-01
S	8.90E+01	8.90E-03	6.94E-04	3.21E+01	16	8.90E-02
Cl	7.00E-02	7.00E-06	5.46E-07	3.91E+01	17	7.00E-05
K	3.00E-02	3.00E-06	2.34E-07	3.91E+01	19	3.00E-05
Ca	1.00E+01	1.00E-03	7.80E-05	4.01E+01	20	1.00E-02
Sc	2.00E-02	2.00E-06	1.56E-07	4.50E+01	21	2.00E-05
Ti	3.60E+01	3.60E-03	2.81E-04	4.79E+01	22	3.60E-02
V	4.10E+02	4.10E-02	3.20E-03	5.09E+01	23	4.10E-01
Cr	7.00E+04	7.00E+00	5.46E-01	5.20E+01	24	7.00E+01
Mn	4.70E+03	4.70E-01	3.67E-02	5.49E+01	25	4.70E+00
Fe	9.16E+05	9.16E+01	7.14E+00	5.58E+01	26	9.16E+02
Co	1.20E+02	1.20E-02	9.36E-04	5.89E+01	27	1.20E-01
Ni	1.70E+03	1.70E-01	1.33E-02	5.87E+01	28	1.70E+00
Cu	1.30E+03	1.30E-01	1.01E-02	6.35E+01	29	1.30E+00
Zn	7.00E+00	7.00E-04	5.46E-05	6.54E+01	30	7.00E-03
Ga	2.90E+01	2.90E-03	2.26E-04	6.97E+01	31	2.90E-02
Ge	1.30E+01	1.30E-03	1.01E-04	7.26E+01	32	1.30E-02
As	5.60E+01	5.60E-03	4.37E-04	7.49E+01	33	5.60E-02
Se	7.00E-02	7.00E-06	5.46E-07	7.90E+01	34	7.00E-05
Br	1.00E-02	1.00E-06	7.80E-08	7.99E+01	35	1.00E-05
Rb	2.00E-02	2.00E-06	1.56E-07	8.55E+01	37	2.00E-05
Sr	6.00E-02	6.00E-06	4.68E-07	8.76E+01	38	6.00E-05
Y	2.00E-02	2.00E-06	1.56E-07	8.89E+01	39	2.00E-05
Zr	1.30E+01	1.30E-03	1.01E-04	9.12E+01	40	1.30E-02
Nb	1.50E+01	1.50E-03	1.17E-04	9.29E+01	41	1.50E-02
Mo	4.00E+02	4.00E-02	3.12E-03	9.59E+01	42	4.00E-01
Ag	2.00E-01	2.00E-05	1.56E-06	1.08E+02	47	2.00E-04
Cd	1.00E-01	1.00E-05	7.80E-07	1.12E+02	48	1.00E-04
In	3.00E-01	3.00E-05	2.34E-06	1.15E+02	49	3.00E-04
Sn	2.80E+02	2.80E-02	2.18E-03	1.19E+02	50	2.80E-01
Sb	9.00E+00	9.00E-04	7.02E-05	1.22E+02	51	9.00E-03
Te	2.00E-02	2.00E-06	1.56E-07	1.28E+02	52	2.00E-05
I	3.00E-03	3.00E-07	2.34E-08	1.27E+02	53	3.00E-06
Cs	3.00E-03	3.00E-07	2.34E-08	1.33E+02	55	3.00E-06
Ba	4.00E-03	4.00E-07	3.12E-08	1.37E+02	56	4.00E-06
La	1.00E-02	1.00E-06	7.80E-08	1.39E+02	57	1.00E-05
Ce	3.00E-02	3.00E-06	2.34E-07	1.40E+02	58	3.00E-05
Hf	1.00E+02	1.00E-02	7.80E-04	1.78E+02	72	1.00E-01
Ta	0.00E+00	0.00E+00	0.00E+00	1.81E+02	73	0.00E+00
W	5.80E+01	5.80E-03	4.52E-04	1.84E+02	74	5.80E-02
Pt	2.00E-01	2.00E-05	1.56E-06	1.95E+02	78	2.00E-04
Au	4.00E-02	4.00E-06	3.12E-07	1.97E+02	79	4.00E-05
Hg	3.00E-02	3.00E-06	2.34E-07	2.01E+02	80	3.00E-05
Tl	8.00E-03	8.00E-07	6.24E-08	2.04E+02	81	8.00E-06
Pb	1.00E+00	1.00E-04	7.80E-06	2.07E+02	82	1.00E-03
Bi	4.00E-03	4.00E-07	3.12E-08	2.09E+02	83	4.00E-06
Th	5.00E-03	5.00E-07	3.90E-08	2.32E+02	90	5.00E-06
U	3.00E-03	3.00E-07	2.34E-08	2.38E+02	92	3.00E-06
Sum	1.00E+06	1.00E+02	7.80E+00	-	-	1.00E+03

Table C-6: Material Constituents in Operational and Refurbishment L&ILW

Wasteform	**Material Characteristics (including percentage by mass unless stated)**
Old Bottom Ash	Coarse ash, heterogeneous (54 wt% > 9.5 mm).
Old Baghouse Ash	Fine ash, homogeneous (90 wt% < 0.8 mm).
New Bottom Ash	Light brown powder containing coarse materials. pH increasing < 9 in 1% ash in water to 11 in 29% ash in water.
New Baghouse Ash	Fine grey powder, with pH ranging from 12.1 -12.6 in ash-water mixtures.
Compacted Wastes (Baled and Boxed)	Paper 24%, Plastic 37%, Rubber 7%, Cotton 4%, Metal 15%, other organics 3%, other inorganics 10% (all % by volume).
Non-pro/Non-pro Drummed	Metal 33%, Inorganic and Organic Absorbent 14%, Paper 8%, Plastic 5%, Wood 7%, Cotton 3%, Rubber 2%, Glass 2%, Concrete 6%, other inorganic materials 19% (all % by volume).
CANDECON Resin	Polystyrenedivinyl benzene copolymer IX resin, approximately 0.5 mm in diameter, containing EDTA and other chelating agents as well as corrosion inhibitor.
LL Resin	Polystyrenedivinyl benzene copolymer IX resin, approximately 0.5 mm in diameter, containing granulated activated carbon and MACRONET polymer beads.
ALW Resin	Polystyrenedivinyl benzene copolymer IX resin, approximately 0.5 mm in diameter.
ALW Sludge	Sludge containing a clay-based flocculant, comprised of a blend of clay minerals, polymers and pH adjusting agents.
Moderator Resin	Styrene divinyl benzene resin with sulfonic acid groups on the cation and quaternary ammonium groups on the anion. Generally the anion portion contains nitrate (37 g/L), carbonate and borate, while cation portions can contain up to 30 g/L of gadolinium.
PHT IX Resin/IX Columns	Styrene divinyl benzene resin with sulfonic acid groups on the cation and quaternary ammonium groups on the anion. Generally the cation portion contains mostly iron and lithium, while the anion portion is mostly carbonate.
Core Components	Typical alloys such Inconel-600 or stainless steel (SS) 304L. PNGS SIR flux detector (cable and emitter) is 0.17 kg. PNGS “B” Vertical Flux Detector is 4.36 kg. PNGS “B” Horizontal Flux Detector is 5.85 kg.
Filters and Filter Elements	Stainless steel and carbon steel permanent vessels containing resin impregnated pleated paper, honeycomb-wound viscose elements, and epoxy impregnated fibreglass, and stainless steel disposable filters containing sintered stainless steel woven wire mesh. The proportions by mass or volume are not known.
Pressure Tubes	Zr-2.5%Nb alloy. Approx weight of each is 61 kg.
End Fittings	Stainless steel (SS-403). Approx weight of each is 163 kg.
Calandria Tubes	Zircaloy-2. Approx. weight of each is 23 kg.
Calandria Tube Inserts	Stainless steel (SS-410). Approx weight of each is 1.2 kg.
Feeder Pipes	Carbon steel
Heat Exchangers	Carbon steel shell, copper alloy tubes
Steam Generators	Inconel 600 tubes, carbon steel shell and shroud, and head and tubesheet.

Table C-7: Physical Properties of Wastes

Parameter	Dry bulk density (kg m^{-3})	Total porosity/void fraction[1] (-)	Initial moisture content (kg water/kg waste)
Old Bottom Ash	680	na	Na
Old Baghouse Ash	340	na	Na
New Bottom Ash	550 (1)	0.3	0.01 (13)
New Baghouse Ash	390 (2)	0.3 (9)	0.001
Compacted Wastes - Boxes	1,000	0.5	0.001
Compacted Wastes - Bales	770 (3)	0.5	0.001
Non-processible – Drums	500	0.4 (10)	0.001 (11)
Non-processible – Boxes	227	0.9	0.001
Non-processible – Other	670(4) 3,290 (5)	0.9 (4) 0.2 (5)	0.001
LLW Resin	750 (16)	0.42	0.44 - 0.48 (15)
ALW Resin	750 (16)	0.42	0.44 - 0.48 (15)
ALW Sludge	1120 (3)	0.3	0.01 (12)
Steam Generators	1,250 – 1,740(6)	0.9 (6)	0.001
CANDECON Resin	850 (16)	0.42	0.44 - 0.48 (15)
Moderator Resin	850 (16)	0.42	0.44 - 0.48 (15)
PHT Resin	850 (16)	0.42	0.44 - 0.48 (15)
Misc. Resin	850 (16)	0.42	0.44 - 0.48 (15)
Irradiated Core Hardware	880 (7)	0.9	0.001
Filters and Elements	880 (7)	0.9	0.1 (14)
Retube Waste	970 (8)	0.9	0.001

Notes:
(1) Based on 700 kg tare weight and 1.8 m^3 bin volume.
(2) Based on 1000 kg tare weight and 1.8 m^3 bin volume.
(3) Round-off.
(4) Heat exchangers.
(5) Encapsulated tile hole (included cement grout). Void space less due to grouting.
(6) Steam generators to be segmented into pieces; shell side to be grouted prior to cutting; liquid to be drained from the tube side; exposed surfaces of segments covered with shield plates. Density and void space data exclude grout.
(7) Based on containment in tile hole equivalent liners and tile hole liners
(8) Based on 160 kg per end fitting and 16 end fittings per box.
(9) Finer constituents than bottom ash. Porosity of sand ranges from 0.2 to 0.4.
(10) Contains granular fills and less void space.
(11) Expect to be dry, but wet wastes are drummed.
(12) Expect to be dry, since it is immobilised with polymer gel.
(13) May contain some moisture as ash is doused (for cooling) during loading of bins. Some of the moisture may evaporate during storage.
(14) Expect some moisture. Varies (>1% but <50%).
(15) Mostly interstitial (bead) water. Water is drained from the resins during transfer to the resin liners at the stations, but some water remains on the bottom of the liners.
(16) Based on dry resin.

APPENDIX D: UNCERTAINTIES ASSOCIATED WITH CONCENTRATIONS OF RADIONUCLIDES AND CHEMICALS IN OPERATIONAL AND REFURBISHMENT L&ILW

A semi-quantitative assessment of the uncertainties associated with the radionuclide and chemical characteristics of various waste streams is presented in this Appendix. The assessments in many instances refer to Log Dispersion (LD), which is defined as the Antilog of the standard deviation of the Log of the data. The dispersion serves as a measure of variability as it relates to the Log Mean (LM) value. The LM is calculated as the Antilog of the average Log value. The assessments for gamma activity, scaling factors, reactor retube wastes, and chemical composition are detailed in Tables D-1 to D-4 respectively.

The significant findings are summarized below:

D.1 Uncertainties in Gamma Activity Measurements

- The gamma activity of the new baghouse ash is significantly lower than that of the old baghouse ash. Limited additional characterization is warranted.

- Data for baled waste are the underlying basis for deriving the gamma activity of compacted waste. Because box compaction employs higher forces than were employed during past baling operations, contents of box compacted waste differ somewhat from those of the bales.

- There is some uncertainty associated with gamma activity measurements of both boxed and drummed non-processible (NP) wastes. The available database for these dominant and heterogeneous waste streams is relatively sparse.

- In general, resin and sludge wastes are very homogeneous compared to bulk compacted and NP waste streams. As such, their characterization needs are lower. However,

    - PHT and moderator resin data are based on Darlington's wastes. Pickering chemistry is controlled in much the same way as Darlington, so the characterization data is not expected to be significantly different. Absence of equivalent data for Bruce stations is a source of uncertainty, although CANDU reactors are generally operated with similar water chemistry.

    - Heavy water upgrader resins are exposed to both moderator and PHT heavy waters. This explains the significant dispersion (LD values) associated with Co-60 and Cs-137 activities for these resins.

D.2 Uncertainties in Scaling Factor Measurements

- The gamma activity of the new baghouse ash is significantly lower than that of the old baghouse ash. Because of the different characteristics of baghouse ash from the new incinerator, additional characterization of DTM radionuclides is recommended.

- Scaling factors for NP wastes are largely based on characteristics of boxed wastes. Their applicability to the wide variety of drummed wastes is uncertain.

- The C-14/H-3 ratio for incinerable waste is used as the basis for estimating tritium inventories in various bulk LLW. While this approach is basically sound, its validity has not been directly confirmed. Further, the ratio would strictly apply only to waste streams such as box compacted waste, where there is no pathway for out diffusion of tritium; it is conservative for other packages such as unsealed boxes of NP and baled wastes.

- In general, scaling factor data for all resins and sludge are limited. Even though up to 30 PHT and 28 moderator resin samples have been analysed, most of the DTM radionuclide results are restricted to C-14.

- Data for Pu-241 in all waste streams are limited. There are limited data for I-129, Cl-36 and Tc-99 in PHT, heavy water upgrader and moderator resins, but these are supplemented by model-based estimates. Their concentrations in other resin wastes are expected to be insignificant.

D.3 Uncertainties Associated with Reactor Refurbishment Waste Activities

- Activities from retube wastes are based on ORIGEN calculations. ORIGEN calculates radionuclides to within a factor of 3 in general (some exceptions), and Zr and Nb within 30% for a specific irradiation history. There is also some indication that the ORIGEN results are generally higher than actual inventories by a factor of 1 to 3.

- ORIGEN results for activated impurities are sensitive to assumed impurity levels. For example, Co-60 will be related to the amount of Co impurity in the pressure tube. The Pickering B ORIGEN calculations assume 0.3 ppm impurity, while previous measurements of Co in 6 Zr-Nb samples indicated impurity levels of less than 5 ppm. Inventory calculations for impurity-based species such as Co-60 will therefore be less accurate. The results for Zr and Nb, however, depend on the main alloying content and are therefore not sensitive to impurities.

- ORIGEN results for Bruce A, Pickering Units 1 and 2, and Pickering B were compared to see if there is significant variation between reactors, when scaled to the same exposure conditions. The results indicated little variation between reactors for the same source material. This report uses the ORIGEN results for Pickering B for pressure tubes which correspond to the average channel, but 25 Full Power Years (FPY). Average inventories will vary with the actual irradiation duration, which are likely less than the calculational 25 FPYs.

D.4 Uncertainties in Chemical Compositions

- The uncertainty in the elemental composition and the concentrations of various organics in the old baghouse ash cannot be assessed because of limited data.

- The levels of organics in the new bottom and baghouse ash have not been measured and may differ from the levels associated with the old ash.

- The elemental compositions of baled and compacted wastes are inferred from the elemental composition of ash. Carbon is estimated from the composition in Table C-6.

- The elemental composition data for both boxed and drummed NP wastes are subject to uncertainty. In particular, the levels of metals such as lead, mercury, cadmium, nickel, and some organics associated with specific types of NP wastes have been estimated but not measured.

- Composition data for filters and filter elements have not been developed.
- In general, composition data for various types of resins are well developed.

Table D-1: Uncertainties Associated with Gamma Activity Measurements

Waste Stream	Uncertainty in Measurement Data
Bottom Ash (old)	➢ Data based mostly on sampled ash ➢ LD < 5 for most nuclides
Bottom Ash (new)	➢ Data based on 6 samples ➢ Similar characteristics as old bottom ash ➢ LD < 5 for most nuclides
Baghouse Ash (old)	➢ Data based mostly on sampled ash; 3 drums assayed also ➢ LD < 5 for most nuclides
Baghouse Ash (new)	➢ Data based on 6 samples ➢ Characteristics differ significantly from those of old baghouse ash ➢ LD < 5 for most nuclides
Baled Waste	➢ Data based on assay of several bales ➢ LD < 5 for most nuclides
Compacted Waste	➢ Data based on assay results for bales; 7 compactor boxes also assayed ➢ LD < 5 for most nuclides
Non-processible (Boxes)	➢ Data based on assay results for several bags; 85 boxes also assayed ➢ LD < 5 for most nuclides
Non-processible Drummed	➢ Data based on assay results for 100 drums and dose rate data for 100 drums. However, drums contained a wide assortment of wastes. ➢ LD > 5 for dessicant, glass, hose, metals, miscellaneous, concrete, core samples, filters, solidified aqueous wastes ➢ LD < 5 for bagged waste, eddy current probes, floor sweeping compound, sludge/aquaset, solidified oil, solidified sludge
CANDECON cation resin	➢ Data based on several resin samples ➢ LD values for Co-60 and Cs-137 are < 5
CANDECON mixed bed resin	➢ Data based on several resin samples ➢ LD values for Co-60 and Cs-137 are < 5
LL Resin	➢ Data based on 7resin samples ➢ LD values for Co-60 and Cs-137 are 45 and 87 respectively
ALW Resin	➢ Data based on several resin samples ➢ LD values for Co-60 and Cs-137 are < 5
ALW Sludge	➢ Data based on 4 sludge samples ➢ LD values for Co-60 and Cs-137 are 6 and 23 respectively
PHT Resin	➢ Data based on several resin samples ➢ LD values for Co-60 and Cs-137 are < 5
Moderator Resin	➢ Data based on several resin samples ➢ LD values for Co-60 and Cs-137 are < 5
Fuelling Machine Filters	➢ Data based on 4 crud samples ➢ LD value for Co-60 is < 5

Table D-2: Uncertainties Associated with Scaling Factor Measurements

Waste Stream	Uncertainty in Scaling Factors (SF)
Bottom Ash (old)	➢ SFs based on up to 20 samples ➢ LD values are generally < 5; LD value for Ni-63 ~10 ➢ Pu-241 based on 1 measurement, LD < 10 assumed based on overall Pu variability
Bottom Ash (new)	➢ SFs based on 2 samples ➢ LD values are generally < 5 ➢ LD for Ni-63 ranges between 5-10
Baghouse Ash (old)	➢ SFs based on up to 10 samples ➢ LD values are generally < 5 ➢ Pu-241 based on 1 measurement, LD < 10 assumed based on overall Pu variability
Baghouse Ash (new)	➢ SFs based on 2 samples ➢ LD values generally < 5
Compact Bales	➢ See box compacted waste
Box Compacted	➢ SFs based on up to 25 samples ➢ LD values for Pu-239+Pu-240, C-14, Ni-63, Sr-90 are 5-10 ➢ LD values for other nuclides are < 5
Non-processible (Boxes)	➢ SFs based on up to 20 samples ➢ LD values for Pu-239+Pu-240, C-14 and Sr-90 are 5-10 ➢ LD values for other nuclides are < 5
Non-processible Drummed	➢ SFs based on up to 8 samples ➢ LD values for Pu-239+Pu-240 and Fe-55 are 5-10 ➢ LD values for other nuclides are < 5
CANDECON cation resin	➢ Insufficient data (1 value) to estimate LD values
CANDECON mixed bed resin	➢ Insufficient data (1 value) to estimate LD values
LL Resin	➢ SFs based on up to 7 samples ➢ LD values for Pu-239+Pu-240, Ni-63 and Sr-90 are 5-10 ➢ LD values for other nuclides are < 5 ➢ Insufficient data (1 value) for I-129 to estimate LD value
ALW Resin	➢ SF data available only for C-14 (11 samples) ➢ LD value for C-14 is 5-10
ALW Sludge	➢ SF data available only for C-14 (1 sample) ➢ Insufficient data (1 value) to estimate LD values
PHT Resin	➢ SFs based on 30 samples ➢ LD values are generally < 5 ➢ LD values for Fe-55 & Am-241 are 5-10
Moderator Resin	➢ SFs based on up to 28 samples ➢ Insufficient data to estimate LD values for Sr-90
Fuelling Machine Filters	➢ SFs based on 2 samples ➢ LD values for C-14, Fe-55 & Ni-63 are <5

Table D-3: Uncertainties Associated with Retube Wastes

Waste Stream	Uncertainty
Pressure Tubes (PT)	- Radionuclides were calculated using ORIGEN-S for Pickering B average-channel, 25 FPY, 270 days decay. - Comparison of ORIGEN calculations with measurements on Pickering Unit 2 PTs indicates agreement with factor of 1.5 for Mn-54, Zr-95, Nb-95, Sn-113, Sb-124, Hf-181; within factor of 3 for Co-60 and Sb-125; and factor of 10 for Ta-182, with calculations always similar to or larger than measured. (Aydogdu et al. 1989) - Actual exposure is variable, and less than 25 FPY by up to factor of 2 - Comparison of ORIGEN results for Zr and Nb isotopes between different reactors shows comparable results when put on same basis, so reactor-specific differences are small. - Zr-93 and Nb-94 inventory in this report is likely accurate to within factor of 3, and is likely overestimated.
End Fittings	- Radionuclides were calculated using ORIGEN-S for Pickering B average-channel, 25 FPY, 270 days decay. - Comparison of ORIGEN results with measured dose rates for Pickering Unit 2 end fittings showed agreement within factor of 2 at reactor side, and dropping off similar or faster in measurements than calculations (Aydogdu et al. 1989). - Actual exposure is variable, and less than 25 FPY by up to a factor of 2.
Calandria Tubes	- Radionuclides were calculated using ORIGEN-S for Pickering B average-channel, 25 FPY, 270 days decay. - Actual exposure is variable, and less than 25 FPY by up to a factor of 2.
Calandria Tube Inserts	- Radionuclides were calculated using ORIGEN-S for Pickering B average-channel, 25 FPY, 270 days decay. - Actual exposure is variable, and less than 25 FPY by up to a factor of 2.

Table D-4: Uncertainties Associated with Chemical Composition Measurements

Waste Stream	Uncertainty in Chemical Composition
Bottom Ash (old)	➢ Elemental composition data are based on more than 5 samples ➢ LD values for all elements are < 5 ➢ Data on organics based on 3 samples. Uncertainty for PAH high (LD ~10); uncertainty for other organics low (LD < 5)
Bottom Ash (new)	➢ Data based on 6 samples ➢ LD values for most elements are < 5 ➢ Data on organics have not been measured
Baghouse Ash (old)	➢ Elemental composition data are based on 1 sample. Hence uncertainty in the data is unknown. ➢ Data on organics based on 1 sample. Hence, uncertainty in the data is unknown
Baghouse Ash (new)	➢ Data based on 6 samples ➢ LD values for most elements are < 5 ➢ Data on organics have not been measured
Compact Bales	➢ Elemental data are based on elemental composition of ash. No direct measurements have been made. ➢ Physical composition based on principal materials present in the waste has been quantified; some variability from mean composition is expected.
Box Compacted	➢ Data are based on elemental composition of ash. No direct measurements have been made. ➢ Composition based on principal materials present in the 'old' compactable waste has been quantified; some variability from mean composition is expected. ➢ Composition of the 'new' compactable waste has not been quantified; metal content is expected to be higher than that present in baled waste.
Non-processible (Boxes)	➢ Elemental composition data deduced from an estimated mean composition for boxed and drummed non-processible wastes. This data is subject to great uncertainty. ➢ The amount of lead in the form of shielding blankets and sheeting is uncertain ➢ Physical composition based on principal materials present in the waste has been quantified (several bags examined); however, significant variability from mean composition is expected because of the heterogeneity of the waste stream. ➢ The quantities of toxic metals such as mercury, cadmium, nickel and some organics associated with fluorescent lamps and batteries are expected to be small, but will be estimated in a future revision

Table D-4: Uncertainties Associated with Chemical Composition Measurements (cont'd)

Waste Stream	Uncertainty in Chemical Composition
Non-processible Drummed	➢ Elemental composition data deduced from an estimated mean composition for boxed and drummed non-processible wastes ➢ The amount of lead in the form of shielding blankets and sheeting is estimated but uncertain ➢ Physical composition based on principal contents of 200 drums has been quantified; however, significant variability from mean composition is expected because of the heterogeneity of the waste stream.
CANDECON cation resin	➢ Elemental data has been determined for one sample. However, such data have also been estimated from plant data measured during the decontaminations. ➢ Uncertainty for most elements from measured elemental data is expected to be within a factor of 5 ➢ Overall reagent loadings on combined cation and mixed bed resins are reasonably well known
CANDECON mixed bed resin	➢ Elemental data has been determined for one sample. However, such data have also been estimated from plant data measured during the decontaminations. ➢ Uncertainty for most elements from measured elemental data is expected to be within a factor of 5 ➢ Overall reagent loadings on combined cation and mixed bed resins are reasonably well known
LL Resin	➢ Elemental data have been determined for 4 samples ➢ LD values for most elements are < 5
ALW Resin	➢ Elemental data have been determined for 8 samples ➢ LD values for most elements are < 5
ALW Sludge	➢ Elemental data have been determined for 3 samples ➢ LD values for most elements are < 5
PHT Resin	➢ Elemental data have been determined for 28 samples ➢ LD values for most elements are < 5
Moderator Resin	➢ Elemental data have been determined for 21 samples ➢ LD values for most elements are < 5
Filters	➢ No composition breakdown presently available
Steam Generators, Heat Exchangers	➢ Composition based on primary metal types used for shell and tube side

APPENDIX E: REFERENCE DGR CONTAINER DATA SHEETS

Existing storage containers:

- AIBO2 – old style ash bin
- AIBN – new style ash bin*
- BRACK – bale rack
- B25 – green bin compactor box*
- NPB4 – 4 high stacking, old style non-pro blue bin
- NPB47 – 47”, new style non-pro blue bin*
- DRACK – old style drum rack
- DBIN – new style drum bin*
- RB90 – old style LL resin box
- RTK – LL resin pallet tank*
- NPBSB – ALW sludge box*
- SPC – shield plug box
- HX – heat exchanger (from IC-HX)
- ETH – encapsulated tile hole
- RL - 3m^3 resin liner
- RLOPK – resin liner overpack
- THLIC18 – IC-18 tile-hole-equivalent liner
- THLIC2 – IC-2 tile-hole-equivalent liner
- THLSTG3 – tile-hole-liner
- RWC(EF) – retube end-fitting box*
- RWC(PT) – retube pressure tube box*

Future DGR-specific containers:

- BINOPK - LLW container overpack for AIB02, AIBN, RB90, NPBSB, and DRACK containers
- RLSHLD - 3m^3 resin liner shield container (for RL and RLSS, 2 liners per shield)
- THESHLD - IC-18 tile-hole-equivalent liner shield container (for THLIC18, one liner per shield)
- SGSGMT - Steam generator segment (cut up SG)
- ILWSHLD - ILW shield (replaces tile-hole-equiv IC-18 once DGR in service)**

* default container for future waste arisings (2006 onwards)

** default container for post 2018 waste arisings

Note: Container datasheets provide nominal descriptions and are for information only, and may vary from container to container. All waste inventory calculations are based on the actual data recorded in IWTS, and on future forecasts.

Container Description

Container name: Ash Bin (Old)*
IWTS container code: AIBO2
CATID: 216422

Dimensions (m): 2.29 L x 1.22 W x 1.47 H
External surface area (m^2): 15.9

Gross volume (m^3): 4.2
Net internal volume (m^3): 3.4

Material: galvanized mild steel, 2.6 mm thick (12 ga.)

Empty mass (kg): 681
Avg full mass (kg): 2,950

Stackability: 5 high
Handling: forklift pockets

Waste Properties

Typical contents: incinerated incinerable waste

Typical composition: bottom ash

Potential hazardous constituents: dioxins, furans, chlorinated benzenes, PCBs, PAHs

Avg waste density (kg/m^3): 680

Contact Dose rate (mSv/h): <0.01: 9.5%; 0.01-0.05: 5.6%; 0.05-0.10: 14.7%; 0.10-0.20: 25.4%; 0.20-0.50: 38.1%; 0.50-1: 5.0%; 1-2: 1.3%; 2-10: 0.4%; >10: 0.0%

Specific activity (Bq/m^3): 1.9E+09

Forecast Inventory*

	To 2018	**To 2052**
Number of containers:	316	316
Total gross volume (m^3):	1,215	1,215
Net internal volume (m^3):	935	935

Ref

Dwg # n/a

*entire forecast inventory to be packaged in LLW container overpacks (BINOPK)

no drawing available

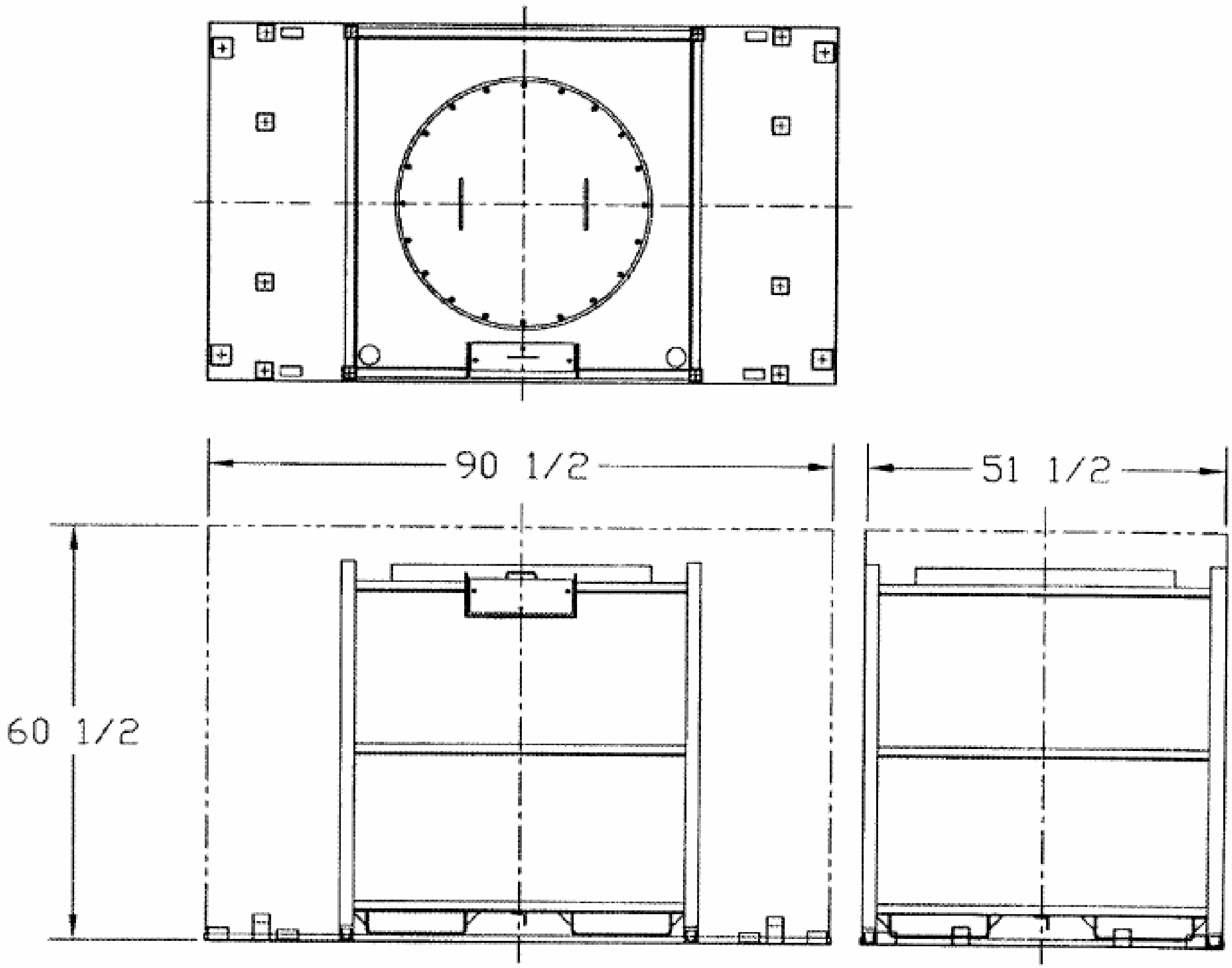
Container Description	*Container name:*	Ash Bin (New)*
	IWTS container code:	AIBN
	CATID:	576616
	Dimensions (m):	1.32 L x 1.32 W x 1.40 H
	External surface area (m^2):	10.9
	Gross volume (m^3):	2.5
	Net waste volume (m^3):	1.8
	Material:	hot dip. galvanized carbon steel, 3.4 mm thick (10 ga.)
	Empty mass (kg):	380
	Avg full mass (kg):	1,604
	Stackability:	4 high
	Handling:	forklift pockets

Waste Properties	*Typical contents:*	incinerated incinerable waste
	Typical composition:	bottom ash, baghouse ash
	Potential hazardous constituents:	dioxins, furans, chlorinated benzenes, PCBs, PAHs
	Avg waste density (kg/m^3):	550 (bottom ash), 390 (baghouse ash)
	Contact Dose rate (mSv/h):	<0.01: 9.5%; 0.01-0.05: 5.6%; 0.05-0.10: 14.7%; 0.10-0.20: 25.4%; 0.20-0.50: 38.1%; 0.50-1: 5.0%; 1-2: 1.3%; 2-10: 0.4%; >10: 0.0%
	Specific activity (Bq/m^3):	1.7E+09

Forecast Inventory		**To 2018**	**To 2052**
	Number of containers:	397	950
	Total gross volume (m^3):	993	2,375
	Net waste volume (m^3):	715	1,712

Ref	Dwg # 0125-DRAW-79710-10300

*entire forecast inventory to be packaged in LLW container overpacks (BINOPK)


90 1/2
51 1/2
60 1/2

Container Description	*Container name:*	Bale Rack	
	IWTS container code:	BRACK	
	CATID:	216420	
	Dimensions (m):	2.29 L x 1.22 W x 1.2 H	
	External surface area (m^2):	5.6	
	Gross volume (m^3):	3.4	
	Net waste volume (m^3):	1.64	
	Material:	painted mild steel, open sides	
	Empty mass (kg):	150	
	Avg full mass (kg):	n/a	
	Stackability:	5 high	
	Handling:	forklift pockets	
Waste Properties	*Typical contents:*	low-force compacted compressible low level waste	
	Typical composition:	24% paper, 37% plastic, 7% rubber, 4% cotton, 15% metal, 3% other organics, 10% other inorganics	
	Potential hazardous constituents:	cadmium, mercury, lead, and other heavy metals	
	Avg waste density (kg/m^3):	766	
	Contact Dose rate (mSv/h):	<0.01: 24.6%; 0.01-0.05: 25.4%; 0.05-0.10: 12.7%; 0.10-0.20: 9.7%; 0.20-0.50: 11.6%; 0.50-1: 7.5%; 1-2: 4.9%; 2-10: 3.1%; >10: 0.4%	
	Specific activity (Bq/m^3):	9.5E+10	
Forecast Inventory		**To 2018**	**To 2052**
	Number of containers:	1,491	1,491
	Total gross volume (m^3):	5,069	5,069
	Net waste volume (m^3):	2,445	2,445
Ref	Dwg # 0125-DXX-79160-0002 (rack identical to drum rack and holds 4 bales)		

drawing similar to drum rack

Container Description

Container name: Compactor box (“green bin”)
IWTS container code: B25
CATID: 215982

Dimensions (m): 1.84 L x 1.12 W x 1.30 H
External surface area (m^2): 11.8

Gross volume (m^3): 2.8
Net waste volume (m^3): 2.3

Material: painted mild steel, 4.6 mm thick (7 ga.)

Empty mass (kg): 486
Avg full mass (kg): 2,722

Stackability: 5 high
Handling: forklift pockets

Waste Properties

Typical contents: low-force compacted compressible low level waste

Typical composition: 24% paper, 37% plastic, 7% rubber, 4% cotton, 15% metal, 3% other organics, 10% other inorganics

Potential hazardous constituents: cadmium, mercury, lead, and other heavy metals

Avg waste density (kg/m^3): 1000

Contact Dose rate (mSv/h): <0.01: 57.9%; 0.01-0.05: 26.8%; 0.05-0.10: 8.8%; 0.10-0.20: 3.4%; 0.20-0.50: 1.7%; 0.50-1: 0.8%; 1-2: 0.5%; 2-10: 0.1%; >10: 0.0%

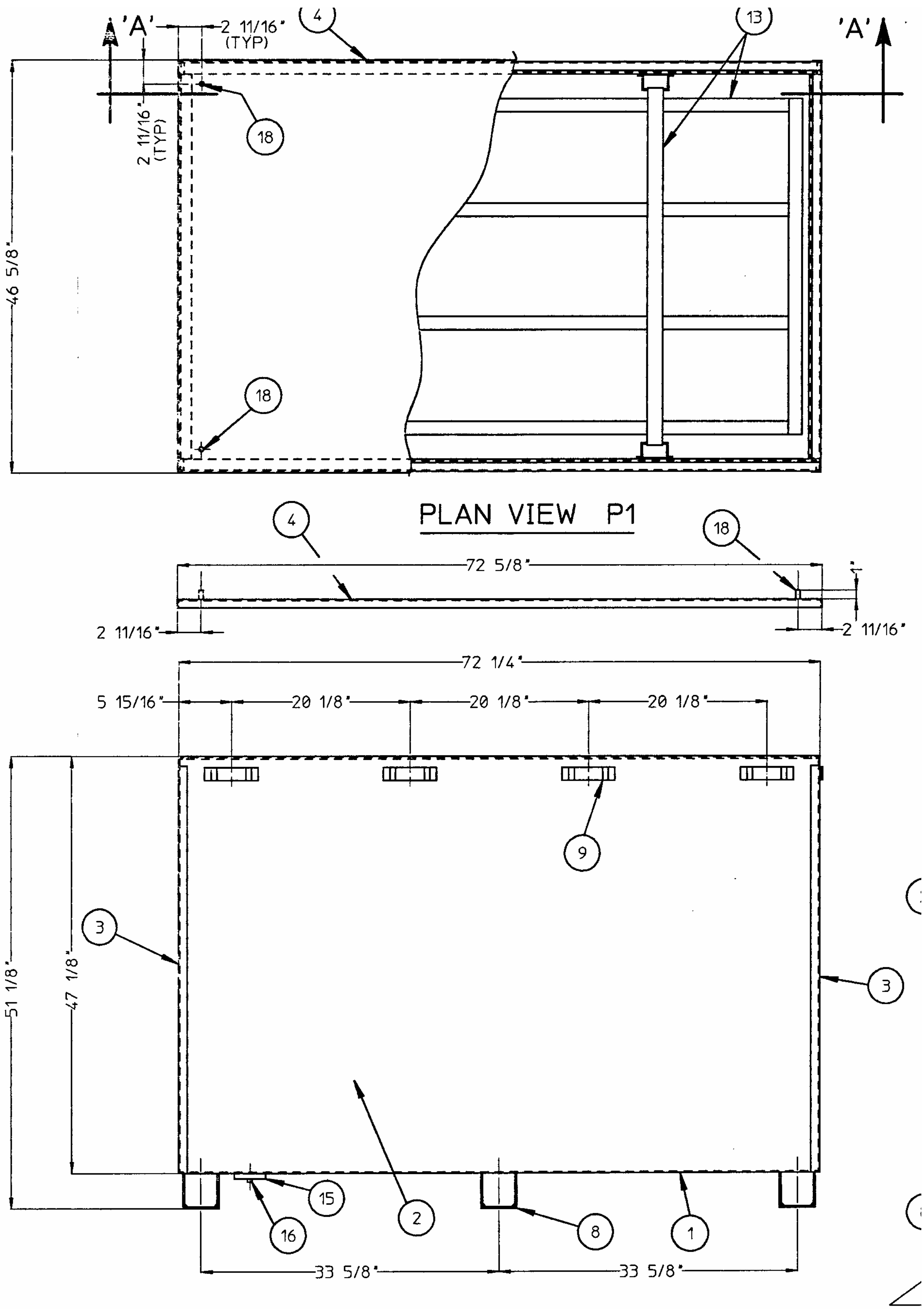
Specific activity (Bq/m^3): 1.2E+11

Forecast Inventory

	To 2018	**To 2052**
Number of containers:	3,563	5,298
Total gross volume (m^3):	9,976	14,834
Net waste volume (m^3):	8,195	12,185

Ref

Dwg # 01098-DDX-79165-0001


'A'
2 11/16"
(TYP)
4
13
'A'
18
2 11/16"
(TYP)
46 5/8"
18
PLAN VIEW P1
4
18
72 5/8"
2 11/16"
2 11/16"
72 1/4"
5 15/16"
20 1/8"
20 1/8"
20 1/8"
9
3
3
51 1/8"
47 1/8"
15
2
8
1
16
33 5/8"
33 5/8"

Container Description

Container name: 4 High Non-Pro Bin
IWTS container code: NPB4
CATID: 216421-4

Dimensions (m): 2.29 L x 1.22 W x 1.47 H
External surface area (m^2): 15.9

Gross volume (m^3): 4.2
Net waste volume (m^3): 3.2

Material: painted mild steel, 3 mm thick (11 ga.)

Empty mass (kg): 340
Avg full mass (kg): 1066

Stackability: 4 high
Handling: forklift pockets

Waste Properties

Typical contents: non-processible waste comprised of IX columns, scaffolding, piping, shavings, angle irons, etc.

Typical composition: 33% metal, 14% absorbent, 8% paper, 5% plastics, 5% wood, 3% cotton, 2% rubber, 5% glass, 6% concrete, 19% other

Potential hazardous constituents: some non-pro contains asbestos from insulation and gasket material, and some contains lead (batteries and shielding), cadmium/lithium (batteries) and mercury (relays and fluorescent tubes)

Avg waste density (kg/m^3): 227

Contact Dose rate (mSv/h): <0.01: 64.1%; 0.01-0.05: 15.5%; 0.05-0.10: 6.9%; 0.10-0.20: 3.7%; 0.20-0.50: 4.5%; 0.50-1: 2.0%; 1-2: 1.2%; 2-10: 1.9%; >10: 0.2%

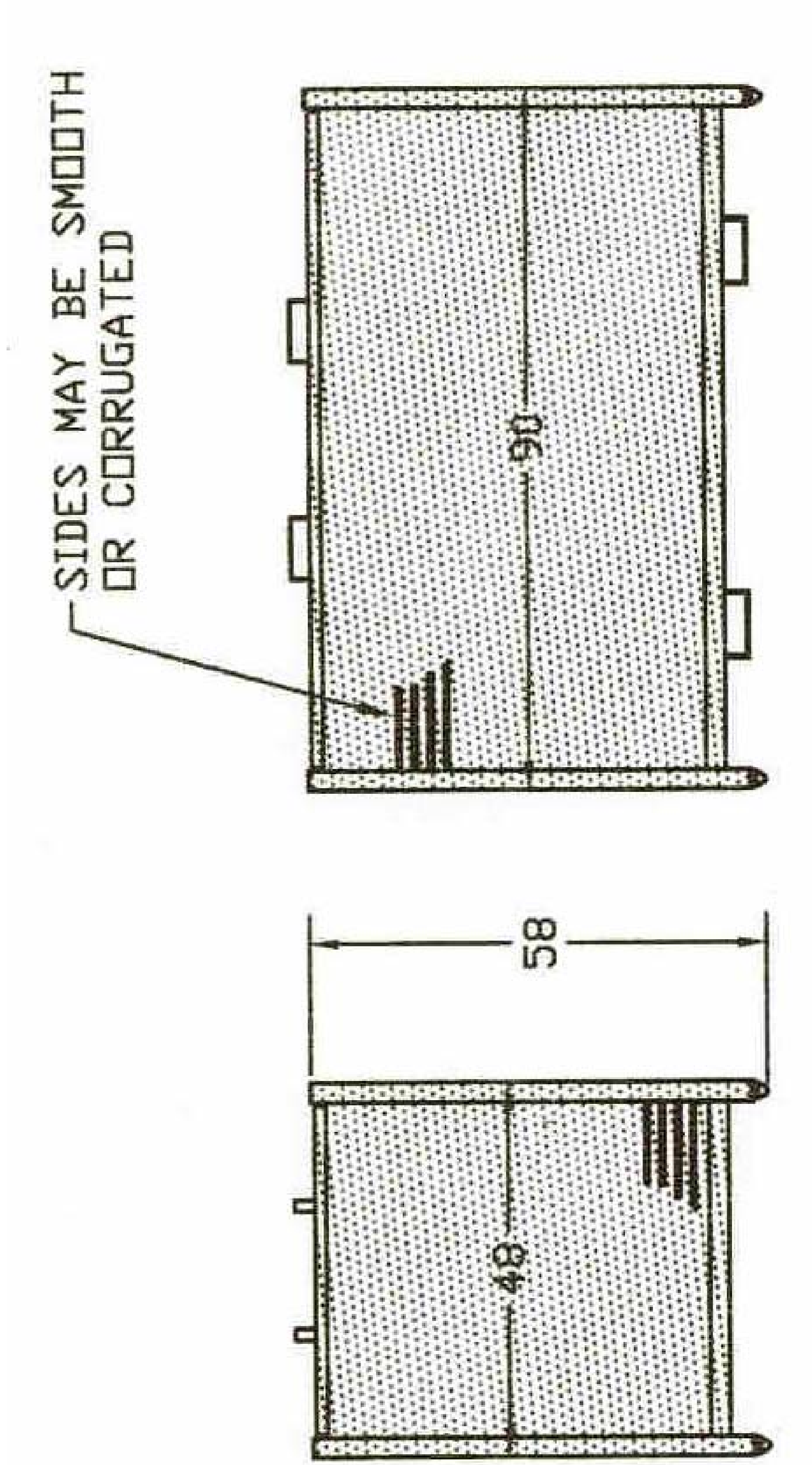
Specific activity (Bq/m^3): 1.8E+10

Forecast Inventory

	To 2018	**To 2052**
Number of containers:	4,978	4,978
Total gross volume (m^3):	20,910	20,910
Net waste volume (m^3):	12,176	12,176

Ref

Dwg # 0125-DXH-79160-0004


SIDES MAY BE SMOOTH
OR CORRUGATED
90
58
48

Container Description

Container name: Non-Pro Container (47'' High)
IWTS container code: NPB47
CATID: 490723

Dimensions (m): 1.96 L x 1.32 W x 1.19 H
External surface area (m^2): 13

Gross volume (m^3): 3.2
Net waste volume (m^3): 2.5

Material: HSS frame with sheet metal sides and bottom

Empty mass (kg): 360
Avg full mass (kg): 1,460

Stackability: 5 high
Handling: forklift pockets

Waste Properties

Typical contents: non-processible waste comprised of IX columns, scaffolding, piping, shavings, angle irons, etc.

Typical composition: 33% metal, 14% absorbent, 8% paper, 5% plastics, 5% wood, 3% cotton, 2% rubber, 5% glass, 6% concrete, 19% other inorganic

Potential hazardous constituents: some non-pro contains asbestos from insulation and gasket material, and some contains lead (batteries and shielding), cadmium/lithium (batteries) and mercury (relays and fluorescent tubes)

Avg waste density (kg/m^3): 227

Contact Dose rate (mSv/h): <0.01: 64.1%; 0.01-0.05: 15.5%; 0.05-0.10: 6.9%; 0.10-0.20: 3.7%; 0.20-0.50: 4.5%; 0.50-1: 2.0%; 1-2: 1.2%; 2-10: 1.9%; >10: 0.2%

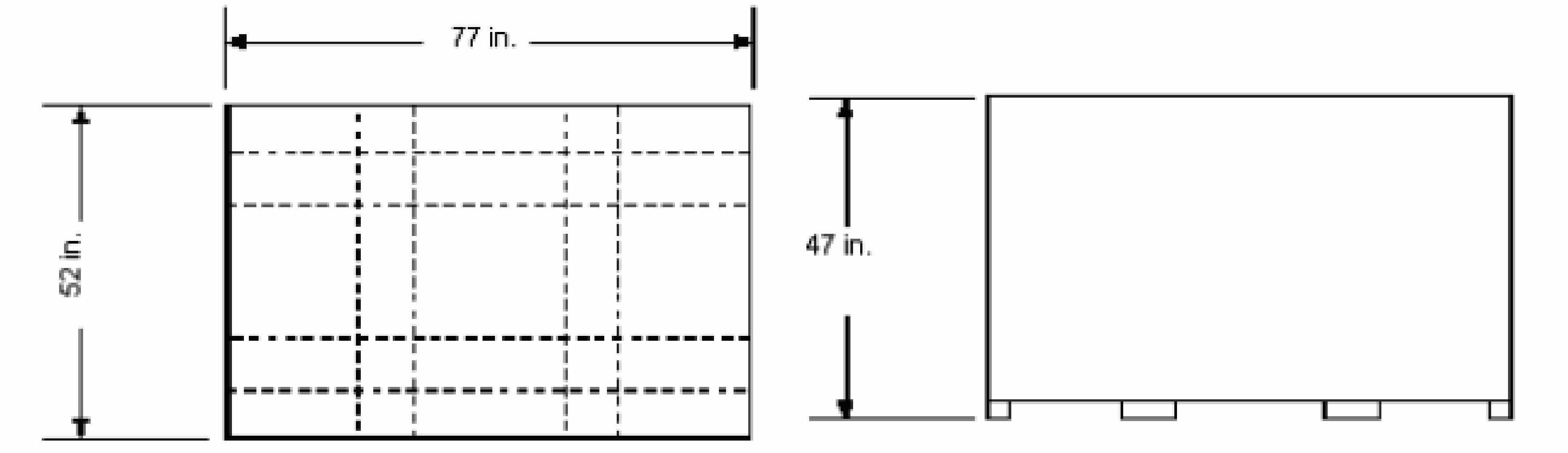
Specific activity (Bq/m^3): 1.8E+10

Forecast Inventory

	To 2018	To 2052
Number of containers:	8,986	15,349
Total gross volume (m^3):	28,756	49,117
Net waste volume (m^3):	22,465	38,372

Ref

Dwg # 01098-DRAW-79165-10003 sheet 0002

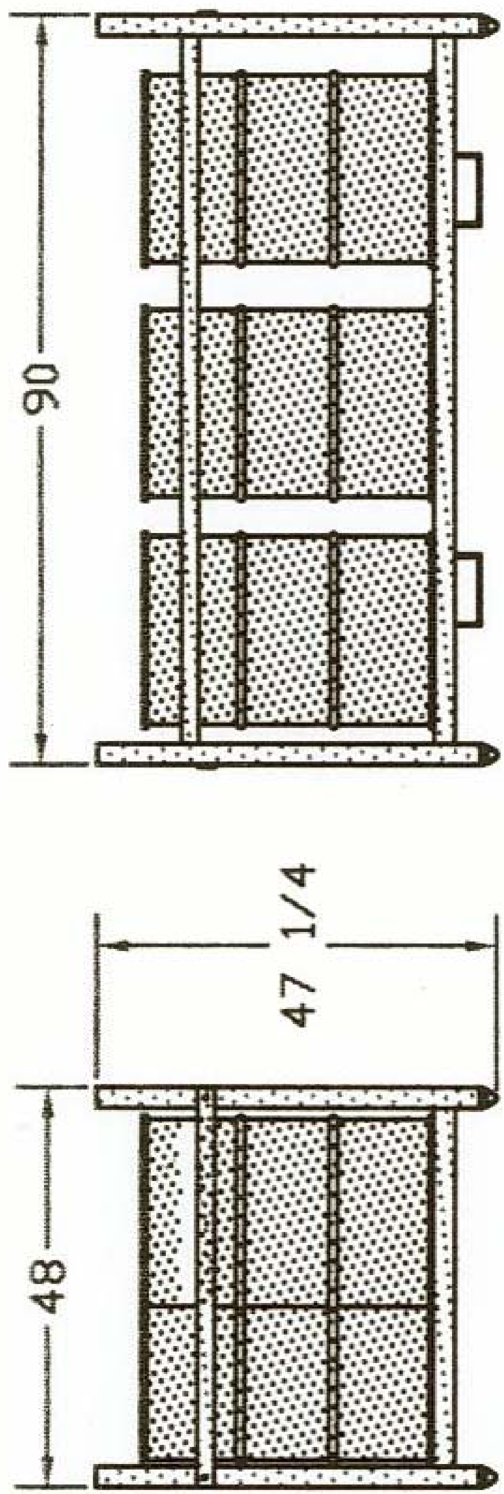

77 in.
52 in.
47 in.

Container Description	*Container name:*	Drum Rack
	IWTS container code:	DRACK
	CATID:	216420
	Dimensions (m):	2.29 L x 1.22 W x 1.2 H
	External surface area (m^2):	2.8
	Gross volume (m^3):	3.4
	Net waste volume (m^3):	1.5 (based on 6 drums at 0.25 m3 each)
	Material:	painted mild steel, open top and sides
	Empty mass (kg):	150
	Avg full mass (kg):	1,490
	Stackability:	5 high
	Handling:	forklift pockets

Waste Properties	*Typical contents:*	scrap metal (valves, motors), eddy current probes, shavings, etc.
	Typical composition:	33% metal, 14% absorbent, 8% paper, 5% plastics, 5% wood, 3% cotton, 2% rubber, 5% glass, 6% concrete, 19% other
	Potential hazardous constituents:	some non-pro contains asbestos from insulation and gasket material, and some contains lead (batteries and shielding), cadmium/lithium (batteries) and mercury (relays and fluorescent tubes)
	Avg waste density (kg/m^3):	500
	Contact Dose rate (mSv/h):	<0.01: 70.7%; 0.01-0.05: 13.8%; 0.05-0.10: 4.9%; 0.10-0.20: 2.4%; 0.20-0.50: 2.2%; 0.50-1: 1.6%; 1-2: 1.0%; 2-10: 2.9%; >10: 0.4%
	Specific activity (Bq/m^3):	2.6E+11

Forecast Inventory*		**To 2018**	**To 2052**
	Number of containers:	2,959	2,959
	Total gross volume (m^3):	10,061	10,061
	Net waste volume (m^3):	4,439	4,439

Ref	Dwg # 0125-DXX-79160-0002


90
47 1/4
48

Container Description

Container name:	Drum Bin
IWTS container code:	DBIN
CATID:	402974
Dimensions (m):	1.96 L x 1.32 W x 1.03 H
External surface area (m^2):	11.9
Gross volume (m^3):	2.8
Net waste volume (m^3):	2.2 (based on internal volume of bin)
Material:	HSS carbon steel and sheet carbon steel (lidded)
Empty mass (kg):	290
Avg full mass (kg):	1,450
Stackability:	5 high
Handling:	forklift pockets

Waste Properties

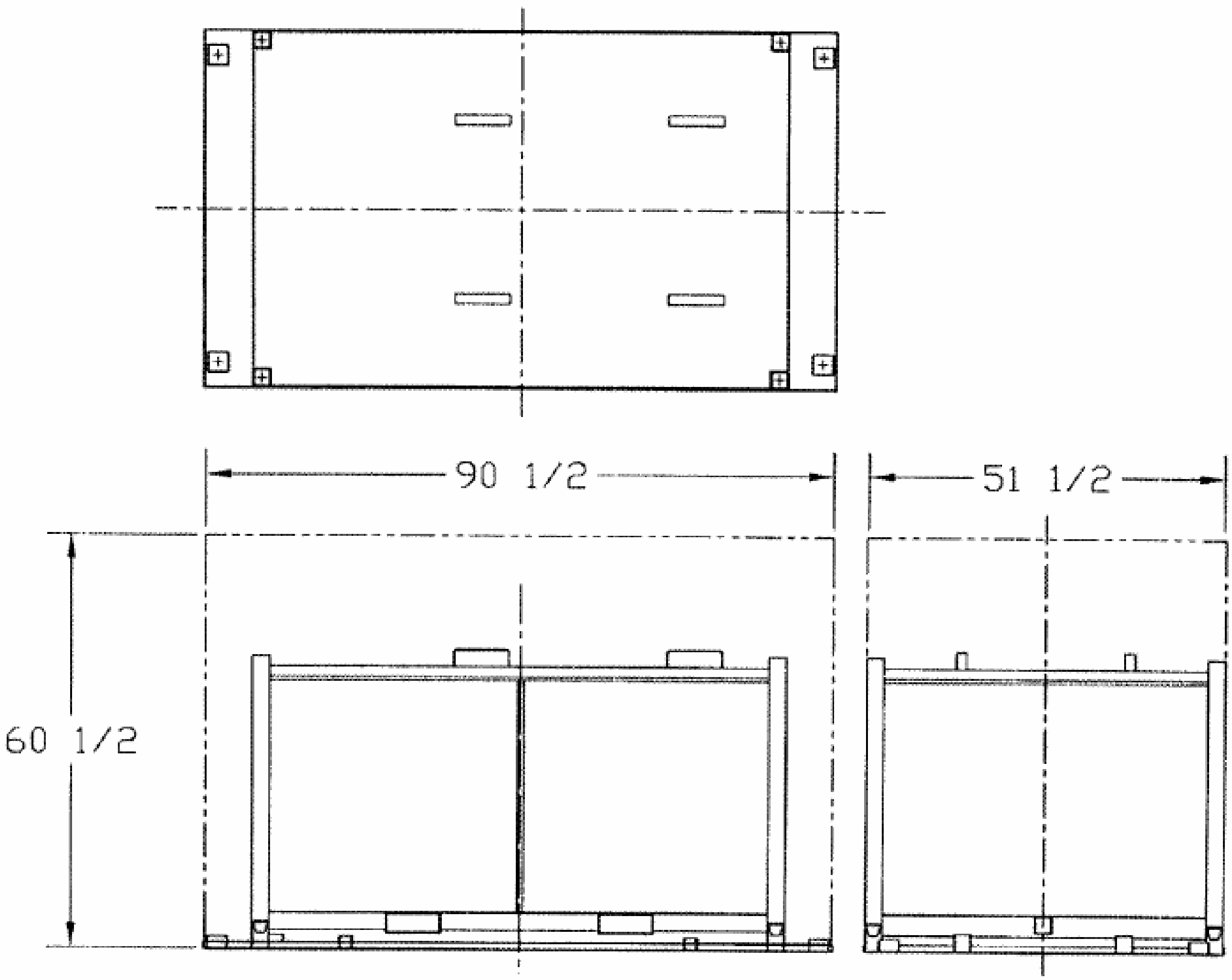
Typical contents:	scrap metal (valves, motors), eddy current probes, shavings, etc.
Typical composition:	33% metal, 14% absorbent, 8% paper, 5% plastics, 5% wood, 3% cotton, 2% rubber, 5% glass, 6% concrete, 19% other
Potential hazardous constituents:	some non-pro contains asbestos from insulation and gasket material, and some contains lead (batteries and shielding), cadmium/lithium (batteries) and mercury (relays and fluorescent tubes)
Avg waste density (kg/m^3):	500
Contact Dose rate (mSv/h):	<0.01: 70.7%; 0.01-0.05: 13.8%; 0.05-0.10: 4.9%; 0.10-0.20: 2.4%; 0.20-0.50: 2.2%; 0.50-1: 1.6%; 1-2: 1.0%; 2-10: 2.9%; >10: 0.4%
Specific activity (Bq/m^3):	2.6E+11

Forecast Inventory

	To 2018	**To 2052**
Number of containers:	1,626	3,317
Total gross volume (m^3):	4,553	9,288
Net internal volume (m^3):	3,57	7,297

Ref

Dwg # 01098-DRAW-79165-10005 sheet 0002


90 1/2
51 1/2
60 1/2

Container Description

Container name: Low Level Resin Box (90”)
IWTS container code: RB90
CATID: 216423

Dimensions (m): 2.29 L x 1.22 W x 1.47 H
External surface area (m^2): 15.9

Gross volume (m^3): 4.2
Net waste volume (m^3): 3.4

Material: galvanized mild steel, 6.3 mm thick

Empty mass (kg): 1180
Avg full mass (kg): 3,655

Stackability: 4 high
Handling: forklift pockets

Waste Properties

Typical contents: dewatered low level ion exchange resin

Typical composition: resin beads containing interstitial water

Potential hazardous constituents: may contain heavy metals and misc. organics

Avg waste density (kg/m^3): 750 (dry)

Contact Dose rate (mSv/h): <0.01: 48.6%; 0.01-0.05: 1.2%; 0.05-0.10: 15.6%; 0.10-0.20: 5.9%; 0.20-0.50: 0.0%; 0.50-1: 1.8%; 1-2: 1.8%; 2-10: 12.6%; >10: 12.6%

Specific activity (Bq/m^3): 2.7E+12

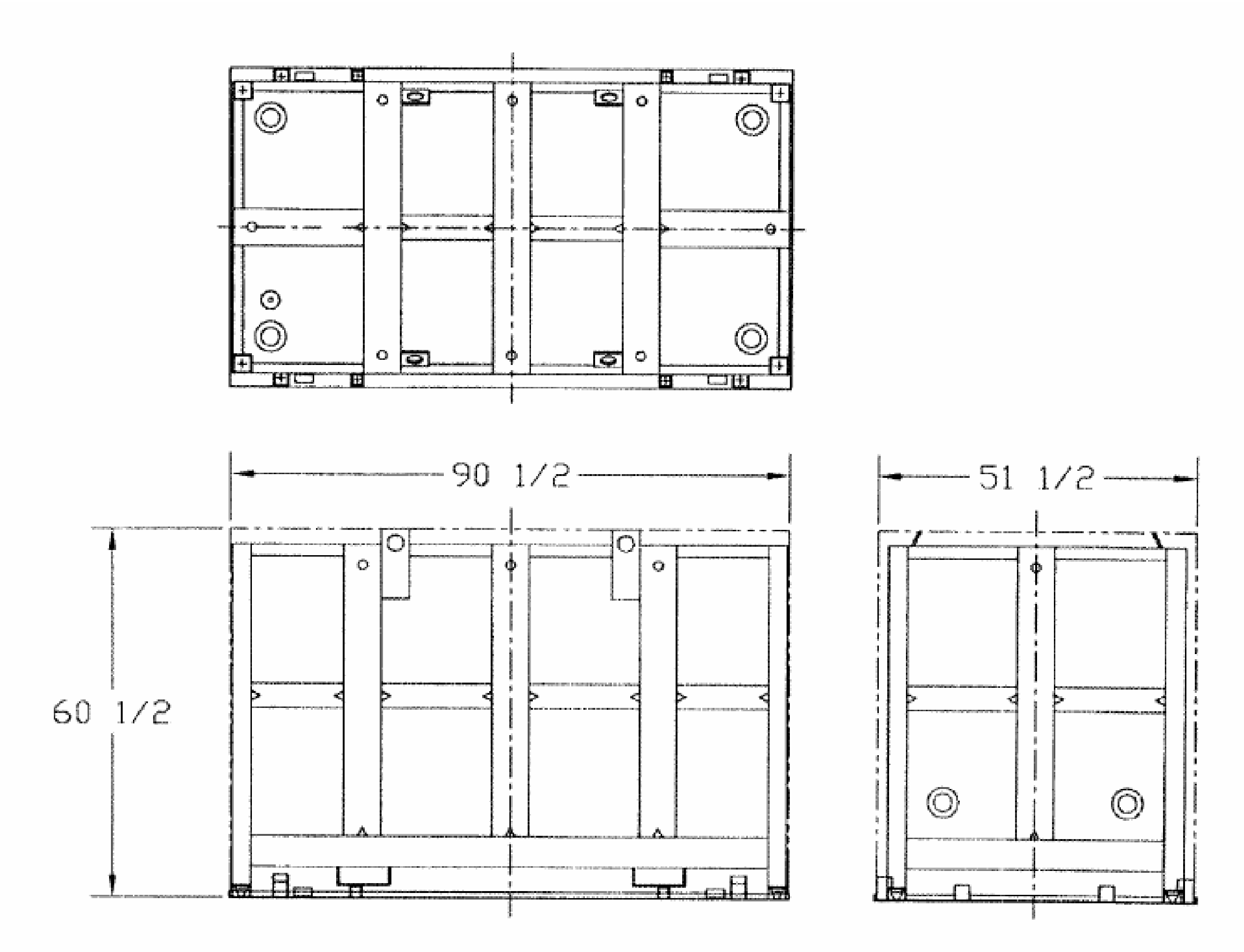
Forecast Inventory*

	To 2018	To 2052
Number of containers:	45	45
Total gross volume (m^3):	189	189
Net waste volume (m^3):	153	153

Ref

Dwg # 0125-DXH-79160-0003

*entire forecast inventory to be packaged in LLW container overpacks (BINOPK)


90 1/2
51 1/2
60 1/2

Container Description

Container name:	Low Level Resin Pallet Tank
IWTS container code:	RTK
CATID:	488022 or 562649 for Darlington
Dimensions (m):	1.24 L x 1.24 W x 1.68 H
External surface area (m^2):	11.4
Gross volume (m^3):	2.7
Net waste volume (m^3):	1.5
Material:	n/a
Empty mass (kg):	320
Avg full mass (kg):	2,000
Stackability:	3 high
Handling:	forklift pockets

Waste Properties

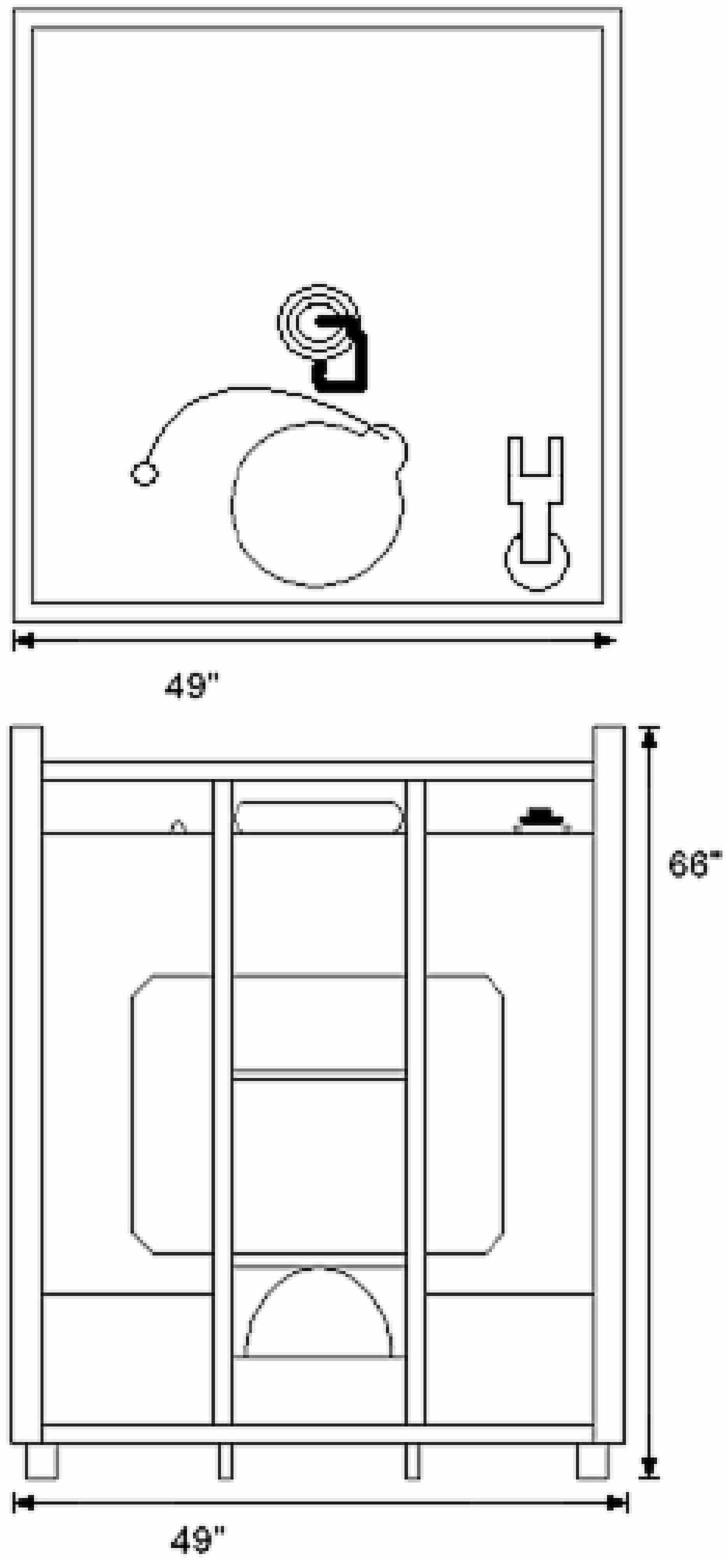
Typical contents:	dewatered low level ion exchange resin
Typical composition:	resin beads containing interstitial water
Potential hazardous constituents:	may contain heavy metals and misc. organics
Avg waste density (kg/m^3):	750 (dry)
Contact Dose rate (mSv/h):	<0.01: 48.6%; 0.01-0.05: 1.2%; 0.05-0.10: 15.6%; 0.10-0.20: 5.9%; 0.20-0.50: 0.0%; 0.50-1: 1.8%; 1-2: 1.8%; 2-10: 12.6%; >10: 12.6%
Specific activity (Bq/m^3):	2.0E+08

Forecast Inventory

	To 2018	**To 2052**
Number of containers:	869	2,126
Total gross volume (m^3):	2,428	5,820
Net waste volume (m^3):	1,412	3,297

Ref

Dwg # PTC-330TDA-OPG488022 (Aco-Assman drawing)


49"
66"
49"

Container Description

Container name: ALW Sludge Box
IWTS container code: NPBSB
CATID: 506066

Dimensions (m): 1.96 L x 1.32 W x 1.03 H
External surface area (m^2): 11.9

Gross volume (m^3): 2.7
Net waste volume (m^3): 2.2

Material: HSS and carbon steel sheet with seal welded joints

Empty mass (kg): 380
Avg full mass (kg): 1,820

Stackability: 5 high
Handling: forklift pockets

Waste Properties

Typical contents: solidified ALW sludge

Typical composition: sludge from ALW system

Potential hazardous constituents: n/a

Avg waste density (kg/m^3): n/a

Contact Dose rate (mSv/h): <0.1: 75%; 0.1-1: 25%; >1: 0%;

Specific activity (Bq/m^3): 3.0E+09

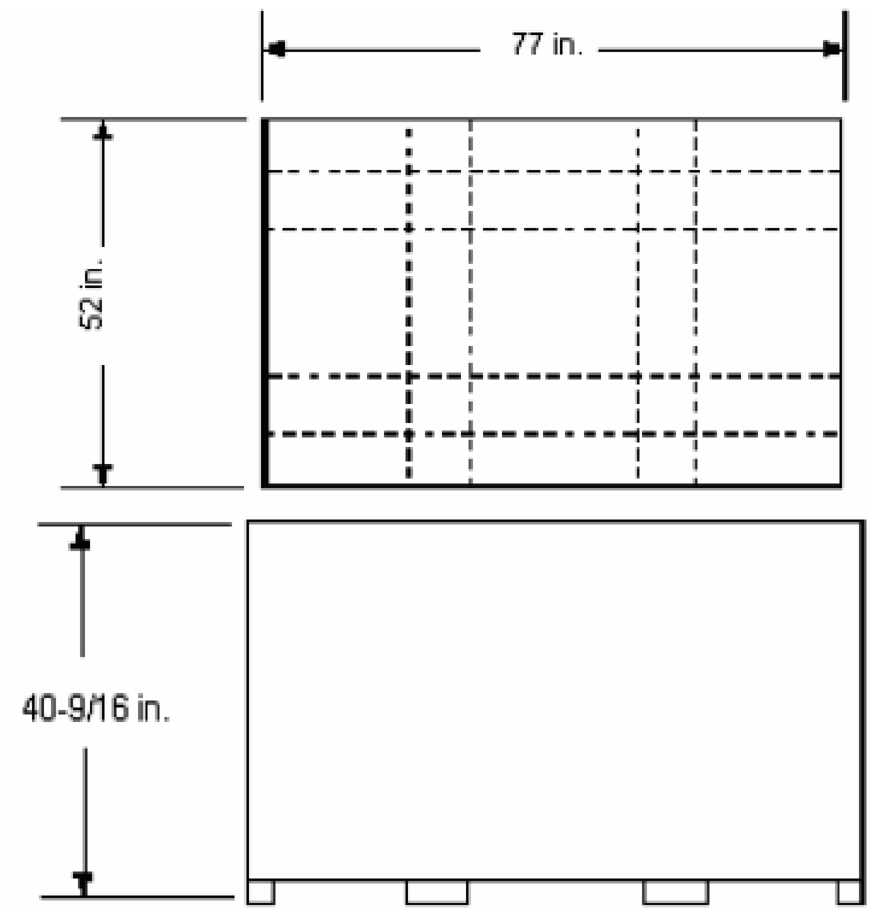
Forecast Inventory

	To 2018	To 2052
Number of containers:	730	1,534
Total gross volume (m^3):	1,971	4,142
Net waste volume (m^3):	1,606	3,375

Ref

Dwg # 01098-DRAW-79165-10006

*entire forecast inventory to be packaged in LLW container overpacks (BINOPK)


77 in.
52 in.
40-9/16 in.

Container Description

Container name:	Shield Plug Container
IWTS container code:	SPC
CATID:	n/a
Dimensions (m):	3.0 L x 1.8 W x 1.8 H
External surface area (m^2):	28.1
Gross volume (m^3):	11.9
Net waste volume (m^3):	7.4
Material:	ASTM 30 carbon steel
Empty mass (kg):	13,000
Avg full mass (kg):	26,000
Stackability:	no stacking
Handling:	crane

Waste Properties

Typical contents:	shield plugs
Typical composition:	n/a
Potential hazardous constituents:	n/a
Avg waste density (kg/m^3):	n/a
Contact Dose rate (mSv/h):	<0.1: 0%; 0.1-1: 6.6%; 1-2: 6.7%; 2-10: 26.7%; >10: 60%
Specific activity (Bq/m^3):	n/a

Forecast Inventory

	To 2018	**To 2052**
Number of containers:	9	9
Total gross volume (m^3):	111	111
Net waste volume (m^3):	69	69

Ref

Dwg # NK29-DRAW-35633-10043

no drawing available

Container Description

Container name: LLW Container Overpack
IWTS container code: BINOPK
CATID: 624979

Dimensions (m): 2.54 L x 1.78 W x 1.88 H
External surface area (m^2): 25.1

Gross volume (m^3): 8.5
Net waste volume (m^3): 6.56

Material: sheet metal reinforced with extruded or formed shapes

Empty mass (kg): 1,591
Avg full mass (kg): 5,400 (max)

Stackability: 3 high
Handling: forklift pockets

Waste Properties

Typical contents: low level waste containers damaged during loading or handling, or that have corroded over extended storage

Typical composition: n/a

Potential hazardous constituents: n/a

Avg waste density (kg/m^3): n/a

Contact Dose rate (mSv/h): n/a

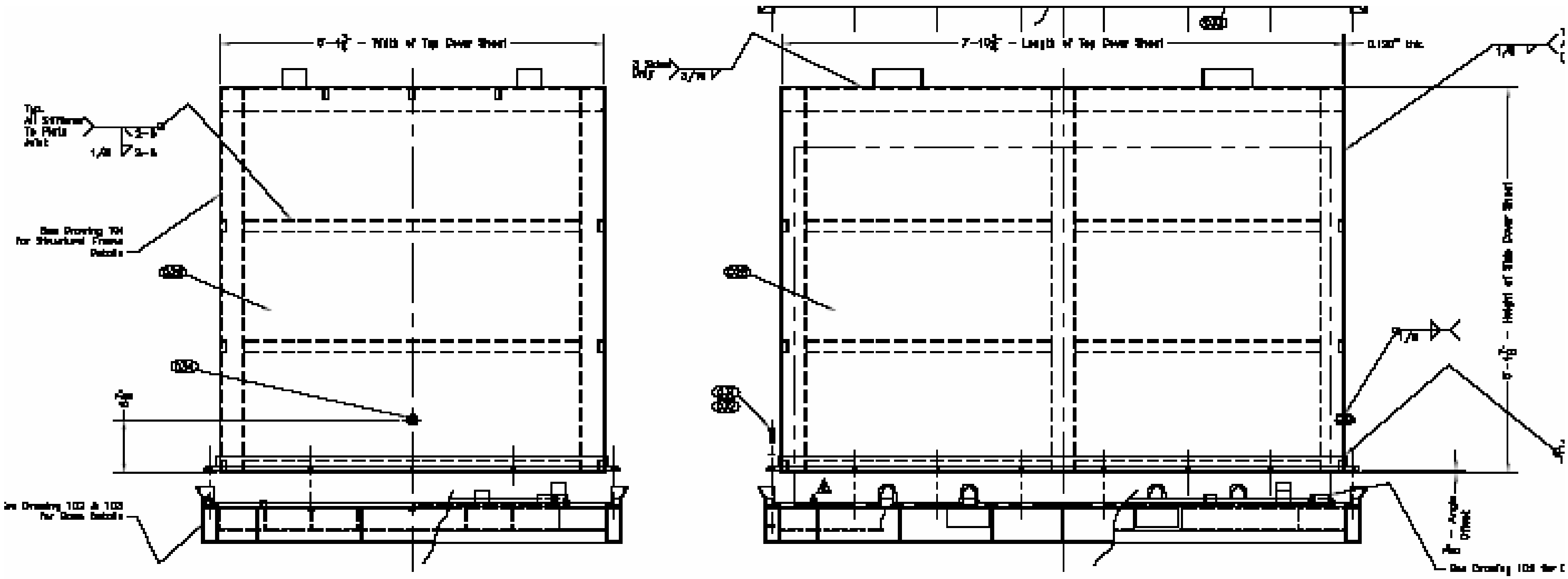
Specific activity (Bq/m^3): n/a

Forecast Inventory

	To 2018	To 2052
Number of containers:	1,784	3,141
Total gross volume (m^3):	15,164	26,699
Net waste volume (m^3):	11,703	20,605

Ref

Dwg # 01098-DRAW-79135-10001



Container Description

Container name: Heat Exchanger
IWTS container code: HX
CATID: n/a

Dimensions (m): n/a
External surface area (m^2): n/a

Gross volume (m^3): 10-51

Material: carbon steel shell, high alloy steel tubes

Empty mass (kg): 10,000-30,000
Avg full mass (kg): n/a

Stackability: n/a
Handling: crane

Waste Properties

Typical contents: n/a

Typical composition: n/a

Potential hazardous constituents: n/a

Avg waste density (kg/m^3): n/a

Contact Dose rate (mSv/h): <0.1: 56.1%; 0.1-1: 36.6%; 1-2: 7.3%; >2 0%

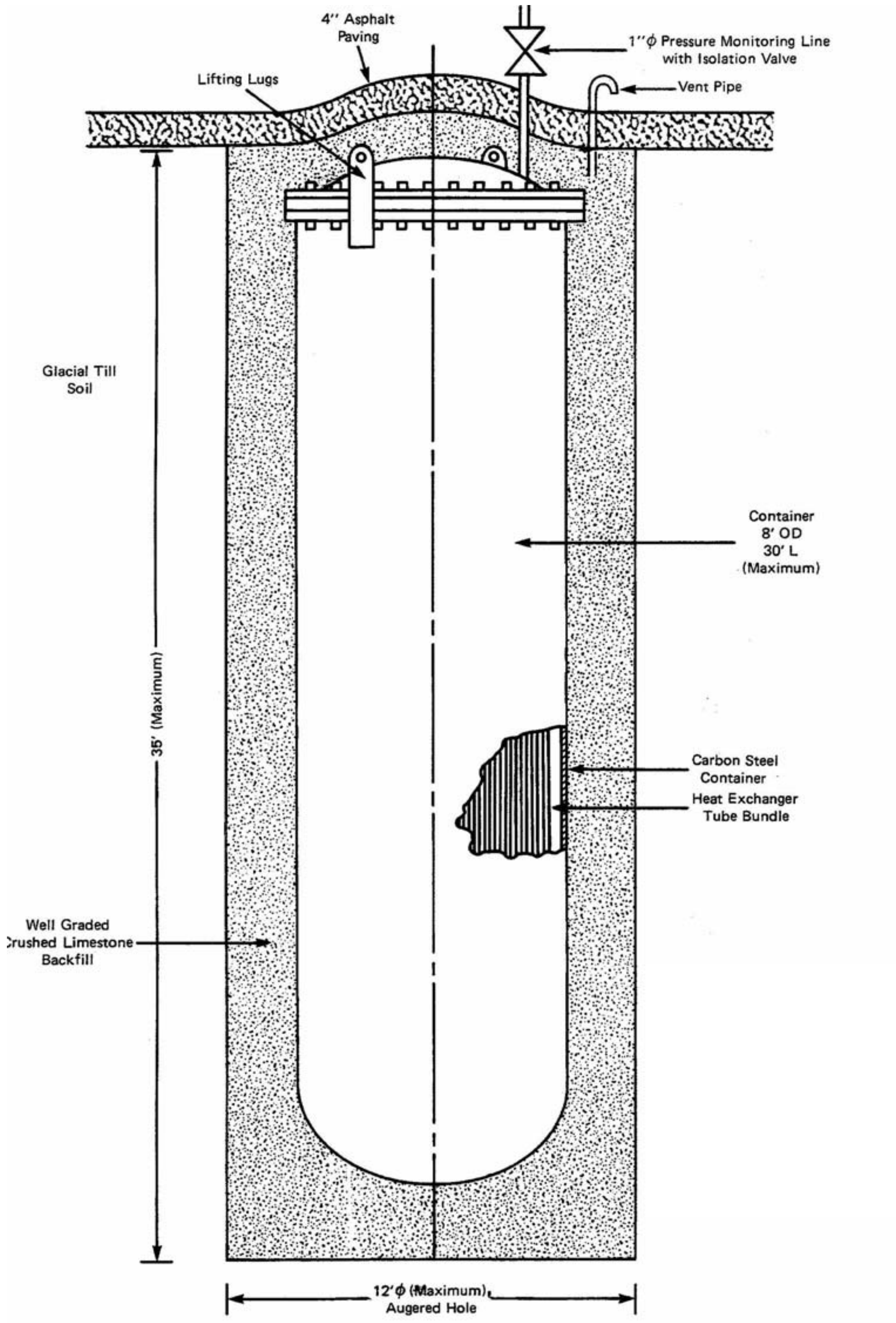
Specific activity (Bq/m^3): 1.8E+10

Forecast Inventory

	To 2018	**To 2052**
Number of containers:	82	82
Total gross volume (m^3):	1,892	1,892

Ref

Dwg # n/a



Note: This sketch is not to scale.

Container Description

Container name: Encapsulated Tile Hole
IWTS container code: ETH
CATID: n/a

Dimensions (m): 1.5 OD x 4.6 OL
External surface area (m^2): 20.5

Gross volume (m^3): 7.6
Net waste volume (m^3): 7.6

Material: Tile hole removed and encapsulated in cement in steel pipe, 9.5 mm thick

Empty mass (kg): n/a
Avg full mass (kg): 25,000

Stackability: 1 high
Handling: forklift pockets

Waste Properties

Typical contents: small filters and disposable ion-exchange columns

Typical composition: n/a

Potential hazardous constituents: n/a

Avg waste density (kg/m^3): n/a

Contact Dose rate (mSv/h): <0.01: 0.0%; 0.01-0.05: 56.5%; 0.05-0.10: 26.1%; 0.10-0.20: 13.0%; 0.20-0.50: 4.4%; 0.50-1: 0.0%; 1-2: 0.0%; 2-10: 0.0%; >10: 0.0%

Specific activity (Bq/m^3): 1.8E+10

Forecast Inventory

	To 2018	To 2052
Number of containers:	23	66
Total gross volume (m^3):	177	504
Net waste volume (m^3):	177	504

Ref

Dwg # 0125-DRAW-79100-10002 sheet 0001

no drawing available

Container Description

Container name:	Resin Liner
IWTS container code:	RL
CATID:	216823 (old design)
Dimensions (m):	1.63 OD x 1.8 OL
External surface area (m^2):	13.4
Gross volume (m^3):	3
Net waste volume (m^3):	3
Material:	coal tar epoxy mild steel, 6.3 mm thick
Empty mass (kg):	795
Avg full mass (kg):	4,545
Stackability:	6 high
Handling:	crane

Waste Properties

Typical contents:	dewatered intermediate level ion exchange resin
Typical composition:	resin beads containing interstitial water
Potential hazardous constituents:	may contain heavy metals and misc. organics
Avg waste density (kg/m^3):	850 (dry)
Contact Dose rate (mSv/h):	<0.01: 7.0%; 0.01-0.05: 0.8%; 0.05-0.10: 3.5%; 0.10-0.20: 2.6%; 0.20-0.50: 6.1%; 0.50-1: 4.5%; 1-2: 3.6%; 2-10: 21.4%; >10: 50.5%
Specific activity (Bq/m^3):	7.9E+12

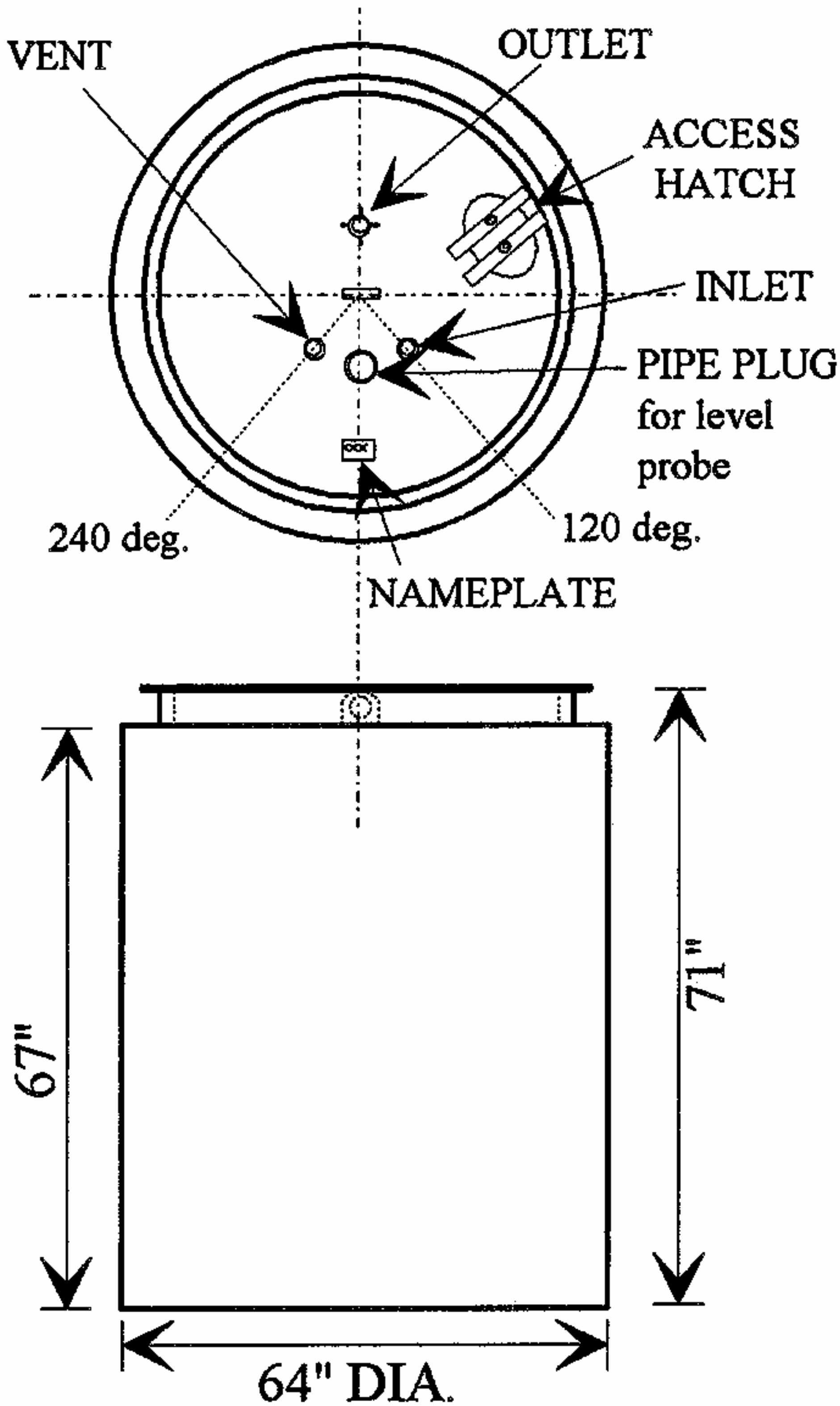
Forecast Inventory

	To 2018	To 2052
Number of containers:	1,650	2,713
Total gross volume (m^3):	4,950	8,139
Net waste volume (m^3):	4,950	8,139

Ref

Dwg # 0125-D0H-79162-0001 R1

Note: 1,436 of total to be packaged in RLSHLD1, 364 in RLSHLD2, and 153 in RLSHLD3, and 400 overpacked in RLOPK


VENT
OUTLET
ACCESS HATCH
INLET
PIPE PLUG for level probe
240 deg.
120 deg.
NAMEPLATE
67"
71"
64" DIA.

Container Description

Container name:	Resin Liner Overpack	
IWTS container code:	RLOPK	
CATID:	n/a	
Dimensions (m):	1.66 OD x 1.9 OL	
External surface area (m^2):	14.2	
Gross volume (m^3):	4.1	
Net waste volume (m^3):	3	
Material:	stainless steel	
Empty mass (kg):	1,450	
Avg full mass (kg):	6,000	
Stackability:	6 high	
Handling:	crane	

Waste Properties

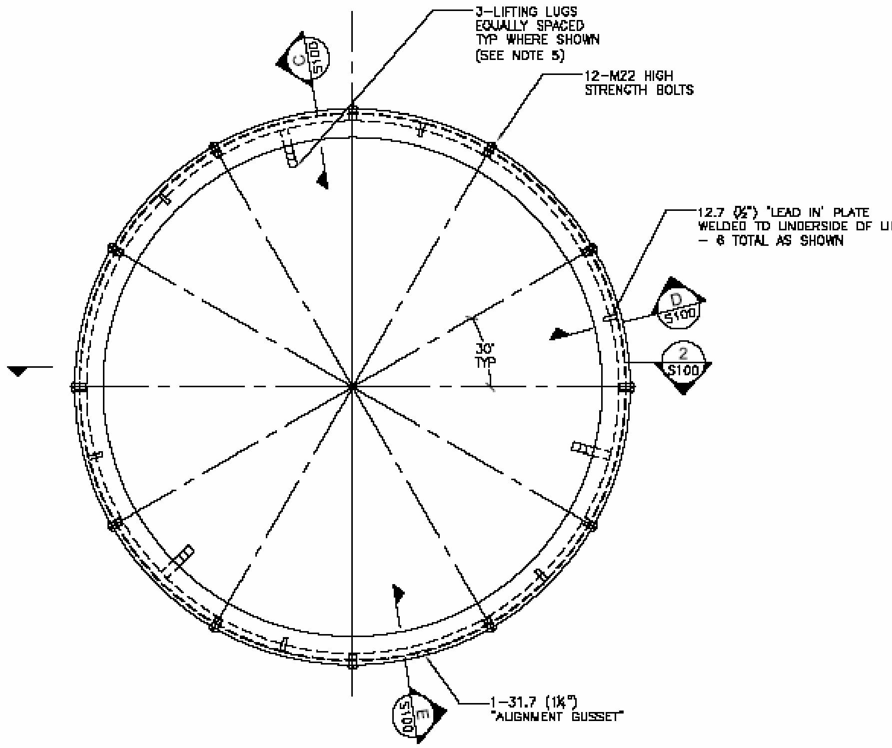
Typical contents:	dewatered intermediate level ion exchange resin
Typical composition:	resin beads containing interstitial water
Potential hazardous constituents:	may contain heavy metals and misc. organics
Avg waste density (kg/m^3):	850 (dry)
Contact Dose rate (mSv/h):	<0.01: 7.0%; 0.01-0.05: 0.8%; 0.05-0.10: 3.5%; 0.10-0.20: 2.6%; 0.20-0.50: 6.1%; 0.50-1: 4.5%; 1-2: 3.6%; 2-10: 21.4%; >10: 50.5%
Specific activity (Bq/m^3):	7.9E+12

Forecast Inventory

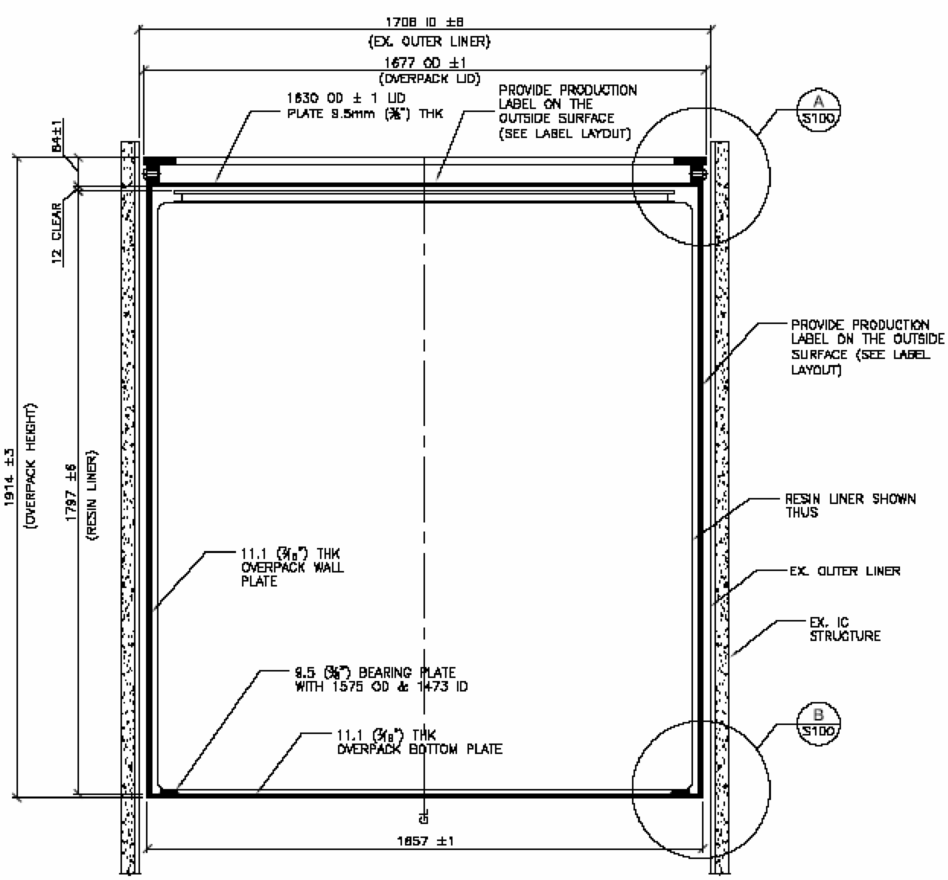
	To 2018	**To 2052**
Number of containers:	400	400
Total gross volume (m^3):	1,640	1,640
Net waste volume (m^3):	1,200	1,200

Ref

Dwg # 01098-DRAW-79164-00007



PLAN VIEW 1
1 : 10 S100



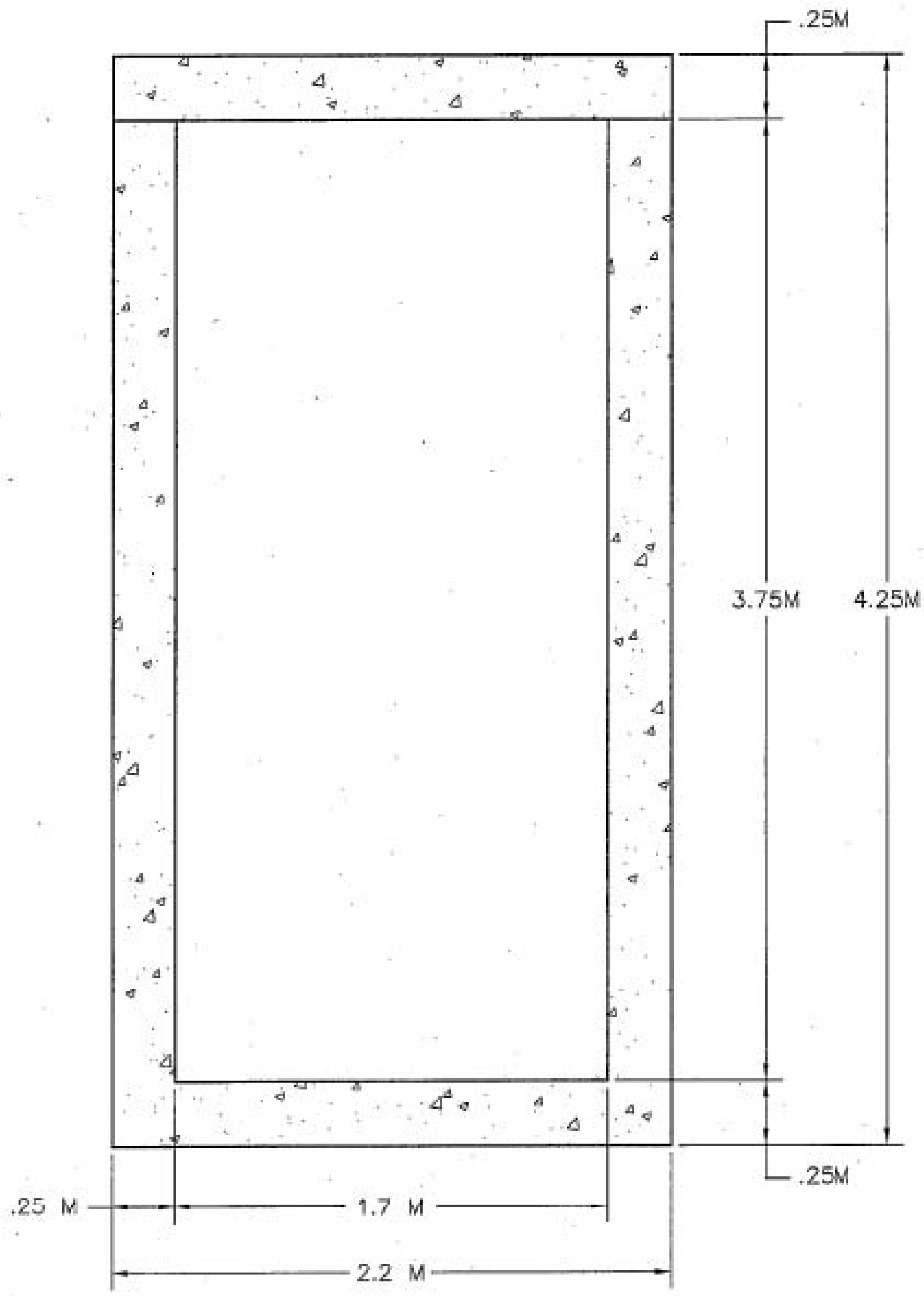
SECTION 2
1 : 10 S100

Container Description	*Container name:*	Resin Liner Shield 1	Picture n/a
	IWTS container code:	RLSHLD1	
	CATID:	n/a	
	Dimensions (m):	2.2 OD x 4.25 OL	
	External surface area (m^2):	37	
	Gross volume (m^3):	16.2	
	Net waste volume (m^3):	6	
	Material:	250 mm thick concrete	
	Empty mass (kg):	17,760	
	Avg full mass (kg):	26,850	
	Stackability:	1 high	
	Handling:	crane?	
Waste Properties	*Typical contents:*	2 resin liners containing dewatered intermediate level ion exchange resin	
	Typical composition:	resin beads containing interstitial water	
	Potential hazardous constituents:	may contain heavy metals and misc. organics	
	Avg waste density (kg/m^3):	850 (dry)	
	Contact Dose rate (mSv/h):	< 2	
	Specific activity (Bq/m^3):	7.9E+12	

Forecast Inventory		**To 2018**	**To 2052**
	Number of containers:	480	718
	Total gross volume (m^3):	7,776	11,600
	Net waste volume (m^3):	2,880	4,308

Ref	Dwg # n/a

Note: Design under review



EMPTY WEIGHT = 17,760 Kg.

Container Description

Container name:	Resin Liner Shield 2
IWTS container code:	RLSHLD2
CATID:	n/a
Dimensions (m):	2.4 OD x 4.45 OL
External surface area (m^2):	42.6
Gross volume (m^3):	20.1
Net waste volume (m^3):	6
Material:	350 mm thick concrete
Empty mass (kg):	28,556
Avg full mass (kg):	37,646
Stackability:	1 high
Handling:	crane?

Picture n/a

Waste Properties

Typical contents:	2 resin liners containing dewatered intermediate level ion exchange resin
Typical composition:	resin beads containing interstitial water
Potential hazardous constituents:	may contain heavy metals and misc. organics
Avg waste density (kg/m^3):	850
Contact Dose rate (mSv/h):	< 2
Specific activity (Bq/m^3):	7.9E+12

Forecast Inventory

	To 2018	**To 2052**
Number of containers:	111	182
Total gross volume (m^3):	2,230	3,664
Net internal volume (m^3):	666	1,092

Ref

Dwg # n/a

Note: Design under review

no drawing available

Container Description

Container name:	Resin Liner Shield 3
IWTS container code:	RLSHLD3
CATID:	n/a
Dimensions (m):	2.53 OD x 2.74 OL
External surface area (m^2):	31.8
Gross volume (m^3):	13.8
Net waste volume (m^3):	3
Material:	350 mm thick concrete with 40 mm thick steel insert
Empty mass (kg):	24,420
Avg full mass (kg):	28,965
Stackability:	1 high
Handling:	crane?

Picture n/a

Waste Properties

Typical contents:	1 resin liner containing dewatered intermediate level ion exchange resin
Typical composition:	resin beads containing interstitial water
Potential hazardous constituents:	may contain heavy metals and misc. organics
Avg waste density (kg/m^3):	850
Contact Dose rate (mSv/h):	< 2
Specific activity (Bq/m^3):	7.9E+12

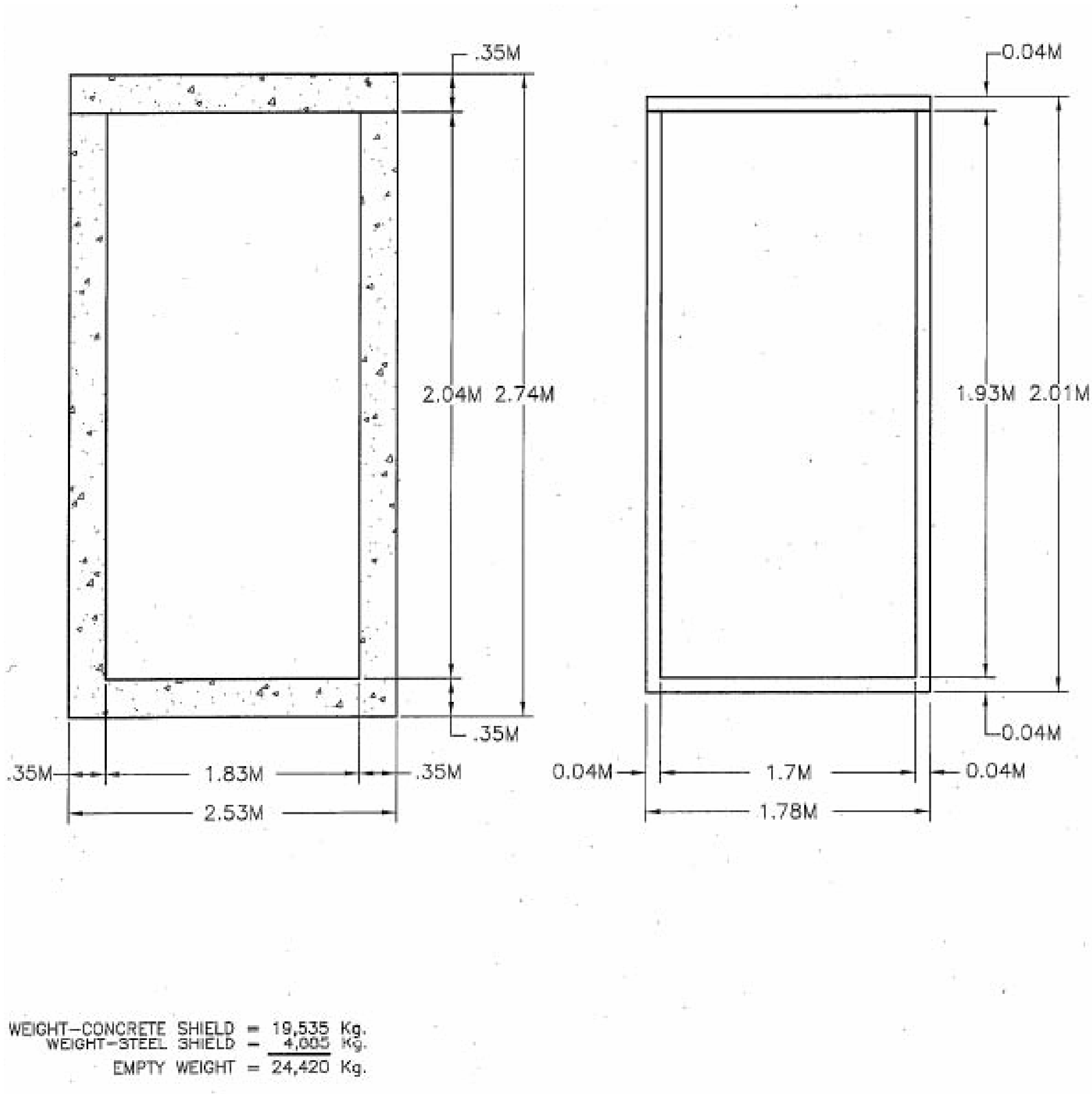
Forecast Inventory

	To 2018	**To 2052**
Number of containers:	47	153
Total gross volume (m^3):	649	2,108
Net waste volume (m^3):	141	459

Ref

Dwg # n/a

Note: Design under review


.35M
2.04M 2.74M
.35M
.35M
1.83M
.35M
2.53M
0.04M
1.93M 2.01M
0.04M
0.04M
1.7M
0.04M
1.78M
WEIGHT–CONCRETE SHIELD = 19,535 Kg.
WEIGHT–STEEL SHIELD = 4,885 Kg.
EMPTY WEIGHT = 24,420 Kg.

Container Description

Container name:	IC-18 Tile Hole Equivalent Liner
IWTS container code:	THLIC18
CATID:	n/a
Dimensions (m):	0.55 OD x 11.8 OL
External surface area (m^2):	20.8
Gross volume (m^3):	2.8
Net waste volume (m^3):	2.7
Material:	carbon steel pipe (10 mm thick)
Empty mass (kg):	1400
Avg full mass (kg):	3600
Stackability:	n/a
Handling:	lifting bracket

Picture n/a

Waste Properties

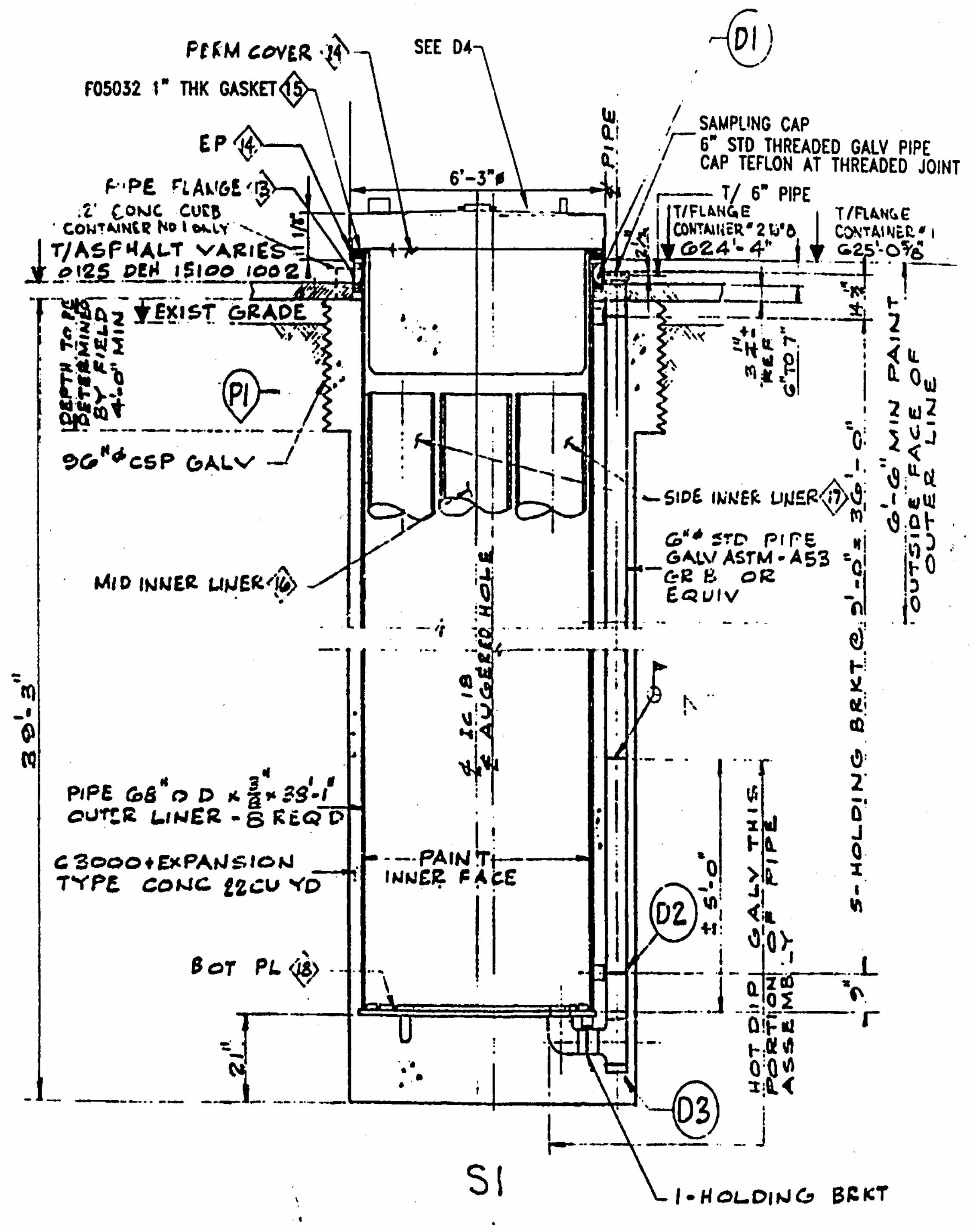
Typical contents:	filters, IX columns, bagged wastes, and core components
Typical composition:	n/a
Potential hazardous constituents:	n/a
Avg waste density (kg/m^3):	n/a
Contact Dose rate (mSv/h):	<0.01: 2.9%; 0.01-0.05: 0.7%; 0.05-0.10: 0.0%; 0.10-0.20: 0.0%; 0.20-0.50: 0.0%; 0.50-1: 4.4%; 1-2: 4.1%; 2-10: 57.2%; >10: 30.7%
Specific activity (Bq/m^3):	n/a

Forecast Inventory

	To 2018	**To 2052**
Number of containers:	444	444
Total gross volume (m^3):	1,245	1,245
Net waste volume (m^3):	1,119	1,119

Ref

Dwg # 01098-D0H-27900-5008 R02


PERM COVER 24
SEE D4
D1
F05032 1" THK GASKET 15
SAMPLING CAP
6" STD THREADED GALV PIPE
CAP TEFLON AT THREADED JOINT
EP 14
PIPE FLANGE 13
6'-3"
T/ 6" PIPE
2' CONC CURB
CONTAINER No 1 ONLY
T/FLANGE
CONTAINER #2 & #8
624'-4"
T/FLANGE
CONTAINER #1
625'-0 5/8"
T/ASPHALT VARIES
0125 DEH 15100 1002
EXIST GRADE
DEPTH TO BE DETERMINED BY FIELD
4'-0" MIN
P1
96"ϕ CSP GALV
SIDE INNER LINER 17
6'-6" MIN PAINT OUTSIDE FACE OF OUTER LINE
6"ϕ STD PIPE
GALV ASTM-A53
GR B OR
EQUIV
MID INNER LINER 16
AUGERED HOLE
39'-3"
5-HOLDING BRKT @ 5'-0" = 36'-0"
PIPE 68" O D x 3/8" x 33'-1"
OUTER LINER - 8 REQ'D
C3000+EXPANSION
TYPE CONC 22CU YD
PAINT
INNER FACE
D2
±5'-0"
HOT DIP GALV THIS PORTION OF 6" PIPE ASSEMBLY
BOT PL 18
21"
D3
S1
1-HOLDING BRKT

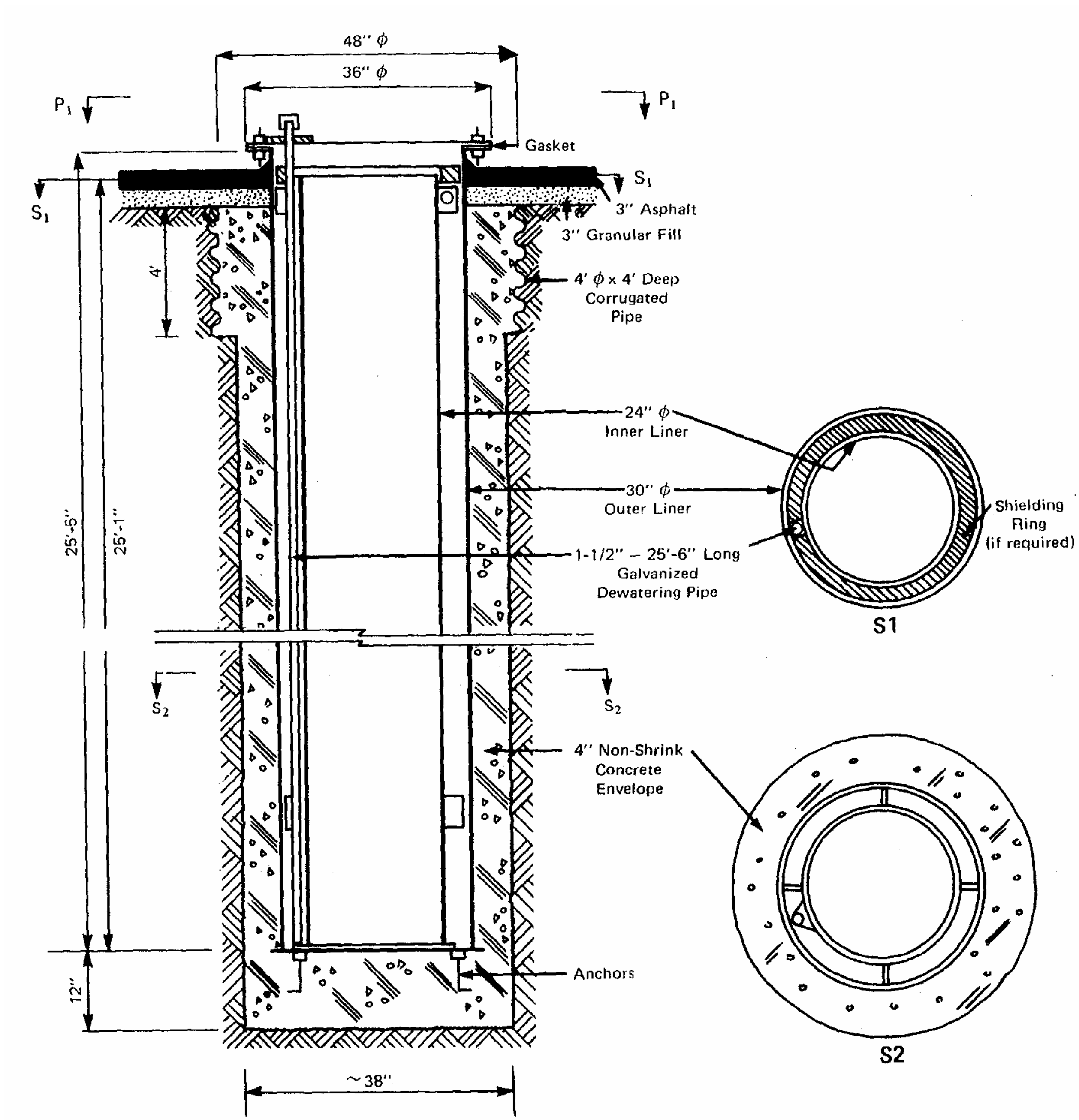
Container Description	*Container name:*	IC-2 Liner
	IWTS container code:	THLIC2
	CATID:	n/a
	Dimensions (m):	0.61 OD x 7.6 OL
	External surface area (m^2):	15.2
	Gross volume (m^3):	2.2
	Net waste volume (m^3):	2.1
	Material:	retrievable inner and fixed outer liners made of carbon steel inside an augered hole
	Empty mass (kg):	1,000
	Avg full mass (kg):	4,500
	Stackability:	n/a
	Handling:	lifting bracket
		Picture n/a
Waste Properties	*Typical contents:*	filters, IX columns, bagged wastes, and core components
	Typical composition:	n/a
	Potential hazardous constituents:	n/a
	Avg waste density (kg/m^3):	n/a
	Contact Dose rate (mSv/h):	<0.01: 2.9%; 0.01-0.05: 0.7%; 0.05-0.10: 0.0%; 0.10-0.20: 0.0%; 0.20-0.50: 0.0%; 0.50-1: 4.4%; 1-2: 4.1%; 2-10: 57.2%; >10: 30.7%
	Specific activity (Bq/m^3):	n/a

Forecast Inventory

	To 2018	To 2052
Number of containers:	20	20
Total gross volume (m^3):	44	44
Net waste volume (m^3):	43	43

Ref

Dwg # 0125-D0H-15900-5001 R02


48" φ
36" φ
P1
P1
Gasket
S1
S1
3" Asphalt
3" Granular Fill
4' φ x 4' Deep
Corrugated
Pipe
4'
24" φ
Inner Liner
30" φ
Outer Liner
1-1/2" – 25'-6" Long
Galvanized
Dewatering Pipe
25'-5"
25'-1"
Shielding
Ring
(if required)
S1
S2
S2
4" Non-Shrink
Concrete
Envelope
Anchors
12"
~38"
S2

Container Description

Container name:	Tile Hole Liner
IWTS container code:	THLSTG3
CATID:	n/a
Dimensions (m):	0.61 OD x 3.0 OL
External surface area (m^2):	6.3
Gross volume (m^3):	0.9
Net waste volume (m^3):	0.8
Material:	retrievable steel liner with welded end plate
Empty mass (kg):	450
Avg full mass (kg):	2,000
Stackability:	n/a
Handling:	lifting bracket

Waste Properties

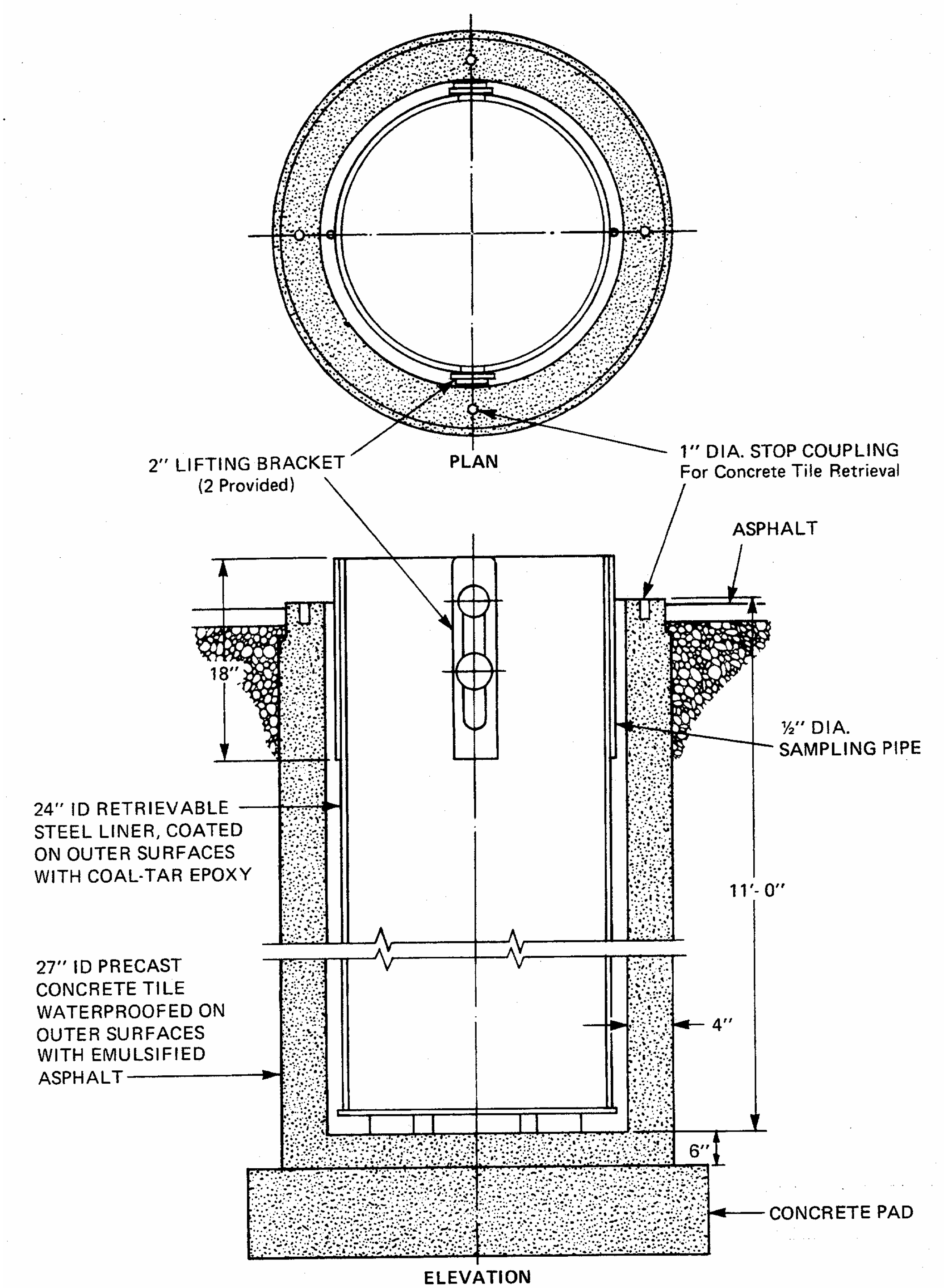
Typical contents:	filter vessels, IX columns, core component liners, filter elements and bagged waste
Typical composition:	n/a
Potential hazardous constituents:	n/a
Avg waste density (kg/m^3):	n/a
Contact Dose rate (mSv/h):	<0.01: 2.9%; 0.01-0.05: 0.7%; 0.05-0.10: 0.0%; 0.10-0.20: 0.0%; 0.20-0.50: 0.0%; 0.50-1: 4.4%; 1-2: 4.1%; 2-10: 57.2%; >10: 30.7%
Specific activity (Bq/m^3):	n/a

Forecast Inventory

	To 2018	**To 2052**
Number of containers:	201	201
Total gross volume (m^3):	176	176
Net waste volume (m^3):	170	170

Ref

Dwg # 0125-DAH-27942-2005 R01



2″ LIFTING BRACKET
(2 Provided)
PLAN
1″ DIA. STOP COUPLING
For Concrete Tile Retrieval
ASPHALT
18″
½″ DIA.
SAMPLING PIPE
24″ ID RETRIEVABLE
STEEL LINER, COATED
ON OUTER SURFACES
WITH COAL-TAR EPOXY
11′- 0″
27″ ID PRECAST
CONCRETE TILE
WATERPROOFED ON
OUTER SURFACES
WITH EMULSIFIED
ASPHALT
4″
6″
CONCRETE PAD
ELEVATION

Container Description

Container name:	Retube Waste Container (End Fitting)
IWTS container code:	RWC(EF)
CATID:	n/a
Dimensions (m):	1.70 L x 3.35 W x 1.92 H
External surface area (m^2):	30.8
Gross volume (m^3):	10.9
Net waste volume (m^3):	2.7
Material:	steel-concrete-steel construction
Empty mass (kg):	29,200
Avg full mass (kg):	33,500
Stackability:	3 high
Handling:	forklift

Picture n/a

Waste Properties

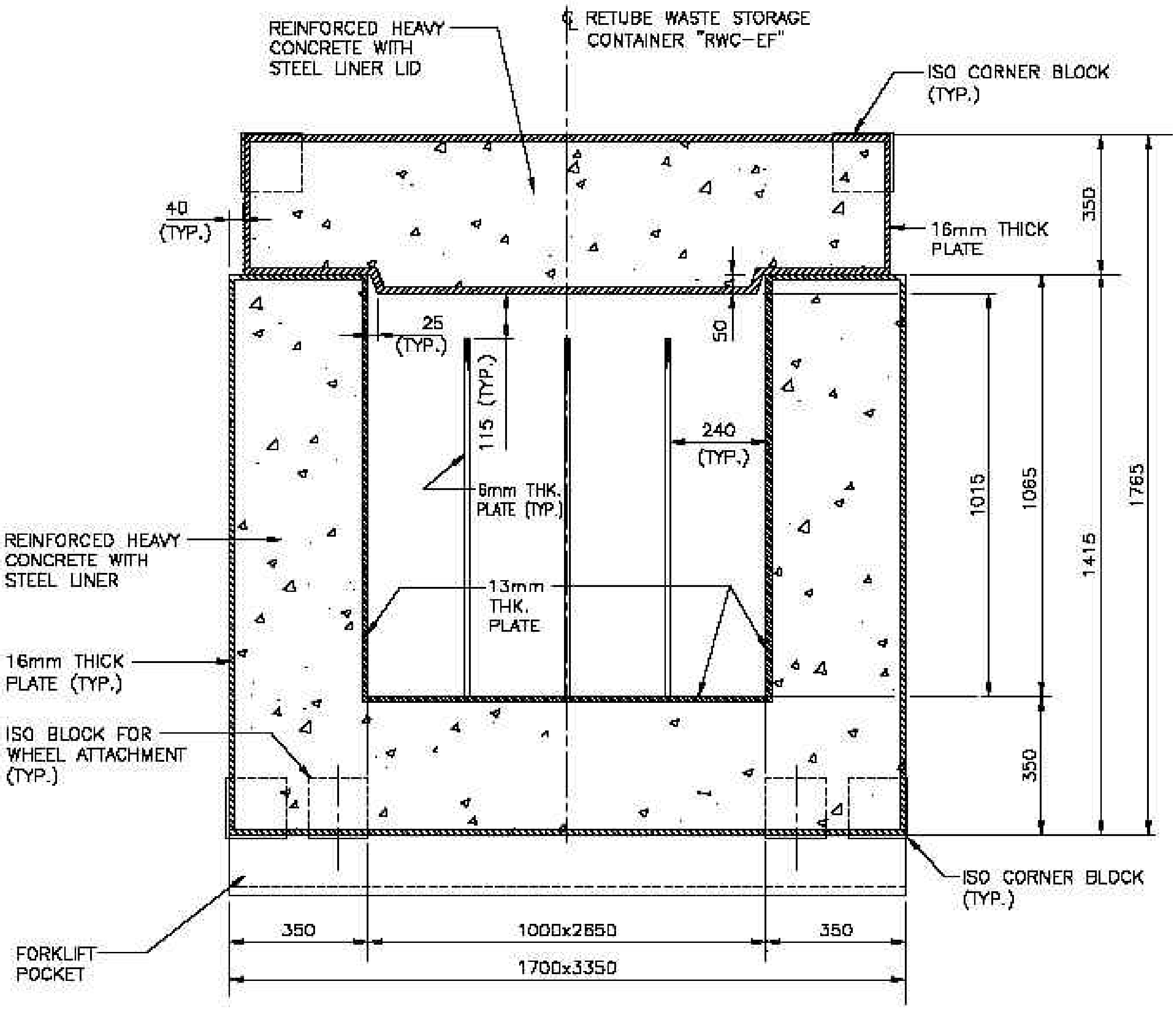
Typical contents:	end fittings
Typical composition:	n/a
Potential hazardous constituents:	n/a
Avg waste density (kg/m^3):	966
Contact Dose rate (mSv/h):	n/a
Specific activity (Bq/m^3):	9.2E+14
Heat Load (watts/container):	3 yrs: 102; 5 yrs: 77; 10 yrs: 39

Forecast Inventory

	To 2018	**To 2052**
Number of containers:	677	918
Total gross volume (m^3):	7,402	10,038
Net waste volume (m^3):	1,828	2,479

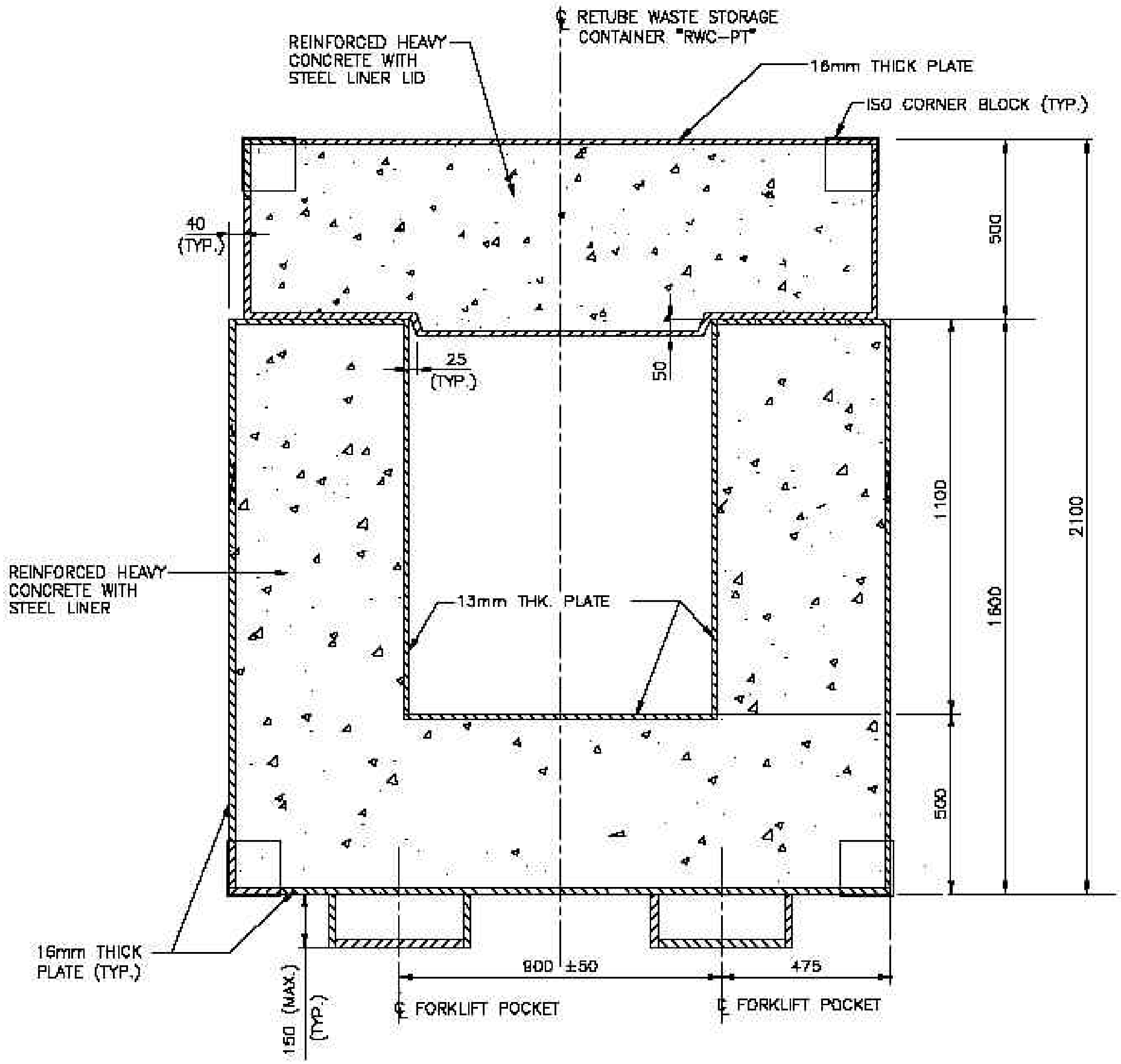
Ref

Dwg # AECL dwg 21RT-79150-002-1-GA



REINFORCED HEAVY CONCRETE WITH STEEL LINER LID
℄ RETUBE WASTE STORAGE CONTAINER "RWC-EF"
ISO CORNER BLOCK (TYP.)
40 (TYP.)
16mm THICK PLATE
350
25 (TYP.)
50
115 (TYP.)
240 (TYP.)
6mm THK. PLATE (TYP.)
1015
1065
1415
1765
REINFORCED HEAVY CONCRETE WITH STEEL LINER
13mm THK. PLATE
16mm THICK PLATE (TYP.)
ISO BLOCK FOR WHEEL ATTACHMENT (TYP.)
350
ISO CORNER BLOCK (TYP.)
FORKLIFT POCKET
350
1000x2650
350
1700x3350

Container Description	*Container name:*	Retube Waste Container (Pressure Tube)		Picture n/a
	IWTS container code:	RWC(PT)		
	CATID:	n/a		
	Dimensions (m):	1.85 L x 1.85 W x 2.25 H		
	External surface area (m^2):	23.5		
	Gross volume (m^3):	7.7		
	Net waste volume (m^3):	0.8		
	Material:	steel-concrete-steel construction		
	Empty mass (kg):	26,600		
	Avg full mass (kg):	29,100		
	Stackability:	2 high		
	Handling:	forklift		
Waste Properties	*Typical contents:*	pressure tubes, calandria tubes, or calandria tube inserts		
	Typical composition:	n/a		
	Potential hazardous constituents:	n/a		
	Avg waste density (kg/m^3):	2,288		
	Contact Dose rate (mSv/h):	n/a		
	Specific activity (Bq/m^3):	2.5E+15 (CTs), 3.3E+15 (PTs), and 4.8E+15 (CTIs)		
	Heat Load (watts/container):	pressure tubes – 3 yrs: 10; 5 yrs: 9; 10 yrs: 7.5 calandria tubes – 3 yrs: 12; 5 yrs: 7; 10 yrs: 2.6 calandria tube inserts – 3 yrs: 60; 5 yrs: 45; 10 yrs: 23		
Forecast Inventory		**To 2018**	**To 2052**	
	Number of containers:	338	458	
	Total gross volume (m^3):	2,603	3,528	
	Net waste volume (m^3):	270	366	
Ref	Dwg # AECL dwg 21RT-79150-001-1-GA-0 R0			



℄ RETUBE WASTE STORAGE CONTAINER "RWC-PT"
REINFORCED HEAVY CONCRETE WITH STEEL LINER LID
16mm THICK PLATE
150 CORNER BLOCK (TYP.)
40 (TYP.)
25 (TYP.)
50
500
1100
2100
1600
500
REINFORCED HEAVY CONCRETE WITH STEEL LINER
13mm THK. PLATE
16mm THICK PLATE (TYP.)
150 (MAX.) (TYP.)
900 ±50
475
℄ FORKLIFT POCKET
℄ FORKLIFT POCKET

Container Description

Container name:	Steam Generator (Bruce A)
IWTS container code:	SG(BA)
CATID:	n/a
Dimensions (m):	2.6/2.4 OD x 11.7 OL
External surface area (m^2):	n/a
Gross volume (m^3):	58
Material:	carbon steel shell, high alloy steel tubes
Empty mass (kg):	88,000
Avg full mass (kg):	n/a
Stackability:	n/a
Handling:	heavy lift rigging, forklift

Waste Properties

Typical contents:	n/a
Typical composition:	n/a
Potential hazardous constituents:	n/a
Avg waste density (kg/m^3):	n/a
Contact Dose rate (mSv/h):	n/a
Specific activity (Bq/m^3):	1.6E+10

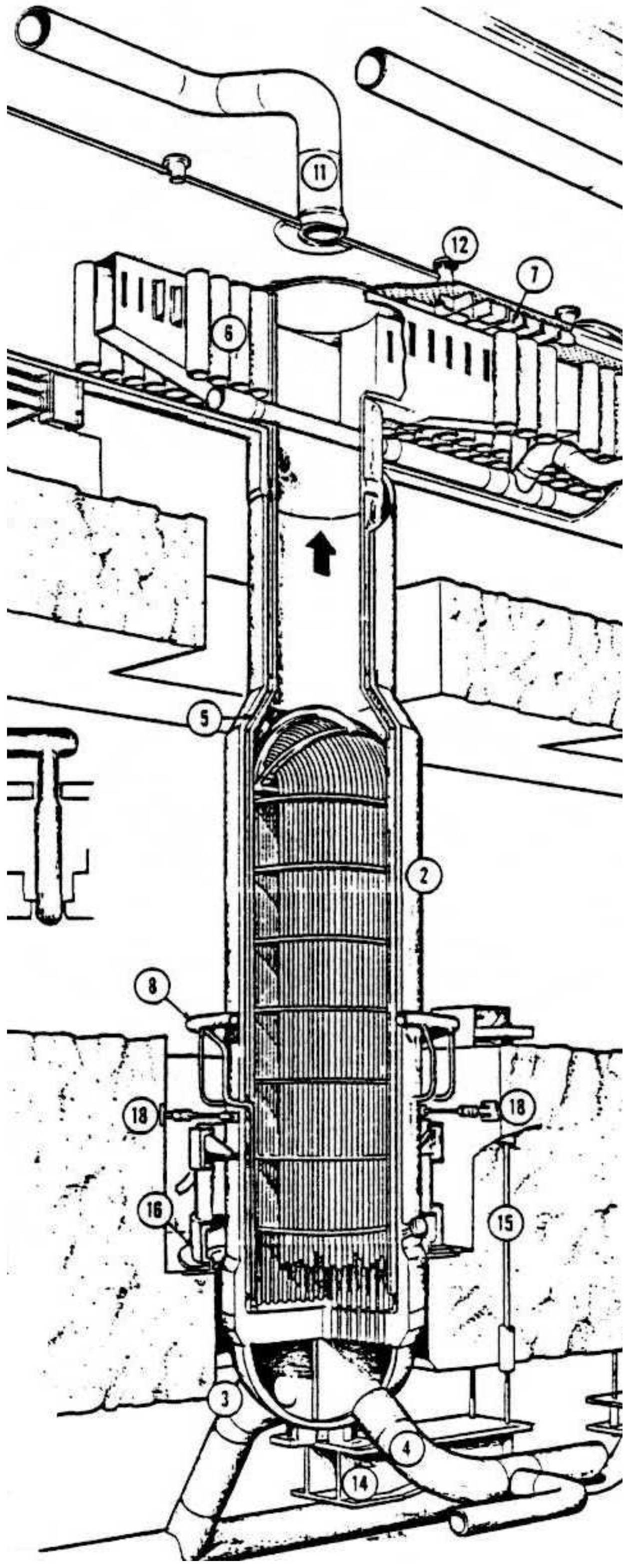
Forecast Inventory*

	To 2018	**To 2052**
Number of containers:	32	32
Total gross volume (m^3):	1,868	1,868

Ref

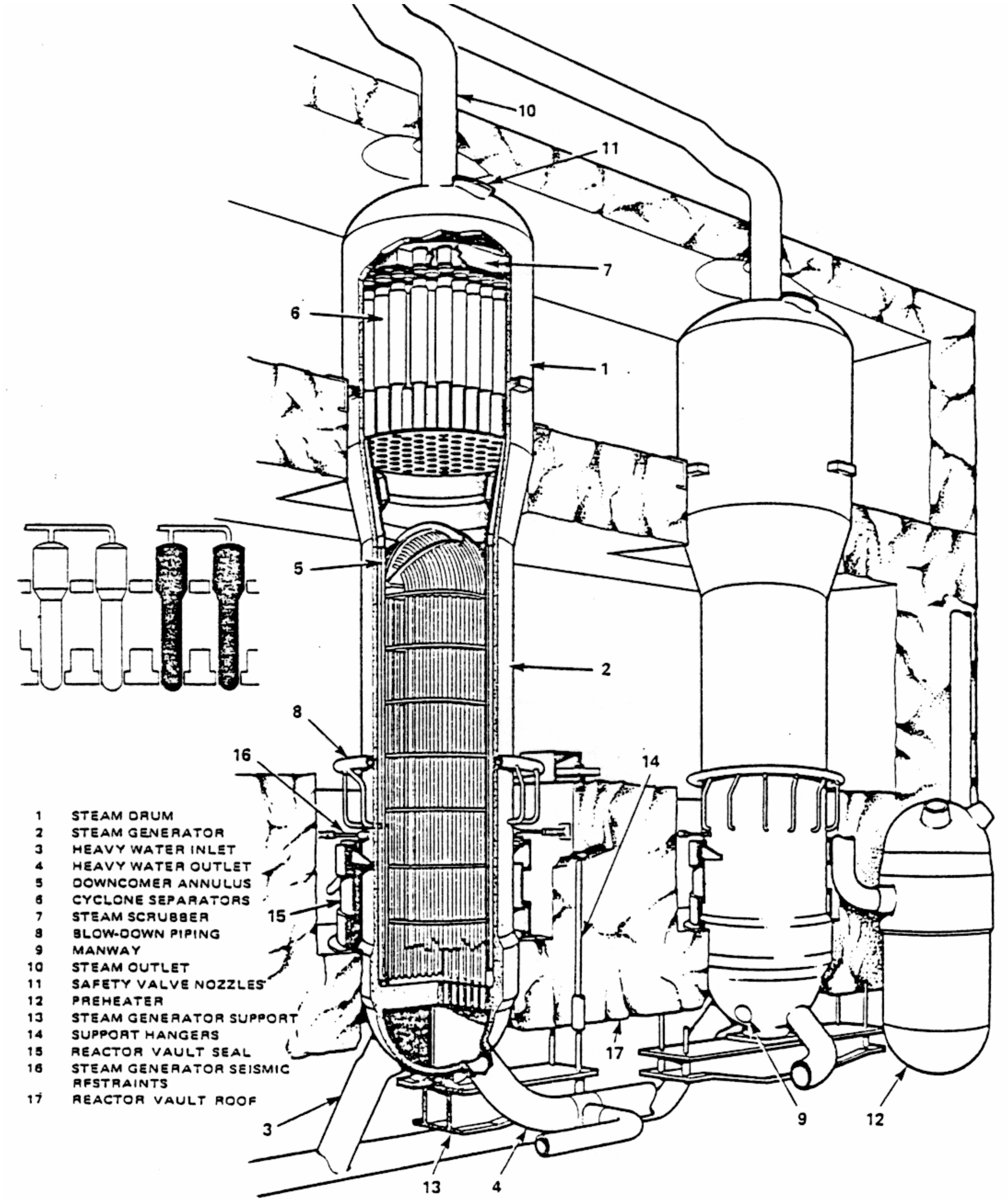
Dwg # n/a

*steam generators to be segmented into 5 pieces (SGSGMT)


11
12
7
6
5
2
8
18
18
16
15
3
4
14

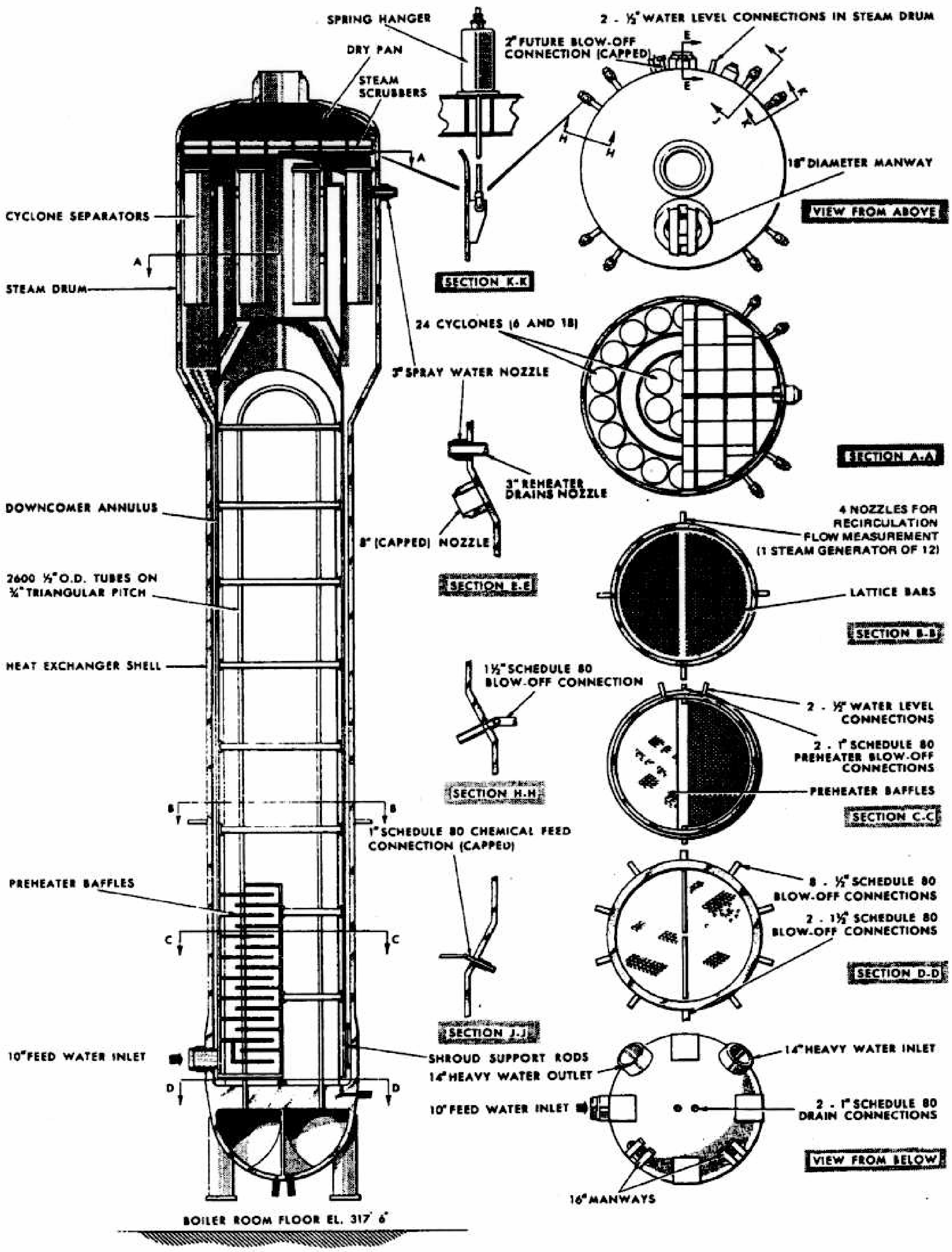
Container Description	*Container name:*	Steam Generator (Bruce B)	Picture n/a
	IWTS container code:	SG(BB)	
	CATID:	n/a	
	Dimensions (m):	3.6/2.5 OD x 15.5 OL	
	External surface area (m^2):	n/a	
	Gross volume (m^3):	108	
	Material:	carbon steel shell, high alloy steel tubes	
	Empty mass (kg):	135,000	
	Avg full mass (kg):	n/a	
	Stackability:	n/a	
	Handling:	heavy lift rigging, forklift	
Waste Properties	*Typical contents:*	n/a	
	Typical composition:	n/a	
	Potential hazardous constituents:	n/a	
	Avg waste density (kg/m^3):	n/a	
	Contact Dose rate (mSv/h):	n/a	
	Specific activity (Bq/m^3):	1.6E+10	
Forecast Inventory		**To 2018**	**To 2052**
	Number of containers:	32	32
	Total gross volume (m^3):	3,457	3,457
Ref	Dwg # n/a		

*steam generators to be segmented into 8 pieces (SGSGMT)


10
11
7
6
1
5
2
8
16
14
15
17
3
13
4
9
12
1 STEAM DRUM
2 STEAM GENERATOR
3 HEAVY WATER INLET
4 HEAVY WATER OUTLET
5 DOWNCOMER ANNULUS
6 CYCLONE SEPARATORS
7 STEAM SCRUBBER
8 BLOW-DOWN PIPING
9 MANWAY
10 STEAM OUTLET
11 SAFETY VALVE NOZZLES
12 PREHEATER
13 STEAM GENERATOR SUPPORT
14 SUPPORT HANGERS
15 REACTOR VAULT SEAL
16 STEAM GENERATOR SEISMIC RESTRAINTS
17 REACTOR VAULT ROOF

Container Description	*Container name:*	Steam Generator (Pickering)	Picture n/a
	IWTS container code:	SG(P)	
	CATID:	n/a	
	Dimensions (m):	2.5/1.8 OD x 14.3 OL	
	External surface area (m^2):	n/a	
	Gross volume (m^3):	48.9	
	Material:	carbon steel shell, high alloy steel tubes	
	Empty mass (kg):	85,000	
	Avg full mass (kg):	n/a	
	Stackability:	n/a	
	Handling:	heavy forklift rigging, forklift	
Waste Properties	*Typical contents:*	n/a	
	Typical composition:	n/a	
	Potential hazardous constituents:	n/a	
	Avg waste density (kg/m^3):	n/a	
	Contact Dose rate (mSv/h):	n/a	
	Specific activity (Bq/m^3):	1.6E+10	
Forecast Inventory		**To 2018**	**To 2052**
	Number of containers:	48	48
	Total gross volume (m^3):	2,349	2,349
Ref	Dwg # n/a		

*steam generators to be segmented into 6 pieces (SGSGMT)


SPRING HANGER
DRY PAN
STEAM SCRUBBERS
CYCLONE SEPARATORS
STEAM DRUM
2" FUTURE BLOW-OFF CONNECTION (CAPPED)
2 - ½" WATER LEVEL CONNECTIONS IN STEAM DRUM
18" DIAMETER MANWAY
VIEW FROM ABOVE
SECTION K-K
24 CYCLONES (6 AND 18)
3" SPRAY WATER NOZZLE
SECTION A-A
3" REHEATER DRAINS NOZZLE
8" (CAPPED) NOZZLE
SECTION E-E
DOWNCOMER ANNULUS
2600 ½" O.D. TUBES ON ¾" TRIANGULAR PITCH
HEAT EXCHANGER SHELL
4 NOZZLES FOR RECIRCULATION FLOW MEASUREMENT (1 STEAM GENERATOR OF 12)
LATTICE BARS
SECTION B-B
1½" SCHEDULE 80 BLOW-OFF CONNECTION
SECTION H-H
2 - ½" WATER LEVEL CONNECTIONS
2 - 1" SCHEDULE 80 PREHEATER BLOW-OFF CONNECTIONS
PREHEATER BAFFLES
SECTION C-C
1" SCHEDULE 80 CHEMICAL FEED CONNECTION (CAPPED)
PREHEATER BAFFLES
8 - ½" SCHEDULE 80 BLOW-OFF CONNECTIONS
2 - 1½" SCHEDULE 80 BLOW-OFF CONNECTIONS
SECTION D-D
SECTION J-J
10" FEED WATER INLET
SHROUD SUPPORT RODS
14" HEAVY WATER OUTLET
14" HEAVY WATER INLET
10" FEED WATER INLET
2 - 1" SCHEDULE 80 DRAIN CONNECTIONS
VIEW FROM BELOW
16" MANWAYS
BOILER ROOM FLOOR EL. 317' 6"

Container Description	*Container name:*	Steam Generator Segment	
	IWTS container code:	SGSGMT	
	CATID:	n/a	
	Dimensions (m):	1.8-3.6 OD x 2.0-4.3 OL	
	External surface area (m^2):	43.6 (max)	
	Gross volume (m^3):	21.1 (max)	
			Picture n/a
	Material:	carbon steel shell, high alloy steel tubes	
	Empty mass (kg):	n/a	
	Avg full mass (kg):	25,730	
	Stackability:	n/a	
	Handling:	heavy forklift rigging, forklift	
Waste Properties	*Typical contents:*	n/a	
	Typical composition:	n/a	
	Potential hazardous constituents:	n/a	
	Avg waste density (kg/m^3):	n/a	
	Contact Dose rate (mSv/h):	n/a	
	Specific activity (Bq/m^3):	1.6E+10	
Forecast Inventory		**To 2018**	**To 2052**
	Number of containers:	512	512
	Total gross volume (m^3):	7,673	7,673
Ref	Dwg # n/a		

Note: Total mass includes grout weight

no drawing available

Container Description

Container name:	ILW Shield
IWTS container code:	n/a
CATID:	n/a
Dimensions (m):	1.0 OD x 1.7 OL
External surface area (m^2):	6.9
Gross volume (m^3):	1.3
Net waste volume (m^3):	0.25
Material:	n/a
Empty mass (kg):	2015
Avg full mass (kg):	2290
Stackability:	several
Handling:	forklift

Picture n/a

Waste Properties

Typical contents:	filters, IX columns, bagged wastes, and core components
Typical composition:	n/a
Potential hazardous constituents:	n/a
Avg waste density (kg/m^3):	n/a
Contact Dose rate (mSv/h):	< 2
Specific activity (Bq/m^3):	n/a

Forecast Inventory

	To 2018	**To 2052**
Number of containers:	0	7,383
Total gross volume (m^3):	0	9,858
Net waste volume (m^3):	0	1,846

Ref

Dwg # n/a

Note: Design under review

no drawing available