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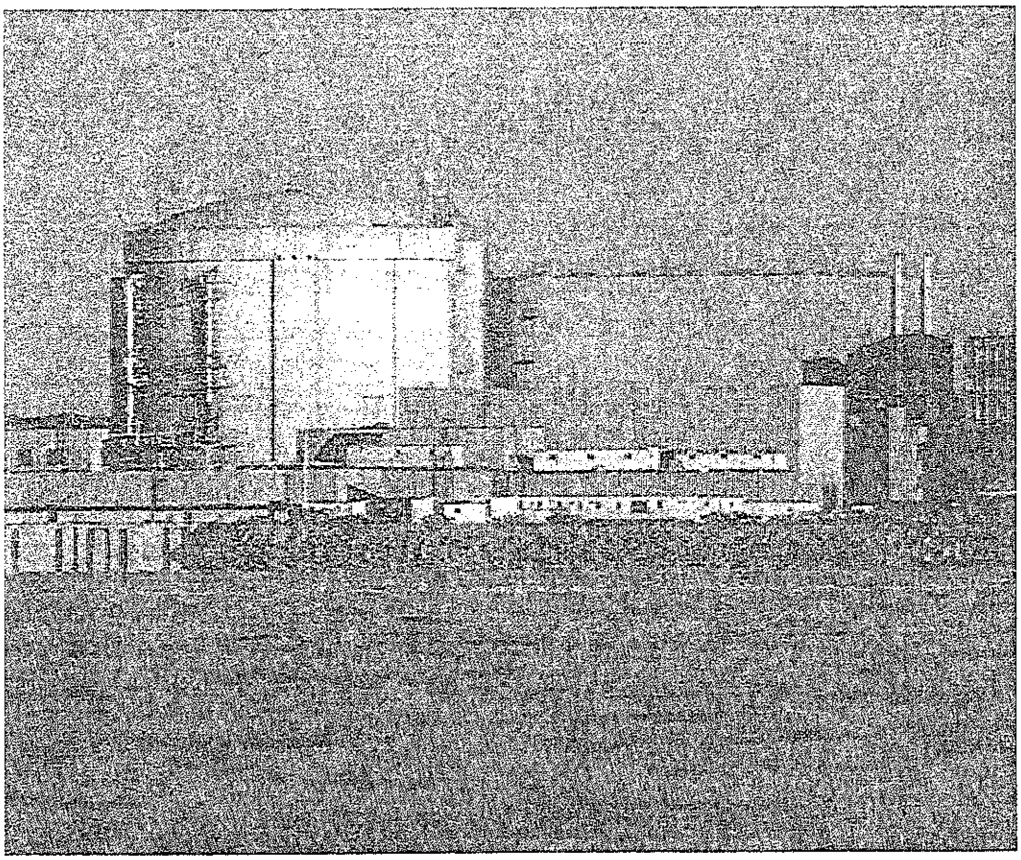
207 **DA2**
Projet de modification des installations de stockage des déchets radioactifs et réfection de Gentilly-2
Bécancour **6212-02-005**

PRELIMINARY DECOMMISSIONING PLAN
for the
GENTILLY 2 NUCLEAR GENERATING STATION



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REVISION LOG

No.	CRA No.	Date	Item Revised	Reason for Revision
0		4/26/01		Original Issue

ABBREVIATION LIST

AECB	Atomic Energy Control Board (obsolete)
AECL	Atomic Energy of Canada Ltd.
ALARA	As Low As Reasonably Achievable
ASDR	L'Aire de Stockage des Dechets Radioactifs
CANDU	Canadian Deuterium Uranium (Reactor)
CANSTOR	Canadian Storage Modules (for used reactor fuel)
CNSC	Canadian Nuclear Safety Commission
D&D	Decontamination and Dismantling
DOC	Decommissioning Operations Contractor
DWP	Detailed Work Procedure
GBq	Giga Bequerels
GWP	Generic Work Procedure
HEPA	Highly Efficiency Particulate Absolute (filter)
HQ	Hydro-Quebec
HTS	Heat Transport System
ILW	Intermediate-Level Waste
IP	Industrial Package
K Pa	Kilo Pascal
LLW	Low-Level Waste
LTP	License Termination Plan
M^3	Cubic Meter
MWe	Mega Watt electrical
PCB	Polychlorinated Biphenyl
PDP	Preliminary Decommissioning Plan
SAFSTOR	Safe Storage (decommissioning strategy)
Sv	Sievert
TBq	Terra Bequerels

1. INTRODUCTION

1.1 PURPOSE

This Preliminary Decommissioning Plan (PDP or plan) has been prepared for the Hydro-Quebec (HQ) Gentilly Unit 2 Station to comply with the requirements of Canadian Nuclear Safety Commissioning (CNSC) Regulatory Guide G-219, "Decommissioning Plan for Licensed Activities," and dated June 2000 (Ref. 1), referred to herein as G-219. It will be filed with the CNSC during the operating portion of the station's life cycle. In addition to the regulatory requirement for submittal of this plan, HQ management will use the plan to:

- Guide the facilitation of the decommissioning process
- Document the preferred decommissioning strategy that represents a technically feasible, safe and environmentally acceptable approach in light of current knowledge
- Provide a structured and dynamic outline for establishing and maintaining an acceptable financial guarantee program
- Provide guidance for future decommissioning planning and the preparation of a detailed decommissioning plan

1.2 SCOPE

This PDP covers the decommissioning of the Gentilly 2 Nuclear Generating Station. The site also contains Gentilly 1, a CANDU BLW-250 MWe unit that was decommissioning in 1986. After the decommissioning, the reactor and turbine buildings were licensed by the Atomic Energy Control Board (AECB) as a Waste Management Facility on July 1, 1986. The Gentilly 1 service building is now an integral part of the Gentilly 2 station and is used as a Training and Service Building. Under contract, HQ provides a minimal amount of services to the Gentilly 1 Waste Management Facility; however, this facility is not owned by Hydro-Quebec, and thus, not included within the scope of the PDP. Thus, all future references to the Gentilly station in this document are in reference to the Unit 2 generating station and the Unit 1 service building.

This plan provides general descriptions of activities that are scheduled to occur many decades in the future. Many of these activities are highly complex in nature, and are likely to involve regulatory and technological issues that are still evolving. Therefore, this PDP is based on conservative information and predictions. This PDP should therefore be considered a living document, which will ultimately lead to preparation of a detailed decommissioning plan just prior to the permanent shutdown of the station.

1.3 STRUCTURE AND CONTENT OF PLAN

This PDP has been prepared to directly correspond with the required plan contents, as listed in Section 6.1.2 of G-219. Therefore, the contents of this plan are presented as follows:

Section 2	Description of the site to be decommissioned
Section 3	Overview of site radiological, chemical and physical conditions expected after station shutdown
Section 4	Discussion of the decommissioning planning envelope and strategy for decommissioning
Section 5	Discussion of the site's end-state objectives
Section 6	Description of the anticipated work scope and process, anticipated hazards and proposed mitigating protective strategies, and estimated occupational radiation exposures and radioactive wastes
Section 7	Assessment of the potential impact that the project may have on surrounding natural and human environments
Section 8	Conceptual schedule for anticipated activities
Section 9	Estimated costs to conduct the decommissioning
Section 10	Discussion of HQ's plan for funding the project
Section 11	Information that HQ will maintain throughout the station's life cycle to facilitate the project

2. DESCRIPTION OF SITE TO BE DECOMMISSIONED

2.1 SITE LOCATION

The Gentilly site is located in the Municipality of Becancour County of Nicolet, Province of Quebec, on the south bank of the St-Laurent River, about 15 km east of Trios-Rivieres. The geographic location of the site is indicated on Figure 1 of the Appendix.

The plant site is located in a rural area currently under development as an industrial park. Adjacent properties to the Gentilly site are exclusively industrial or agriculturally based concerns. The closest population center, the Town of Champlain, is located on the north bank of the St-Laurent River, approximately 4 km from the plant site. The local population density within the first 10 km radius of the plant is estimated at 25 persons per square km, with no population living in the exclusion zone of at least one kilometer from the production building.

The HG-owned site consists of approximately 240 hectares of low trees and shrubs indigenous to the local area, with the plant structures situated on a small point at the river edge. The mean site grade elevation is 7.16 meters above sea level and 0.37 meters above the high water level of the St-Laurent River. Automobile and truck access to the plant is via a single 2 km road from Autoroute 30. The site has an unused rail spur. Although there is no currently active facility, the existing barge landing station may be upgraded to provide shipping transportation for large components or quantities of materials. The St-Laurent Seaway Ship Channel is approximately 1000 meters from the plant at the closest point.

2.2 COMPONENTS TO BE DECOMMISSIONED

The major station components consist of CANDU Series 600, pressurized heavy water nuclear reactor and associated electrical power generation equipment. The nuclear reactor has a gross electrical power rating of 675 MWe. The major components containing the bulk of the radioactivity that will require decontamination and/or dismantling to achieve free-release of the station are located in the Reactor Building. Figure 2 provides a cut-away view of a CANDU Series 600 reactor building and shows the major components that are located within it. Schematic representations of the major radioactive components that will require dismantling and disposal, the main moderator and heat transport systems, are presented in Figures 3 and 4, respectively.

The bulk of the decommissioning work will entail removal of components from these two systems, and include the following major components:

- Reactor (calandria and shield tank) (465 metric tons)
- Moderator heat exchangers (2, at 56 tons each) and circulating pumps (2, at 12 tons each)
- Calandria head trunk
- Steam generators (4, at 200 tons each) and heat transfer system (HTS) pumps (4, at 75 tons each)
- Pressurizer (110) tons
- HTS degasser (45 tons)
- HTS piping and associated valves
- Components and piping associates with the heavy water purification, recovery, and liquid poison systems

Decommissioning will also entail removal of the CANSTOR used fuel storage containers, of which there are five. These containers are located in the Dry Storage Site, as shown on Figure 5.

2.3 STRUCTURES TO BE DECOMMISSIONED

The Gentilly station consists of a reactor building, turbine building, service building, pump-house, cooling water intake and discharge channels, dry fuel storage facility, transmission switchyard, warehouse, training facilities, and administrative offices. Other lesser buildings or structures on site contain a variety of systems or components required for operation of the reactor.

The reactor building is the largest component of the containment boundary; it contains the calandria, active nuclear fuel, and all equipment directly associated with the production of steam. The containment structure consists of a pre-stressed concrete cylindrical wall, spherical segmental dome, and a base slab. The containment is designed to contain an internal pressure of 124 kPa (gauge) under peak accident conditions. An impermeable lining is integral to the building to prevent air or water leakage. An inner dome at the top of the reactor building, together with the building perimeter wall, form a water storage tank for the internal containment dousing system and emergency core cooling.

The turbine building is a conventional industrial structure containing the turbine and its auxiliary systems, the Class III diesel generators, the chlorination system, and the heating system heaters and pumps. The walls and roof consist of prefabricated steel elements and insulation. The turbine building consists of a main hall housing the turbine and generator, and auxiliary areas for electrical power distribution equipment, batteries, air compressors, extraction pumps, feedwater heaters, and deaerators.

The service building is a conventional, reinforced concrete structure containing the control room, irradiated fuel hall and bays, heavy water treatment apparatus, and radioactive waste compacting room. It also contains conventional service facilities such as a storeroom, workshops, a changing room, decontamination center, and chemistry laboratories.

The dry fuel storage facility (south of the decommissioned Gentilly 1 reactor containment structure) is composed of independent, reinforced concrete vaults containing 20 vertically positioned galvanized carbon steel storage cylinders, known as CANSTOR modules. The capacity of each module is 12,000 fuel bundles. At present, there are five modules. A rail crane services the facility and provides access to each module.

Solid low-level wastes (LLW) and intermediate-level wastes (ILW) are stored in engineered, underground, concrete storage vaults referred to as the ASDR (l'Aire de Stockage des Dechets Radioactifs). They are located about 300m south of the Gentilly 1 reactor building.

Contaminated liquids are processed using ion-exchange resins. Used radioactive resins are currently stored on site in two storage tanks.

All other structures of a conventional construction and nature as associated with the operation of a nuclear power station. The layout of these structures is depicted on Figure 5.

3. OVERVIEW OF SITE CONDITIONS AFTER SHUTDOWN

As the station is still in an operational mode, and will then undergo a long period of dormancy prior to initiating dismantling and decontamination, conditions within it are still subject to change. Actual conditions will be characterized upon plant shutdown and again prior to commencement of detailed decommissioning panning. However for the purposes of this PDP, when the conditions of decommissioning activities need to be defined and limiting conditions and safety risks assessed, the radiological, hazardous, and physical conditions can be predicted with sufficient accuracy.

The radiological conditions are expected to provide the most limiting conditions when considering the decommissioning work that must be performed. Hence, these potential conditions will be described in more detail. The hazardous chemical and physical conditions are expected to be similar to that encountered during the dismantling of a conventional fossil power station or petro-chemical facility, and will be described in less detail.

3.1 RADIOLOGICAL CONDITIONS

The most significant of the radiological conditions at Gentilly are assumed to be similar to that of a standard CANDU 600 MWe station. Atomic Energy of Canada, Ltd. (AECL) conducted a study (Ref. 2) for such a station, and estimated the radionuclide inventory and radiation levels associated with the major sources of radioactivity, excluding the irradiated fuel and incidental radioactivity in resins at the time of reactor shutdown. The results of this study are based on hypothetical conditions, with an assumed nominal forty years of operation, and average capacity factor of 80%, and fuel failure rate of 0,06%. These are worst-case bounding assumptions, and are likely to overestimate the actual radioactive inventory. The results of this study are summarized herein.

3.1.1 Radionuclide Inventory

1. Background

There are two origins of radioactivity found in a station of this type. The first consists of activated material resulting from materials exposure to the neutron flux. The second consists of radioactive material produced directly from the fission of fuel.

The materials exposed to the neutron flux of the reactor for extended periods of time will become activated by the capture of free neutrons. The levels and types of radionuclides produced are dependent upon the chemical composition of the exposed materials, the duration of exposure, and the neutron flux and energies. The principle materials subject to neutron activation are the reactor structure, the heavy water, and corrosion products that may circulate in the heat transport and moderator systems. Therefore, activation products can be found as volumetric source within structures or components, or as a dispersible contamination that can accumulate on any surface wetted by fluids from the above systems.

The fission process gives rise to large quantities of highly radioactive fission products. These are retained in the irradiated fuel bundles and are the largest source of radioactivity. Although disposal of the fuels' radioactivity is not specifically a dismantling and decontamination activity, it does come into play if fission products are released from the fuel via a fuel cladding failure. Fission produces can therefore accumulate within systems or on surfaces wetted by fluids that come in contact with the fuel. The potential quantity of fission products depends on fuel leak rates and the timing between when a leak is detected and when it has been isolated from the HTS.

The major radionuclides that can accumulate in a typical CANDU 600 reactor are H-3, C-14, Fe-55, Co-60, Ni-63, Sr-90, Nb-94 & 95, Zr-95, Ru-106, Cs-134 & 137, Pm-147 and Eu-154.

2. Estimated Radionuclides Inventory

The AECL study estimated a total of 851 TBq of long-lived activation products in the reactor components and nearby structures at shutdown. A breakdown of this radioactivity (by individual radionuclides and allocated to the individual rector components) is given in Table 1 of the Appendix.

The total estimated inventory of long-lived fission-products to be present within the HTS and auxiliary systems was 9,24 TBq. Table 2 presents a breakdown by individual radionuclides.

The HTS and moderator systems will be filled with heavy water at the time of reactor shutdown in 2010. The most significant radioactivity contained in this water will be tritium. Water in the HTS and moderator systems was estimates to have H-3 concentrations of 92,5 GBq/l and 2 072 GBq/l, respectively, if no tritium removal is done during the operational life of the station (Ref. 2). This represents a total Tritium inventory of 6,03E8 GBq.

As can be seen from the preceding data, most of the radioactivity within the facility is concentrated within the calandria (as an activated metal) and in the tritiated heavy water. Only a small fraction represents contamination dispersed throughout the systems.

Figure 6 shows the effect of radioactive decay over time on the radionuclide inventory (including both activation and fission products) in the reactor. Initially, the inventory is dominated by short-lived radionuclides such as Co-60, Nb-95, and Fe-55. As can be seen, this provides for a very rapid rate of decay in total radioactivity during the first four to five years, followed by a slower by still rapid rate of decay out to about 27 years after shutdown. Afterwards, the radioactive inventory is dominated by much longer-lived radionuclides, such as Ni-63, Sr-90, Nb-94, Cs-137, and Ag-108m, producing a much slower rate of decay.

3.1.2 Major Component Dose Rates

Of all the hazardous types of material present within the station, the projected radionuclide inventory will present the greatest potential impact on worker health and is likely to be the single limiting parameter in the determination of how the decommissioning work can be performed. Due to the radionuclides present, the dominant exposure pathway will be via direct radiation exposure. As such, it warrants a discussion of the radiation exposure projected to occur from the radionuclide inventory.

The AECL study projected gamma radiation levels based on the estimates post-shutdown radionuclide inventories. Figure 7 provides a plot of the projected gamma radiation fields from the major in-core reactor components versus time. As can be seen, a decrease in radiation levels of almost two orders of magnitude is obtained after an initial 30-year decay period.

Figure 8 provides similar gamma dose rate information for the major out-of-core components expected to be the dominant contributors to personnel radiation exposure. The AECL study based this projection on Co-60 only and, as such, the rate of dose rate drop-off in the out years should be less due to contributions from longer-lived radionuclides such as Cs-137. However, the Co-60 levels initially dominate the radionuclide inventory to such an extent that the non-inclusion of other radionuclides has a negligible effect on the projected exposure rates.

3.2 CHEMICALS AND HAZARDOUS MATERIALS

The following section provides a brief overview of those hazardous materials that could be encountered by decommissioning workers at plant shutdown and beyond. The station will be characterized in detail at shutdown, allowing time for the exact nature and extent of hazardous chemicals and materials to be assessed. This information will then be used to develop detailed plans and procedures to address safety concerns during the decommissioning.

Based upon a review of the station's operating history, the following is a listing of the hazardous chemicals and materials that have been used at the station:

Above Ground or Day Fuel Storage Tanks
There are 12 above ground storage tanks as follows:
- Fire System Diesel Fuel Tanks: 1 @ 225 IG and 1 @ 250 IG
- Stand-by Diesel Generator Tank: 4 @ 500 IG
- Emergency Diesel Tank: 2 @ 200 IG
- Close Loop Service Water Diesel Pump Tanks: 2 @ 250 IG
- Automotive Fuel Tanks: 2 @ 250 IG

Underground Fuel Storage Tanks
There are 8 underground storage tanks as follows:
- Stand-by Diesel Generator Tank: 2 @ 20 000 IG
- Emergency Diesel Tank: 2 @ 500 IG
- Close Loop Service Water Diesel Pump Tanks: 2 @ 20 000 IG
- Grid Transformer Emergency Spill Collection Tank: 1 @ 113 000 Liters, and 1 @ 11 390 Liters (Both normally empty)

Waste Oil
The waste oil is stored in approved storage sheds in steel drums. Will be eliminated off-site per HQ disposal procedures.

PCP Contaminated Transformer Oil
All PCB contaminated transformer oil has been removed from the Gentilly Generating Station site.

Mercury
Mercury contained in instruments and switched will be removes and collected prior to final disposal of the equipment as per approved procedures. The mercury will be reclaimed or processed by an authorized and approved contractor.

Asbestos Containing Material
The only asbestos containing material present at the station is in minor quantities present in gaskets, packings, and insulators. All asbestos containing materials will be removed and disposed of in accordance with the HQ procedures and practice for working with Asbestos Containing Materials.

Lead-Based Paints
Lead-Based paints may have been used for coating many steel components, some concrete structures and underground carbon steel piping. At time of decommissioning, the paint shall be tested to determine if it contains lead. If it does, then the paint and/or components will be removed, processed, and disposed of in accordance with all rules and regulations for the Province of Quebec, and by an authorized and licensed contractor.

A comprehensive characterization program will be conducted upon shutdown of the station, to determine the nature and extent of hazardous materials. It is possible that other items may be discovered at that time. The following lists generic hazardous items with the potential for being present within a nuclear power facility:

Metallic Lead
- Shielding blocks, blankets, and sheets
- Wool packing in penetrations
- Plumbing joints

Asbestos-Containing Materials
- Insulation on components
- Equipment gaskets
- Floor Tile

Hazardous Constituents in Paint
- Lead
- PCBs
- Cadmium
- Asbestos
- Mercury

Fuel Oil Residues
- Tanks and feed lines
- Diesel generators
- Auxiliary and heating boilers

Lubricating Oils and Greases
- Motors
- Mechanical power transmissions

Metallic Mercury
- Electrical switches
- Manometers and gauges

PCBs and Di-Electric Oils
- Electrical transformers
- Busways
- Bushings

3.3 PHYSICAL CONDITIONS

HQ is committed to the continued maintenance of the Gentilly Station in a manner that eliminated physical personnel hazards. These safety efforts will continue through remaining station operations to the completion of decommissioning. However, HQ recognizes that, upon station shutdown, the station's physical condition will not remain in the static state. Physical degradation of structures and equipment is likely to occur as the station ages during the dormancy period. Furthermore, the decommissioning work will cause the station to physically change. Therefore, there will be the potential for hazardous physical conditions. HQ will conduct surveillance and monitoring to identify unsafe physical conditions, such that any hazards would be managed through the safety programs that HQ will implement.

The following is a listing of typical physical conditions that can be anticipated to arise in an aging facility and/or during demolition and dismantling work. These will require diligent management to maintain safe conditions for the decommissioning workers:

Energy-Related Conditions
- Degraded electrical insulation
- Embedded electrical conduits
- Unrecognized energized circuits
- Pressurized systems and equipment
- Fire and explosion (e.g., accumulation of combustible gases and materials)

Mechanical
- Falling overhead objects
- Loss of railings providing fall protection
- Creation of sharp objects and impaling hazards

Structural
- Roof and floor weakness
- Slippery surfaces (e.g., water/ice infiltration)
- Confined space atmospheric degradation (e.g., oxygen depletion from oxidation of steel)
- Collapse of structures

4. DECOMMISSIONING STRATEGY

4.1 PLANNING ENVELOPE

It is currently envisioned that the entire site will be decommissioned as a single project. However, for the purposed of efficiently planning and managing the decommissioning project, it will be conducted in phases, with the work further subdivided into smaller manageable work units (packages). The project is planned to have three phases: Preparation For Dormancy, Dormancy, and Dismantling and Site Restoration. Each of these phases is categorized by generic work activities, such as engineering and planning, work area preparations, equipment removal, decontamination, waste processing and disposal, demolition, final surveys, license termination applications, and site restoration. These activities are than applied to specific decommissioning work packages. The major dismantling and decontamination packages are discussed in Section 6.

4.2 STRATEGY

HQ intends to decommission the Gentilly Station for unrestricted release after maintaining the station in a state of extended dormancy. The duration of the dormancy period will be such the final dismantling of Gentilly 2 will commence around the year 2044. This scenario, defined within the decommissioning industry as Safe Storage or SAFSTOR has been defined as "Deferred Removal" in Canada's G-219. A graphical representation of this scenario, as it relates to Gentilly, is provided in Figure 9.

The deferred decommissioning strategy is considered to be the most beneficial, based on two considerations: the ALARA principle and the availability of permanent waste disposal. HQ has chosen the deferred removal decommissioning strategy to minimize both the occupational radiation dose to the decommissioning staff and any potential exposure of the public. The radiological hazards encountered during the decommissioning of the reactor would principally be caused by radionuclides produced during operation. The majority of this radioactivity at station shutdown will be short-lived radionuclides such as H-3, Fe-55, Nb-95, Zr-95, and Co-60. These radionuclides will decay with time. If dismantling is delayed for a sufficient period, dismantling crews will be exposed to lower radiation fields. Co-60, a strong gamma emitter will become the dominant radiation source after about four years of shutdown. With radiation fields from Co-60 decreasing by about a factor of two every 5,26 years, a 34-year dormancy period will reduce the radiation levels to which decommissioning workers will be exposed by a factor of about 88.

Decommissioning of the Gentilly Station will generate a significant quantity of low-level radioactive waste, as is described in Section 6.4. This waste material, as well as the irradiated fuel, will require disposal in a licensed facility. Currently, no such facilities exist in Canada. Dismantling the facility without a known disposal option would present certain difficulties that will be avoided by use of the deferred removal strategy. They include the need to store and monitor the wastes until a disposal facility becomes available, and the potential double-handling of wastes to meet unknown future disposal facility requirements. HQ will maintain dormancy into such a site is made available. However, non-nuclear parts of the plant could be dismantled at any time.

5. END-STATE OBJECTIVES

The objective of the decommissioning is to permanently retire the Gentilly Station from service in a manner that will ensure the health, safety, and security of workers, the public, and the environment. During the course of the decommissioning, all radioactive and hazardous materials above prescribed limits will be removed from the site. Upon completion of the decommissioning, the site will be in a condition that will permit the CNSC to issue a License for Abandonment. The site will then be restores to an end-state determined near the end of the decommissioning (e.g., industrial re-use, return to nature, etc.).

Due to the phase nature and extended performance period of this decommissioning project, it is appropriate to provide intermediate end-state objectives for each of the three main project phases. They are described herein.

5.1 PREPARATION FOR DORMANCY

At the end of the Preparation for Dormancy phase, the reactor will have been de-fuelled and dewatered. Most of the external non-fixed surface contamination will have been removed from accessible areas of the station. Internal chemical decontamination will have removed much of the radioactive material contained within internally contaminated systems. The largest source of remaining radioactivity will be the fuel remaining in the irradiated fuel bays and the neutron activated calandria and its internals. Most of the other hazardous materials will also have been removed from the site. Plant systems will have been drained, de-energized, and secured, except for those required for use during the Dormancy Phase.

5.2 DORMANCY

Radioactive decay will have substantially reduced the residual contamination levels throughout the station, and reduced the dose rates surrounding the calandria and it internals. Plant systems (except for those in use during the period of dormancy) will remain in a drained, de-energized, and secure state. The facility will remain intact, with the structures and systems maintained in a safe condition.

5.3 DISMANTLING AND SITE RESTORATION

By the end of the Dismantling and Site Restoration phase the site will be free of all hazards. All radioactive contamination and hazardous materials in excess of the prescribed limits will have been removed from the site. All of the plant systems will have been dismantled and the structures and land areas decontaminated.

A final report of the decommissioning will have been prepared. The final report will describe the decommissioning work that was performed and the outcome of that work, the results of the final surveys that were performed, and the interpretation of those results. Any other information required by the applicable regulations will also be included in the report. The final report will have been submitted to the CNSC in support of an application for a License to Abandon.

Once the CNSC has verified the results of the final surveys, any unnecessary buildings will be demolished to a depth of one meter below grade level. Open excavations or foundations will be backfilled with clean and stable material. The site will have been restored to and environmentally stable state, suitable for use for other industrial or commercial uses.

6. DECOMMISSIONING PROGRAM

This section of the PDP first provides an overview of the major decommissioning tasks and activities, followed by a discussion of the anticipated hazards to be encountered, the strategy for providing protection against those hazards, estimates of occupational radiation doses projected, and waste volumes expected to be generated.

6.1 DECOMMISSIONING ACTIVITIES

The activities associated with the preferred decommissioning strategy (deferred removal) are logically divided into three major phases. The initial phase prepares for and places the facility into an extended state of dormancy. During this extended dormancy (the second phase), the facility will be left intact with structures maintained in a sound condition. Systems not required to be operational in support of site surveillance and security will be drained, de-energized, and secured. Access to contaminated areas will be physically secured to provide for controlled access for periodic inspection and maintenance activities during dormancy. The third and final decommissioning phase removes the facility from dormancy and removes the radiological and hazardous attributes from the facility. The site is then restored to a condition that allows its use for some other unrestricted industrial, commercial, or residential purpose. The site will be released from regulatory control upon conclusion of the decommissioning and license termination. Additional discussion of each phase is provided herein.

6.1.1 Phase 1 – Preparation For Dormancy

HQ will submit a detailed decommissioning plan to the CNSC one year prior to scheduled end of operations. This plan, conforming to the content requirements of Section 6.2.2 of G-219, will be a detailed expansion of this PDP. The plan would also address any plan changes or any unreviewed environmental impacts.

In anticipation of the cessation of station operations, detailed preparations will be undertaken to provide a smooth transition from plant operations to site decommissioning. The organization required to manage the intended decommissioning program will be assembled from available plant staff and outside resources, as required. Preparations will include the planning for permanent defueling of the reactor and removal of the heavy water from the heat transfer and moderator systems, revision of technical specifications appropriate to the operating conditions and requirements, a radiological and hazardous material characterization of the facility and major components, and the development of dormancy plans and procedures. Existing operational technical specifications will be reviewed and modified to reflect plant conditions and the safety concerns associated with permanent cessation of operations.

The primary objectives will be adherence to the principles of ALARA for protection of workers and the public both before and during the dormancy period, and the continued protection of the environment.

Specific Objectives and Activities

The major work package activities associated with placing the station into dormancy are as follows:

- Prepare and submit a Detailed Decommissioning Plan to the CNSC, addressing the following decommissioning issues:

  - Facilities to be decommissioned
  - Historical site assessment
  - Specific end-state objectives
  - Long term institutional controls
  - Facility characterization/condition results
  - Strategy overview
  - Work packages
  - Schedule details
  - Waste management plans
  - Environmental assessment
  - Cost estimate update
  - Financial guarantee arrangements
  - Public involvement/issues
  - Project management organization
  - Quality assurance program
  - Emergency response plan
  - Site security program
  - Radiation protection program
  - Environmental protection program
  - Personnel training and qualifications
  - Human factors program
  - Occupational health and safety

- Regulatory involvement
- Final survey program and criteria
- Retention of documentation and records
- Final report outline

* Defuel the reactor, transferring the fuel bundles to the irradiated fuel bay. These fuel bundles are required by the current dry storage canister design limitations to cool in the storage bay for a period of seven years. Plant personnel will carry out this activity in accordance with existing operating technical specifications. The existing bay will continue to operate until all fuel is transferred to the CANSTOR modules.
* Drain/de-energize/secure all non-contaminated systems not required to support dormancy operations.
* Dispose of contaminated filter elements and resin beds not required for processing wastes from decontamination activities.
* Decontaminate the heat transport, moderator, and other active systems.
* Drain/de-energize/secure all other contaminated systems.
* Decontaminate systems as required for future maintenance and inspection.
* Prepare lighting and alarm systems where continued use is required.
* De-energize and/or secure portions of fire protection, electric power, and heating, ventilation, and air-conditioning systems whose continued use is not required.
* Clean loose surface contamination from building access pathways or from outside the buildings.
* Perform interim radiation surveys of plant; post warning signs as appropriate.
* Erect physical barriers and/or secure all access to radioactive or contaminated areas, except as required for controlled access; i.e., for inspection and maintenance.
* Install security and surveillance monitoring equipment and relocate security fence around secured structures, as required.

6.1.2 Phase 2 - Dormancy

The primary activities to be performed during the envisioned dormancy period are those required to ensure safety of the public and environment. The goal is to maintain structural integrity of the facility, prevent human intrusion and contain the radioactivity. The strategy for accomplishing this will include use of a security force, preventive and corrective maintenance on security systems, area lighting, general building maintenance, ventilation of buildings, routine radiological inspections of contaminated structures, maintenance of structural integrity, irradiated fuel handling, and a site environmental and radiation protection/monitoring program.

Resident maintenance personnel will perform equipment maintenance, inspection activities, and routine service. The work force will maintain the structures in a safe condition, provide adequate lighting and ventilation, and perform periodic preventive maintenance in essential site services.

Security during the dormancy period will be conducted primarily to prevent unauthorized entry and to protect the public from any consequences of its own actions. Security will be provided by on-site security force personnel, fencing, sensors, alarms, surveillance equipment, etc., which will be maintained in good condition for the duration of this period. Fire and radiation alarms will also to be monitored and maintained.

An environmental surveillance program will be carried out during the dormancy period to ensure that any potential releases of radioactive material to the environment are detected. Appropriate emergency procedures will be established, maintained and initiated in the unlikely event that a release were to occur above prescribed limits.

A radiation protection program will be implemented during the dormancy period to both support the ongoing facility maintenance and surveillance activities, and monitor the radiological condition of the facility.

For the most part, both the radiation protection and environmental surveillance programs will be scaled back versions of the programs now in effect during normal plant operations, commensurate with the types of activities being conducted.

Handling of irradiated fuel will occur twice during the dormancy period: first with the offloading from the fuel bay into the canisters and ending seven years following plan shutdown; and, second, with the transfer of the fuel to shipping casks for removal from the Gentilly site. Plant personnel are envisioned to perform all required tasks in both instances. The shipment of fuel to a final repository is expected to continue into Phase 3, Dismantling Operations, and end in the 2049 timeframe.

6.1.3 Phase 3 – Removal

Phase 3, Removal, is characterized by three distinct sub-phases, they are: D&D (decontamination and dismantling) Preparations, D&D Operations, and Site Restoration. The activities needed to carry out each of these sub-phases are summarized below.

(1) D&D Preparations

Detailed preparations will be undertaken to provide a smooth transition from Dormancy to the removal phase. The organization required to manage the intended D&D activities will be assembled from the dormancy plant staff at Gentilly as well as from outside resources, as required. In addition, HQ will hire a Decommissioning Operations Contractor (DOC) to provide contract management of the decommissioning labor force and subcontractors. Preparatory activities, as well as subsequent Phase 3 activities, will be conducted jointly by the HQ/DOC team.

Preparatory activities will include all necessary upfront planning, regulatory notifications and approvals, organizational realignments, equipment and resource procurements, and the facility modifications and upgrades needed to support the D&D activities.

One of the first preparatory activities will include conducting an initial comprehensive and detailed radiological and hazardous material characterization of those facility areas and major components needed to identify the requirements of the D&D program. All characterization work cannot be realistically accomplished upfront, due to hazards and interferences that are present; therefore, the characterization program will continue on into the D&D and restoration phases to support ongoing decommissioning work and planning.

Once the initial detailed characterization is accomplished, the specific plans that will lead to license termination will be developed (herein referred to as a License Termination Plan, or LTP). This LTP will be an extension of the Detailed Decommissioning Plan that will be prepared upon plant shutdown, and will specify the actions and controls needed to safely lead to the License to Abandon the changed generating station.

This LTP will include the site characterization results, specific description of the D&D activities, plans for site remediation, detailed plans for the final radiation survey, designation of the end-use of the site, an analysis of safety and environmental risks and controls, and an updated cost estimate for completing the decommissioning.

Development of work package activity specifications and implementation procedures will also be started at this time. These will include both generic work procedures (GWPs) and detailed work procedures (DWPs). The GWPs will control routine activities to be repeated throughout the D&D phase (for example, operation and maintenance of a HEPA ventilation unit, or mechanical cutting of contaminated pipe). DWPs will control unique one-time operations (for example, segmentation of calandria pressure tubes). It is expected that development of the DWPs will continue throughout the D&D and restoration phases, which will allow incorporation of the latest in-process characterization data and lessons learned from implementation of prior activities.

Preparations will also include planning and making the physical changes to the facility to support the upcoming D&D work. This will include reactivation of required support systems, installation of new support equipment, and making modifications to the facilities to reflect the change of mission.

Specific Objectives and Activities

Engineering and Planning

The primary objective for engineering and planning activities will be to develop D&D protocols that meet ALARA objectives for protection of personnel from exposure to radiation hazards as well as providing continued protection of the health and safety of the public and the environment. Engineering and planning will include, but is not limited to, the following activities:

- Site preparation plans for the proposed D&D activities.
- Site characterization study to determine nature and extent of site radioactive and chemical contamination, including radiation profile surveys of work areas, major components (including the calandria and internals), sampling of internal piping contamination levels, and core sampling of the primary shield.
- Correlation of survey data for the development of activated material packaging and transportation procedures.
- Detailed procedures and sequences for removal of systems and components.
- Evaluation of the disposition alternatives for the calandria and its internals.
- Plans for decontamination of structures and systems.
- Design/procurement and testing of special tooling and equipment.
- Identification/selection of specialty contractors and venders.
- Plans for removal and disposal of radioactive/hazardous materials.
- Sequential planning of activities to minimize conflicts with simultaneous tasks.
- Development and/or upgrade of procedures for: occupational exposure control; control and release of liquid and gaseous effluent; processing of radwaste, including resins, filter media, metallic and non-metallic components generated in D&D; site security and emergency programs; and industry safety.

Physical Preparations

The objective of the physical preparatory activities will be to reconfigure the site to handle the change of its mission from Dormancy to Removal. This will include, but is not limited to, the following activities:

- Preparation of site support and material storage facilities, as required.
- Cleaning of loose contamination and processing and disposal of existing liquid and solid wastes.

- Specification and fabrication of transport and disposal containers for highly activated materials, including shielding and stabilization.
- Installation of material handling and treatment equipment and set up of material staging areas.
- Upgrade of laboratory and survey procedures, equipment, and facilities needed to support the decommissioning.
- Construction of temporary facilities and modification of existing storage facilities to support the D&D activities. New tasks may include adding changing rooms and contaminated laundry facilities for increased work force, establishing laydown areas to facilitate equipment removal and preparations for off-site transfer, upgrading roads to facilitate hauling and transportation, and modifying the reactor building to facilitate access for large/heavy equipment.
- Design and fabrication of shielding in support of removal and transportation activities as well as contamination control envelopes; specification/procurement of specialty tooling and remotely operated equipment. Modification of containment to support segmentation activities and prepare rigging for segmentation and extraction of heavy components, including the HTS.
- Procurement of required shipping canisters, cask liners, and Industrial Packages (IPs) from suppliers.

(2) D&D Operations

This, the second sub-phase of Phase 3, is where all radioactivity in excess of release criteria applicable at the time of D&D will be removed from the site and disposed of in accordance with disposal practices in use at that time.

This PDP identifies the major D&D activities (in a conceptual context) that will need to be accomplished. Identification and description of specific D&D methodologies are not provided within this PDP, as considerable uncertainties exist due to this work being performed many decades into the future. Decommissioning technologies are likely to be different in the future and can be expected to evolve and improve with time.

Additionally, current operational radiation protection and environmental monitoring data can realistically provide only broad scale predictions of the future decommissioning work scope. Specific characterization data that can only be performed after station shutdown or dismantling of major components will be needed to identify many of the details. Site conditions could also change during the station's remaining operational phase. However, this is not intended to mean that HQ does not recognize that future decommissioning activities can be significantly facilitated through current pre-shutdown efforts.

A listing and brief description of the major D&D activities follows herein. The philosophy to be employed in selecting the best approach in carrying out these activities will be driven by the need to minimize radiation exposure, industrial safety, and cost risks. HQ believes that cost risks are directly correlated to the first two, and that cost benefits will follow by minimizing them. Sub-section 6.2, Anticipated Hazards and Protective Strategy, provides discussion of the philosophy by which D&D work methodologies will be selected and planned.

Specific Objectives and Activities

- Conduct decontamination of components and piping systems as required to control (minimize) worker exposure. Remove, package, and dispose of all piping and components that are no longer essential to support D&D operations.
- Remove steam generators for shipment and controlled disposal. Decontaminate exterior surfaces, as required, and seal-weld openings (nozzles, inspection hatches, and other penetrations). These components are anticipated to serve as their own disposal containers, provided that all penetrations are properly sealed and the internal contaminants are stabilized. Steel radiation shields may be added to those external areas of the steam generators to meet transportation limits and regulations.
- Remove the main HTS and moderator piping and pumps. Package the piping in IPs; seal the pumps with steel plate as to serve as their own containers. Ship both for radioactive waste disposal.
- Install calandria cutting tools and equipment in reactor vault and test.

- Segment the calandria structure with the ILW removal first. This may be accomplished in a manner similar to the operations used to remove and replace pressure tubes at operating CANDU reactors. The anticipated sequence of events for this activity is:

  - Install temporary radiation shielding as necessary.
  - Remove all horizontal and vertical control elements and their associated drive mechanisms.
  - Drain water from calandria vault as required, but keeping water level as high as possible to provide shielding to the removal crew.
  - Cut welds and remove end fittings and pressure tubes from calandria; cut into lengths to fit shielding cask liners for disposal.
  - Cut welds and remove calandria tubes from calandria structure; cut into lengths to fit shielded cask liners for disposal.
  - In parallel with the pressure tube and calandria tube removal, begin removal of the steel ball shielding in the calandria faces. Steel shot removal must be coordinated with pressure tube and calandria tube removal to minimize area doses to segmentation crew.
  - Transport all ILW to the fuel bay for packaging via a modified irradiated fuel handling system.
  - Segment the balance of the calandria structure.
  - Remove systems and associated components as they become nonessential to the calandria removal operation, related decommissioning activities, or worker health and safety (e.g., waste collection and processing systems, electrical and ventilation systems, etc.).
  - Remove the metallic components from the canister and check for radioactive contamination.
  - Remove calandria steel liner. Remove contaminated concrete from other surfaces and route for controlled disposition.
- Remove contaminated equipment and material from the Service Building, irradiated fuel bay, and heavy water upgrading facilities.
- Remove all remaining LLW, along with any remaining hazardous and toxic materials. Material removed in the decontamination and dismantling of the station will be

routed to an on-site central processing area. At this time, the ASDR will be emptied of any remaining LLW, and will be decontaminated.

- Survey and certify material free of contamination as free release for unrestricted disposition, e.g., as scrap, recycle, or general disposal, and/or characterize contaminated material and package for controlled disposal at the regional low-level radioactive waste disposal facility.
- Perform in-process characterization of soil and structures, to identify structures and/or underlying soil that contain radionuclide concentrations that exceed site release requirements. Remove non-conforming material as radioactive and/or hazardous waste. Repeat process until indications are that free-release criteria are met.

  Note: The soil removal portion of this activity is speculative at this time, and may only be necessary for those facilities and plant areas if or when historical records indicate the potential for radionuclides having been present in the soil, where system failures have been recorded, or where it is required to confirm that subsurface process and drain lines were not breached over the operating life of the station.
- Remove remaining (clean) components, equipment, and plant services, or other encumbrances as necessary to support the final status survey(s).
- Finalize plans for and, begin conduct of, final status surveys to ensure that all radioactive materials in excess of permissible residual levels have been remediated, using the regulatory and industry guidance applicable at the time. Prepare the end-state report for the final disposition of the license and submit to CNSC and other applicable regulators. The regulators may then review and evaluate the information, perform and independent confirmation of radiological site conditions, and make a determination on final termination of the license.

  Note: It is possible and likely that final status surveys will be conducted on a segmented basis, as separate facilities are finished. Additionally, it is possible that some portions of the final status survey may be performed during the site restoration sub-phase, as some structures may need to be removed to provide access for survey activities.

(3) Site Restoration

Following completion of D&D operations, Site Restoration, the third sub-phase of Removal activities will begin. This PDP envisions that demolition of those buildings or structures that are located outside the secured area (which would be radiologically unaffected) would be outside of the decommissioning work scope and would be dealt with after the termination of the regulatory licenses has occurred.

Efficient removal of the contaminated materials and verification that residual radionuclide concentrations are below regulatory limits will result in substantial damage to many of the structures. Blasting, coring, drilling, scarification (surface removal), and the other decontamination activities will substantially damage power block structures, including the reactor and service buildings. Verifying that subsurface radionuclide concentrations meet site release requirements may require removal of grade slabs and lower floors, potentially weakening footings and structural supports.

This removal activity will be necessary for those facilities and plant area where historical records or in-process characterization data indicate the potential for radionuclides having been present in the soil, where system failures have been recorded, or where it is required to confirm that subsurface process and drain lines were not breached over the operating life of the station.

This PDP presumes that non-essential structures and site facilities within the secure area will be dismantled as a continuation of the decommissioning activity. Foundations and exterior walls are envisioned to be removed to a nominal depth of one meter below grade whenever possible. The one-meter depth should allow for the placement of gravel for drainage and topsoil for vegetation thereby establishing a stable soil base. Site areas affected by the dismantling activities will be cleaned of demolition debris and the station area graded to conform with existing profiles, and as required to prevent ponding and inhibit the refloating of subsurface materials.

Specific Objectives and Activities

- Perform demolition of the remaining portions of the containment structure and interior portions of the reactor building. Concrete rubble and clean fill produced by demolition activities are used on site to backfill voids. Suitable materials can be used on site for fill; otherwise the rubble is removed for disposal as construction debris.
- Remove remaining buildings using conventional demolition techniques for above ground structures, including the turbine and administrative buildings, and other site structures.
- Remove remaining CANSTOR modules using conventional demolition techniques.
- Prepare the final dismantling program report.

6.2 ANTICIPATED HAZARDS AND PROTECTIVE STRATEGY

The primary hazards that are anticipated during D&D are industrial accidents, migration of radioactive or hazardous material, and exposure of personnel to radiation and radioactive/hazardous materials. HQ currently has programs in place for dealing with these types of hazards and expects to extend them into decommissioning phases. However, HQ recognizes that decommissioning work is different from operating a power plant, and that these programs will require modifications. The following presents a discussion of the protective strategy that will be used to mitigate the hazards that will be unique to decommissioning.

The protective strategy for D&D that is currently envisioned by HQ is based upon the recognized need to minimize the risks that are inherent to nuclear decommissioning work (i.e., excessive radiation exposures, work injury, environmental damage and escalation of project cost). HQ intends to keep abreast of nuclear industry decommissioning experience as it unfolds between now and the start of D&D. Lessons learned from these experiences will be the foundation of planning and engineering activities for Gentilly. It is HQ's philosophy that safety programs are not an isolated aspect of the work, and must be integrated into the work packages through proper planning. By building upon the experience of others, HQ can avoid repeating mistakes that contribute to increased worker exposure to decommissioning risks. The following protective strategies will be used to mitigate decommissioning risks, based on project experiences within the industry.

Decommissioning work is inherently different from operating a nuclear power station. By its very nature, decommissioning activities tend to create dispersible contamination and breakdown the safety and confinement barriers that were engineered into a power plant's design. As such, D&D planning must account for this and incorporate alternate methods to control these hazards. Work packages will be scheduled such that work activities will progress from the areas of greater contamination towards those areas of lesser contamination potential. This will allow maximized use of existing physical controls. Existing engineered confinement barriers (e.g. intact building structures, air gradients, negative air pressure, etc.) will be used and maintained as required. Whenever required, temporary engineered confinement barriers will be used to replace or augment the existing confinement barriers. These may include use of HEPA ventilated tent enclosures, application of negative air pressure on equipment, and use of HEPA vacuum collection systems on dust/fume producing D&D equipment.

Early removal of high-dose/high activity components and systems will be favored, such that subsequent work can be performed in more favorable conditions, thereby keeping doses ALARA. Similarly, removal of components in whole or large pieces will also be favored to minimize worker involvement with higher risk operations (e.g., segmentation activities and prolonged handling of high dose rate items).

In general, contaminated structures will be dealt with only after all otherwise contaminated items have been removed from an area. This approach will allow work to proceed with the lowest possible ambient radiation levels. Experience indicates that structural decontamination is an iterative process. Structural materials incrementally are removed until in-process surveys indicate free-release status had been achieved. For this process to be effective, ambient radiation levels need to be as low as possible to prevent false-positive indications of contamination and/or contamination masked due to degraded detection sensitivity. Additionally, it is important to eliminate any potential of recontaminating a decontaminated area by first removing all other sources of contaminants. This will reduce occupational radiation exposure and minimize the need for rework, which can prolong worker exposure to radiation and risk of industrial type accidents.

Cost-benefit analyses will be used on a case-by-case basis to determine whether decontamination of structures and equipment, with the intent of free-release, is the best approach. Experience shows that decontamination can be costly from the standpoint of the labor required to perform the work and verify its effectiveness. In some cases, bulk removal of a structure with disposal as radioactive waste can be easier that decontamination with free-release. This supposition will depend on the cost of radioactive waste disposal at the time of the D&D activities. However, and more importantly, the added risks or worker injury due to use of more labor intensive D&D methodologies must be factored into the cost benefit analysis.

6.3 OCCUPATIONAL RADIATION EXPOSURE ESTIMATE

The AECL study that projected the radiological conditions for a generic series 600 CANDU reactor also estimated the occupational radiation exposure that would be incurred by decommissioning that generic plant with 50 and 100-year dormancy periods. AECL estimated incurred personnel exposure to be 4,69 and 4,48 Person-Sv, respectively. However, the Gentilly decommissioning work is envisioned to commence after a dormancy period (hypothetically assumed to be about 30 years). Therefore, the estimated radiation exposure for the work performed after the dormancy period would require adjustment to reflect a larger radioactive inventory and the resulting higher radiation fields.

As previously discussed in Section 3, Co-60 will dominate in the production of radiation fields approximately four years after station shutdown. As such, the difference in radiation fields between a 30 and a 50-year dormancy period may be approximately by the ratio of the remaining fraction of Co-60 for the two dormancy periods. The resulting difference in radiation fields (i.e., $e^{-30x0,1317}/e^{-50x0,1317}$) would be a factor of about 13,9. However, as reflected in the AECL 50 and 100 year estimates, the higher dose rate work is performed with varying amounts of temporary shielding to account for the differences in radiation fields. It is reasonable to assume that the doses for the shielded work activities can be maintained at the AECL-predicted levels by using additional shield thickness. Therefore, only the unshielded work activity dose expenditures would increase by a factor of 14.

Based upon the above, the estimated radiation exposure is estimated to be 4,87 Person-Sv. This adjusted radiation exposure was determined in the AECL study as follows:

- Placing Station into Dormancy, 1,82 Person-Sv
- Shielded Dismantling Work, 2,8535 Person-Sv
- Unshielded Dismantling Work, 0,014 Person-Sv x 14 = 0,196 Person-Sv

6.4 PROCESS WASTE ESTIMATE

One of the principal goals of the decommissioning program is the removal of all radioactive material in excess of prescribed limits in effect at the time of dismantling. Therefore, as a natural consequence of the decommissioning program, radioactive wastes requiring disposal in a licensed facility will be generated. The gross volume estimated to be generated is 6 855 M^3. The radioactive waste volumes generated during the various decommissioning activities, apportioned as LLW and ILW, are shown by line activity in Table 3. The LLW and ILW that has been generated during the operation of the station and is currently stored in the site's ASDR have been included within these summaries.

7. SURROUNDING ENVIRONMENTAL IMPACTS

Regulatory guidance within G-219 specifies that a Preliminary Decommissioning Plan should include the "identification of any features of the surrounding natural and social environment that could be significantly affected by the decommissioning process." This section highlights the major potential impacts on the natural and human environment anticipated during the course of the decommissioning work. That is to say that these impacts are not a certainty, but are presented to provide awareness, such that mitigation strategies might be addressed during planning. This listing is not intended to be exhaustive, and a through assessment of the environmental and socio-economic impacts of the decommissioning project will be performed as a part of the detailed planning process prior to shutdown. That assessment will be documented in Gentilly's Detailed Decommissioning Plan.

7.1 NATURAL ENVIRONMENT

Some of the possible impacts on difference components of the natural environment are summarized below.

Air Quality

The decontamination and demolition of nuclear systems could release airborne radioactivity. All potential release points will be monitored, and releases will be minimized through the use of temporary containment structures and local filtered ventilation.

Heavy construction equipment powered by internal combustion and any vehicles used for transport of waste and other materials may release exhaust gases into the atmosphere. The nature and extent of these releases will depend on the type of equipment in use at the time of the decommissioning, but are expected to be similar to that of any large-scale construction project.

Non-radioactive nuisance dusts, fumes, and other emissions from standard demolition operations, such as torch cutting or concrete breaking operations, may have some transient impact on air quality. Wherever feasible, these types of emissions will be limited by use of temporary containments or water misting. However, these non-radioactive nuisances will have a very limited impact on people, as no one lives in the one-kilometer exclusion zone around the station.

Water Quality
Routine radioactive releases to bodies of water are not anticipated to occur during the decommissioning of the station once it has been shut down and drained of fluids. Any contaminated fluids generated during dismantling (e.g., concrete dust slurries from cutting operations) are expected to be of minimal volume, and will be dealt with by evaporation or solidification.

Non-radiological effects may include some increase in turbidity of the water along the river shoreline during backfilling and sealing of the station's water inlets and outlets as well as from runoff during site restoration work. Runoff from the site restoration work will be controlled by standard construction techniques (e.g., silt fences).

Land Use
The current land use may not change, as future use of the site is likely to be continued industrial activities. However, as future economic impacts cannot be predicted, future use could also include residential use or a return to a natural state. As such, no future negative impacts are anticipated.

The radioactive and hazardous wastes generated during the decommissioning will require treatment or disposal at off-site facilities. This requires a commitment of land resources, but is not uniquely due to the decommissioning of Gentilly.

Most of the clean demolition waste will be comprised of concrete rubble. This will be used as backfill material for the resulting subsurface foundation voids. Excess concrete and scrap metals will be recycled whenever possible. Other clean non-recyclable demolition debris may require a commitment of land for off-site landfill disposal.

Vegetation
The land areas closest to the station are covered by grass or scrub vegetation. The naturally vegetated areas of the plant site are not likely to be impacted during the course of the decommissioning work since they are well removed from the generating station. The nuisance dust produced during the demolition and site restoration work may provide some minor transient impact to some of the vegetation in the area.

Wildlife

Some parts of the site that are not routinely used have become a habitat for wildlife. A variety of species of mammals, birds, reptiles and amphibians have been observed in these areas. None are considered rare, threatened, or endangered. Many of the birds and mammals (e.g., squirrels, white tail deer, and coyote) are highly mobile and probably move throughout the site and surrounding area in search of food. These populations may increase during the dormancy period since there may be less activity on the site. The increased level of activity during the dismantling and site restoration work, along with the noise and dust that may be generated, may impact these animals. Increased traffic volumes during some phases of the decommissioning may also impact wildlife due to the traffic noise or collisions between vehicles and animals. However, long-term impacts to wildlife are not anticipates.

Generically speaking, the warm water of the condenser cooling water outlets may have created an artificially enhanced environment for aquatic life near the station's discharge canal. This in turn, may have enhanced the area as a feeding ground for the local water birds, such as ducks, geese, and gulls. Shutting down the plant will cause this habitat to revert back to its natural state.

Aquatic Life

As described above, the operation of the station may have created an artificially enhanced habitat for some fish species, particularly in the warm water released from the condenser cooling water outlets. Shutting sown the plant will cause this habitat to revert to its natural state.

Some increase in turbidity of the water along the river shoreline may result from filling and sealing the station's water inlets and outlets as well as from runoff during the site restoration work. This may have a temporary impact on some aquatic life.

Noise

Several station systems are known to be noise sources. Examples include vents, the standby generators, and the paging system. Shutdown of the station will reduce and eventually eliminate these noise sources.

Heavy construction equipment, concrete breaking, and blasting may be used during the dismantling work toward the end of the decommissioning. This work may produce transient, elevated noise levels in the local area.

7.2 HUMAN ENVIRONMENT

This section focuses on the potential for socio-economic impacts at the local community and regional levels associated with the decommissioning of Gentilly. The purpose of this section is to identify specific social environment features that may experience impacts when decommissioning.

As the remaining station operations, shutdown, dormancy, and dismantling/restoration will span about half a century, the surrounding human environment that could be impacted by the decommissioning can be expected to significantly change from other non-decommissioning factors as well. As such, assessing the degree of impacts due to the decommissioning activities may not provide completely accurate results at this time. As such, the preliminary assessment provided herein presents a qualitative listing of the source of potential impacts, but not a quantitative assessment of the impacts. The negative impact (mostly economic) will be assessed prior to station shutdown. This and other negative impacts will be documented in the Detailed Decommissioning Plan. It will be updated periodically throughout the decommissioning process, as appropriate. This will provide useful information that can be used to plan mitigating actions.

The three phases associated with decommissioning will each have discrete activities that may have a socio-economic impact on the surrounding local communities. The sources of these potential impacts, are listed by phase, as follows:

Shutdown/Preparation for Dormancy
The most significant source of community effect will be changes in the size of the workforce when the station is shut down. Presently, there are approximately 600 workers at the station as it operates. After the station is shutdown, most of the established workforce will no longer be required. A smaller number, possibly less than 290 workers may be needed for defueling and heavy water draining. After that, about 160 will be needed to complete preparation of the station for dormancy. The reduction of staff would probably be staggered over the preparatory period. Some displaced workers and their families may not move away from the community, and may or may not find

employment locally. Other workers and their families may move away from the community. The loss of jobs, income, and population will affect the local communities in a variety of ways, including effects in the housing market, services, consumer spending and social aspects.

Local traffic patterns may change, as the staff is reduced at the station. Approximately 400 to 450 light vehicles per day now access the Gentilly Site, plus 800 other types of vehicles per month to support operation of the station; this number would decrease incrementally. Any nuisance effects associated with current worker traffic would be much less.

Some resulting radioactive waste, both low and intermediate level, will be transported to a receiving facility. The volume of these wastes is not expected to be large, so the number of truck trips would be much less, probably no more than the present trucking activity caused by the operation of the station.

The closure of the station will change the pattern of local expenditures and tax payments. Local and regional purchases of goods and services associated with the operation of the station would all but cease. There may be some spending associated with the shutdown activities. It is possible that indirect economic effects would occur. It can be assumed that the amount of local taxation would change when the station is no longer producing electricity.

Dormancy
The dormancy period will last for about 30 years. A very small workforce (20 to 30 people) will be required during that period, which may represent some opportunities for local employment and consumer spending.

The last of the wet-stored irradiated fuel remaining at the station will be removed from the fuel bay and placed into dry storage during the early part of dormancy (i.e., approximately 2016). Off-site shipment of the dry stored fuel will commence later in dormancy at approximately the year 2040. Any transportation of the fuel will be an issue, and may have an impact on the local and regional community.

After the initial reduction of property value following station shutdown, it can be assumed that the amount of taxes paid to the local municipality would remain constant over the period of dormancy.

Dismantling and Site Restoration

After a period of about thirty years, when dismantling begins, the workforce would increase to several hundred at peak. Since dismantling and restoration activities will extend over approximately six or seven years at the site, some of these workers may relocate into the community. There may be local spending associated with the dismantling activities. It is possible that local contractors and suppliers would benefit. These changes may affect the local and regional community.

Other activities associated with the decommissioning may also be a source of effect. Most of the waste generated by the dismantling will not be radioactive. Of this waste, the concrete-based materials will be used for fill at the reactor site. Other materials such as metals will be shipped for reuse, recycle, or disposal at conventional landfills. The availability, proximity, and cost of the disposal and any impacts related to hauling services may potentially affect community services and infrastructure. Both LLW and ILW will be transported to a receiving facility. The volume of these wastes would not be large, so it is currently expected that the number of truck trips would be small. Transportation plans for all shipments could extend over the duration of the dismantling phase, spreading the trips over the entire period.

The site will be restored for alternative use(s) at the conclusion of the third phase. All the visual and noise effects of a large industrial station would be eliminated. The workforce will no longer be required and the local spending will cease. The site may remain an industrial zone, and its future use may be an issue with the local/regional community. Under current assessment legislation, tax monies will continue to be paid on the same buildings and structures until they are removed; it can be assumed that the amount will then be significantly less.

8. CONCEPTUAL DECOMMISSIONING SCHEDULE

It is the current intention of HQ to run the station until its design date of 2013, as a minimum, or if possible, extend the life of the station beyond that date. The initiation of phase 3 dismantling depends upon irradiated fuel acceptance by Canada's national repository, whereby the used fuel can be removed from the station. (For the purposes of the decommissioning cost analysis presented in Section 9, it was assumed that shutdown would hypothetically occur in the year 2010, with the acceptance of the used fuel starting in the year 2040.)

The dismantling operations are estimated to last approximately 11 years, followed by submittal of the end-state report to the CNSC. Gentilly decommissioning project completion would occur during the year 2049, if off-site shipment of the used fuel could begin in 2040. The length of the actual dormancy period will depend upon the actual shutdown date, and the ability to start off-site shipment of the used fuel. An overall project scenario timeline (based upon the hypothetical milestone dates) is provided as Figure 9. The critical-path project schedule corresponding to this timeline, provided as Figure 10, was extracted from the Gentilly Decommissioning Cost Study prepared by TLG Services, Inc. (TLG) (Ref. 3).

The basis for this schedule is provided herein. The schedule estimate reflects the results of a precedence network developed for the site decommissioning activities, i.e., a PERT (Program Evaluation and Review Technique) software package. Critical path activities were used to establish durations between key milestones within each of the project phases; these durations were then used to establish a critical path for the entire project. The durations used in the precedence network reflect the actual man-hour estimates to perform the work, adjusted by stretching certain activities over their slack range and shifting the start and end dates of others. The following assumptions were made in the development of the decommissioning schedule:

- All work (except calandria and internals removal activities) is performed during an 8-hour workday, 5 days per week, with no overtime.
- Final reactor defueling does not interfere with the preparation of the unit for dormancy.
- Calandria removal activities are performed by using separate crews for different activities, and working on different shifts.
- Multiple crews work parallel activities to the maximum extent possible, consistent with: optimum efficiency; adequate access for cutting, removal and letdown space; and the stringent safety measures necessary during removal/demolition of heavy components and structures.

- For plant systems removal, the systems with the longest removal durations in areas on the critical path are considered to determine the duration of the activity.
- Site Restoration activities commence upon completion of the dismantling activities for the station.

9. DECOMMISSIONING COST ESTIMATE

A decommissioning cost analysis was prepared under contract by TLG (Ref. 3). The purpose of this analysis was to Provide HQ with sufficient information to assess its financial obligations as they pertain to the eventual decommissioning of the Gentilly Generating Station. The TLG analysis provided a scenario-dependent cost estimate prepared in advance of the detailed engineering preparations required to carry out the decommissioning of Gentilly. The decommissioning strategy assumed by TLG for this cost estimate is in agreement with the Deferred Removal strategy presented and described within this PDP.

The total projected cost, in year 2000 Canadian dollars, to decommission the Gentilly facility was estimated by TLG to be 438,9M$ (based upon the hypothetical 2010 shutdown date). However, it is the current intention to, as a minimum, run the station until its design date of 2013, or extend the life of the facility beyond that date. This would theoretically reduce the decommissioning cost to 429,6M$ by eliminating three years of dormancy. These estimated costs reflect site-specific features of the station, HQ-specific conditions, the local cost of labor, and projected future costs of radioactive waste disposal for all facilities, including the CANSTOR storage containers. However, these costs do not include the cost of packaging, transportation, and final disposal of the used fuel. Summaries of the major activities contributing to the total cost are provided in Table 4. The anticipated annual costs are provided in Table 5. All costs in both tables include appropriate levels of contingency.

This decommissioning cost is based on the acceptance and transfer of all Gentilly's irradiated fuel at a Canadian national repository no later than the year 2049. Concurrent with this date, all other radiological remediation will have been completed at the plant site and only conventional site restoration activities will remain.

The TLG decommissioning cost analysis for Gentilly was based upon current regulatory and technical requirements and their present-day costs, available technologies, and current decommissioning philosophies. Staffing, including management, engineering, specialists, technicians, and clerical combine with the removal labor costs to represent the majority of the costs to decommission the Gentilly station. These costs are a direct result of the labor-intensive nature of the decommissioning process, as well as the required management controls needed to ensure a safe successful decommissioning program.

Radioactive waste management (packaging, transportation, and disposal) represents the next largest cost component. The disposal rates projected are indicative of the life-cycle expenses incurred in siting, developing, and licensing new disposal facilities, and then running and maintaining them. Packaging and transportation costs are sensitive to the waste volume generated in the D&D process, transportation regulations and fees, and the final destination location (i.e., distance to the disposal site).

The removal costs for systems, components, and structures are primarily driven by the cost of labor. These costs reflect composite labor costs for Gentilly, as supplied by HQ. Materials and consumables associated with removal activities were included using representative costs for the region. Select special materials or equipment required for the decommissioning were assumed to originate in the U.S. and reflect appropriate currency conversions. Productivity adjustments were applied to activity durations, based on the anticipated working conditions for each particular station area or major component. "Other" incidental costs, such as property taxes, specialized engineering, insurance, and fees are also included.

10. FINANCIAL GUARANTEE ARRANGEMENTS

The actual practice to annually write off the financial guarantee for the complete dismantling of all Gentilly 2 infrastructures on HQ's books will be continued. This ensures that an adequate amount of funding will be available at the final shutdown of the station. A commitment from the government of Quebec will be expressed.

11. FACILITY OPERATIONAL RECORDS

Over the remaining operational life of the station, and extending to the end of the dormancy phase, HQ will collect and maintain information that might facilitate the planning and conduct of decommissioning activities. It is also recognized that such information is vital to planning an adequate final status survey. The types of records and documentation that may be required, and which will be maintained, include but are not limited to:

- Layout of facilities and buildings
- Configuration of plant systems
- Radiological monitoring data
- Descriptions of any hazardous materials in the station
- Information pertaining to any spills or releases of radioactive materials or environmentally hazardous substances that may have occurred

Records and documentation will be kept and maintained in an orderly manner that will guarantee their future usability.

12. REFERENCES

1. Regulatory Guide G-219, "Decommissioning Planning for Licensed Activities," Canadian Nuclear Safety Commission, June 2000

2. "Conceptual Decommissioning Plan for The Point LePreas G.S.," Atomic Energy of Canada Limited, CANDU Operations, June 1987

3. "Decommissioning Cost Study for the Gentilly 2 Nuclear Generating Station," Doc. No. H08-1374-002, prepared by TLG Services, Inc., June 2000

APPENDIX

FIGURE 1: SITE LOCATION

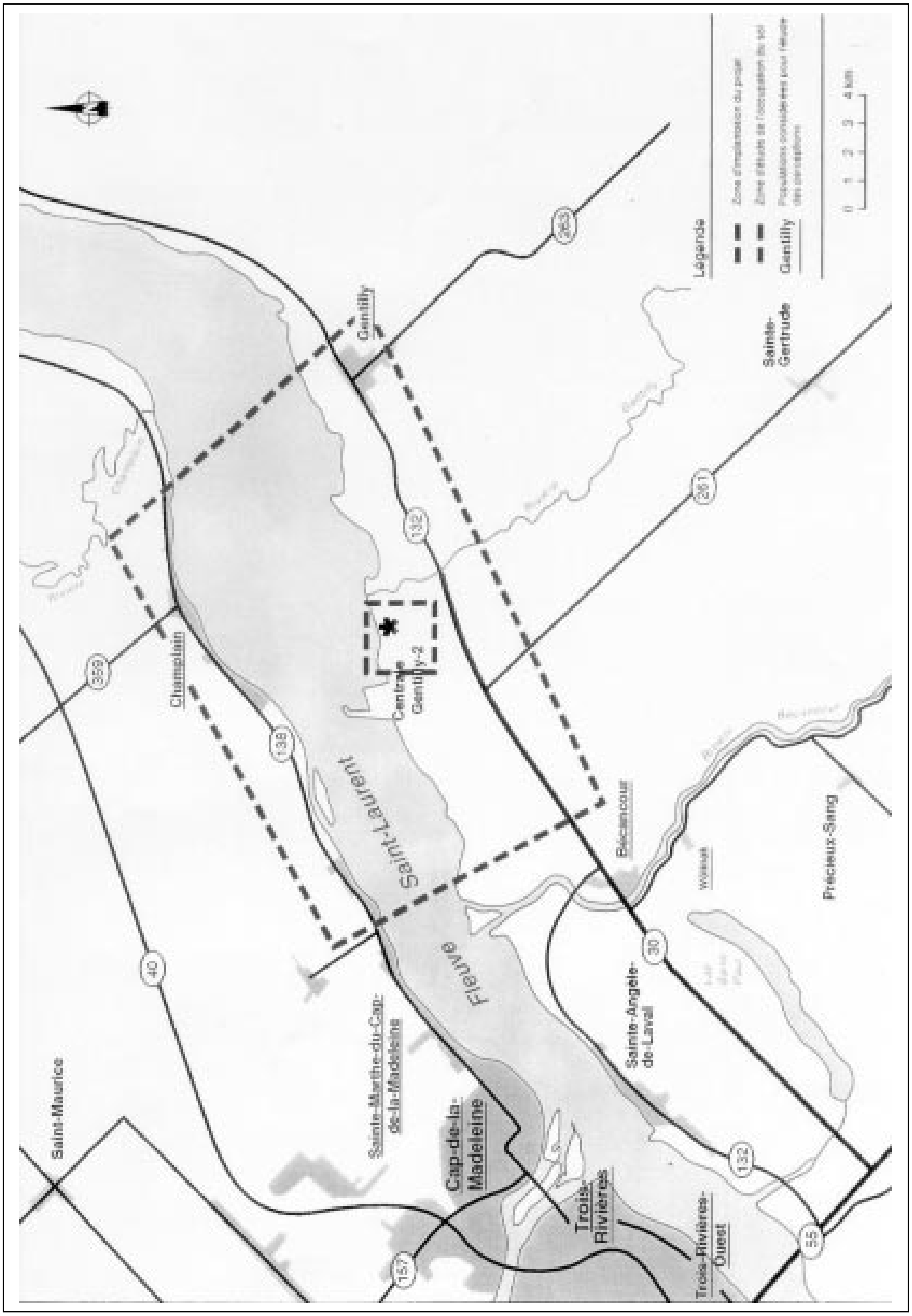


FIGURE 2: REACTOR BUILDING CUTAWAY

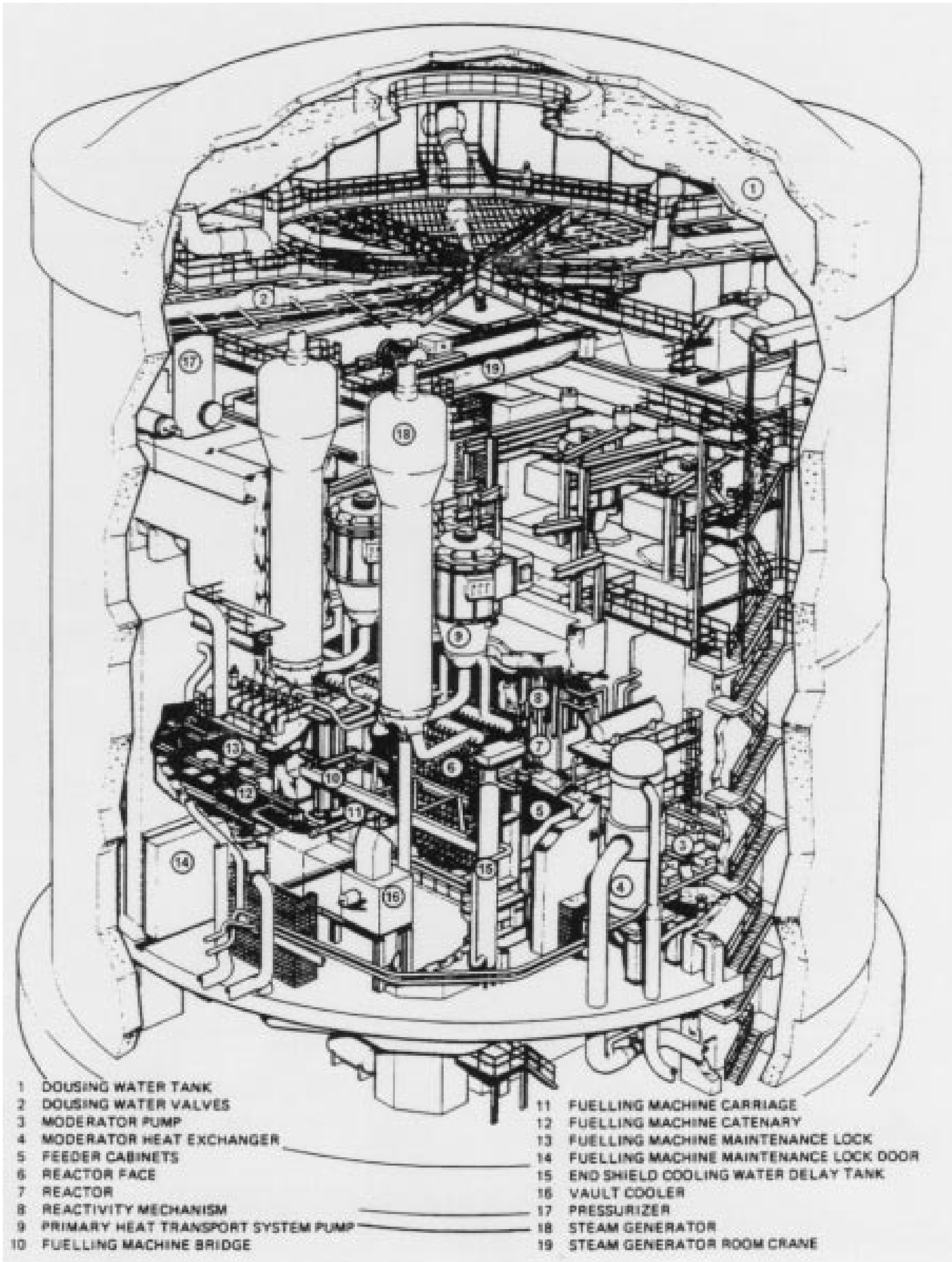


FIGURE 3: MAIN MODERATOR SYSTEM

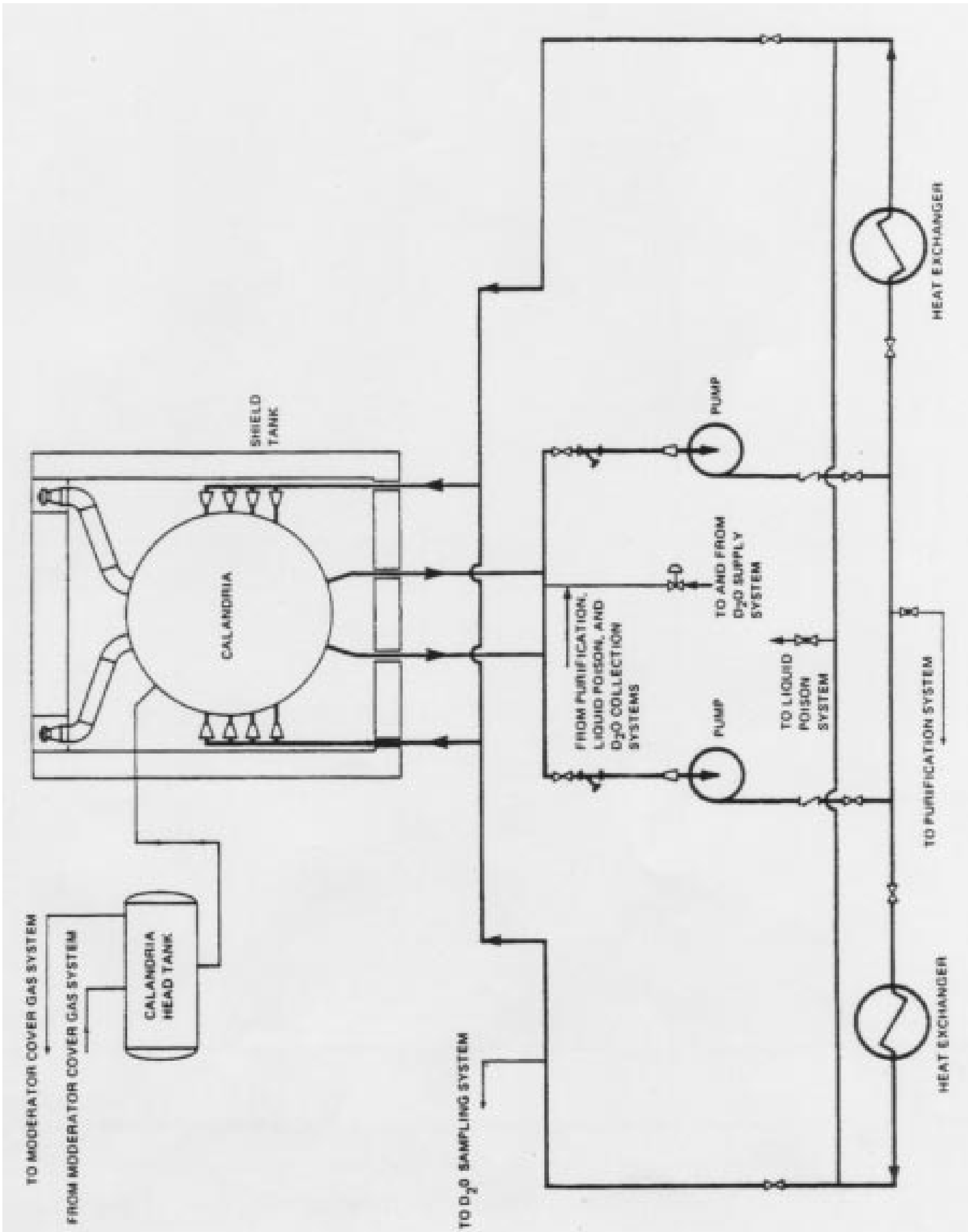


FIGURE 4: MAIN HEAT TRANSPORT SYSTEM

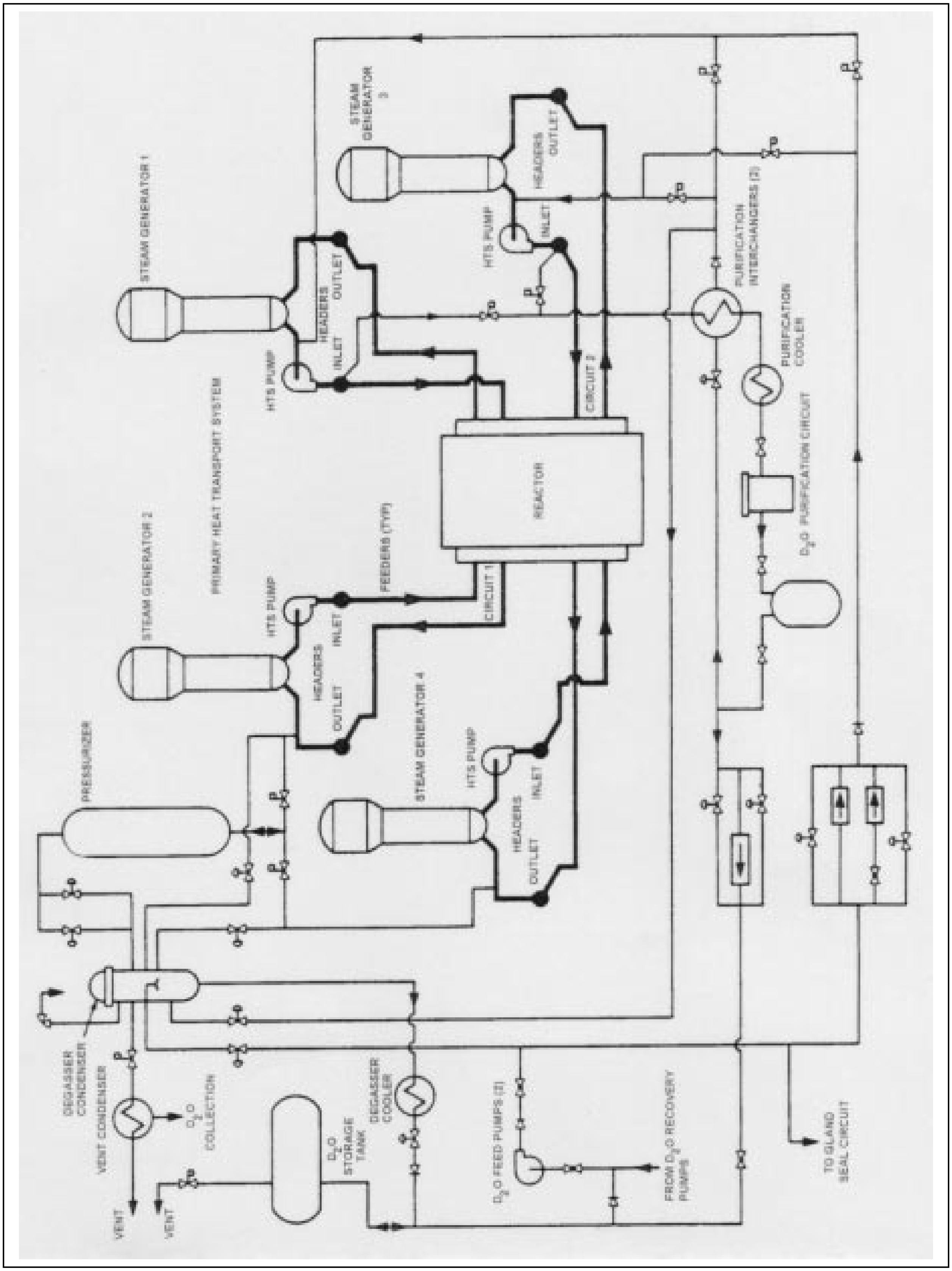


FIGURE 5: LAYOUT OF PLANT STRUCTURES

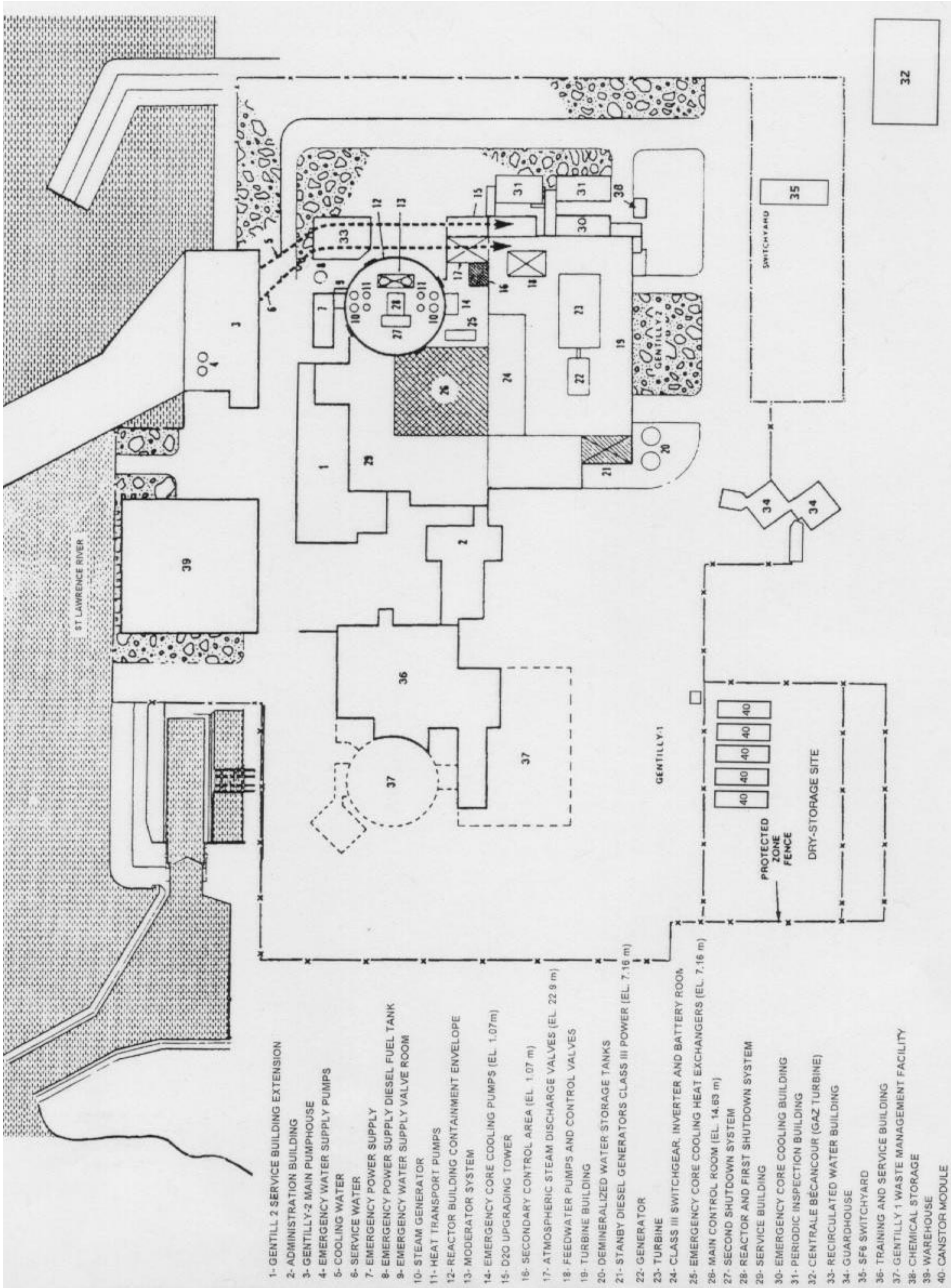


FIGURE 6
ACTIVITY OF MAJOR LONG-LIVED RADIOACTIVE ISOTOPES IN REACTOR STRUCTURES FOLLOWING SHUTDOWN

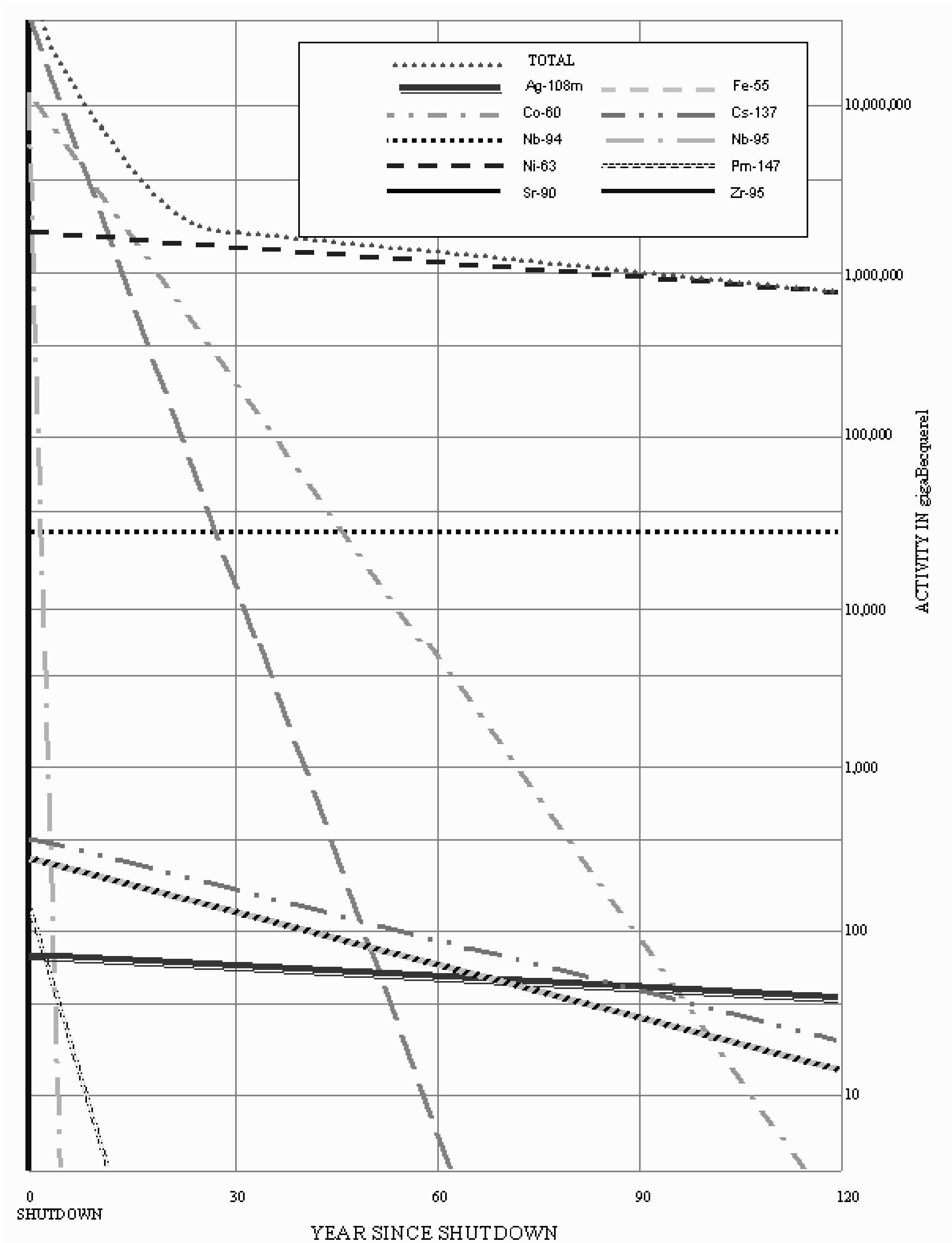


FIGURE 7
GAMMA RADIATION FIELDS FROM IN-CORE COMPONENTS

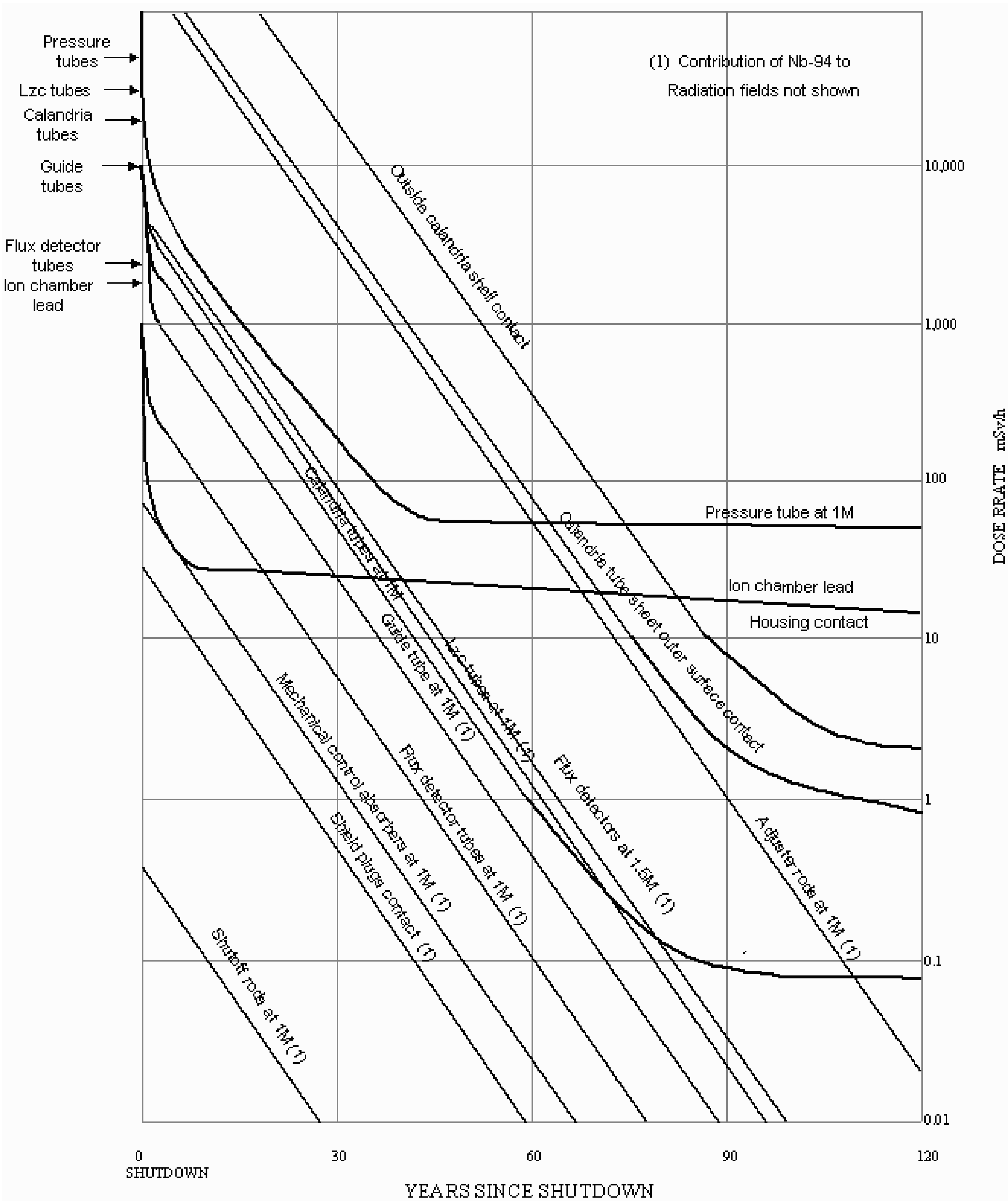


FIGURE 8: CO-60 GAMMA RADIATION FIELDS FROM OUT-OF-CORE COMPONENTS, NO DECONTAMINATION

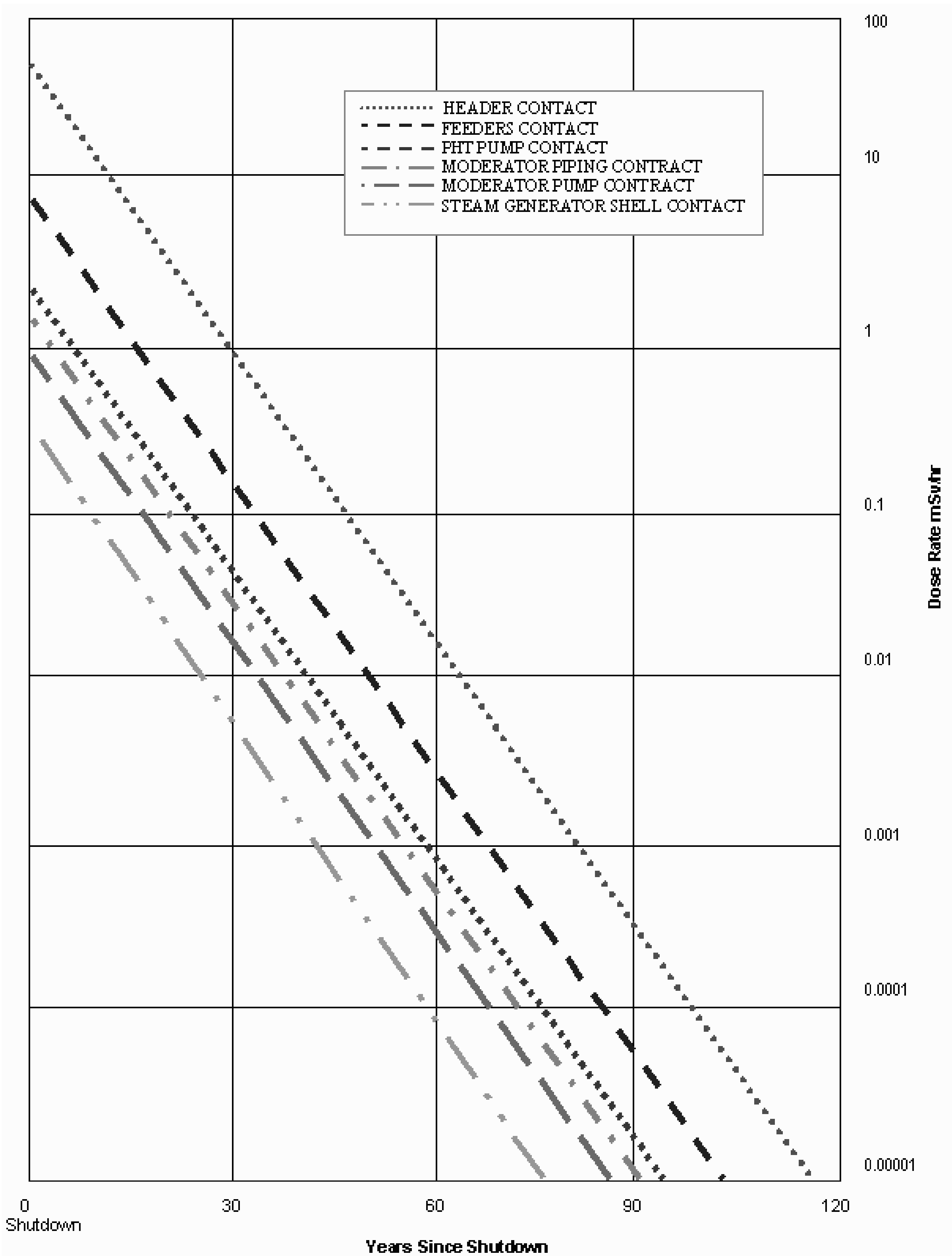
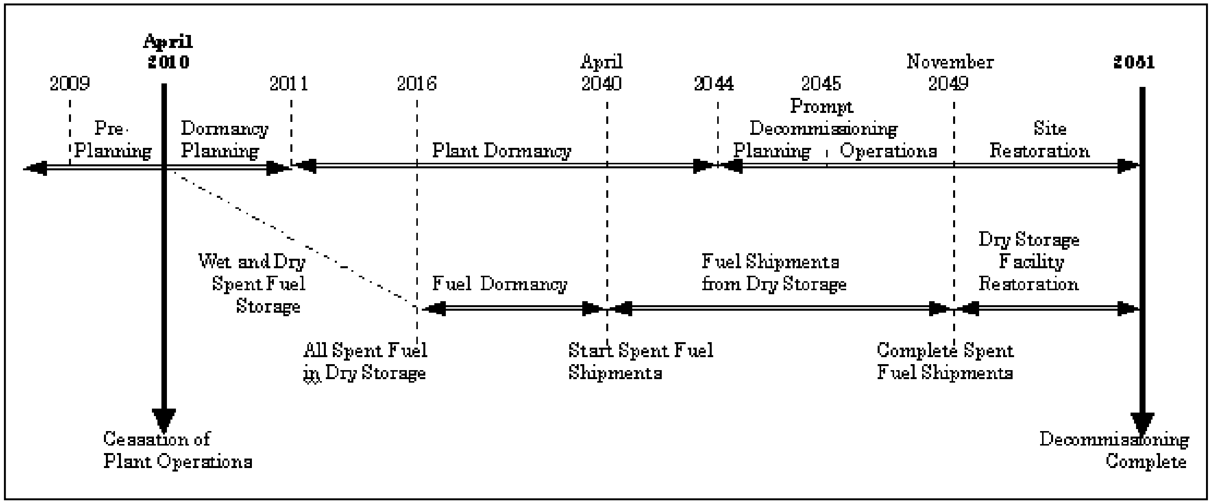


FIGURE 9: DECOMMISSIONING SCENARIO TIMELINE



The key assumptions regarding the development of this scenario are:

a. Cessation of power production in 2010.
b. Isolation of the plant systems and components, except those required to store spent fuel, and initiation of SAFSTOR by 2011.
c. Placement of last irradiated spent fuel into dry storage occurs within 6 years of cessation of power production.
d. Start of WMO spent fuel acceptance for permanent disposal in 2040. Completion of shipments from the Gentilly 2 site by 2049.
e. Low and Intermediate level waste repository available by 2040. Repository available throughout decommissioning.
f. Site decommissioning occurs simultaneously with spent fuel shipments. Radioactive materials license is terminated by November, 2049.
g. Restoration of the site and dry spent fuel storage facility area completed by 2051.

FIGURE 10: DECOMMISSIONING ACTIVITY SCHEDULE

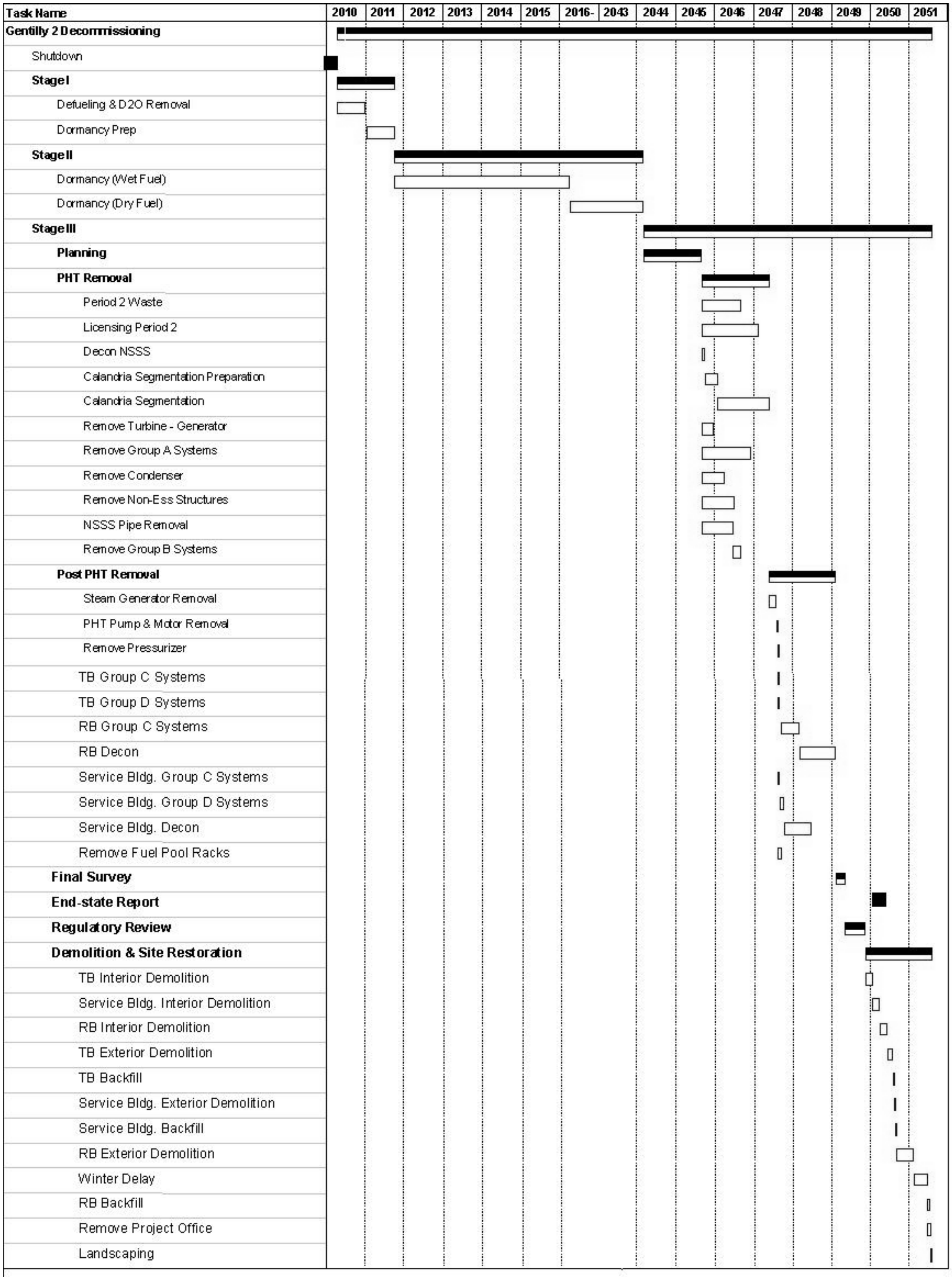


TABLE 1
TOTAL ACTIVITY OF LONG-LIVED ISOTOPES
(In Reactor Components Immediately After Reactor Shutdown)

	Isotope and Activity in G Bq						
Item (Quantity)	**Co-60**	**Zr-95**	**Nb-95**	**Ag-108m**	**Nb-94**	**Fe-55**	**Ni-63**
Pressure Tubes (380)	229	141 000	141 000		274	3 700	
Calandria Tubes (380)	4 800	55 000	55 000		0,4	1 300	
Adjuster Rods (27)	31 000					67 000	2 500
Solid Zone Control Absorbers (4)	1,2					13,3	0,5
Shutoff Rods (28)	0,1					0,6	
Guide Tubes – Adjuster Rods (27) Solid Absorbers (4) Shutoff Rods (28)	50	5 500	5 500			78	
Liquid Zone Control Tubes (6)	137	1 600	1 600				
Flux Detectors: Vertical (26)	740						
Flux Detectors: Horizontal (7)	67	740	740				
Lead Housing for Ion Chamber (6)				0,6			
Calandria Shell	40 700				0,2	126 000	12 000
Calandria Tube Sheet	7 400				0,1	27 800	2 800
Carbon Steel Shot in End Shields (178 Mg)	6 300					92 500	
End Fittings	14 000						
Fuelling Machine Tube Sheet	0,4						
Shield Plugs	2 400						
Steam Generators	1,8						
Feeders	0,1						
Headers	0,1						
TOTAL	**107,8x10^3**	**203,8x10^3**	**203,8x10^3**	**0,6**	**274,7**	**318,4x10^3**	**17,3x10^3**

TABLE 2

TOTAL INVENTORY OF LONG-LIVED FISSION PRODUCTS
(In Heat Transport and Auxiliary Systems After Reactor Shutdown)

	For 0.06% of Bundles Failed	
Isotope	**Activity in T Bq**	**Half Life (Yrs)**
Sr-90	2,7	29
Ru-106	1,3	1
Cs-134	0,2	2
Cs-137	3,6	30
Pm-147	1,4	2,6
Eu-154	0,04	8,2

TABLE 3

DECOMMISSIONING RADIOACTIVE WASTE DISPOSAL VOLUMES

WBS Period	Period Description	Volumes (m^3) LLW	ILW
1	Preparation for Dormancy	69	143
2	Dormancy	93	0
3	Preparation for Dismantling	1 008	0
4	Dismantling	5 029	513
5	Site Restoration	0	0
	TOTALS	6 199	656

TABLE 4

SUMMARY OF DECOMMISSIONING COSTS
(Year 2000 Canadian Dollars)

Work Category	Costs (M$)	Percentage Total Costs
1. Decontamination	13,1	3,0
2. Removal	69,0	15,7
3. Packaging	11,5	2,6
4. Transportation and Disposal (Off-site)	43,4	9,9
5. Project Management (Staffing)	100,3	22,8
6. Contingency	72,2	16,5
7. Other (Insurance, taxes, fees, energy, equipment, and supplies)	129,5	29,5
Total	439,0	100,0

TABLE 5

SUMMARY OF ANNUAL DECOMMISSIONING EXPENDITURES
(Year 2000 Canadian Dollars)

Year	Stage I Preparations	Stage II Dormancy	Stage III Preparations	Stage III Decommissioning	Stage III Site Restoration	Totals
2010	45,939,939					45,939,939
2011	34,582,776	1,120,874				35,703,649
2012		4,452,352				4,452,352
2013		4,440,187				4,440,187
2014		4,440,187				4,440,187
2015		4,440,187				4,440,187
2016		3,450,888				3,450,888
2017		3,110,971				3,110,971
2018		3,110,971				3,110,971
2019		3,110,971				3,110,971
2020		3,119,495				3,119,495
2021		3,110,971				3,110,971
2022		3,110,971				3,110,971
2023		3,110,971				3,110,971
2024		3,119,495				3,119,495
2025		3,110,971				3,110,971
2026		3,110,971				3,110,971
2027		3,110,971				3,110,971
2028		3,119,495				3,119,495
2029		3,110,971				3,110,971
2030		3,110,971				3,110,971
2031		3,110,971				3,110,971
2032		3,119,495				3,119,495
2033		3,110,971				3,110,971
2034		3,110,971				3,110,971
2035		3,110,971				3,110,971
2036		3,119,495				3,119,495
2037		3,110,971				3,110,971
2038		3,110,971				3,110,971
2039		3,110,971				3,110,971
2040		3,119,495				3,119,495
2041		3,110,971				3,110,971
2042		3,110,971				3,110,971
2043		3,110,971				3,110,971
2044		427,354	27,788,899			28,216,253
2045			20,411,019	16,340,796		36,751,815
2046				44,845,041		44,845,041
2047				43,273,927		43,273,927
2048				42,423,534		42,423,534
2049				28,816,197	2,672,163	31,488,361
2050					15,989,175	15,989,175
2051					9,024,028	9,024,028
	80,522,715	106,819,397	48,199,918	175,699,495	27,685,366	438,926,892