



# Supplier Document

## Environmental Risk Assessment for Gentilly-1 WASTE FACILITY

**61-505210-ASD-001**

### Revision 2.0

Accepted by:	<u>Julie Therrien</u>	<u>2025/05/26</u>
	G1 & DP, Facility Authority	Date

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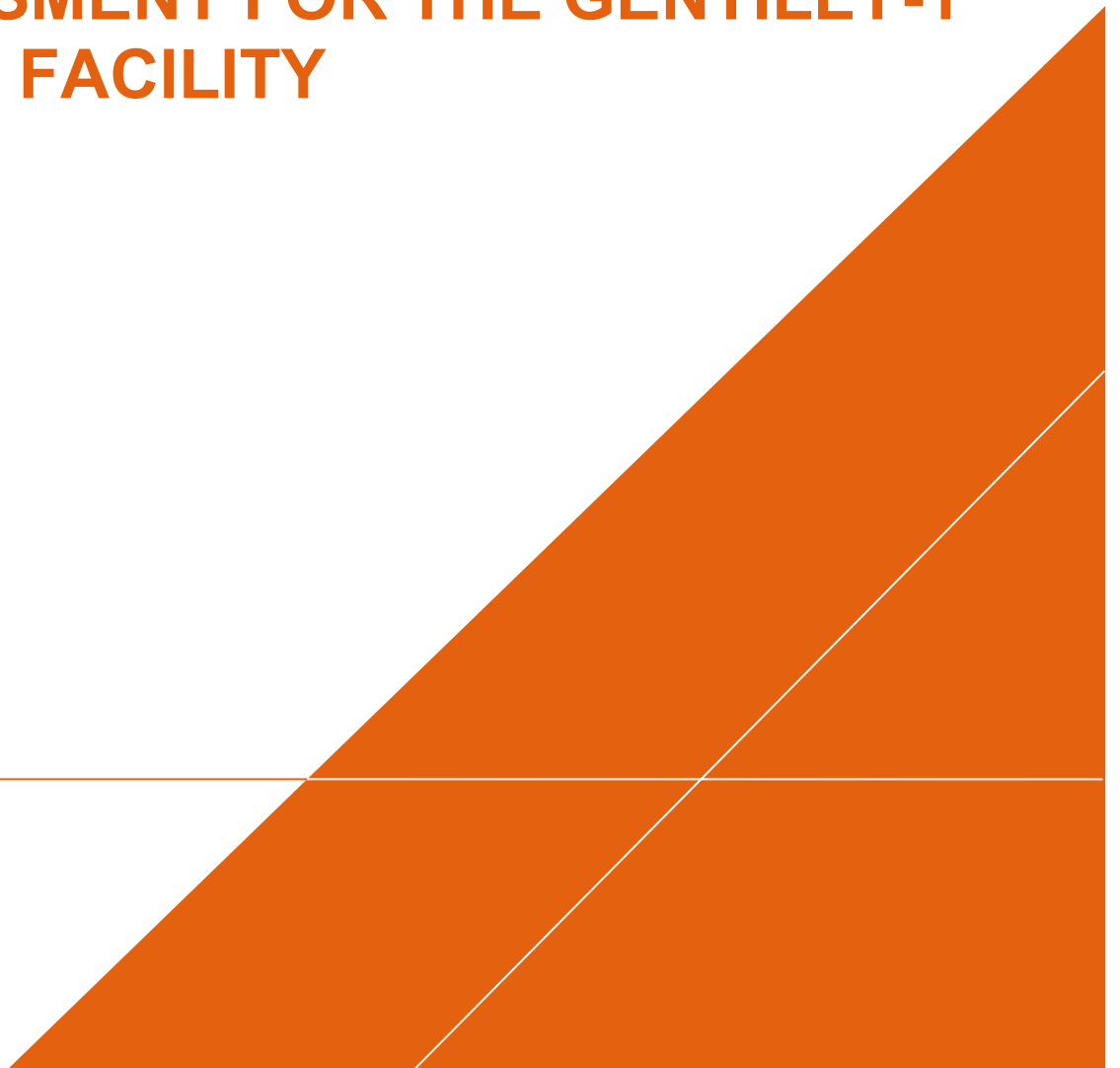


Canadian Nuclear Laboratories

# ENVIRONMENTAL RISK ASSESSMENT FOR THE GENTILLY-1 WASTE FACILITY

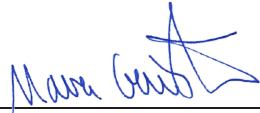
Revision 2

May 2025



Environmental Risk Assessment for the Gentilly-1 Waste Facility

Arcadis Project Director, Approver;



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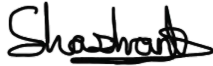
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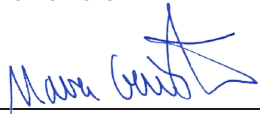
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## ENVIRONMENTAL RISK ASSESSMENT FOR THE GENTILLY-1 WASTE FACILITY

### REVISION 2

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## ACRONYMS AND ABBREVIATIONS

ACM	Asbestos-containing Material
AECL	Atomic Energy of Canada Limited
CANDU	CANada Deuterium Uranium
CDWQ	Canadian Drinking Water Quality
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
COPC	Contaminant of Potential Concern
CSA	Canadian Standards Association
D&D	Decommissioning & Demolition
ECCC	Environment and Climate Change Canada
EcoRA	Ecological Risk Assessment
EMP	Effluent Monitoring Plan
ERA	Environmental Risk Assessment
G-1	Gently-1
G1WF	Gently-1 Waste Facility
G-2	Gently-2
G2NGS	Gently-2 Nuclear Generating Station
HC	Health Canada
HHRA	Human Health Risk Assessment
HQ	Hydro Québec
MELCCFP	Ministère de l'Environnement, de la Lutte contre les Changements Climatiques, de la Faune et des Parcs
MPS	Moderator Purification System
MS	Moderator System
NEC	No-Effect Concentration
NEW	Nuclear Energy Worker
PCBs	Polychlorinated Biphenyls
PHTS	Primary Heat Transport System
QA	Quality Assurance
QC	Quality Control
SARA	Species at Risk Act (Canada)
SCR	Station de Contrôle Radiologique (Radiological Control Station)
SFCA	Spent Fuel Canister Area
SWS	Storage with Surveillance

## Environmental Risk Assessment for the Gently-1 Waste Facility

## 1.0 INTRODUCTION

### 1.1 Background

The Gently-1 Waste Facility (G1WF) is located in Bécancour, Québec, on the south bank of the St. Lawrence River, approximately 15 km east from the city of Trois-Rivières. This facility is owned by Atomic Energy of Canada Limited (AECL) and operated by Canadian Nuclear Laboratories (CNL) under the Prototype Reactor Decommissioning Group. It is located on the Gently site, which is owned by Hydro Québec (HQ) and also houses the G-2 Nuclear Generating Station (G2NGS), which was permanently shut down in 2012. The G-1 reactor and its associated facilities and infrastructures were permanently shut down in 1984 and are currently in a safe Storage with Surveillance (SWS) state, and under controlled surveillance until final decommissioning and/or demolition is undertaken.

### 1.2 Goals, Objectives, and Scope

The objective of this report is to prepare an Environmental Risk Assessment (ERA) for the G1WF, including Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (EcoRA), for both radiological and chemical/physical stressors. The assessment is for current conditions under normal operating conditions. This G1WF ERA has been completed for current conditions, i.e., SWS, and is consistent with the following guidance documents:

- REGDOC 2.9.1, *Environmental Principles, Assessments and Protection Measures, Version 1.2*, (CNSC 2020).
- Nuclear Safety and Control Act Radiation Protection Regulations (CNSC 2000).
- Canadian Standards Association (CSA) Standard N288.6-22, *Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills* (CSA 2022a).
- CSA Standard N288.1-20, *Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities* (CSA 2020).
- CSA N288.0:22, *Environmental management of nuclear facilities: Common requirements of the CSA N288 series of standards* (CSA 2022b), Section 7.1.2 (Quality Assurance (QA) Program).
- International Standard for Standardization (ISO) 9001:2015 Quality management systems.

This ERA is prepared as part of the periodic review and update required by REGDOC 2.9.1 (CNSC 2020) and CSA N288.6-22 (CSA 2022a); the previous iteration was completed in 2019. As per REGDOC 2.9.1 (CNSC 2020), the scope of this ERA is commensurate with the scale and complexity of the very low environmental risks associated with the G1WF.

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

### 1.3 Organization of Report

The main report sections are as follows:

- Section 1:** Presents background information and briefly outlines the scope of this report.
- Section 2:** Provides a site and project description, including the engineered site features and the natural/physical environment surrounding the facility.
- Section 3:** Presents the HHRA for radiological contaminants.
- Section 4:** Presents the EcoRA for radiological contaminants.
- Section 5:** Presents the HHRA for chemicals and physical stressors.
- Section 6:** Presents the EcoRA for chemicals and physical stressors.
- Section 7:** Discusses the conclusions and recommendations of the assessment.
- Section 8:** Present references.

This report has been prepared in accordance with the requirements of CSA Standard N288.6-22: *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* (CSA 2022a). Appendix A presents a concordance table demonstrating how the sections of the present ERA align with the ERA contents suggested in CSA N288.6-22 (CSA 2022a).

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

## 2.0 SITE DESCRIPTION

This section is based on information from the following sources, unless otherwise stated:

- Detailed Decommissioning Plan (CNL 2023);
- Safety Analysis Report (CNL 2019a);
- Effluent Monitoring Plan (CNL 2021); and,
- Environmental Risk Assessment for HQ's Gentilly Site (HQ 2022).

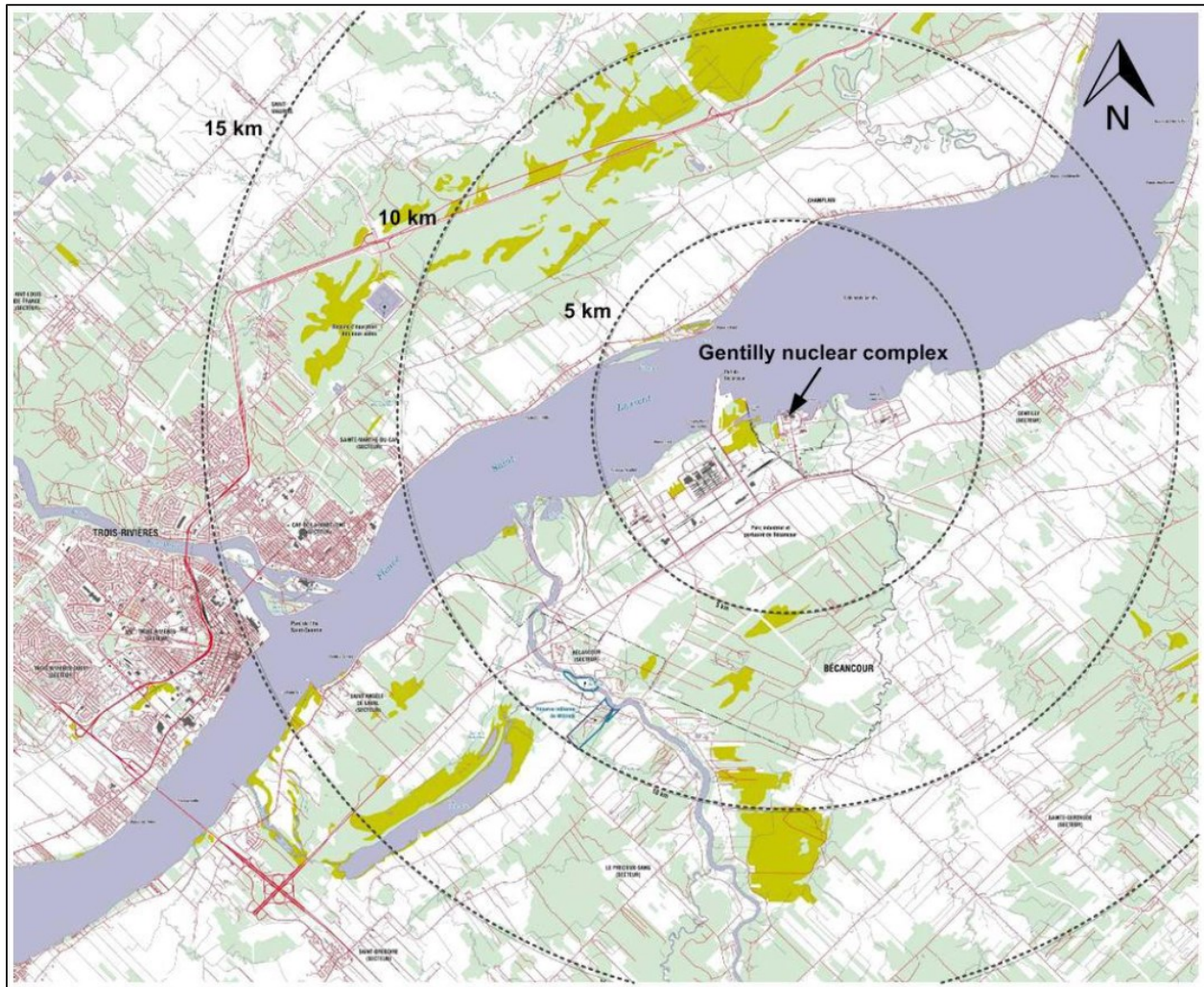
### 2.1 Project Description

The G1WF is being decommissioned following a three-phased approach that has been established for reactor decommissioning. Phase 1 Decommissioning brings the facility to a safe, sustainable shutdown state. Phase 2 Decommissioning is a period of safe SWS. Phase 3 Decommissioning (i.e., Decommissioning & Demolition (D&D)) is final decommissioning. The Gentilly-1 (G-1) Nuclear Generating Station has already completed Phase 1 Decommissioning and is in Phase 2 Decommissioning (i.e., SWS). Phase 3 Decommissioning (i.e., D&D) will result in the removal of the building structures and associated components and equipment, and the return of the land to HQ for industrial re-use after decommissioning.

### 2.2 Location

HQ's Gentilly site, which includes the G1WF as well as the G2NGS, is located in Bécancour, Québec, on the south bank of the St. Lawrence River. The site location (i.e., 46°25'19" N and 72°21'30" W) is approximately 15 km east from the city of Trois-Rivières. The G1WF is on the same site as the G2NGS (685 MWe), permanently shut down on December 28, 2012, and a gas turbine plant (352 MWe), both of which are owned by HQ. The location of the Gentilly site is shown in Figure 2-1 (CNL 2023).

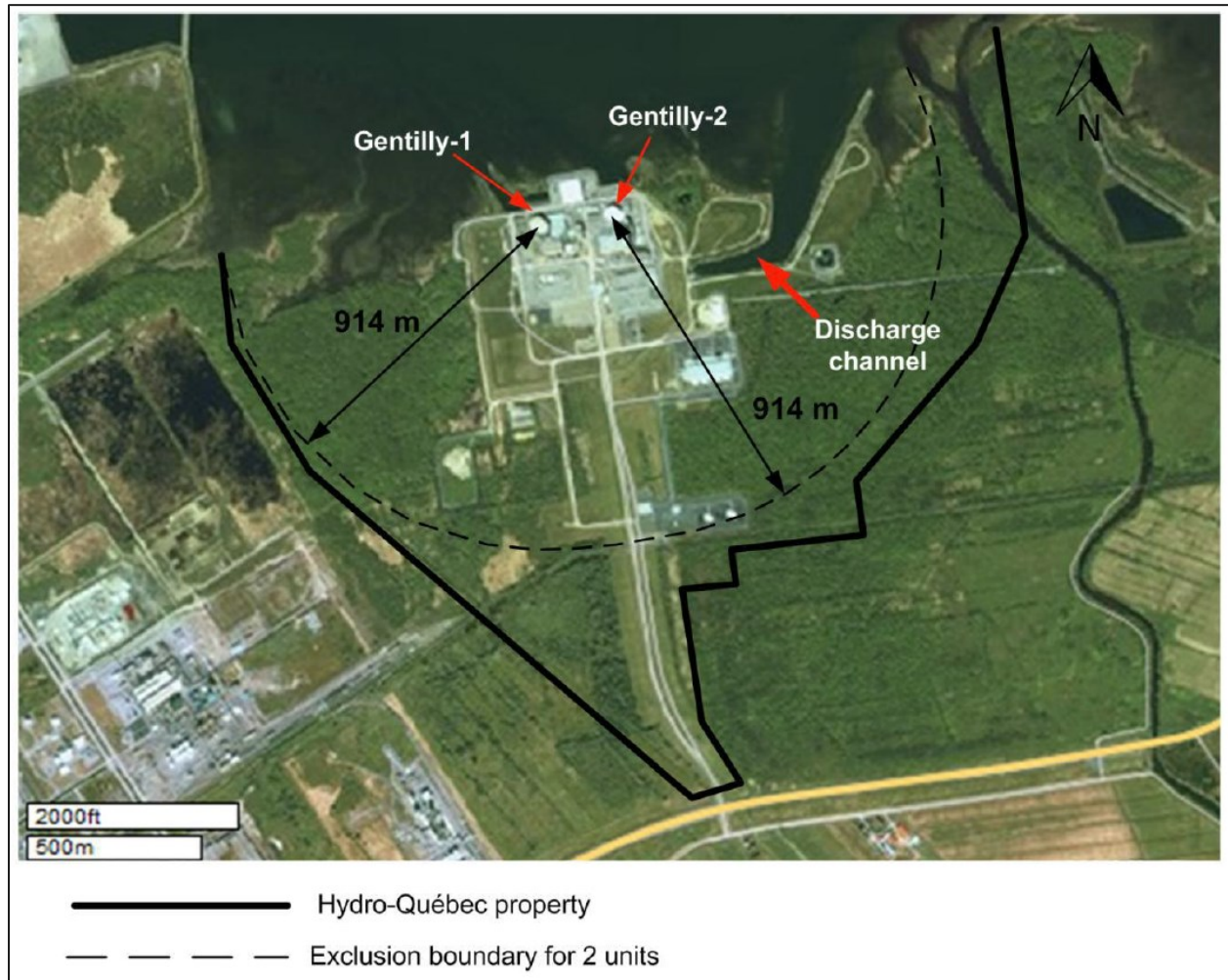
Environmental Risk Assessment for the Gently-1 Waste Facility



**Figure 2-1 Gently Site Location (CNL 2023)**

The Gently site consists of 240 hectares of land owned by HQ and provides an exclusion radius of 914 m on land from the units. The exclusion of all unauthorized persons from this site limits exposure of the surrounding population and prevents any habitation, in accordance with the requirements and regulations of the Canadian Nuclear Safety Commission (CNSC). Figure 2-2 depicts the Gently site layout, including the G1WF and the G2NGS. AECL maintains ownership of the G1WF and leases the land from HQ (CNL 1986). CNL operates the G1WF under the authority of a Waste Facility Decommissioning Licence (WFDL) (CNL 2019b) issued by the Canadian Nuclear Safety Commission (CNSC), pursuant to the Class 1 Nuclear Facilities Regulations (CNSC 2017). The agreements are in place with HQ with respect to rights of access to and the security of the property (CNL 2024).

Environmental Risk Assessment for the Gently-1 Waste Facility



**Figure 2-2 Gently Site Layout (CNL 2023)**

The Gently site is located close to the Bécancour Waterfront Industrial Park (Gouvernement du Québec 2007), which is situated on 7,000 hectares of land to the west of the power station site (see Figure 2-3). The Gently site is connected to Highway 30 in the west via Route 132. The bridge on Highway 55 allows access across the St. Lawrence River and connects the industrial park to the city of Trois-Rivières. The industrial park is served daily by the Canadian National Railway and the Gently site has its own rail head. Trois-Rivières and Montreal airports are located 20 minutes and less than two hours from this industrial park respectively.

Environmental Risk Assessment for the Gentilly-1 Waste Facility



*Note: The marker for "Gentilly" (middle-right) indicates the town of Gentilly, not the G1WF.*

**Figure 2-3 Surrounding Region of the Bécancour Waterfront Industrial Park (CNL 2023)**

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

### 2.3 Engineered Site Features

The G1WF, located adjacent to the G2NGS, consists of a permanently shutdown, partially decommissioned 250 MW prototype CANada Deuterium Uranium (CANDU) boiling water reactor and its associated structures and ancillaries, including:

- The Reactor Building;
- The Service Building (basement only, the remainder of the Service Building is owned by HQ);
- The south volume of the Turbine Building including the Spent Fuel Canister Area (SFCA) (as discussed in Section 2.3.2, the north volume was cleaned and transferred to HQ); and,
- The Spent Resin Storage Area (i.e., Spent Resin Tanks and Vaults; empty since 2018).

The general layout of the G1WF is presented in Figure 2-4.

During operations, the buildings were connected by process systems (e.g., steam lines) and utilities (e.g., electrical power) but each building existed as a separate structure. Since entering SWS, the process systems within each of the buildings have been isolated from each other.

Environmental Risk Assessment for the Gentilly-1 Waste Facility

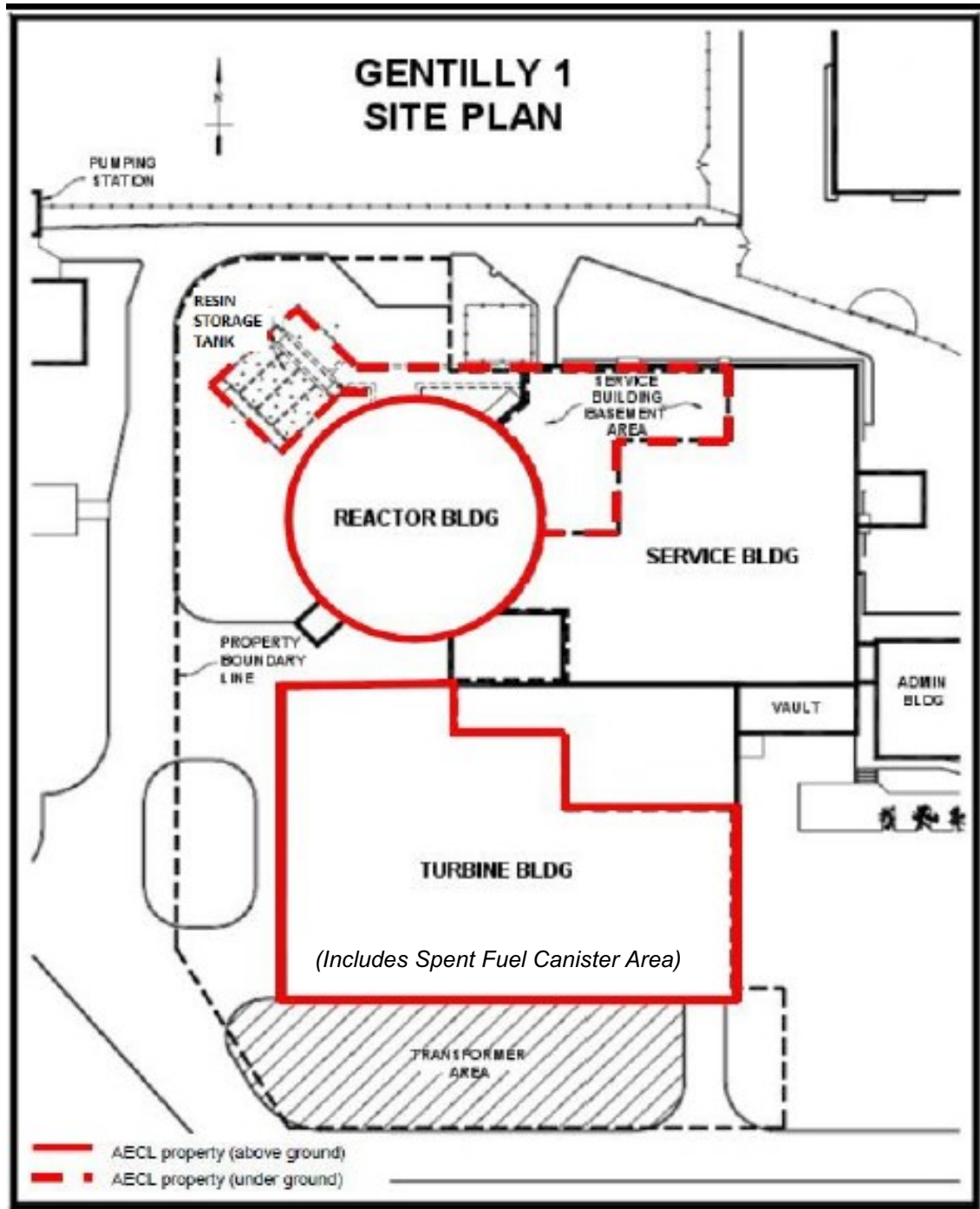


Figure 2-4 General Layout of G1WF (CNL 2023)

## Environmental Risk Assessment for the Gently-1 Waste Facility

### 2.3.1 Reactor Building

The main purpose of the Reactor Building was to house the reactor and its associated equipment, and to provide containment. The Reactor Building was designed with an exterior containment structure and a separate internal structure that supports the reactor and its associated systems, as shown in Figure 2-5 (CNL 2023). The containment structure is comprised of three structural components: a concrete base slab (1.372 m thick) founded on rock, a cylindrical concrete outer wall (1.22 m thick) and a concrete dome (0.61 m thick). It encloses a total volume of 52,000 m<sup>3</sup>. The internal space is divided into six levels including the basement (CNL 2023).

The fuel has been removed from the reactor and is stored in the SFCA, which is a dry storage facility located in Room T-110 at the Turbine Building. The process systems, including the Primary Heat Transport System (PHTS) and the Moderator System (MS) have been drained and dried in order to reduce the loads on the structures. The equipment of the MS and the Moderator Purification System (MPS) were transferred to AECL Chalk River Laboratories (CNL 2023).

Since the activities performed in 1984 to 1986 to bring the reactor and its associated components to a safe, sustainable shutdown state, regular monitoring and surveillance, including hazard reduction campaigns have been performed (CNL 2023). The facility's equipment, operations tools, and supplies were disconnected, dismantled, and removed. The resulting waste materials had been stored within the Reactor Building at different floors and in the Turbine Building. These legacy waste materials, totaling approximately 423,000 kg, were removed from the Reactor Building between 2017 and 2022 (CNL 2023).

Residual radioactivity is present in both fixed and loose form, although predominantly inside the reactor structures as opposed to on external surfaces (CNL 2021). Total radioactivity remaining on reactor structures has been both calculated and empirically derived from measurements; the available information is summarized in Table 2-1 below (CNL 2019a). Note that although no alpha emitters were detected on surfaces during a sampling campaign in 1983, it is expected that these do exist inside the reactor systems due to fuel failure. However, in its current SWS state with no anticipated dismantlement of these systems, alpha emitters are expected to remain contained inside the reactor structures (CNL 2019a).

A dehumidifier operates continuously during the summer months within the Reactor Building. The dehumidifier condensate is collected in sump T-005 situated in the Turbine Building (CNL 2019a; 2021).

Environmental Risk Assessment for the Gentilly-1 Waste Facility

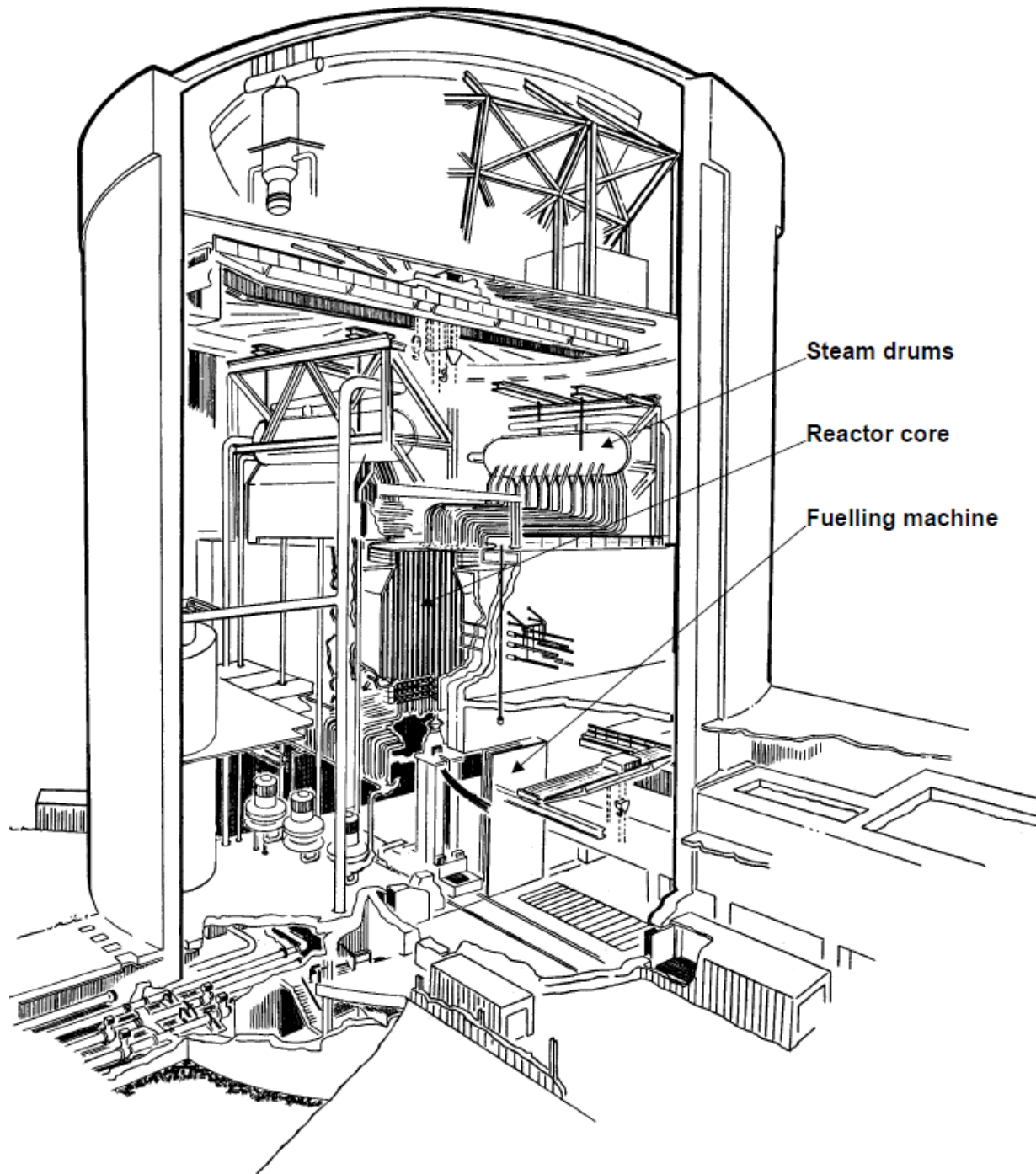


Figure 2-5 Reactor Building (viewing towards North-West) (CNL 2023)

Environmental Risk Assessment for the Gentilly-1 Waste Facility

**Table 2-1 Estimated Radiological Inventory Remaining in the Reactor Building in 2015 (CNL 2019a)**

Source of Radioactivity in Reactor Building	Total Radioactivity by 2015 (Empirically Derived from Measurements)
Reactor Core & Structure	2.11E+14 Bq
Heat Transport System	1.17E+11 Bq
Moderator System	1.77E+10 Bq
Loose surface contamination on other surfaces within the building, e.g., walls and floor.	The Reactor Building is designated as a Zone 3 Radiation level and Zone 2 Contamination level.

Non-radiological contaminant sources also exist within the Reactor Building:

- Refrigerant (R22) that was removed from a now obsolete dehumidifier is stored in a cylinder within the building and is a potential for fugitive halocarbon emissions (CNL 2021).
- The dehumidifier that operates continuously during the summer months within the Reactor Building presents a potential for fugitive halocarbon emissions (R404A) (CNL 2021).
- One instance of lead shielding in a room that is cordoned off. CNL (2021) indicates that there is no feasible pathway through which lead from the shielding material could enter the Reactor Building under-drainage system (i.e., the groundwater pumping system (North Pit (P3) and South Pit (P4)).
- Lead paint is present in the building (CNL 2019a). CNL (2021) indicates that there is no feasible pathway through which lead from the lead paint could enter the Reactor Building under-drainage system (i.e., the groundwater pumping system (North Pit (P3) and South Pit (P4)).
- Some asbestos material (pipe insulation) remains in the Reactor Building. Accessible asbestos-containing material (ACM) and degraded ACM were abated.
- Polychlorinated Biphenyl (PCB)-containing ballasts remain in the Reactor Building. The PCB ballasts that remain in the Reactor Building are at a very high level, and do not present a current hazard.

The Reactor Building’s concrete walls serve as a containment structure, preventing the release of residual contamination (radiological and non-radiological) to the environment and providing shielding against any gamma radiation. There is no forced ventilation in the Reactor Building, such that significant airborne emissions from the Reactor Building to the outdoor environment are not a possibility for either radiological or non-radiological airborne contaminants. However, there is one louver (2 feet x 2 feet) that could provide for a passive exchange of indoor/outdoor air such that fugitive radioactive emissions are a possibility. Estimates of these fugitive emissions show that they are insignificant – it would require an implausible passive exhaust rate through the one building louver of 3,500 m<sup>3</sup>/s in order to trigger the monitoring criterion of 0.0005 mSv per year (see Appendix A of CNL 2021 for details on estimate calculations) (CNL 2021).

## Environmental Risk Assessment for the Gently-1 Waste Facility

Note that an under-drainage system exists for the building (described in detail in Section 2.3.5). This groundwater pumping system operates using North Pit (P3) and South Pit (P4) and serves to divert ingress groundwater away from the Reactor Building, and no contamination from the Reactor Building is expected in this system (CNL 2021).

### 2.3.2 Turbine Building

The Turbine Building has been divided into 3 sections: the SFCA, the south area, and the north area (CNL 2019a).

During the initial decommissioning, the fuel was removed from the reactor core and was stored in the SFCA, which is a dry storage facility owned by AECL and operated by CNL. The north area of the turbine building was decontaminated to meet HQ's Zone 1 (uncontaminated area) criteria and then transferred to HQ (HQ 1983). HQ staff that are periodically present in the north area of the Turbine Building are Nuclear Energy Workers (NEWs) and therefore are covered by HQ's assessments and safety programs.

CNL still maintains the southern part of the building, which contains the turbine and turbine system (CNL 2019a, 2021).

#### 2.3.2.1 Spent Fuel Canister Area

All process systems within the SFCA have been removed, and there are no airborne or waterborne exit points from this area to the outdoor environment (supply and exhaust fans are shut down and isolated, and there are no sumps in the area). Fuel bundles are stored in dry storage canisters. Pump and filter assemblies are used to sample the air inside each canister annually; this entails monitoring of the air between the canister liner and sealed fuel baskets by circulating this air through a filter. Filters are analyzed for gross alpha activity and gross beta activity. Gross alpha contamination levels in the past five years (2019 to 2023) are below the detection limit of 0.0292 Bq/filter. Gross beta contamination levels in the past five years (2019 to 2023) are below the detection limit of 0.0323 Bq/filter. Since there are no exit points from this building to the outdoor environment and canister air monitoring shows no evidence of leakage, the SFCA is not considered an airborne or waterborne effluent source term (CNL 2021).

#### 2.3.2.2 Southern Part of Turbine Building

The turbine generators, associated steam piping, and condenser water piping are still in place. Contaminated pipes are capped. Total radioactivity remaining on the turbine system as of 2010 was calculated to be 1.39E+09 Bq (CNL 2019a; 2021). Residual radioactivity is present in both fixed and loose form, although predominantly inside the piping and equipment as opposed to on external surfaces. Airborne re-suspension of any loose surface contamination could occur. There is no forced ventilation or any windows in the building. However, there are a total of 2 louvers (each is 15 feet x 9 feet) in the southern part of the Turbine Building, such that fugitive airborne emissions are a possibility. However, estimates of these fugitive emissions show that they are insignificant – it would require an implausible combined passive exhaust rate through the two building louvers of 3,500 m<sup>3</sup>/s in order to trigger a dose to public of 0.0005 mSv per year (see Appendix A of (CNL 2021) for details on estimate calculations) (CNL 2021).

## Environmental Risk Assessment for the Gently-1 Waste Facility

In terms of non-radiological contaminant sources, there were previously some small volumes of waste in the building – such as a lead wall, old mercury-containing instruments, waste oils, etc. - but these were removed in 2022 and sent for offsite disposal.

There are four sumps located in the Turbine Building, termed T-002, T-004, T-005, and T-007. These sumps may receive ingress groundwater or condensation in-leakage from within the Turbine Building. Sump T-005 collects condensate from the Reactor Building dehumidifier and could therefore become contaminated. These sumps are assessed in more detail in Section 2.3.5 (CNL 2021).

### 2.3.3 Service Building

The Service Building is divided into two sections: North and South. The north section is two storeys high with a basement below. The south section is four storeys high (without basement). In 1993, AECL<sup>1</sup> and HQ agreed that all areas, with the exception of the basement of the Service Building, be transferred to HQ. The affected areas were cleaned to meet HQ Zone 1 (uncontaminated area) criteria. CNL maintains the basement of the Service Building as part of the G1WF. All process systems that traversed the boundaries between the HQ and CNL controlled areas were severed on CNL's side and capped if contaminated (CNL 2023). HQ staff that are periodically present in the Service Building are NEWs and therefore are covered by HQ's assessments and safety programs.

On CNL's side, only the sump systems are operational. The sumps have been decontaminated and are manually operated when high water levels are detected during visual inspection (CNL 2023). There are two sumps located in the Service Building, termed S-001 and S-012. Sump S-012 could become contaminated by water coming from the spent resin vault (CNL 2021).

The Service Building is a Radiological Safety Contamination Zone 2. However, there are no airborne exit points from the Service Building to the outdoor environment, such that fugitive emissions to the atmosphere are not a possibility (CNL 2021).

### 2.3.4 Spent Resin Storage Area

The Spent Resin Storage Area is located adjacent to the basements of the Service Building and the Reactor Building and consists of two (2) reinforced concrete vaults and one (1) stainless steel tank. The two (2) concrete vaults are referred to as the PHTS Spent Resin Vault and the MPS Resin Tank Vault. The MPS Resin Tank Vault contains the stainless steel MPS tank. The vaults contained spent ion exchange resins used in the deionization of the PHTS cooling water and the MPS. The resins and legacy piping systems were removed, leaving only the physical structure of the concrete vaults and liner, and MPS tank. Since the spent resins have been removed from the vaults, ambient radiation fields to terrestrial non-human biota are very low (CNL 2021).

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<sup>1</sup> On November 3, 2014, Canadian Nuclear Laboratories (CNL), a wholly-owned subsidiary of Atomic Energy of Canada Limited (AECL), became responsible for the management and operation of AECL's sites. AECL is used in this document to refer to CNL activities prior to November 3, 2014.

## Environmental Risk Assessment for the Gently-1 Waste Facility

### 2.3.5 Drainage System

Several drainage systems and associated pumps are still operational. They are described below based on information from CNL (2021) and descriptions from CNL facility staff:

- a groundwater pumping system (North Pit (P3) and South Pit (P4)) is located outside the Reactor Building with permanently installed pumps (7172-P3 and 7172-P4) which automatically drain upon high water-level detection to the stormwater system of HQ's G2NGS;
- four sumps, termed T-002, T-004, T-005, and T-007, located within the Turbine Building (drained using portable pumps into totes and transferred overland as liquid waste to HQ to be handled at the discretion of the Gently-2 (G-2) facility);
- two sumps, S-001 and S-012, located within the Service Building (drained using portable pumps into totes and transferred overland as liquid waste to HQ's G-2 facility to be handled at the discretion of the G-2 facility);
- one sump for the MPS resin tank vault (within the Spent Resin Storage Area) is directed to S-012 (pumped manually into totes); and,
- drainage piping that directs groundwater from the PHTS Spent Resin Vault and the MPS Resin Tank Vault to the Reactor Building underground drainage system.

All other sumps and pumps are isolated from operation. Figure 2-6 provides an overview of drainage System in the Turbine Building, Spent Resin Storage Area, and Reactor Building (CNL 2021).

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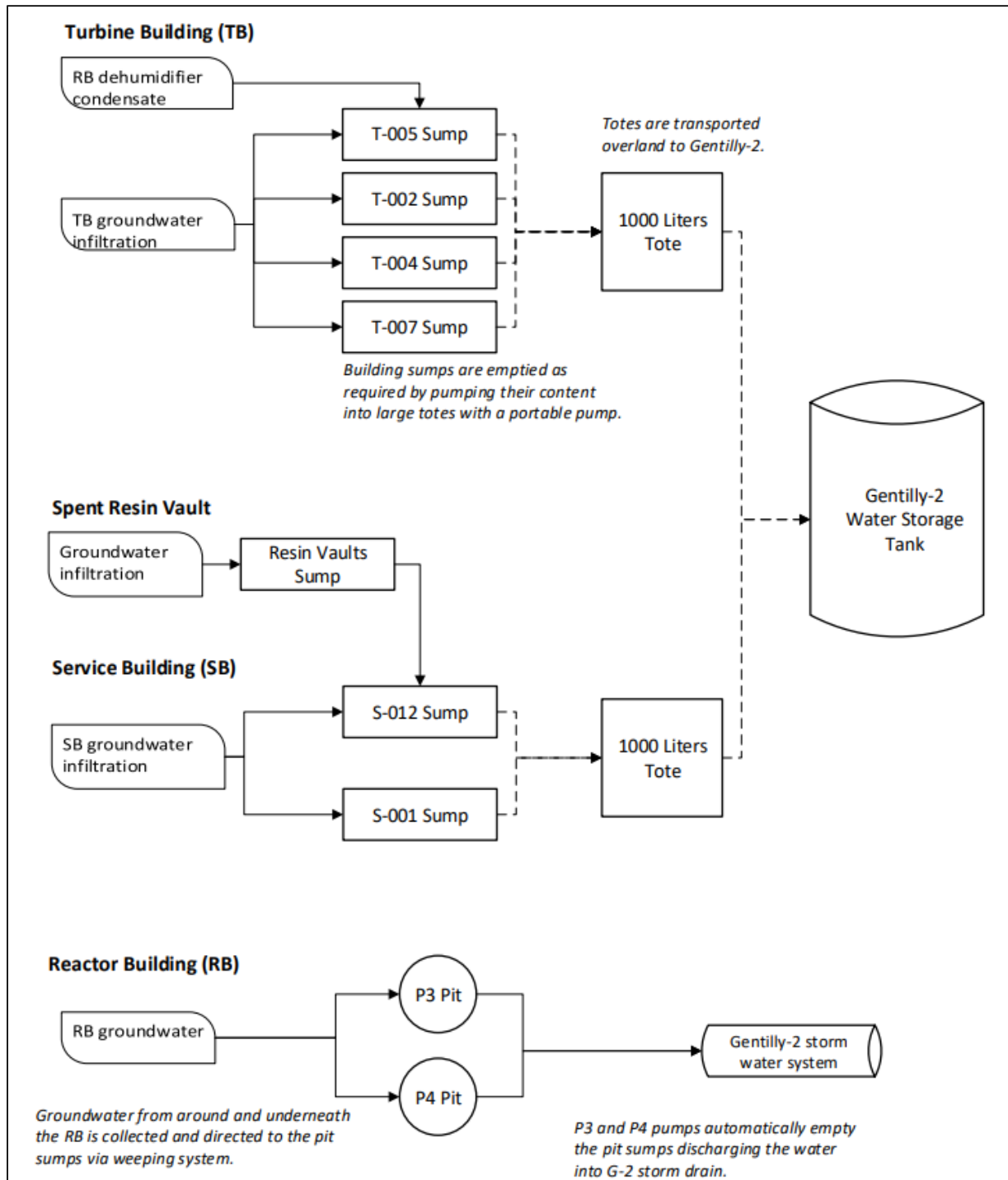


Figure 2-6 Flow Sheet – Drainage System (CNL 2021)

## Environmental Risk Assessment for the Gently-1 Waste Facility

**2.3.5.1 Groundwater Pumping System**

A groundwater pumping system (North Pit (P3) and South Pit (P4)) is located outside the Reactor Building. The system collects precipitation and groundwater from around and underneath the Reactor Building and the Spent Resin Storage Area using a weeping tile system. These sumps are automatically drained upon high level detection to the storm water system of HQ's G2NGS, which ultimately discharges to the St. Lawrence River. There is no reason to expect any contamination in these sumps given the source term. Groundwater monitoring is performed twice per year.

**2.3.5.2 Sumps T-002, T-004, T-005, and T-007**

Sumps T-002, T-004, T-005, and T-007 are all situated within the Turbine Building. All four sumps collect any water from within the Turbine Building. Additionally, sump T-005 collects condensate from the Reactor Building dehumidifier. Note that sumps T-002, T-004, and T-007 accumulate so little water that they rarely require draining (CNL 2021).

Given the source term, there is no reason to expect any significant contamination in these sumps. However, some radioactive contamination is expected given the Radiological Safety Contamination Zone 2 designation of the Turbine Building. Furthermore, the historical presence of Polychlorinated Biphenyls (PCB) within the Turbine Building does present a potential for finding residual PCBs in the sumps. Lastly, Sump T-005 could become radioactively contaminated by the Reactor Building dehumidifier condensate (CNL 2021).

Past empirical monitoring of these sumps indicates gross beta/gamma activities ranging from 1 to 400 Bq/L and tritium activities ranging from 3.37E+04 to 1.47E+05 Bq/L. Volumes collected per year (from T-005) have ranged from approximately 100 L to 13,100 L (CNL 2021).

Results of a characterization campaign undertaken in 2015 (Audet 2016) did indicate the presence of some parameters of potential interest. Tritium and gross beta activity were detected at concentrations similar to past empirical monitoring results and showed the presence of Cs-137 as the dominant beta-emitter. The concentration of total PCB detected in sump T-002 (590 µg/L) was elevated in comparison to sumps T-004 and T-005 (1.3 and 4.0 µg/L, respectively). The presence of PCBs in sump T-002 is attributed to historical storage of hydraulic oil in the area (since drained during Phase I Decommissioning). Copper was detected in sumps T-002, T-004, and T-005 (0.051 mg/L, 0.091 mg/L, and 0.023 mg/L, respectively), but at concentrations lower than the CNL internal guideline (2.5 mg/L). Mercury was detected in all T-series sumps at similar concentrations in each (range of 31 ng/L to 77 ng/L) and all lower than the CNL internal guideline (1,000 ng/L). Some extractable organic compounds were detected at low concentrations, as were dioxins/furans at sump T-002 (CNL 2021).

Up until mid-2015, the four sumps were sampled and drained as required (i.e., when full) into the stormwater system of HQ's G-2 Generation Station using portable pumps. As of mid-2015, the contents of these sumps are pumped either into 1000-Litre totes (T-002, T-004, and T-005) or 200-Litre drums (T-007), which are then transported overland to HQ's G2NGS and accepted as waste. Given that the contents of these sumps are not discharged to the environment by the G1WF, and are instead handled as liquid waste subject to

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

HQ waste acceptance criteria and disposed of by HQ according to their specifications, they are not considered a waterborne effluent source term of G1WF (CNL 2021).

### **2.3.5.3 Sumps S-001 and S-012**

Sumps S-001 and S-012 are situated within the Service Building. Both sumps are located indoors at a low elevation and as such, collect any water from within the Service Building (mainly condensation in-leakage). Sump S-001 is located within a Radiological Safety Contamination Zone 2, such that water collecting in the sump could have come in contact with some loose surface contamination. In 2018, the spent resin was retrieved, and the resin vault area was covered by a dome. Currently, Sump S-012 collects any groundwater from within the Service Building (mainly condensation in leakage), and any groundwater, although unlikely, that may have entered into the emptied spent resin vault and tank (CNL 2021).

Up until mid-2015, the two sumps were sampled and drained as required (i.e., when full) into the stormwater system of HQ's G2NGS using portable pumps. As of mid-2015, the contents of these sumps are pumped (using portable pumps) either into 200-Litre drums and then from there into 1000-Litre totes, which are then transported overland to HQ's G2NGS and accepted as waste. Given that the contents of these sumps are not discharged to the environment by the G1WF, but are instead handled as liquid waste subject to HQ waste acceptance criteria and disposed of by HQ according to their specifications, they are not considered a waterborne effluent source term of G1WF (CNL 2021).

### **2.3.5.4 PHTS Spent Resin Storage Vault Sump**

The PHTS Spent Resin Vault Sump receives any groundwater that may have entered the PHTS spent resin vault (see Section 2.3.4 for details). Any water collected in the vault sump would be pumped into totes and analyzed prior to being transferred to HQ. As such, this sump is not considered a waterborne effluent source term of G1WF (CNL 2021).

## **2.4 Description of Natural and Physical Environment**

### **2.4.1 Meteorology**

The meteorology of the site and region is typical of the St. Lawrence River, which is influenced by prevailing westerly winds. The cold temperate climate is humid and relatively invariant because of the proximity to the river. The meteorology of the Gentilly site is monitored by HQ for the G-2 station.

#### **2.4.1.1 Temperature**

Table 2-2 details the monthly temperature data for Bécancour for the period of 2009 to 2022 (WWO 2023). Over the 2009-2022 period, January and February are the coldest months while July and August are the hottest months (as shown in bold in the Table 2-2). So far, the lowest temperature observed in Bécancour during the last 25 years (1998-2022) was -36.8°C in 2014 January and the highest temperature was +35.4°C in 2020 July (WSC 2023a).

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**Table 2-2 Monthly Temperature (°C) in Bécancour for a 14-year Period (2009-2022) (WWO 2023)**

Month	Temperature Minimum	Temperature Maximum	Temperature Minimum Avg.	Temperature Maximum Avg.
January	-21	-4	<b>-15</b>	<b>-7</b>
February	-22	-2	<b>-14</b>	<b>-5</b>
March	-14	4	-8	0
April	-4	12	0	8
May	5	20	7	17
June	11	23	12	21
July	14	26	<b>16</b>	<b>24</b>
August	14	27	<b>15</b>	<b>24</b>
September	9	22	11	19
October	2	16	5	12
November	-6	7	-2	4
December	-14	2	-9	-3

Note: maximum values shown in **bold**.

#### 2.4.1.2 Precipitation

The monthly data for maximum rainfall, snowfall, and precipitation in Bécancour is shown in Table 2-3 for the period of 2009 to 2022 (WWO 2023). The total monthly precipitation is the total of the monthly snowfall and monthly rainfall, with 1 cm of snowfall equivalent to 1 mm of rainfall. In Bécancour, over the 2009-2022 period, maximum monthly rainfall was 301.15 mm in 2011 August, maximum monthly snowfall was 77.9 cm in 2020 February, and maximum monthly precipitation was 301.15 mm in 2011 August (as shown in bold in the Table 2-3).

#### 2.4.1.3 Wind

Table 2-4 details the annual wind speed at Bécancour for the period of 2009 to 2022 (WSC 2023b). Over the 2009-2022 period, the highest maximum annual wind speed at Bécancour was 71 km/h in 2021 with an hourly mean speed of 11.2 km/h (as shown in bold in the Table 2-4).

The schematic of the records of origin and speed of the winds at Bécancour for 2022 is presented in Figure 2-7 (HQ 2023). The records of origin and speed of the winds at Bécancour was made through the meteorological tower belonging to the Ministère de l'Environnement, de la Lutte contre les Changements Climatiques, de la Faune et des Parcs (MELCCFP). The instrumentation battery of this tower is at a height of 10 meters. The raw data set of the MELCCFP tower was made available by the Quebec Cooperative Meteorological Network. The three prevalent wind directions capable of dispersing atmospheric emissions from G-2 towards Farm No. 1 (see Figure 3-1), the human receptor location closest to the site, are winds coming from the north, the north-northwest and the northwest. These three wind directions represent about 24% of all winds.

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**Table 2-3 Maximum Rainfall, Snowfall, and Precipitation in Bécancour for a 14-year Period (2009-2022) (WWO 2023)**

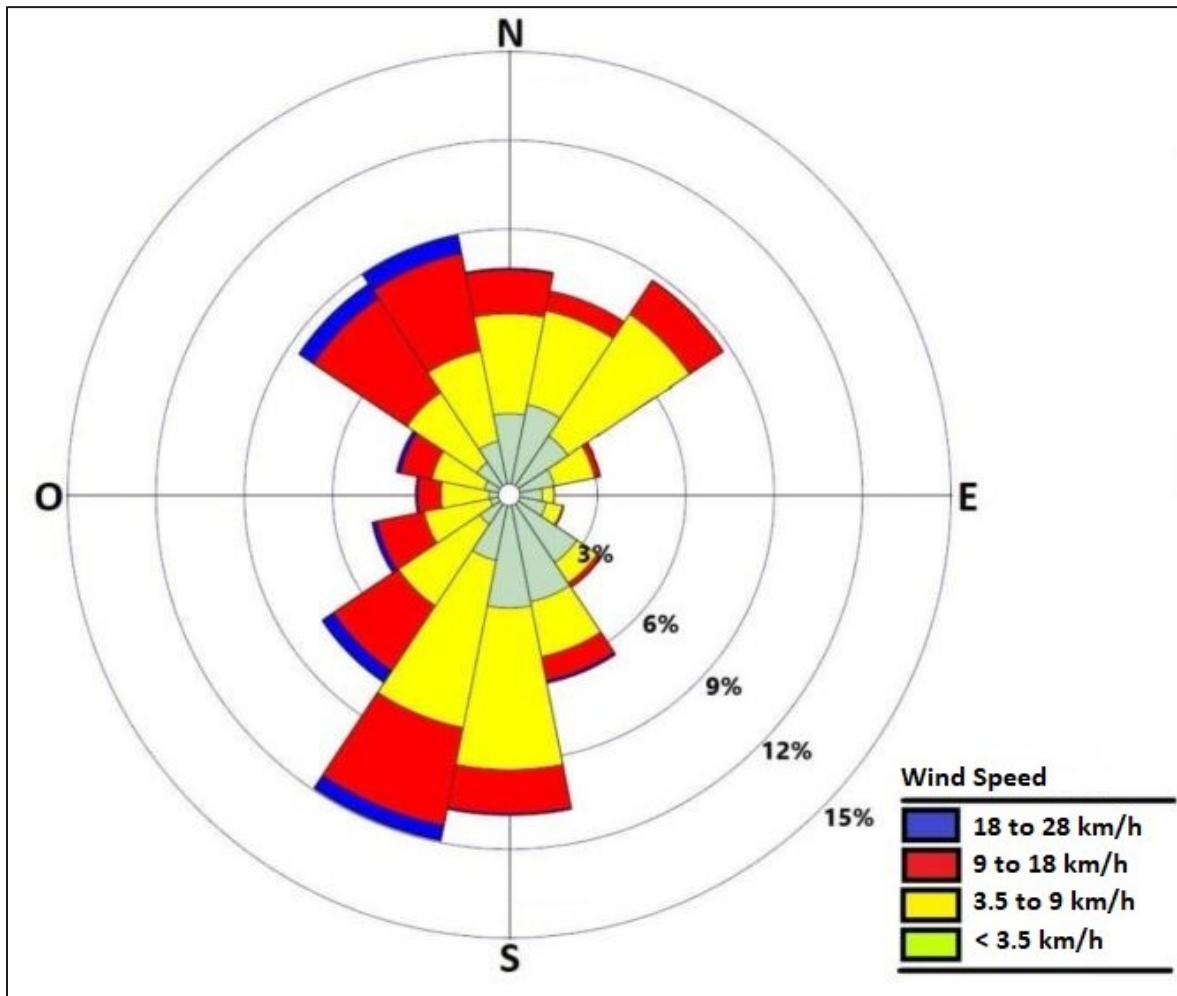
Month	Rainfall (mm)	Snowfall (cm)	Precipitation (mm)
January	109.61	64.60	174.21
February	157.42	<b>77.90</b>	235.32
March	143.14	76.20	219.34
April	182.57	38.70	221.27
May	185.07	2.90	187.97
June	163.04	0	163.04
July	175.14	0	175.14
August	<b>301.15</b>	0	<b>301.15</b>
September	233.32	0	233.32
October	191.65	10.00	201.65
November	142.56	32.80	175.36
December	148.90	75.10	224.00

Note: maximum values shown in **bold**.

**Table 2-4 Annual Wind Speed in Bécancour for a 14 year Period (2009-2022) (WSC 2023b)**

Year	Maximum (km/h)	Hourly Mean(km/h)
2009	57	13.0
2010	56	13.4
2011	70	13.4
2012	59	12.9
2013	50	12.1
2014	50	12.5
2015	55	11.9
2016	52	12.1
2017	46	11.8
2018	45	11.9
2019	59	12.0
2020	45	11.3
2021	<b>71</b>	11.2
2022	65	12.2

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**Figure 2-7** Rose of the origin of the winds at the MELCCFP instrumented site in Bécancour for the year 2022 (HQ 2023)

**2.4.1.4** *Climate Change Impacts*

Climate change could potentially result in increased frequency of tornado events and in flooding. According to the Meteorological Service of Canada during 1985-2023, four tornadoes occurred around Trois-Rivières (1995 July, 2011 September, 2020 July, and 2021 June) and all were F0 on the Fujita Tornado Damage Scale. The maximum annual speed of 71 km/h has been recorded between 2009-2022. Therefore, tornados would pose no unacceptable environmental risk to the G1WF.

To deal with potential flooding, a dike has been constructed around the perimeter of the Gentilly site to protect both the G1WF and the G2NGS against river levels as high as 7.7 m, with 0.2 m wavelets. The height of the dike was chosen such that the probability of flooding due to natural variation in the St. Lawrence River is less than once every 10,000 years based on historical data. In addition, during normal water level conditions in the St. Lawrence River, the dike will provide protection against the wave generated by a failure of the hydroelectric dam at the Gouin Reservoir.

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### 2.4.2 Hydrology – Surface Water

The portion of the St. Lawrence River within the region where the Gentilly site is located is known as a fluvial estuary and is approximately 2 km wide. The average flow rate of the St. Lawrence River, as measured in Trois-Rivières, is 11,600 m<sup>3</sup>/s. Salt water does not reach this portion of the St. Lawrence River, and the tidal influence is less than 0.3 m. There are long stretches of shallow marshland along the southern shore of the St. Lawrence River in this region that are often flooded (AECL 2009).

There are two tributaries to the St. Lawrence River on the south shore of this region: the Bécancour River, west of the Gentilly site, and the Gentilly River east of the Gentilly site. Those rivers have relatively low flow rates; with the Bécancour River averaging 7.5 m<sup>3</sup>/s (AECL 2009).

### 2.4.3 Groundwater Flow

Regionally, groundwater flow is towards the St. Lawrence River (CNL 2021).

A groundwater recharge zone is located immediately to the south of the G1WF and the G2NGS. Groundwater flow from this recharge zone is towards the G1WF and the G2NGS and the two valleys to the east and west. The highest water table conditions are observed from the end of April to mid-May, corresponding to seasonal snow melt. The lowest levels occur in mid-August (CNL 2021).

Most information on the water table near the G1WF site comes from six monitoring well networks (P1 to P6) installed at the G2NGS's Solid Radioactive Waste Management Site, immediately to the west of the G1WF. Monitoring information indicates that the water table is shallow, typically 1.5 to 3 m below grade. Groundwater flow and the water table at the G1WF are strongly influenced by the groundwater pumping system (north and south pits P3 and P4) which act as a local groundwater sink. These pumps are located at the base of the Reactor Building approximately 7 m below grade and 2.64 m below sea level, well below the natural water table elevation as noted above. The groundwater pumping system maintains the groundwater table below the foundation of the Reactor Building and draw groundwater flow radially inward to the sumps from around the Reactor Building. In terms of contaminant transport, any releases to ground in the immediate vicinity of the G1WF would migrate towards the building sumps as opposed to migrating towards the river (CNL 2021).

### 2.4.4 Natural Environment

It is important to distinguish the G1WF site from the Gentilly site and the surrounding area. There is no natural area within the G1WF site. The G1WF site is entirely comprised of buildings and hardscape (e.g., concrete, asphalt and packed gravel areas). Figure 2-4 shows the area that comprises the G1WF. Figure 3-6 (in Section 3.2) presents a satellite image showing ground cover. Thus, the following descriptions of the natural environment apply to the area outside of the G1WF site, and in most cases, to the area outside of the Gentilly site altogether. Information is obtained from CNL (2019) and Calian (2022) unless otherwise noted.

The St. Lawrence River is located north of the Gentilly site. Along the river the area consists mainly of farmland and pasture, wetlands, and forests (CNL 2019a). Overall, flora and fauna in the region surrounding the Gentilly site are typical of the St. Lawrence lowlands region.

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Forests are more prominent inland, further from the river. They typically belong to maple grove family (CNL 2019a). Closer to the river, humid areas and wetlands are found. Wetlands are present to the north, northwest, and northeast of the Gentilly site. These wetlands are comprised of a mix of shallow water, low water marshes, high water marshes, and shrub swamp (Calian 2022).

It is important to note that the Gentilly site is located in the humid prairie, which is a transition between aquatic and terrestrial environments (CNL 2019a). As a result, there are several areas with overlapping terrestrial and aquatic aspects.

### **2.4.4.1 Terrestrial Vegetation**

Forests belong to the maple grove family and are dominated by the sugar maple, the red maple and other broad-leaved trees (CNL 2019a). Humid soils are more widespread than dried soils, and peat bogs have been observed on the north side of the river (across the river from the Gentilly site). The flora of the Gentilly site are dominated by young broad-leaved trees on fallow land (CNL 2019a).

In the surrounding area some forest stands are found within wetlands, these include species such as red ash (*Fraxinus pennsylvanica*), silver maple (*Acer saccharinum*), bur oak (*Quercus macrocarpa*) and basswood (*Tilia americana*). Calian (2022) notes that some of these wetland forest stands may also include butternut (*Juglans cinerea*), which is a species at risk (SAR), but the presence of butternut in the exclusion zone around the Gentilly site has not been confirmed.

Species at risk are discussed separately in Section 4.1.1.

### **2.4.4.2 Terrestrial Wildlife**

#### Herpetofauna

CNL (2019) notes that amphibian and reptilian species (such as frogs and turtles) are present in the region. Calian (2022) mentions that past studies identified the following species: American toad (*Anaxyrus americanus*), spring peeper (*Pseudacris crucifer*), bearded tree frog (*Hyla versicolor*), wood frog (*Lithobates sylvaticus*), northern leopard frog (*Lithobates pipiens*), green frog (*Lithobates clamitans*), blue-spotted salamander (*Lateral Ambystoma*), bullfrog (*Rana catesbeiana*), and common garter snake (*Thamnophis sirtalis sirtalis*).

Species at risk are discussed separately in Section 4.1.1.

#### Birds

Based on information from a past bird survey and from federal and provincial databases, Calian (2022) notes several terrestrial bird species as potentially occurring in the region, including: rough-legged hawk (*Buteo lagopus*), American Kestrel (*Falco sparverius*), American Robin (*Turdus migratorius*), cat mockingbird (*Dumetella carolinensis*), European starling (*Sturnus vulgaris*), American redstart (*Setophaga ruticilla*), yellow-rumped warbler (*Setophaga coronata*), masked warbler (*Geothlypis trichas*), slate junco (*Junco hyemalis*), song sparrow (*Melospiza melodia*), and white-throated sparrow (*Zonotrichia albicollis*).

Species at risk are discussed separately in Section 4.1.1.

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Mammals

The region surrounding the Gentilly site provides a variety of habitat for mammals. Small mammals like shrews, mice and voles are present close to the humid area. White-tailed deer live in the woodlands south of the Gentilly site (CNL 2019a). In addition, Calian (2022) notes the presence of coyote (*Canis latrans*), raccoon (*Procyon lotor*), weasel (*Mustela sp.*), red fox (*Vulpes vulpes*), North American red squirrel (*Tamiasciurus hudsonicus*), eastern grey squirrel (*Sciurus carolinensis*), chipmunk (*Tamias striatus*), barred skunk (*Mephitis mephitis*), as well as small mammals like voles, shrews, etc.

Species at risk are discussed separately in Section 4.1.1.

**2.4.4.3 Aquatic, Wetland and Riparian Vegetation**

As mentioned earlier, the region in which the Gentilly site is located is a transition between aquatic and terrestrial environments (CNL 2019a). Closer to the river, the flora is typical of humid areas and swamps, including willow plantation and silver maple.

Low marsh areas are largely characterized by the following species (Calian 2022): false rice leersia (*Leersia oryzoides*), swamp rush-rush (*Eleocharis palustris*), corded bridging (*Pontederia cordata*), broad-leaved sagittaria (*Sagittaria latifolia*), American bulrush (*Scirpus americanus*), and acute bulrush (*Scirpus acutus*).

High marsh areas consist of a single group - pale smartweed/curlytop knotweed/willow weed. (*Polygonum lapathifolium*) - while the shrub marsh consists primarily of glossy willow (*Salix lucida*) and interior willow (*Salix interior*) groups (Calian 2022).

Aquatic vegetation bordering the Gentilly site is dominated by the American valley (*Vallisneria americana*). Other aquatic plants in the area include American bulrush (*Scirpus americanus*), broad-leaved sagittaria (*Sagittaria latifolia*), lake bulrush (*Scirpus lacustris*), river bulrush (*Scirpus fluviatilis*), Richardson's pondweed (*Potamogeton richardsonii*) and many others.

Calian (2022) notes that the following plant species - identified as threatened or vulnerable, or likely to be designated as such - could potentially be present in coastal wetland areas in the larger region surrounding the Gentilly site, though these are not considered species at risk for the Gentilly site:

- Clammy hedge-hyssop (*Gratiola neglecta var. glaberrima*);
- Palegreen orchid (*Platanthera flava var. herbiola*);
- Branched ribbon (*Sparganium androcladum*);
- Bident disco'ide (*Bidens discoideus*);
- Hypnid grassgrass (*Eragrostis hypnoides*); and,
- Boubtful linder/yellow-seeded false pimpernel (*Lindernia dubia var. inundata*).

Species at risk are discussed separately in Section 4.1.1.

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**2.4.4.4 Aquatic Wildlife**Fish

According to Calian (2022), up to 46 species of fish have been reported on the south shore of the St. Lawrence River near the Gentilly facility, with the four (4) most common species being northern pike (*Esox Lucius*), yellow perch (*Perca flavescens*), brown bullhead (*Ameiurus nebulosus*) and white sucker (*Catostomus commersoni*). Past catch studies have included yellow minnow (*Notemigonus crysoleucas*), common carp (*Cyprinus carpio*), lake sturgeon (*Acipenser fulvescens*), yellow rock (*Stizostedion vitreum*) and black walleye (*Stizostedion canadense*).

Species of particular interest are as follows (Calian 2022):

- Northern pike, yellow perch, walleye and sturgeon were noted as being important for local economic and recreational purposes.
- Yellow perch is a vulnerable species and has been found in streams on the Gentilly site and uses these streams to breed. Yellow perch populations are monitored by the Quebec Ministry of Natural Resources and Wildlife.
- Carp were identified as being of importance to the G-2 facility because of mortalities that occurred in 2001 when the G-2 facility was operational (operations ended in approximately 2013).
- In fish inventory studies performed in 2001 and 2002 fish were caught in watercourses on the Gentilly site, and in the surrounding area, and in the discharge channel. The following species were deemed to be of interest by the Centre de données sur le patrimoine nature du Québec:
  - White perch (*Morone americana*), captured in the outlet channel; and,
  - Banded killifish (*Fundulus diaphanus*) captured at the Portage Landfill (located off of the Gentilly site to the east) and the Lavigne Landfill (located off of the Gentilly site but near its western border).

Species at risk are discussed separately in Section 4.1.1.

Aquatic Invertebrates

Calian (2022) indicates that the St. Lawrence River is mainly dominated by species of cladocerae and copepods (crustaceans) and the estuary of the St. Lawrence River is mainly composed of benthic organisms including chironomids, gastropods, oligochaetae, spherids, trichoptera and leeches. Past studies identified benthic organisms belonging to the following six invertebrate phyla: Platyhelminthes, Nemertes, Nematodes, Molluscs, Annelids and Arthropods.

Zooplankton species in the St. Lawrence River include (Calian 2022):

- Cladocerans (water fleas) such as *Bosmina longirostris*, *Sida crystallina*, and *Camptocercus rectirostris*,
- Copepods (crustaceans) *Eurytemora affinis* and *Eucyclops agilis*; and,
- Amphipod *Gammarus fasciatus*.

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

Benthic invertebrates consist mainly of molluscs, annelids, and insect larvae, dominated by the gastropod *Bithynia tetaculata* (Calian 2022).

### Aquatic Mammals

Some aquatic mammals, like the muskrat, are present in the region surrounding the Gentilly site (CNL 2019a). Calian (2022) notes the presence of North American river otter (*Lontra canadensis*) and American mink (*Neogale vison*).

### Aquatic Birds

The south shore of the St. Lawrence River is well vegetated and along the river there are tidal flats, marshes and seagrass beds, as well as the presence of a floodplain; these features provide feeding and resting habitat for waterfowl. However, the potential for nesting and brooding is expected to be limited due to lack of cover (Calian 2022).

A large portion of the river corridor in the vicinity of the G-2 facility is a provincially protected area for waterfowl. Species observed in this area include American black duck (*Anas rubripes*), green-winged teal (*Anas carolinensis*), common goldeneye (*Bucephala clangula*), some species of diving ducks, Canada goose (*Branta canadensis*) and, intermittently, snow goose (*Anser caerulescens*) (Calian 2022).

Based on information from a bird survey, and from federal and provincial databases, Calian (2022) notes several aquatic bird species as potentially occurring in the region, including: double-crested cormorant (*Phalacrocorax auritus*), great egret (*Ardea alba*), great blue heron (*Ardea Herodias*), green-winged teal (*Anas crecca*), mallard (*Anas platyrhynchos*), bald eagle (*Haliaeetus leucocephalus*), northern harrier (*Circus cyaneus*), and red-winged blackbird (*Agelaius phoeniceus*). Calian (2022) also notes that bald eagles and great egret have occasionally been observed in the marshes of the site, along the Gentilly River, and in the bay east of the outlet channel.

Species at risk are discussed separately in Section 4.1.1.

## 2.4.5 Land Uses

The majority of the population is located within 10 to 20 km from the Gentilly site, primarily in the city of Trois-Rivières. The area within 5 to 10 km of the site is mostly rural, with the majority of the population residing in the town of Bécancour. Very few people live within 5 km of the Gentilly site as this area is comprised of industrial land and the St. Lawrence River (CNL 2019a).

As mentioned earlier, the G1WF is located close to the Bécancour Waterfront Industrial Park. Approximately 30 companies operate in this industrial park, ranging from heavy industry to professional services companies. The heavy industries consist of electrometallurgy and electrochemistry manufacturers which produce aluminum, metallic silicon and other chemical products (CNL 2019a).

Despite the high industrial presence in the Bécancour Waterfront Industrial Park and in Trois-Rivières, this region continues to be predominantly agricultural. The main farming activity on the north and south shores of the St. Lawrence River is dairy farming. The main field crop in the region is fodder. In the region surrounding the Gentilly site, there are no mining activities and no major institutions, such as convents, hospitals, military facilities or detention facilities (CNL 2019a).

## 3.0 RADIOLOGICAL HUMAN HEALTH RISK ASSESSMENT

### 3.1 Problem Formulation and Conceptual Model

The objective of the radiological HHRA is to assess radiological risk from the G1WF site to human receptors. The assessment is for current conditions and will use the last 5 years of data.

The receptors, selection of contaminants of potential concern (COPCs) and exposure pathways to be assessed are presented below.

#### 3.1.1 Receptors

It is important to note that, as discussed in Section 2.3.5 and the next section (Section 3.1.2), the facility has negligible airborne releases and waterborne releases are of precipitation and groundwater diverted away from the reactor building. No contamination is expected in this water, and it discharges into the G-2 facility's stormwater management system (CNL 2021). Effluent sampling performed in 2015 confirmed that radionuclide levels were less than corresponding criteria. Therefore, no radiological contaminants were retained for further analysis in the HHRA. As such, the results cover all receptor locations (in other words, there is no spatial dependence, aside from gamma rates which are discussed later in Section 3.2).

Human receptors for the G1WF radiological HHRA were selected based on Bukhari (2024) (included as Appendix B). Bukhari (2024) chose receptors consistent with the those identified in the HQ (2023) annual report for the Gentilly site. Since the G1WF is located within the Gentilly site, it shares the same surroundings in terms of populated locations and land usages, and therefore the human receptors chosen for the Gentilly site ERA are applicable. The receptor groups used in the HQ ERA are discussed in HQ's annual reports (e.g., HQ 2023). They include the following:

- **Resident Receptor:** a non-farm resident representing typical, full-time residents in the area surrounding the site. They also encompass (i.e., bound) seasonal exposure (e.g., cottagers). The resident receptor obtains a large portion of their food from grocery stores. Residents are potentially located in several different communities in the area, e.g., municipality of Bécancour, Trois-Rivières, etc. Five approximate locations for potential resident receptors are shown in Figure 3-1 below.
- **Worker Receptor:** represents off-site worker receptors potentially located near SCR-4, Bécancour (central), or Laprade (see Figure 3-1 below).
- **Farm Resident Receptor:** represents residents that are also farmers. Farm residents are more likely to consume their own crop or livestock, but still use grocery stores for a portion of their food. Potentially located near Sud-1, Nord-1, or Est-2 (see Figure 3-1 below).
- **Hypothetical Hunter-Fisher Receptor:** a nearby resident that consumes increased amounts of hunted game and fish obtained near the G-1 site. They are presumed to hunt in the area and fish in Anse à Lamerier (see Map A-7 of HQ (2023)). This receptor location (See Figure 3-1 below) is assumed and approximate, since hunting and fishing activities are not limited to one specific location; the precise location of this receptor is not a limiting factor.

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

Receptor locations are based on proximity to the site (i.e., all locations are within 10 km of the site). Each receptor location includes three age categories as per CSA Guideline N288.1-14 (CSA 2017): adult, child (10 years old), and infant (1 year old).

The above receptors are all located off site. On-site workers are expected to be NEWs, which are covered under the facility's radiation protection program or health and safety program and are not typically incorporated into risk assessments, as per N288.6-22 (CSA 2022a).

Environmental Risk Assessment for the Gentilly-1 Waste Facility



Figure 3-1 HHRA – Locations of Potential Receptors (HQ 2023)

Environmental Risk Assessment for the Gently-1 Waste Facility

**3.1.2 Selection of COPCs**

As outlined in the site’s Effluent Monitoring Plan (EMP) (CNL 2021) and summarized in Section 2 above:

- Airborne effluent: in its current state the G1WF has no functional active ventilation system, and any airborne emissions would be fugitive emissions. As discussed in Section 2, only the Turbine Building and Reactor Building have open exits to the outdoor environment (two louvers in the Turbine Building and one in the Reactor Building) and fugitive emissions from these buildings were estimated to be insignificant (CNL 2021).
- Liquid effluent: as described in Section 2.3.5, only the groundwater pumping system (North Pit (P3) and South Pit (P4)) is subject to automatic operation (i.e., the pumps are automatically activated upon high water-level detection), and discharge occurs automatically to the G-2 facility’s stormwater system. However, this system serves to divert ingress groundwater away from the Reactor Building, and no contamination from the Reactor Building is expected in this system (CNL 2021). All other sumps are drained manually into storage totes, which are then transferred overland to the G-2 facility as liquid waste.

Effluent sampling of the groundwater pumping system (North Pit (P3) and South Pit (P4)) was carried out in 2015 and data were summarized in Audet (2016). Table 3-1 below compares the concentrations measured in the pits in 2015 to corresponding criteria. Criteria are obtained from Health Canada (HC) Guidelines for Canadian Drinking Water Quality (CDWQ) (HC 2024), which has initial screening levels for the presence of radioactivity using gross alpha and gross beta rather than measurements of individual radionuclides. As outlined in HC (2024), concentrations of specific radionuclides should be analyzed and compared to guidelines for individual radionuclides only if the screening levels are exceeded.

**Table 3-1 2015 Effluent Sampling Concentrations and CDWQ**

Radionuclide	Unit	North Pit (P3) and South Pit (P54) Effluent	HC CDWQ (HC 2024)	Exceed CDWQ?
H-3	Bq/mL	0.51	7	No
Gross alpha	Bq/L	<0.44	0.5	No
Gross beta	Bq/L	<0.30	1.0	No

As shown in Table 3-1, concentrations of H-3, total alpha and total beta are all below the corresponding CDWQ guidelines.

Radionuclide concentrations in samples obtained from the G-2 stormwater drainage system give additional perspective on the condition of water in this system. As discussed on Section 2.3.5, the G1WF’s inactive drainage system drains into the G-2 site’s stormwater management system. Locations MCH-1, MCH-2, and MCH-3 (shown in Figure 3-2) are sampling points along the G-2 site’s stormwater drainage channel (i.e., Hydro-Quebec). MCH-2 is located near the northern shore boundary of the G-2 site, whereas MCH-1 and MCH-3 are located along the eastern shore boundary of the G-2 site, near the outfall to the G-2 discharge channel.

Environmental Risk Assessment for the Gentilly-1 Waste Facility

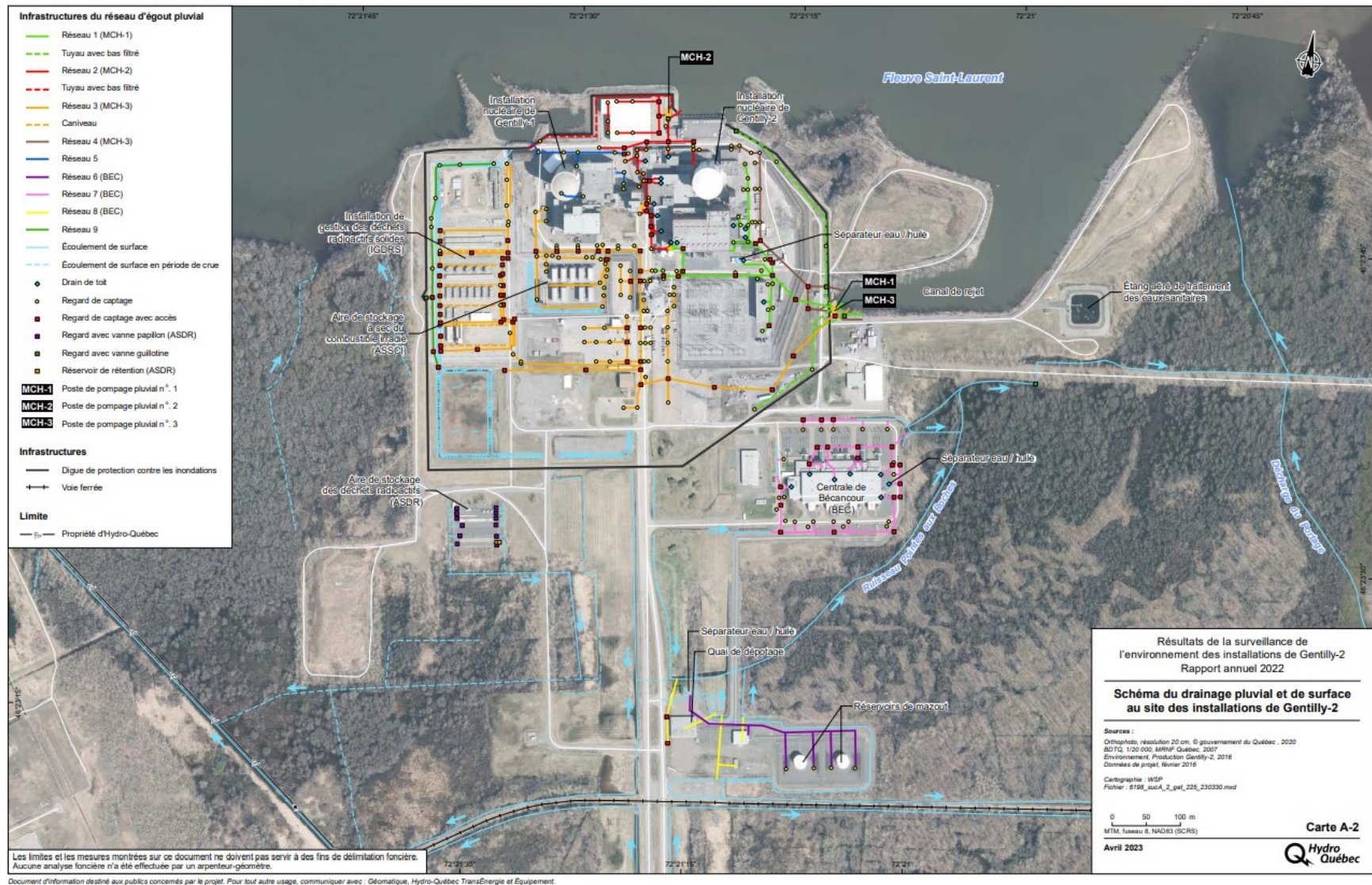


Figure 3-2 Storm and Surface Water Drainage at the Gentilly-2 Facility (Figure A-2 from HQ (2023))

Environmental Risk Assessment for the Gentilly-1 Waste Facility

Table 3-2 below presents radionuclide concentrations measured by Hydro Quebec in the G-2 facility's stormwater drainage system in 2022. These data are obtained from Table 2-6 of HQ (2023).

**Table 3-2 Activity of the Main Radionuclides in the Storm Drainage Systems of the Gentilly-2 Facilities for the Year 2022**

Sump	Date	Tritium (Bq/L)	Carbon-14 (Bq/L)	Gamma Spectrometry		
				Co-60 (Bq/kg)	Sb-125 (Bq/kg)	Cs-137 (Bq/kg)
MCH-1	April 2022	333 ± 6	<0.23	<0.15	<0.37	<0.16
	July 2022	138 ± 5	<0.23	<0.15	<0.35	<0.15
	October 2022	153 ± 6	<0.23	<0.14	<0.30	<0.13
MCH-2	April 2022	214 ± 5	<0.23	<0.12	<0.29	<0.12
	July 2022	215 ± 6	<0.23	<0.13	<0.29	<0.13
	October 2022	237 ± 7	<0.23	<0.12	<0.28	<0.12
MCH-3	April 2022	328 ± 6	<0.23	<0.13	<0.32	<0.13
	July 2022	178 ± 6	<0.23	<0.15	<0.34	<0.15
	October 2022	153 ± 6	<0.23	<0.13	<0.31	<0.12

As shown in Table 3-2, the maximum tritium concentration in storm drainage system effluent is 333 ± 6 Bq/L. For perspective, though this water is not used for drinking, 333 Bq/L is less than Health Canada's 7,000 Bq/L drinking water standard for tritium (HC 2024).

As shown in Table 3-2, C-14 was less than the detection limit of 0.23 Bq/L in all samples. For perspective, though this water is not used for drinking, 0.23 Bq/L is less than Health Canada's 1 Bq/L drinking water standard for gross beta (HC 2024).

Therefore, all individual radionuclides are screened out. It is noted that despite the use of drinking water guidelines for screening, the public does not have access to the site, and would not be drinking water from this system. It should also be noted that concentrations of radiological contaminants attributable to waterborne effluent from the G1WF are expected to be even lower in the receiving environment.

**Based on the information presented above:**

- **the facility has negligible airborne releases to the environment.**
- **the facility's only waterborne releases are of groundwater diverted away from the reactor building. No contamination is expected in this water. Effluent sampling performed in 2015 confirmed that radionuclide levels were less than corresponding criteria.**

**Therefore, no radiological contaminants were retained for further analysis in the HHRA.**

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

### 3.1.3 Exposure Pathways

Since all radiological contaminants were screened out in Section 3.1.2, there are no unacceptable risks to human health expected due to releases of radiological contaminants from the G1WF. Exposure assessment and risk calculations are not required for the G1WF.

Nevertheless, for completeness, the human receptor exposure pathways associated with airborne and waterborne effluents are listed below (based on Bukhari (2024), included in Appendix B):

- Air inhalation;
- Air immersion;
- Water ingestion;
- Water immersion;
- Soil ingestion (incidental);
- Soil external (ground shine);
- Terrestrial animal ingestion;
- Terrestrial plant ingestion;
- Aquatic animal ingestion;
- Aquatic plant ingestion;
- Sediment ingestion (incidental);
- Sediment external; and,
- Gamma radiation.

#### On-Site Groundwater

Groundwater on the G1WF site is not used (including groundwater collected in the sumps). There are also no public receptors on the G1WF site. Therefore, there is no pathway through which public receptors could be exposed to groundwater on the G1WF site.

### 3.1.4 Radiological HHRA – Conceptual Site Model

As discussed in Section 3.1.2, the facility has negligible airborne releases and waterborne releases are of precipitation and groundwater diverted away from the Reactor Building by the groundwater pumping system (North Pit (P3) and South Pit (P4)). No contamination is expected in this water, and, it discharges into the G-2 facility's stormwater management system. Effluent sampling performed in 2015 confirmed that radionuclide levels were less than corresponding criteria. Therefore, no radiological contaminants were retained for further analysis in the HHRA. However, for completeness, Figure 3-3 presents a conceptual site model for the site.

Environmental Risk Assessment for the Gently-1 Waste Facility

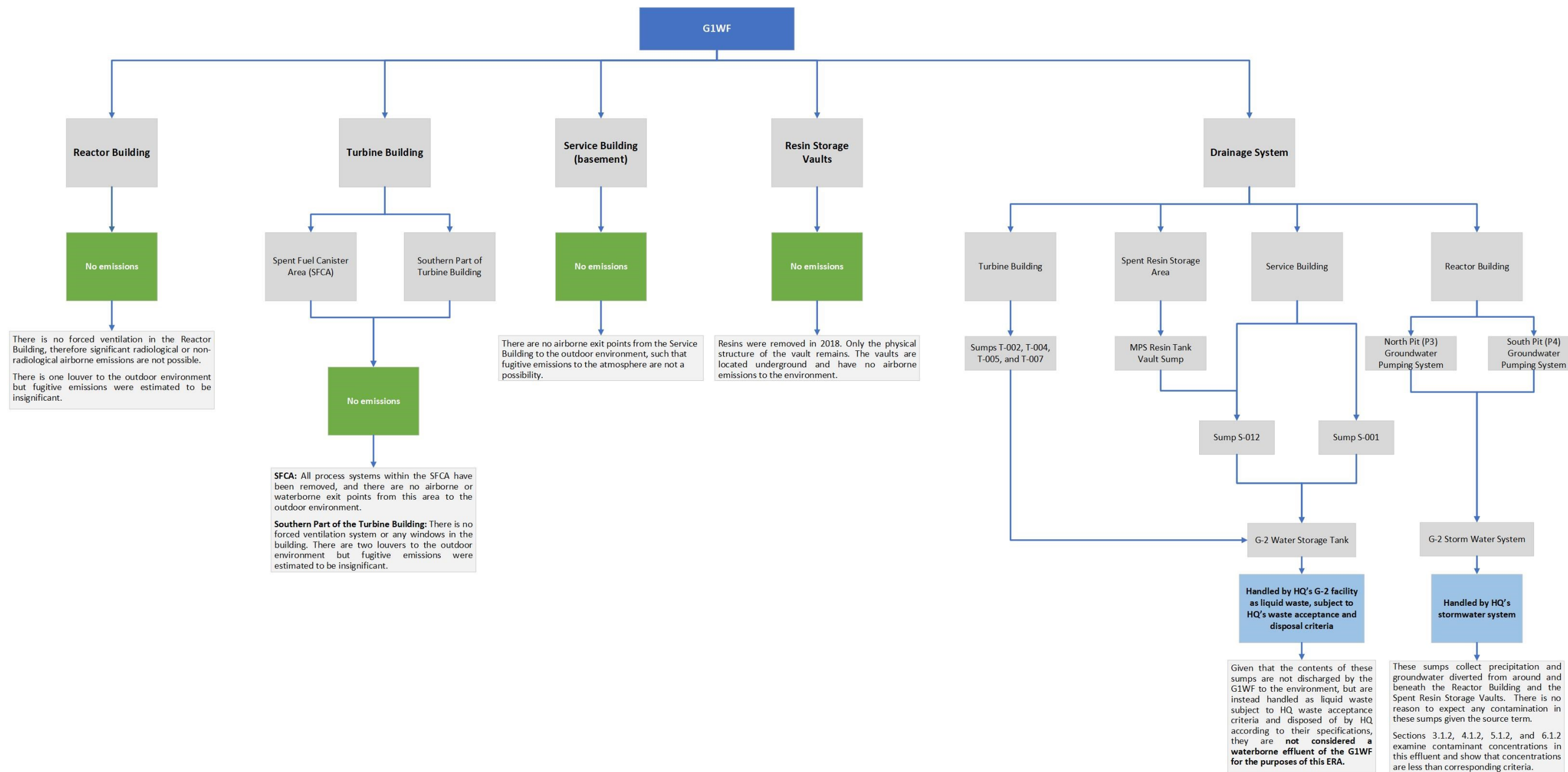


Figure 3-3 Radiological HHRA Conceptual Site Model

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

### 3.2 Exposure Assessment

Since all radiological contaminants were screened out in Section 3.1.2, there are no unacceptable risks to human health expected due to releases of radiological contaminants from the G1WF. Exposure assessment and risk calculations are not required for the G1WF.

Nevertheless, information is available from an assessment of radiological exposure to off-site human receptors performed by HQ for the G-2 site. The results are reported in HQ's annual monitoring reports, the most recent being the report for 2022 (HQ 2023). Doses to human receptors were estimated based on environmental concentrations measured near the Gentilly site. Since the off-site measured concentrations would reflect contributions from the entire Gentilly site, the exposure assessment is expected to encompass exposures from the G1WF site.

As mentioned in HQ (2023), HQ's radiological dose estimates for human receptors were carried out using the "Integrated Model for the Probabilistic Assessment of Contamination Transport" software code. The equations and parameters used in the calculations were consistent with CSA N288.1 guidance. The assessment is summarized as follows:

- Receptors: The receptors evaluated included farm residents, workers at nearby industry, residents from nearby locales and hunter-fisher receptors, assumed to be residents of the Bécancour area. The receptor locations are indicated in Figure 3-1. These receptors would also be relevant to the G1WF.
- Environmental concentrations: HQ radiological sampling was carried out at locations that would also capture any releases from the G1WF.
- Relevant radionuclides: As shown in Section 3.1.2, there are no radiological COPCs for the G1WF. Dose estimates for human receptors from the G-2 facility (as documented in HQ (2023)) were conducted based on H-3, C-14, and gross beta, which cover the radionuclides likely to be emitted into the environment from the G-2 facility. It is expected that the effects of the G1WF should be encompassed or bounded within the HQ (2023) human receptor dose results.

#### Gamma Radiation:

Figure 3-4 shows the locations of radiological control stations (SCRs) around the Gentilly site. Figure 3-5 presents external gamma exposure rates measured at SCR-1, 3, 6, 7, 8, 10, 11, and 12, along with background gamma rates measured at a reference location in Trois-Rivières. Among SCR stations, the station closest and most relevant to the G1WF site is SCR-10, which is located on the G1WF site near the reactor building. Figure 3-5 shows that ambient gamma dose rates at SCR-10 for the past 4 years have been around or below reference (background) rates. Dose rates measured at the other SCR stations provide useful context.

Figure 3-6 shows the locations of ambient gamma monitoring stations along the northern and eastern perimeter of the Gentilly site (i.e., stations labelled "PER"; orange triangles). Among the PER Stations, PER-9 and PER-10 are located on the G1WF fence line within the Gentilly site and are therefore the most relevant to the G1WF. Figure 3-7 presents ambient gamma rates at PER stations (including PER-9 and

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

PER-10), along with a blue-dotted line indicating the background level. Figure 3-7 shows that ambient gamma dose rates near the G1WF (i.e., at PER-9 and PER-10), for the past 5 years, are similar to measured background levels.

Gamma radiation is attenuated by air, such that gamma radiation levels attributable to even large sources are negligible several hundred metres from the source. Gamma dose rates at PER-9 and PER-10 (near the G1WF) are already near background levels, at farther distances these will only decrease further (until reaching background levels). Therefore, no unacceptable risks are expected to off-site human receptors from gamma radiation from G1WF.

Environmental Risk Assessment for the Gentilly-1 Waste Facility

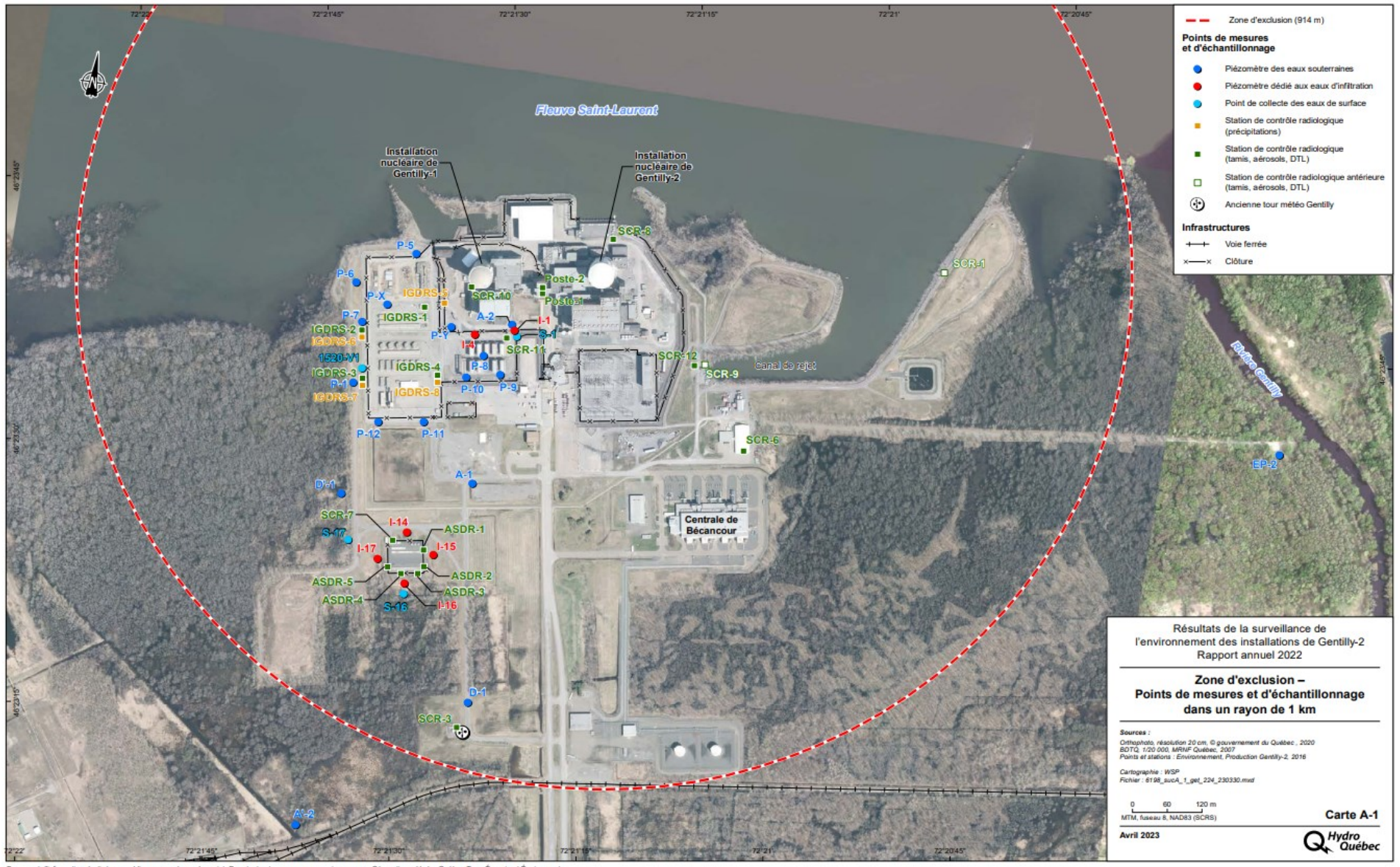


Figure 3-4 Locations of Radiological Control Stations (SCR) Around G-2 Site (HQ 2023)

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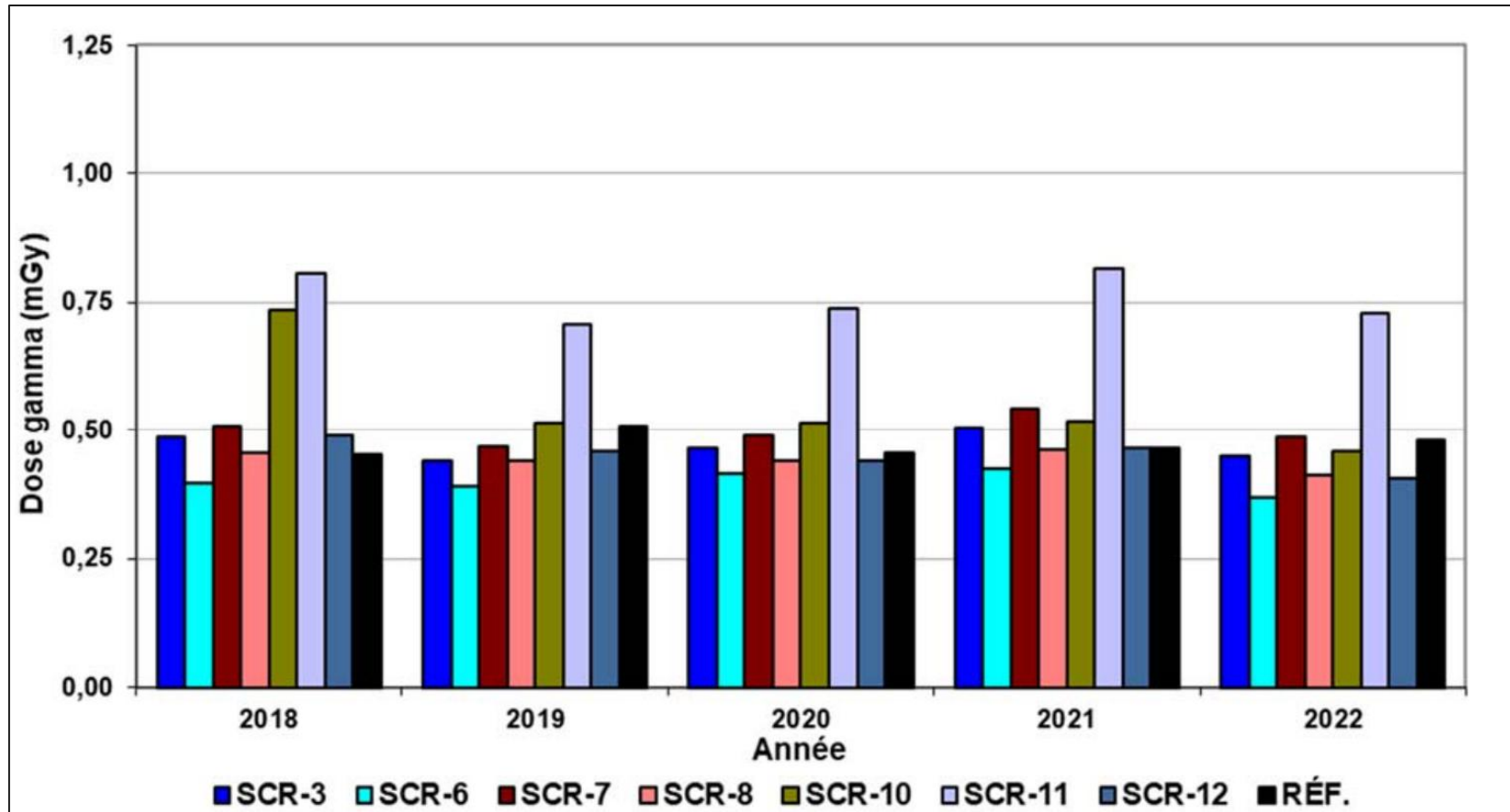
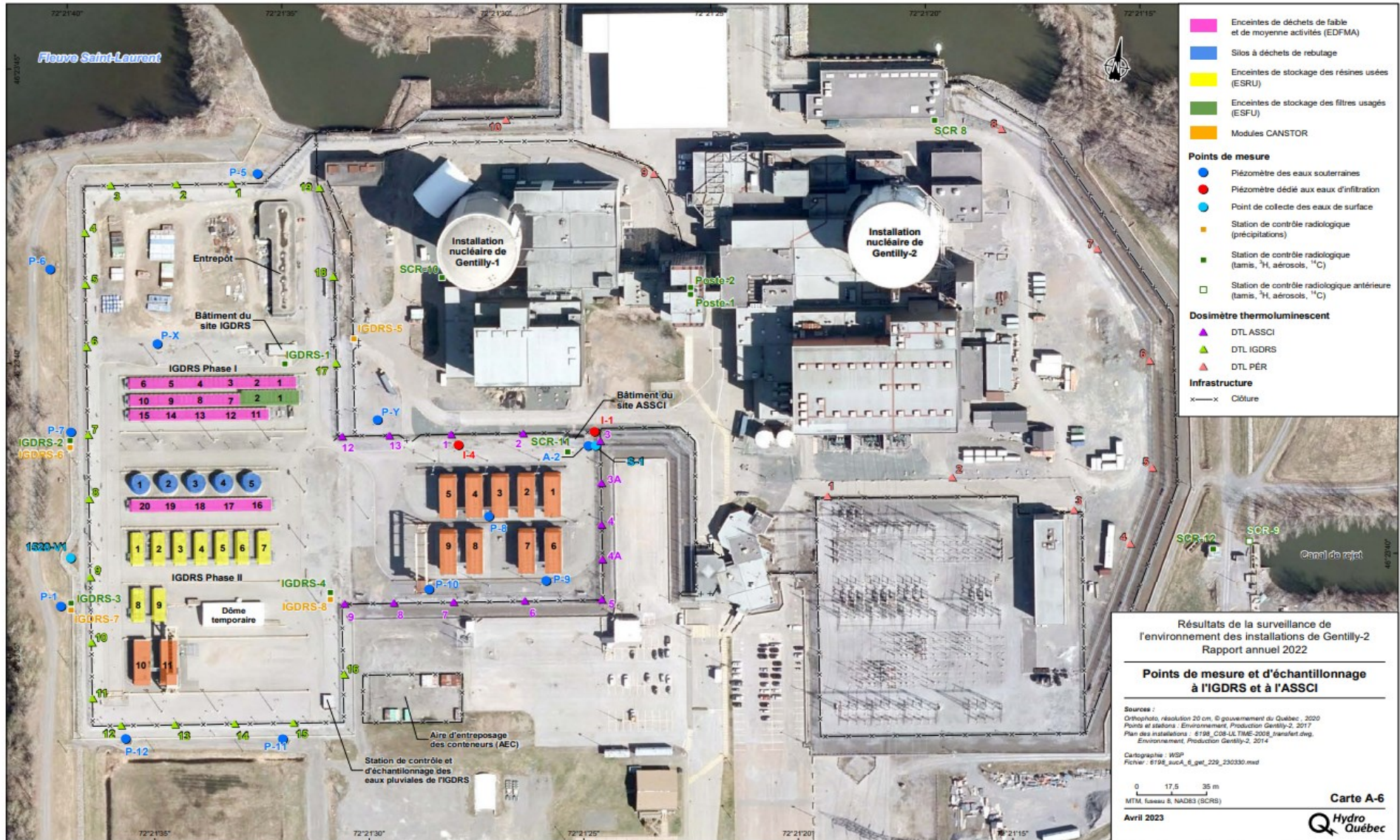


Figure 3-5 Annual Gamma Dose at Radiological Control Stations for the Period 2018-2022 (HQ 2023)

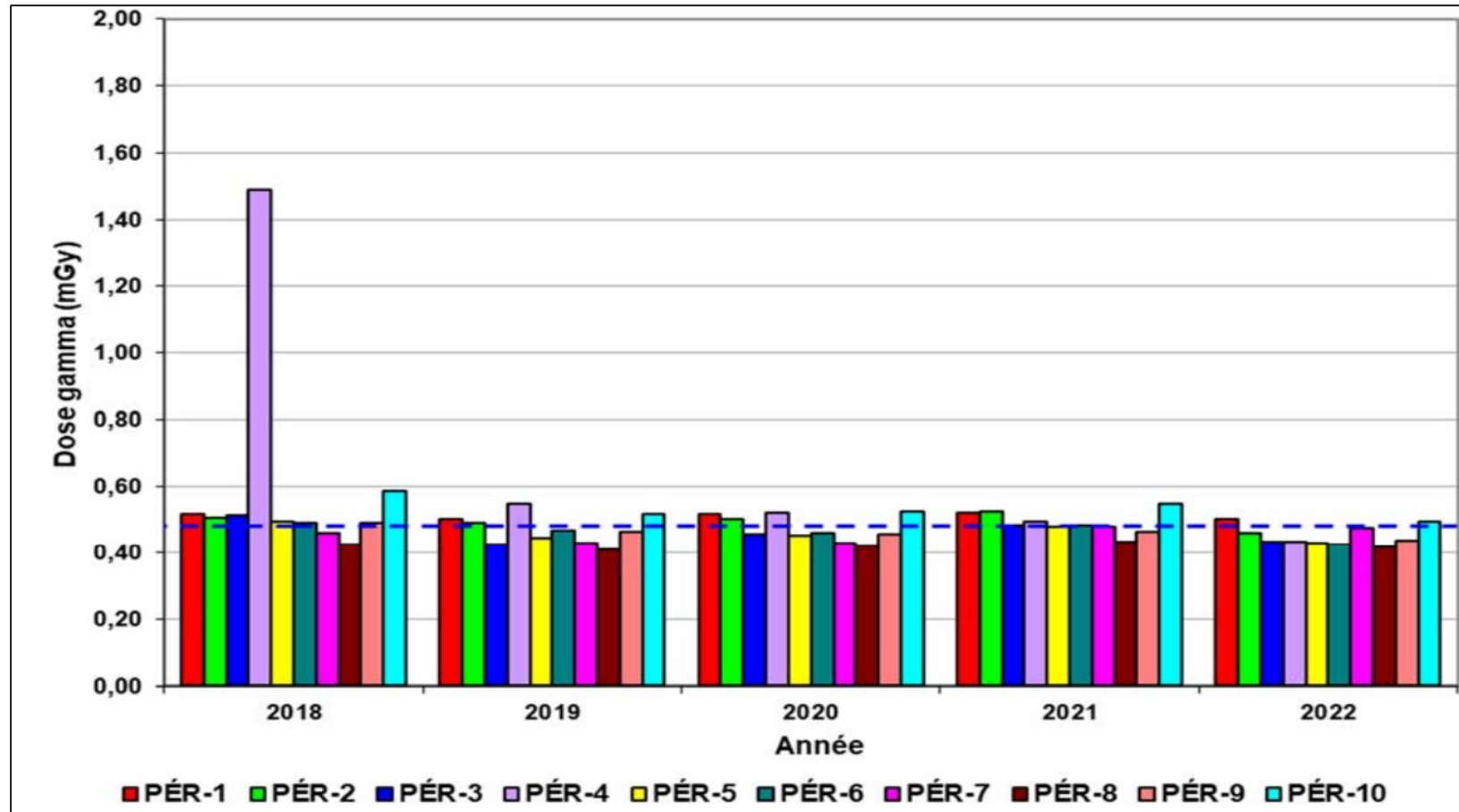
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Figure 3-6 Locations of Gamma Dose Monitoring Around G-2 Site (HQ 2023)

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Note:  
Data indicates annual gamma dose for stations most relevant to the G1WF.  
Locations of PER 1-10 are shown in Figure 3-5.

**Figure 3-7 Annual Gamma Dose at Fenceline Stations for the Period 2018-2022 (HQ 2023)**

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

### 3.3 Effects Assessment

The radiological benchmark used for the human health radiological risk assessment is based on the effective dose limits in the *Nuclear Safety and Control Act Radiation Protection Regulations* (CNSC 2000) for the member of the public, 1 mSv per year. This is consistent with CSA N288.6-22 (CSA 2022a) guidance.

### 3.4 Risk Characterization

Since all radiological contaminants were screened out in Section 3.1.2, there are no unacceptable risks to human health expected due to releases of radiological contaminants from the G1WF. Exposure assessment and risk calculations are not required for the G1WF.

In addition, radiological risk characterization performed for G-2 (as documented in HQ 2023) evaluated the exposure of several human receptors to radiological releases from the Gentilly site for the year 2022. Since the receptors and exposure pathways assessed included those relevant to the G1WF, and the concentration data measurements include the contribution of the G1WF, it is expected that the radiological dose results are bounding of any impacts from the G1WF. HQ (2023) estimated radiation doses to human receptors (i.e., members of the public residing in the area surrounding the site) to be 0.69  $\mu\text{Sv/y}$ , which is less than 0.1% of the CNSC effective dose limit for a member of the public (1 mSv/y), and less than a *de minimis* dose of 10  $\mu\text{Sv/y}$ . This dose was estimated for the most exposed receptor, which is an adult local hunter/fisher. Ingestion of aquatic animals was identified as the major exposure pathway. Similar annual dose calculations for the years 2013 to 2022 also concluded maximum doses to human receptors to be below the *de minimis* dose of 10  $\mu\text{Sv/y}$  for all receptor groups assessed (HQ 2023).

Since the HQ radiological dose calculations for human receptors (HQ 2023) are considered to be bounding of exposure to releases from the G1WF, no unacceptable radiological risk to human health is expected for members of the public resulting from the current conditions at the G1WF.

#### Gamma Radiation:

As discussed in Section 3.2, no unacceptable risks are expected to off-site human receptors from gamma radiation emitted from the Gentilly site, including the G1WF.

## Environmental Risk Assessment for the Gently-1 Waste Facility

### 3.5 Uncertainty

#### Problem Formulation

Receptor selection relies on information from recent studies performed for the G-2 site (i.e., HQ's annual compliance monitoring reports). These were prepared following HQ's quality control program and are considered to be of good quality and recent enough to capture current conditions at the site. Therefore, no significant uncertainties are identified in receptor selection.

COPC selection relies on information from CNL's current effluent monitoring program for the G1WF and from a sampling and measurement study performed in 2015 (i.e., Audet 2016). Both studies were prepared following CNL's quality control program. This supporting information is considered to be of good quality and to reflect current site conditions and operating activities. Concentration data obtained from Audet (2016) remain representative of current emissions because there have been no significant changes to SWS operations at the G1WF since the time of the study.

Some measurement values in this report are reported at the detection limit, which is also sometimes referred to as the minimum detection limit. This creates an initial uncertainty in the use of such data, i.e., the true measured value is between zero and the detection limit. To address this, the most conservative assumption is to assume that the concentration is equal to the detection limit. Where censored data are taken from supporting documents, the detection limit is noted (where possible) and the value was assumed to be equal to the detection limit. Furthermore, comparing measured effluent concentrations from Audet (2016) to drinking water quality criteria is very conservative.

#### Exposure Assessment

Since all radiological contaminants were screened out in Section 3.1.2, exposure assessment calculations were not required for the G1WF.

However, a discussion on gamma dose rates was warranted. The gamma discussion relies on measured gamma dose rates documented in HQ's current annual compliance monitoring report for the G-2 site. This study was prepared following HQ's quality control program and is considered to be of good quality and to reflect current site conditions (encompassing the G1WF). Therefore, no significant uncertainties are identified in the gamma dose rates.

#### Effects Assessment

This section presents the CNSC public dose limit; no significant uncertainties are identified.

#### Risk Characterization

Since all radiological contaminants were screened out in Section 3.1.2, dose calculations and comparison to the dose limit is not required for the G1WF. However, as an additional line of evidence, dose results from HQ's annual compliance monitoring report (HQ 2023) were presented. As mentioned above, HQ's annual compliance report was prepared following HQ's quality control program and is considered to be of good quality and to reflect current site conditions (encompassing the G1WF). No significant uncertainties are identified in this section.

## 4.0 RADIOLOGICAL ECOLOGICAL RISK ASSESSMENT

### 4.1 Problem Formulation and Conceptual Model

The objective of the radiological EcoRA is to assess radiological risk from the G1WF site to ecological receptors. The assessment is for current conditions and uses the last 5 years of data. The receptors, selection of COPCs and exposure pathways to be assessed are presented below.

#### 4.1.1 Receptors

Ecological receptors for the radiological EcoRA were selected based on information in Bukhari (2024) (included in Appendix B), CNL (2019), and Calian (2022). Bukhari (2024) considered the following factors when identifying potential receptors:

- Ecological receptors identified in HQ (2023);
- Species and habitats observed on the G1WF site, and as documented in previous environmental studies;
- Representation of all major plant and animal groups present on the Site (e.g., bird species with terrestrial and aquatic habitat, soil and benthic invertebrates, etc.);
- Receptors that reflect the interests of the facility, regulatory agencies, local First Nations and community stakeholders;
- Potential for exposure (i.e., diet, habitat preferences and behaviours that make the species likely to contact the COPCs);
- Receptors that play important roles in community structure and function (e.g., top predators and major herbivores);
- Inclusion of the various trophic levels (e.g., primary producer, herbivore, carnivore) for species that could potentially use the site;
- Receptors that have cultural or socio-economic significance;
- The availability of information on the receptor, including exposure-related and eco-toxicological data; and,
- Species of conservation status (e.g., vulnerable, threatened, or endangered species).

The resulting list of receptors is as follows:

- Terrestrial Plants (e.g., maple trees and willows);
- Soil Invertebrates (represents worms and insects, including Monarch Butterfly);
- Benthic Invertebrates (including aquatic insect larvae);
- Zooplankton;
- Waterfowl;
- Great Blue Heron (also represents other aquatic birds that feed on small fish and amphibians, such as Least Bittern);
- Pelagic fish (e.g., Largemouth Bass, Northern Pike, Perch, and smaller fish such as Channel Darter);
- Benthic fish (e.g., carp); and,
- Aquatic Plants.

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

According to Calian (2022), aquatic reptiles (e.g., Snapping turtle) and amphibians are also potentially present in the area surrounding the site. Amphibians have a sensitive life stage in water, and so are typically assessed based on contaminant concentrations in water (similar to fish). Furthermore, as discussed in the next section (Section 4.1.2), waterborne releases from the G1WF consist of precipitation and groundwater captured by exterior sumps and sent to the G-2 facility's stormwater management system. The ERA for the G-2 site (Calian 2022) identified no unacceptable risk for these receptors.

Terrestrial birds, mammals, and reptiles are not included among receptors identified Bukhari (2024). These receptors' exposure is primarily driven by soil contaminants originating from airborne releases, and the G1WF has negligible airborne releases (see Section 2.3.5 above and Section 4.1.2 below).

Species at Risk:

AECL (2009) mentions Great Blue Heron (special concern, *Species at Risk Act* (SARA)) and Wood Turtle (threatened, SARA) as being potentially present in the area surrounding the G1WF, as well as rare plant species. HQ (2023) and AECL (2009) mention Lake Sturgeon (under consideration as a SAR).

Calian (2022) also mentions that there have been 7 occurrences in which species of special status have been identified within the Gentilly site, of which only one species is endangered (i.e., a SAR), namely the eastern sand darter (*Ammocrypta pellucida*). The other 6 species are sensitive or vulnerable species: Short Eared Owl (*Asio flammeus*), Peregrine Falcon (*Falco peregrinus*), Least Bittern (*Ixobrychus exilis*), Bridle Shiner (*Notropis bifrenatus*), Stonecat (*Noturus flavus*) and the Channel Darter (*Percina copelandi*), all of which could be found within 2 km of the Gentilly site.

Hydro Québec also did a paper study (Appendix A of Calian (2022)) of the potential for SAR to be present on the Gentilly site. Thirteen (13) species were considered to be moderately or highly likely to be present on the Gentilly site. Of these, the 2 most likely species to be on the site are the channel darter (*Percina copelandi*) and the monarch butterfly (*Danaus plexippus*). Calian (2022) also indicates that the least bittern (*Ixobrychus exilis*) would find the Gentilly site a suitable habitat. The remaining 10 species listed as potentially being moderately likely to find a habitat on the Gentilly site included: little brown bat (*Myotis lucifugus*), northern bat (*Myotis septentrionalis*), tricolored bat (*Perimyotis subflavus*), barn swallow (*Hirundo rustica*), Canada warbler (*Cardellina canadensis*), common nighthawk (*Chordeiles minor*), evening grosbeak (*Coccothraustes vespertinus*), whip-poor-will (*Astrostomus vociferus*), snapping turtle (*Chelydra serpentina*), and river herring (*Moxostoma carinatum*).

Regarding plant species, Calian (2022) indicates the presence of butternut (*Juglans cinerea*) near the Gentilly site. This species is on its way of disappearing from Canada. Only one other plant SAR (American water willow (*Dianthera americana*)) was noted as having a low potential to occur near the Gentilly site. It is believed to have been observed along the Godefroy River in Bécancour (off of the Gentilly site). However, its presence has not been confirmed.

Of the 2 species at risk Calian (2022) identified as being most likely to be on the site, the monarch butterfly is represented by soil invertebrates and the Channel Darter is represented by the fish species listed earlier in this section (this applies to other fish SAR as well, like the eastern sand Darter). Great blue heron (noted by AECL (2009)) is included in the list of receptors; it also represents other aquatic birds with similar diets

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

such as the least bittern (*Ixobrychus exilis*). Wood turtle (noted by AECL (2009)) would be represented by fish because its exposure is similarly dominated by the concentrations in water in which it lives. Rare plant species (noted by AECL (2009)) are represented by terrestrial and aquatic plant receptors.

It is important to note that the G-2 ERA (Calian 2022) assessed releases from the G-2 facility (which include waterborne emissions from the G1WF) and concluded that unacceptable risk is not anticipated on ecological receptors from radiological and chemical contaminants, or physical stressors. For airborne emissions, as discussed in the next section (Section 4.1.2), the G1WF has negligible releases, and therefore no unacceptable risks are anticipated.

### Assessment and Measurement Endpoints

For the radiological EcoRA, the assessment endpoint is no unacceptable risk to receptor populations. Regarding measurement endpoints, doses to biota are calculated and compared to radiological dose benchmarks such as those recommended by CSA N288.6-22 (CSA 2022a); however, as shown in the next section (Section 4.1.2), no radiological contaminants are retained for further assessment.

### **4.1.2 Selection of COPCs**

Based on information from site documentation, including the site's effluent monitoring plan and Bukhari (2024), the following radiological COPCs are relevant to the G1WF:

For terrestrial biota:

- Tritium (H-3);
- Carbon-14; and,
- Cesium-137 (representing gross beta/gamma radionuclides).

For aquatic biota:

- Tritium (H-3);
- Carbon-14;
- Cobalt-60; and
- Cesium-137 (representing gross beta/gamma radionuclides not listed above).

As discussed in Section 2.0 and Section 3.1.2, the majority of potential emission sources at the G1WF have been decommissioned. The ventilation system has been fully shut down, and the only atmospheric emissions are fugitive emissions through the louvers in the turbine building and reactor vault which are estimated to be insignificant (CNL 2021). Liquid emissions are also limited, with the majority of sumps being pumped into totes and transported overland to the G-2 facility as waste, rather than discharging to the environment. The only system that remains active and discharges to the environment is the groundwater pumping system (North Pit (P3) and South Pit (P4)), which collects precipitation and intercepts groundwater. Given this, the assessment focuses on surface water and sediment, as these are the only receiving media that could reasonably be affected by the G1WF's current emissions.

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Table 4-1 below shows the concentrations of the above radiological contaminants measured in the groundwater pumping system (North Pit (P3) and South Pit (P4)) in 2015 (from Audet 2016) and concentrations measured in the G-2 stormwater drainage system in 2022 (from HQ 2023). Data from the CNSC's Independent Environmental Monitoring Program (IEMP) are no longer used, as requested by the CNSC.

**Table 4-1 Concentrations measured in the G1WF groundwater pumping system (North Pit (P3) and South Pit (P4)) and in the G-2 stormwater drainage system**

Location	Year	Value	Unit	Value
G-2 stormwater drainage system	2022	H-3	Bq/L	333 + 6 <i>(maximum among 2022 measurements at MCH-1 to MCH-3)</i>
		C-14	Bq/L	< 0.23 <i>(maximum among 2022 measurements at MCH-1 to MCH-3)</i>
		Co-60	Bq/kg	<0.15 <i>(maximum among 2022 measurements at MCH-1 to MCH-3)</i>
		Cs-137	Bq/kg	<0.16 <i>(maximum among 2022 measurements at MCH-1 to MCH-3)</i>
G1WF groundwater pumping system (North Pit (P3) and South Pit (P4))	2015	H-3	Bq/mL	0.51
		C-14	Bq/L	<7.37
		Co-60	Bq/L	<MDA*
		Cs-137	Bq/L	<1.36

Notes:

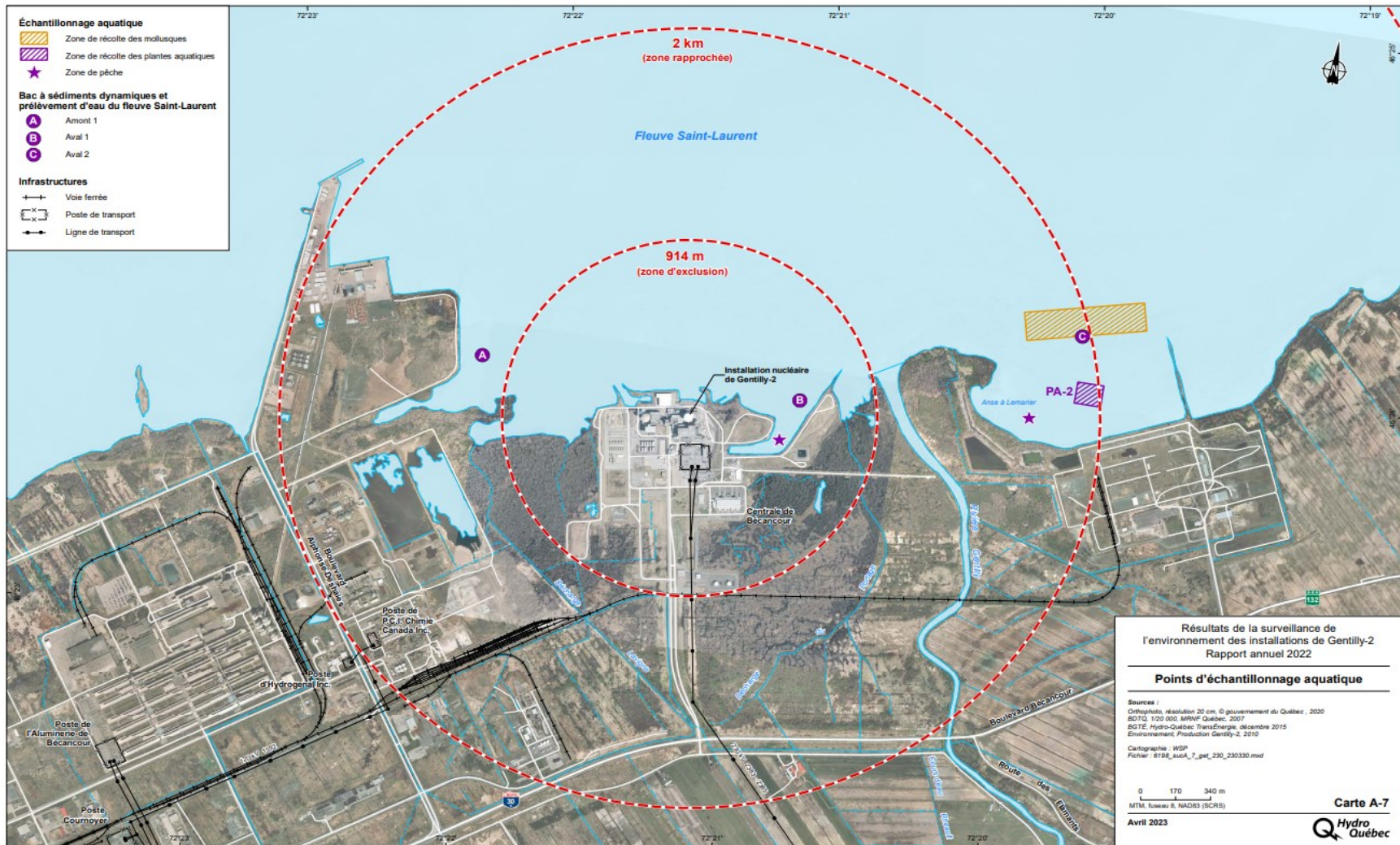
Ref: Audet (2016); HQ (2023)

\* MDA - Minimum Detectable Activity, value not specified in Audet (2016).

In addition to effluent measurements, some environmental concentration data are available at or near the G-2 facility from HQ's annual monitoring reports for 2018 to 2022 (HQ 2023, 2022, 2021, 2020, 2019). These represent the last 5 years of G-2 annual compliance data that was publicly available at the time of this report's preparation.

Table 4-2 summarizes measured concentrations of Co-60 and Cs-137 in sediment (where available) at 2 locations near the Gentilly site (illustrated in Figure 4-1). Location "B" is at mouth of the discharge channel. Location "C" is in a cove at Lemarier. Contaminant levels at these locations are expected to include contributions from the G1WF, given its location on the Gentilly site. Note that data for other radionuclides (e.g., H-3, C-14) are unavailable.

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Figure 4-1 Locations of Sediment Sampling near the G-2 Facility (Locations A, B, C) (HQ 2023)

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**Table 4-2 Measured Sediment Concentrations near the Gentilly Site (HQ 2019-2023)**

C-60				C-137			
Date	Sediment Conc. (Bq/kg dw)	Sampling Location (see Figure 4-1)	Ref	Date	Sediment Conc (Bq/kg dw)	Sampling Location (see Figure 4-1)	Ref
2022	< 0.41	B	HQ 2023	2022	5.0 (0.2)	B	HQ 2023
2022	< 0.43	C	HQ 2023	2022	4.7 (0.2)	C	HQ 2023
2021	29.6 (0.6)	B	HQ 2022	2021	9.3 (0.3)	B	HQ 2022
2021	0.99 (0.08)	C	HQ 2022	2021	7.0 (0.2)	C	HQ 2022
2020	6.6 (0.3)	B	HQ 2021	2020	7.1 (0.2)	B	HQ 2021
2020	< 0.37	C	HQ 2021	2020	3.4 (0.2)	C	HQ 2021
2019	3.3 (0.2)	B	HQ 2020	2019	10.3 (0.4)	B	HQ 2020
2019	2.7 (0.1)	C	HQ 2020	2019	5.9 (0.2)	C	HQ 2020
2018	<b>166 (2)</b>	B	HQ 2019	2018	<b>11.2 (0.5)</b>	B	HQ 2019
2018	1.50 (0.08)	C	HQ 2019	2018	4.2 (0.2)	C	HQ 2019

Notes:

**Bold** indicates maximum values.

See Figure 4-1 for sediment sampling locations “B” and “C”.

For detected results, values in parentheses indicate associated detection limits.

For non-detect results, the value is the detection limit.

For the radiological COPC screening process, maximum radionuclide concentrations are screened against available No-Effect Concentrations (NECs) for non-human biota. A NEC is a derived concentration in the environment that is expected to be protective of receptors that may be exposed to it through one or more pathways. Any concentration below the NEC can be screened out of any further assessment in the EcoRA.

The screening comparison is shown in Table 4-3 below. Note that comparing radionuclide concentrations directly in the effluent (i.e., water concentrations measured from the G1WF groundwater pumping system and the G-2 stormwater drainage system) to NECs effectively assumes that biota are present in the effluent before any dilution occurs in the environment, which is a very conservative assumption. As shown in Table 4-3, all measured concentrations are below their corresponding NECs.

It should be noted that sediment and G-2 drainage water concentrations were sampled from locations that reflect the contributions of the entire Gentilly site. They are, therefore, expected to bound the emissions of the G1WF alone.

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**Table 4-3 Screening of Measured Sediment and Surface Water Concentrations Usings NECs**

Radio-nuclides	Measured Value	Units	Reference	NEC Value	Units	Reference	Exceeds NEC?
<b>Water from G-2 Stormwater Drainage System</b>							
H-3	333 ± 6	Bq/L	See Table 4-1 above	1.26E+07	Bq/L	Chouhan <i>et al.</i> , 2009	No
C-14	< 0.23	Bq/L	See Table 4-1 above	8.45E+03	Bq/L	Chouhan <i>et al.</i> , 2009	No
<b>Water from G1WF Groundwater Pumping System</b>							
H-3	510	Bq/L	See Table 4-1 above	1.26E+07	Bq/L	Chouhan <i>et al.</i> , 2009	No
C-14	< 7.37	Bq/L	See Table 4-1 above	8.45E+03	Bq/L	Chouhan <i>et al.</i> , 2009	No
Co-60	< MDA	Bq/L	See Table 4-1 above	1.92E+03	Bq/L	Chouhan <i>et al.</i> , 2009	Likely No
Cs-137	< 1.36	Bq/L	See Table 4-1 above	9.24E+01	Bq/L	Chouhan <i>et al.</i> , 2009	No
<b>Freshwater Sediment</b>							
Co-60	166 (2)	Bq/kg dw	See Table 4-2 above	5E+04	Bq/kg	US DOE 2019	No
Cs-137	11.2 (0.5)	Bq/kg dw	See Table 4-2 above	1E+05	Bq/kg	US DOE 2019	No

**Notes:**

MDA - Minimum Detectable Activity, value not specified in Audet (2016).  
For sediment, values in parentheses indicate associated detection limits.

As a result, no radiological contaminants were retained for further analysis in the EcoRA. This applies also to ecological receptors that may be present on-site because:

- airborne emissions are negligible;
- all relevant contaminants in waterborne effluent were screened out from further analysis;
- liquid effluent (i.e., precipitation and diverted groundwater) from the groundwater pumping system (North Pit (P3) and South Pit (P4)) is discharged to the G-2 facility's storm water system; and,
- other liquid effluents are transferred to totes and transported to the G-2 facility as liquid waste.

**4.1.3 Exposure Pathways**

As discussed in Section 4.1.2, there are minimal radionuclide releases from the G1WF: airborne effluents are limited to fugitive emissions which were estimated to be insignificant, and liquid effluents are limited to captured/diverted groundwater in the groundwater pumping system (Noth Pit (P3) and South Pit (P4)).

According to Bukhari (2024), the relevant potential exposure pathways based on the ecological receptors at the site are as follows:

- Terrestrial Biota:

## Environmental Risk Assessment for the Gently-1 Waste Facility

- Internal Exposure:
  - Ingestion.
- External Exposure:
  - Air immersion; and,
  - Groundshine.
- Aquatic Biota:
  - Internal Exposure:
    - Ingestion.
  - External Exposure:
    - Water immersion; and,
    - Sediment exposure.

The potential internal exposure pathways for terrestrial and aquatic biota are typically dominated by their food intakes. CSA N288.6 (CSA 2022) mentions that, for terrestrial organisms, the dose from air immersion (aside from noble gases) is usually minor relative to soil and food ingestion exposures and can be ignored in most EcoRAs. Similarly, CSA N288.6 (CSA 2022) mentions that, for ecological receptors, inhalation exposures are usually minor relative to soil and food ingestion exposures and can be ignored in most EcoRAs.

Since all radiological contaminants were screened out, there are no unacceptable risks to ecological receptors expected from releases of radiological contaminants from the G1WF. Further assessment is not warranted.

#### Groundwater

Since the G1WF does not contain any naturalized areas, and any captured/diverted groundwater would be within the underground drainage and groundwater pumping systems, groundwater on the G1WF site is not considered to be accessible to non-human biota.

#### Gamma Radiation:

Gamma radiation exposure is a relevant pathway for non-human biota. See Section 4.2 below for further discussion.

### **4.1.4 Radiological EcoRA – Conceptual Site Model**

As discussed in Section 4.1.2, the facility has negligible airborne releases and waterborne releases are of precipitation and groundwater diverted away from the Reactor Building by the groundwater pumping system (North Pit (P3) and South Pit (P4)). No significant contamination is expected in this water, and, it discharges into the G-2 facility's stormwater management system. Effluent sampling performed in 2015 confirmed that radionuclide levels were less than corresponding criteria. Therefore, no radiological contaminants were retained for further analysis in the EcoRA. However, for completeness, Figure 3-2 (presented earlier in Section 3.1.4) provides a conceptual site model for the site.

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## 4.2 Exposure Assessment

Since all radiological contaminants were “screened out”, there are no unacceptable risks to non-human biota expected from releases of radiological contaminants from the G1WF. Exposure assessment is not required for the radiological contaminants.

Also, as stated in the Effluent Monitoring Plan (CNL 2021):

*“Since there are no significant airborne or liquid releases to the environment during normal operations, there are almost no effluent pathways for radiological or non-radiological contamination that would result in a radiation dose or exposure dose to non-human biota.”*

### Gamma Radiation:

Section 3.2 presents information on gamma dose rates measured near the G1WF. Figure 3-5 presents external gamma exposure rates measured at SCR stations, whereas Figure 3-7 presents external gamma exposure rates measured at PER stations. Figure 3-5 shows that ambient gamma dose rates at SCR-10 (the closest SCR station to the G1WF), for the past 4 years, are similar to measured background dose rates. Similarly, Figure 3-7 shows that ambient gamma rates at PER-9 and PER-10 (the closest per stations to the G1WF), for the past 5 years, are similar to measured background dose rates.

Gamma radiation is attenuated by air, such that gamma radiation levels attributable to even large sources are negligible several hundred metres from the source. Gamma dose rates at PER-9 and PER-10 (near the G1WF) are already near background levels, at farther distances these will only decrease further (until reaching background levels). Therefore, no unacceptable risks are expected to non-human receptors from gamma radiation.

As such, there are no unacceptable risks expected to on-site or off-site non-human biota from external gamma radiation from the G1WF.

## 4.3 Effects Assessment

Since all radiological contaminants were “screened out”, there are no unacceptable risks to non-human biota expected from releases of radiological contaminants and external gamma from the G1WF. Therefore, an effects assessment is not required for the radiological contaminants.

## 4.4 Risk Characterization

Since all radiological contaminants were “screened out”, there are no unacceptable risks to non-human biota expected from releases of radiological contaminants and external gamma from the G1WF. Risk characterization is therefore not required for the radiological contaminants.

Furthermore, the G-2 ERA (Calian 2022) assessed radiological releases from the G-2 facility which include waterborne emissions from the G1WF directed into the G-2 facility's stormwater management system. Calian (2022) concluded that no unacceptable risks were anticipated on ecological receptors.

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

## 4.5 Uncertainty

### Problem Formulation

Receptor selection relies on information from several recent studies performed for the G1WF and G-2 sites, including the G1WF *Safety Analysis Report* (CNL 2019a) and HQ's ERA for the G-2 site (Calian 2022) (which encompasses the G1WF). These were prepared following CNL and HQ's quality control programs and are considered to be of good quality and recent enough to capture current conditions at the site. Therefore, no significant uncertainties are identified in receptor selection.

COPC selection relies on information from CNL's current effluent monitoring program for the G1WF (i.e., CNL 2021), from a sampling and measurement study performed in 2015 (i.e., Audet 2016), and from HQ's recent annual compliance reports (HQ 2022; HQ 2023). Both CNL reports were prepared following CNL's quality control program. This supporting information is considered to be of good quality and to reflect current site conditions and operating activities. Concentration data obtained from Audet (2016) remain representative of current emissions because there have been no significant changes to SWS operations at the G1WF since the time of the study.

The radiological EcoRA does make use of some effluent and environmental data that are reported as less than a detection limit. This uncertainty, and how it is addressed, is applicable to the radiological and non-radiological HHRA and EcoRA. See Section 3.5 for discussion.

### Exposure Assessment

Since all radiological contaminants were screened out in Section 4.1.2, dose calculations were not required for the G1WF.

However, a discussion on gamma dose rates was warranted. The gamma discussion relies on measured gamma dose rates documented in HQ's current annual compliance monitoring report (HQ 2023) for the G-2 site. This report was prepared following HQ's quality control program and is considered to be of good quality and to reflect current site conditions (encompassing the G1WF). Therefore, no significant uncertainties are identified in the gamma dose rates.

### Effects Assessment

Since all radiological contaminants were screened out in Section 4.1.2, an effects assessment was not required for the G1WF. No significant uncertainties are identified.

### Risk Characterization

Since all radiological contaminants were screened out in Section 4.1.2, dose calculations and comparison to dose benchmarks is not required for the G1WF. No significant uncertainties are identified in this section.

## 5.0 HUMAN HEALTH RISK ASSESSMENT FOR CHEMICALS AND PHYSICAL STRESSORS

### 5.1 Problem Formulation and Conceptual Model

The objective of the non-radiological HHRA is to assess risk from exposure to chemicals and physical stressors released from the G1WF site to human receptors. The assessment is for current conditions.

The receptors, selection of COPCs and exposure pathways to be assessed are presented below.

#### 5.1.1 Receptors

The human receptors chosen for the non-radiological HHRA are the same as those chosen for the radiological HHRA. They are described in Section 3.1.1.

#### 5.1.2 Selection of COPCs

Bukhari (2024) mentions that the following hazardous substances have been identified in the equipment and building materials of the G1WF:

- asbestos (in insulation on piping, and on mechanical insulation);
- lead (in lead-based paint on the structures, lead wool used to seal wall openings, lead-containing batteries);
- mercury (in fluorescent and high intensity lights);
- PCBs (in fluorescent light ballasts); and,
- Silica (in poured concrete floors and concrete block walls).

Bukhari (2024) notes select chemicals whose concentrations in the St. Lawrence River are of consideration, based on studies by Cornwell *et al.* (2015) and Marc-Antonie Vaudreuil *et al.* (2024). Lead and PCBs are among these chemicals.

Bukhari (2024) also mentions that groundwater chemical analysis conducted in the area showed the presence of a suite of heavy metals (e.g., iron, zinc, copper, lead, and cadmium), total phosphorus, ammonia, nitrogen, nitrites, nitrates, sulphates, bicarbonates, chlorides, and fecal coliforms, based on studies by Environment and Climate Change Canada (ECCC) *et al.* (2019), Yang *et al.* (1996), and Richman and Dreier (2001).

Based on the information above, Bukhari (2024) identified lead, mercury, and PCBs as the main hazardous substances for screening in the G1WF HHRA.

CNL (2019) additionally identified a small amount of refrigerant (R22), a dehumidifier containing halocarbons, and lead shielding materials within the Reactor Building.

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As described in Section 3.1.2, the facility has very limited releases to the environment. To summarize:

- Airborne emissions are limited to only passive fugitive air exchanges via louvres. Such releases are negligible. Based on this, and an understanding of their waste forms, silica and asbestos – which are hazardous when airborne – do not warrant further assessment.
- Waterborne emissions are limited to those from the groundwater pumping system (North Pit (P3) and South Pit (P4)), which collects and diverts groundwater away from the Reactor Building. Thus, no significant contamination is expected in this effluent. This system discharges into the G-2 facility’s stormwater system.

As there is limited environmental monitoring for non-radiological contaminants at the G1WF and/or G-2 site, screening of COPCs is carried out using:

- effluent samples collected in 2015 from the groundwater pumping system (North Pit (P3) and South Pit (P4)) (Audet, 2016); and,
- water samples taken from the G-2 stormwater system in 2022 (HQ 2023).

Table 5-1 compares concentrations of non-radiological COPCs measured in the G1WF groundwater pumping system (from Audet 2016) and in the G-2 stormwater drainage system (from HQ 2023) against HC CDWQ Guidelines (from HC 2024). Measured concentrations of non-radiological COPCs are below the corresponding HC (2024) CDWQ guidelines. Therefore, all individual COPCs are screened out. It is noted that despite the use of HC (2024) CDWQ guidelines for screening, the public does not have access to the G1WF site and would not be drinking water from this system. It should also be noted that concentrations of COPCs attributable to waterborne effluent from the G1WF are expected to be even lower in the receiving environment.

As there are no guidelines for PCBs in HC (2024), the Ontario Drinking Water Quality Standards (ODWQS) (O. Reg. 169/03) is used for the screening concentration, which is 3 µg/L.

**Table 5-1 Non-Radiological Effluent Concentrations and CDWQ and ODWQS Guidelines**

COPCs	Reference	Unit	G1WF: North Pit (P3) and South Pit P4)	G-2: Stormwater Drainage System (average)	HC CDWQ (HC 2024)/ ODWQS (O. Reg. 169/03)	Exceeds CDWQ/ODWS
Pb	Audet (2016)	mg/L	<0.004	-	0.005/0.010	No
Pb	HQ (2023)	mg/L	-	0.00057	0.005/0.010	No
Pb	HQ (2023)	mg/L	-	0.00050	0.005/0.010	No
Pb	HQ (2023)	mg/L	-	0.00057	0.005/0.010	No
Hg	Audet (2016)	ng/L	<5	-	1000/1000	No
PCBs	Audet (2016)	µg/L	0.1	-	-* / 3**	No

Notes

\* HC (2024) does not provide a reference value for PCBs. According to HC (2024), the PCB guideline was withdrawn in 1978.

\*\* Ontario Drinking Water Quality Standard (O. Reg. 169/03)

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

Given the negligible releases to the environment from the G1WF, and the low (non-detectable) concentrations for the identified potential COPCs in the waterborne effluent, no chemical contaminants are retained for further assessment and no unacceptable risk is anticipated to human receptors from releases from the G1WF.

Noise is the only physical stressor that will be considered in the HHRA.

### 5.1.3 Exposure Pathways

Bukhari (2024) presents a list of potential exposure pathways for the selected human receptors. Potential exposure pathways are presented below; however, since all chemical contaminants were screened out in Section 5.1.2, no unacceptable risks to human health are expected from the G1WF. Exposure assessment and risk calculations are not required for the G1WF.

Nevertheless, for completeness, the potential pathways for human receptors are listed below:

- Inhalation;
- Consumption of drinking water;
- Consumption of contaminated food (e.g., fish, plants, and animals);
- Incidental ingestion of water;
- Incidental ingestion of soil;
- Incidental ingestion of sediment; and,
- Dermal uptake from contact with water.

#### Groundwater

As discussed in Section 3.1.3, on-site groundwater is not used and is not accessible to public receptors.

#### Physical Stressors - Noise

With respect to physical stressors, exposure to facility noise could be considered a potential pathway for the HHRA. Noise as a physical stressor is discussed further in Section 5.4.2.

### 5.1.4 Non-Radiological HHRA – Conceptual Site Model

As discussed in Section 5.1.2, the facility has negligible airborne releases and waterborne releases are of precipitation and groundwater diverted away from the Reactor Building by the groundwater pumping system (North Pit (P3) and South Pit (P4)). No significant contamination is expected in this water, and, it discharges into the G-2 facility's stormwater management system. Effluent sampling performed in 2015 confirmed that concentrations of contaminants relevant to the G1WF were less than corresponding criteria. Therefore, no non-radiological contaminants were retained for further analysis in the HHRA. However, for completeness, Figure 3-2 (presented earlier in Section 3.1.4) provides a conceptual site model for the site.

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

### 5.2 Exposure Assessment

Since all contaminants were “screened out”, there are no unacceptable risks to human health expected due to releases of chemical contaminants from the G1WF. Exposure assessment is therefore not required for the chemical contaminants.

### 5.3 Toxicity Assessment

Since all contaminants were “screened out”, there are no unacceptable risks to human health expected from releases of chemical contaminants from the G1WF. Toxicity assessment is therefore not required for the chemical contaminants.

### 5.4 Risk Characterization

#### 5.4.1 Chemical

Since the screening was conducted based on measured concentrations in the waterborne effluent from G1WF, and concentrations of lead, mercury, and PCBs (potential COPCs identified based on the hazardous substances present at the G1WF) were screened out, no unacceptable risk to human receptors is expected from the exposure to chemicals from the G1WF site under current conditions. Based on the nature and scale of the releases from the G1WF, a quantitative HHRA is not required to further estimate effects. This approach is consistent with REGDOC 2.9.1 (CNSC 2020).

#### 5.4.2 Physical Stressors - Noise

Noise is the only physical stressor identified for consideration for human receptors. The noise levels at the G1WF are comparable to the surrounding area designated as an industrial area. The routine and non-routine activities at the G1WF are not occurring outside of normal work hours in the area.

No data are available on noise levels from the G1WF. However, based on the facility’s current activities (as described in Section 2.0), it can be assumed that there is no expected impact on human receptors. CNL also considers potential noise emissions during its decommissioning planning processes and develops work programs accordingly. If work planning identifies activities with the potential to have significant noise emissions, CNL would consider appropriate prevention and mitigation measures.

### 5.5 Uncertainty

#### *Problem Formulation*

Receptors selection for the non-radiological HHRA is the same as for the radiological HHRA. Uncertainties are discussed in Section 3.5.

COPC selection relies on information from CNL’s supporting memo (Bukhari 2024), the *Safety Analysis Report* for the G1WF (CNL 2019a), and a sampling and measurement study performed in 2015 (Audet

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

2016). These documents were prepared following CNL's quality control program. This supporting information is considered to be of good quality.

Some minor uncertainty exists due to the limited number of measurements in groundwater from the groundwater pumping system: all available data are from a single measurement campaign performed in 2015. However, it is important to note that there have been no significant changes to facility operations or releases since that time. Also, any activities undertaken since then would be decommissioning activities resulting in a net *reduction* of hazardous materials on site. Given this, there is little reason to believe that concentrations in releases would have notably increased in the past 9 years. Nevertheless, this may introduce minor uncertainty. But, comparing measured effluent concentrations from Audet (2016) to surface water quality criteria is considered conservative because it does not account for dilution.

The non-radiological HHRA does make use of some effluent and environmental data that are reported as less than a detection limit. This uncertainty, and how it is addressed, is applicable to the radiological and non-radiological HHRA and EcoRA. See Section 3.5 for discussion.

### Exposure Assessment

Since all contaminants were screened out in Section 5.1.2, exposure assessment calculations were not required for the G1WF. No significant uncertainties are identified.

### Toxicity Assessment

Since all contaminants were screened out in Section 5.1.2, no toxicity assessment was required for the G1WF. No significant uncertainties are identified.

### Risk Characterization

Since all contaminants were screened out in Section 5.1.2, risk calculations are not required for the G1WF.

## 6.0 ECOLOGICAL RISK ASSESSMENT FOR CHEMICALS AND PHYSICAL STRESSORS

### 6.1 Problem Formulation and Conceptual Model

The objective of the non-radiological ecological risk assessment (EcoRA) is to assess risk from exposure to chemicals and physical stressors released from the G1WF site to ecological receptors. The assessment is for current conditions under normal operating conditions.

The receptors, selection of COPCs and exposure pathways to be assessed are presented below.

#### 6.1.1 Receptors

The terrestrial and aquatic receptors identified for the G1WF non-radiological EcoRA are the same as those selected for the radiological EcoRA. The list of receptors and rationale for their selection is outlined in Section 4.1.1.

#### Assessment and Measurement Endpoints

For the non-radiological EcoRA, the assessment endpoint is generally no unacceptable risk to receptor populations. However, SAR are assessed at the individual level rather than the population level. Receptors are assessed by calculating their exposure and comparing it to toxicity benchmarks from literature, consistent with CSA N288.6-22 guidance (CSA 2022a). For SAR, this involves the use of more protective toxicological benchmarks than those used to assess non-SAR receptors at the population level. However, as shown in the next section (Section 6.1.2), no chemical contaminants are retained for further assessment.

#### 6.1.2 Selection of COPCs

COPC identification and screening is presented in Section 5.1.2. To summarize: lead, mercury and PCBs have been identified as potential chemical COPCs based on the hazardous substances identified in facility structures and interior equipment. However, the G1WF has very limited releases: airborne releases are negligible, and waterborne releases are limited to groundwater diverted from around the Reactor Building (contamination of this groundwater is expected to be very low).

Waterborne effluent was sampled and analyzed in 2015. As shown in Section 5.1.2, concentrations of lead, mercury and PCBs were all found to be below detection limits and less than corresponding criteria.

Since concentrations of chemical contaminants are expected to be even lower in the receiving environment than in G1WF's effluent, and given the negligible releases from G1WF, no chemical contaminants are retained for further assessment. As such, no unacceptable risks to ecological receptors are expected from the releases of G1WF. This applies also to ecological receptors that may be present on-site.

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

### 6.1.3 Exposure Pathways

As outlined in Section 6.1.2, no chemical contaminants are retained as COPCs for further assessment. As such, no unacceptable risks to ecological receptors are expected from the releases of G1WF.

Nevertheless, for completeness, Bukhari (2024) identifies the following potential exposure pathways based on the ecological receptors at the site and types of release above. It is noted that this assessment assumes that airborne releases from G1WF are negligible.

However, for completeness, exposure pathways for mammals and birds are typically as follows:

- Inhalation of soil dust (typically assumed to be negligible);
- Ingestion of soil;
- Dermal contact with soil (typically assumed to be negligible);
- Ingestion of terrestrial plants;
- Ingestion of soil invertebrates;
- Ingestion of prey;
- Ingestion of water;
- Dermal contact with water (typically assumed to be negligible);
- Ingestion of fish;
- Ingestion of sediment;
- Dermal contact with sediment (typically assumed to be negligible);
- Ingestion of aquatic plants; and,
- Ingestion of benthic invertebrates.

Exposure pathways for terrestrial plants and soil invertebrates are:

- Direct contact with soil; and,
- Direct contact with groundwater (not applicable to the G1WF, see below).

Exposure pathways for aquatic receptors are:

- Direct contact with surface water; and,
- Direct contact with sediment.

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### Groundwater

As discussed in Section 4.1.3, on-site groundwater captured/diverted by the drainage and pumping systems is not accessible to non-human biota. It is within these underground systems and the G1WF has no naturalized area.

### Physical Stressors

Ecological receptors at the G1WF site could be exposed to physical stressors such as:

- noise;
- bird strikes, and,
- vehicle-wildlife collisions.

These physical stressors are discussed further in Section 6.4.2.

Physical effects of cooling water discharges, thermal effects of waterborne discharges, and fish impingement and entrainment are not applicable because the G1WF has no water intake and no waterborne process effluent (as mentioned in Section 2.3, waterborne releases are of intercepted groundwater which discharges to the G-2 facility's stormwater management system).

Physical effects associated with habitat alteration are not applicable because, as mentioned in Section 2.4.4, there is no natural area within the G1WF site.

### **6.1.4 Non-Radiological EcoRA – Conceptual Site Model**

As discussed in Section 6.1.2, the facility has negligible airborne releases and waterborne releases are of precipitation and groundwater diverted away from the Reactor Building by the groundwater pumping system (North Pit (P3) and South Pit (P4)). No significant contamination is expected in this water, and, it discharges into the G-2 facility's stormwater management system. Effluent sampling performed in 2015 confirmed that concentrations of contaminants relevant to the G1WF were less than corresponding criteria. Therefore, no non-radiological contaminants were retained for further analysis in the EcoRA. However, for completeness, Figure 3-2 (presented earlier in Section 3.1.4) provides a conceptual site model for the site.

## **6.2 Exposure Assessment**

Since all contaminants were "screened out", there are no expected unacceptable risks to ecological receptors due to releases of chemical contaminants from the G1WF. Exposure assessment is not required for chemical contaminants.

## **6.3 Toxicity Assessment**

Since all contaminants were "screened out", there are no expected unacceptable risks to ecological receptors due to releases of chemical contaminants from the G1WF. Toxicity assessment is not required for chemical contaminants.

## Environmental Risk Assessment for the Gently-1 Waste Facility

## 6.4 Risk Characterization

### 6.4.1 Chemical

Taking into consideration the G1WF's very small releases to the environment, and the low (non-detect) concentrations of lead, mercury and PCBs (potential COPCs identified based on the hazardous substances present at the G1WF) measured in the only G1WF waterborne effluent (groundwater pumping system (North Pit (P3) and South Pit (P4))), no unacceptable risks are expected to ecological receptors under current conditions. Based on the nature and scale of the releases from G1WF, a quantitative EcoRA is not required to further quantify risk. This approach is consistent with CNSC REGDOC 2.9.1 (CNSC 2020).

Furthermore, the G-2 ERA (Calian 2022) assessed non-radiological releases from the G-2 facility which include waterborne emissions from the G1WF directed into the G-2 facility's stormwater management system. Calian (2022) concluded that no unacceptable risks were anticipated on ecological receptors.

### 6.4.2 Physical Stressors

#### Noise

The noise levels at the G1WF are comparable to the surrounding area designated as an industrial area. The routine and non-routine activities at the G1WF are not occurring outside of normal work hours in the area.

#### Bird Strikes

Bird strike collisions are monitored and reported as part of the Environmental Protection Program, and there have been no reported bird collisions or mortality at the G1WF; the lack of windows at the facility is a limiting factor. Ongoing mitigation measures and reporting will continue as part of the CNL Environmental Protection Program as the project continues.

#### Vehicle-Wildlife Collisions

The potential for vehicle-wildlife interactions are negligible due to driving or heavy machinery activities being isolated to the G1WF footprint, and employee travel to the work area is conducted on Hydro-Québec property.

## 6.5 Uncertainty

#### Problem Formulation

Receptors selection for the non-radiological EcoRA is the same as for the radiological EcoRA. Uncertainties associated with the radiological EcoRA are discussed in Section 4.5.

COPC selection relies on information from CNL's supporting memo (Bukhari 2024), the *Safety Analysis Report* for the G1WF (CNL 2019a), and a sampling and measurement study performed in 2015 (Audet 2016). These documents were prepared following CNL's quality control program. This supporting information is considered to be of good quality.

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

Like the non-radiological HHRA, the non-radiological EcoRA also has some minor uncertainty due to the limited number of measurements in water from the groundwater pumping system. See Section 5.5 for further discussion of this uncertainty.

The non-radiological EcoRA does make use of some effluent and environmental data that are reported as less than a detection limit. This uncertainty, and how it is addressed, is applicable to the radiological and non-radiological HHRA and EcoRA. See Section 3.5 for discussion.

### Exposure Assessment

Since all contaminants were screened out in Section 6.1.2, exposure assessment calculations were not required for the G1WF. No significant uncertainties are identified.

### Toxicity Assessment

Since all contaminants were screened out in Section 6.1.2, no toxicity assessment was required for the G1WF. No significant uncertainties are identified.

### Risk Characterization

Since all contaminants were screened out in Section 6.1.2, risk calculations are not required for the G1WF. No unacceptable risks are expected to ecological receptors under current conditions.

Based on the discussion in Section 6.4.2, there is no need to collect confirmatory measurement data for the physical stressors.

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

### 7.1 Conclusions

Table 7-1 summarizes the conclusions of this report.

**Table 7-1 Summary of Conclusions**

Radiological HHRA:	Radiological EcoRA:
No unacceptable radiological risk is expected to human health of members of the public resulting from current conditions at the G1WF.	No unacceptable radiological risk is expected to non-human biota resulting from current conditions at the G1WF.
Chemical (Non-Radiological) HHRA:	Chemical (Non-Radiological) EcoRA:
No unacceptable risk is expected to human health of public receptors from exposure to chemical contaminants, or physical stressors (i.e., noise), related to current operations and conditions at the G1WF.	No unacceptable risk is expected to ecological receptors from exposure to chemical contaminants, or physical stressors, related to current operations and conditions at the G1WF.

Under current conditions, based on the data available for the G1WF and surrounding area, no unacceptable risk is expected to human or non-human biota, from exposure to radiological or non-radiological contaminants, or physical stressors.

### 7.2 Cumulative Effects

CNSC's REGDOC 2.9.1 (CNSC 2020) describes cumulative effects as those that are "likely to result from the designated project in combination with other physical activities that have been or will be carried out." For this ERA, a cumulative effects assessment would involve exposing the receptors not only to emissions from G1WF, but also to emissions from other nearby sources, namely the entire Gentilly site (i.e., also including G-2) that could be occurring at the same time.

The radiological HHRA and EcoRA assessments in this ERA were based on environmental concentrations measured at off-site locations. These measurements are assumed to include the effects from the entire Gentilly site (i.e., including the contributions of both G1WF and G-2). The radiological assessments are also based on receptors, COPCs and exposure pathways that are relevant to the Gentilly site as a whole. This is considered reflective of cumulative effects.

The non-radiological HHRA and EcoRA calculations above focus on the COPCs and exposure associated with G1WF rather than the entire Gentilly site, as there are very limited environmental monitoring data for non-radiological contaminants at the Gentilly site. The screening of COPCs was based on results from the G1WF effluent monitoring data as presented in Audet (2016) and the data do not reflect any contributions from G2NGS.

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

Based on the available information, no mitigation measures are recommended at this time.

### **7.3 Risk-Based Recommendations**

The above HHRA and EcoRA did not identify any specific recommendations for follow-up activities.

However, it is noted that there are no measurement data on physical stressors at the G1WF. Although this is considered to be a minor uncertainty (see Sections 5.5 and 6.5), confirmatory measurement data would reduce this uncertainty and increase confidence in the assessment.

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

### 8.0 REFERENCES

- Atomic Energy Canada Limited (AECL). 2009. *Environmental Assessment: La Prade Mock-Up and Training Facility*. Gentilly-2 Life Extension Project. 66RF-509200-ENA-002, Revision 1, 2009 December.
- Audet, M. 2016. *Results of Sampling Effluent Streams from CNL's Prototype Reactor Decommissioning Sites*. Memo to M. Vickard, CNL File # 3640-509000-021-000, March.
- Calian. 2022. *Evaluation des risques environnementaux des installations de Gentilly-2*. Rapport Calian HYDROQ-0013-01-12, Version 2.0.
- Canadian Council of Ministers of the Environment (CCME). 2023. *Canadian Environmental Quality Guidelines - Summary Table*. Accessed from <https://ccme.ca/en/summary-table> in March 2024.
- Canadian Council of Ministers of the Environment (CCME). 2018. *Canadian Environmental Quality Guidelines*. Accessed from: <https://ccme.ca/en/current-activities/canadian-environmental-quality-guidelines> on 05 December 2023.
- Canadian Environmental Assessment Agency (CEAA). 2012. *The Canadian Environmental Assessment Act (CEAA) and its Regulations*. Accessed from: <http://laws-lois.justice.gc.ca/eng/acts/C-15.21/>.
- Canadian Nuclear Laboratories (CNL). 2024. *Gentilly-1 Waste Facility Detailed Decommissioning Plan Volume 1 - Program Overview*. CNL No. 61-508310-DDP-001817. Rev 1. May.
- Canadian Nuclear Laboratories (CNL). 2023. *Gentilly-1 Waste Facility Detailed Decommissioning Plan Volume 1 - Program Overview*. REV 0 61-508310-DDP-00181. Rev 0. March.
- Canadian Nuclear Laboratories (CNL). 2021. *Gentilly-1 Waste Facility Effluent Monitoring Plan Gentilly-1/Gentilly-1 Decommissioning*. 61-509200-PLA-001. Rev 1. October.
- Canadian Nuclear Laboratories (CNL). 2020. *Bounding Accident Analysis for the Phase 3 Decommissioning of the Gentilly-1 Waste Facility*. 61-01320-ASD-001. Rev 0. February.
- Canadian Nuclear Laboratories (CNL). 2019a. *Safety Analysis Report for the Gentilly-1 Waste Facility Gentilly-1/Gentilly-1 Decommissioning*. 61-03610-SAR-001. Rev 2. July.
- Canadian Nuclear Laboratories (CNL). 2019b. *Waste Facility Decommissioning Licence, Gentilly-1 Waste Facility*. 61-508760-130-000-0005. Rev 0. February.
- Canadian Nuclear Laboratories (CNL). 1986. *Gentilly-1 Waste Storage Facility: Licensing Overview Document*. 61-06105-730-007. Rev 1. February.
- Canadian Nuclear Safety Commission (CNSC). 2020. *REGDOC-2.9.1: Environmental Protection: Environmental Principles, Assessments and Protection Measures*. September.

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

- Canadian Nuclear Safety Commission (CNSC). 2017. *Class I Nuclear Facilities Regulations, SOR/2000-204, Statutes of Canada*. September.
- Canadian Nuclear Safety Commission (CNSC). 2000. *Radiation Protection Regulations SOR/2000-203 under the Nuclear Safety and Control Act*. 31 May.
- Canadian Standards Association (CSA). 2022a. *CSA Standard N288.6-22, Environmental Risk Assessments at Nuclear Facilities and Uranium Mines and Mills*. February.
- Canadian Standards Association (CSA). 2022b. *CSA N288.0:22, Environmental management of nuclear facilities: Common requirements of the CSA N288 series of Standards*.
- Canadian Standards Association (CSA). 2020. *CSA Standard N288.1-20, Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities*.
- Canadian Standards Association (CSA). 2017. *CSA Standard N288.1-14, Guidelines for Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for Normal Operation of Nuclear Facilities*. Prepared in March 2014. Revised in November 2017 (Update No. 2).
- Chouhan, S.L., T.L. Yankovich and P.A. Davis. 2009. *Environmental Radionuclide Concentrations Below Which Non-Human Biota Experience No Effects. Radioprotection. Vol. 44. No. 5 (2009). Pp 107-114*.
- Cornwell, E.R., et al. 2015. *Biological and Chemical Contaminants as Drivers of Change in the Great Lakes-St. Lawrence River Basin*. Journal of Great Lakes Research Supplement 41. September 1 (2015) 119-130.
- Environment & Climate Change Canada, Québec's ministère de l'Environnement et de la Lutte contre les changements climatiques, Québec's ministère des Forêts, de la Faune et des Parcs, Parks Canada, Fisheries and Oceans Canada, and Stratégies Saint-Laurent. 2019. *Overview of the State of the St. Lawrence 2019, St. Lawrence Action Plan 2011-2026*. Legal deposit – Bibliothèque et Archives nationales du Québec, 2020, Catalogue no: En154-53/2020E-PDF, ISBN: 978-0-660-35905-2.
- Gouvernement du Québec. 2007. *Société du parc industriel et portuaire de Bécancour* [Online]. Available: <http://www.spipb.com/en/choose/region/>.
- Health Canada (HC). 2024. *Guidelines for Canadian Drinking Water Quality - Summary Tables*. October.
- Hydro Québec (HQ). 2023. *Résultats de la surveillance de l'environnement des installations de Gentilly-2. Rapport annuel 2022*. Rapport technique G2-RT-2023-00518-001. Version Finale. Avril (April).

Environmental Risk Assessment for the Gentilly-1 Waste Facility

- Hydro Québec (HQ). 2022. *Résultats de la surveillance de l'environnement des installations de Gentilly-2. Rapport annuel 2021. Rapport technique G2-RT-2022-00518-001. Version Finale. Avril (April).*
- Hydro Québec (HQ). 2021. *Résultats de la surveillance de l'environnement des installations de Gentilly-2. Rapport annuel 2020. Rapport technique G2-RT-2022-00518-001. Version Finale. Avril (April).*
- Hydro Québec (HQ). 2020. *Résultats de la surveillance de l'environnement des installations de Gentilly-2. Rapport annuel 2019. Rapport technique G2-RT-2022-00518-001. Version Finale. Avril (April).*
- Hydro Québec (HQ). 2019. *Résultats de la surveillance de l'environnement des installations de Gentilly-2. Rapport annuel 2018. Rapport technique G2-RT2022-00518-001. Version Finale. Avril (April).*
- Hydro Québec (HQ). 1983. *Direction Santé et Service de Radioprotection, Rév. 2, Novembre 1983.*
- Ministry of the Environment (MOE). 2011. *Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act. PIBS # 7382e01.*
- Ministry of the Environment (MOE). 2002. *Ontario Regulation (O.Reg.) 169/03 Ontario Drinking Water Standards (ODWS).*
- Ontario Drinking Water Quality Standards, O. Reg. 169/03.*
- Richman, L.A. and S.I. Dreier. 2001. *Sediment Contamination in the St. Lawrence River Along the Cornwall, Ontario Waterfront. J. Great Lakes Res. 27(1):60–83, Internat. Assoc. Great Lakes Res.*
- Vaudreuil M.A., et al. 2024. *Tracking down pharmaceutical pollution in surface waters of the St. Lawrence River and its major tributaries. Science of the Total Environment 912 (2024). 168680.*
- Weather Statistics Canada (WSC). 2023a. *Temperature – Monthly data for Bécancour, Québec. Accessed from: <https://xn--bcancour-b1a.weatherstats.ca/charts/temperature-monthly.html> on 08 Dec 2023.*
- Weather Statistics Canada (WSC). 2023b. *Historical Wind Speed Data Bécancour, Québec. Accessed from: [https://xn--bcancour-b1a.weatherstats.ca/charts/wind\\_speed-wyearly.html](https://xn--bcancour-b1a.weatherstats.ca/charts/wind_speed-wyearly.html) on 08 Dec 2023.*
- World Weather Online (WWO). 2023. *Bécancour Annual Weather Averages. Accessed from: <https://www.worldweatheronline.com/becancour-weather-averages/quebec/ca.aspx> on 08 Dec 2023.*
- Yang, C., K. Telmer, and J. Veizer. 1996. *Chemical dynamics of the “St. Lawrence” riverine system:  $\delta D_{H_2O}$ ,  $\delta^{18}O_{H_2O}$ ,  $\delta^{13}C_{DIC}$ ,  $\delta^{34}S_{sulphate}$ , and dissolved  $^{87}Sr/^{86}Sr$ . Geochimica et Cosmochimica Acta, Vol. 60, No. 5. pp. 851-866.*

## 9.0 QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

Section 10 of CSA N288.6-22 (CSA 2022b) outlines the QA and Quality Control (QC) requirements of an ERA. CSA (2022) describes QA and QC activities as follows:

*“Quality assurance (QA) activities are performed to monitor, document and control the quality of the ERA process (e.g., planning, data gathering, data management, data analysis, report preparation and record keeping) on a continual basis.”*

*“Quality control (QC) activities comprise those activities that specifically monitor and control discrete laboratory and field tasks.”*

It is important to note that no field or laboratory tasks were undertaken for this ERA. This ERA relies on facility descriptions, media concentrations, measured dose, receptor descriptions, and other information from various technical documents (as referenced).

The Arcadis Quality System, which is described below, was implemented in the preparation of this ERA.

### 9.1 Quality Assurance and Quality Control (QA/QC) Applied to the ERA Program

The Arcadis Quality System has been certified to the ISO 9001:2015 standard.

Arcadis is a strong believer in the importance of internal QA/QC mechanisms. Arcadis has an internal Corporate Quality Manual developed as part of the QA Program for executing studies and projects detailing key components and actions. The QA Program assures Arcadis and its clients of the high-quality deliverable that is being produced.

The QA Program provides a framework for a planned and disciplined consideration of all the factors that influence the quality of the work undertaken from the early stage of project initiation, to project execution and project close-out. The QA Program follows ISO 9001:2015 requirements and includes requirements for documentation, management responsibility, resource management, employee training, product realization and monitoring. This is achieved by developing standard operating procedures, assigning responsibilities and establishing appropriate document control. Arcadis' ISO 9001:2015 certificate is presented in Figure 9-1 below.

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Figure 9-1 Arcadis Certificate of Conformance to ISO 9001:2015

## Environmental Risk Assessment for the Gentilly-1 Waste Facility

Operating procedures provide standards against which performance and progress are measured. Responsibility assignment ensures that there is accountability for all project activities and document control procedures ensure project records are systematically archived, easily retrievable and in a standard and consistent format. The QA/QC Program is an integral part of Project Management.

The Quality System adopted for this project included the following major actions:

- **Project Management Tracking Form:**
  - Identify and document client requirements;
  - Define project work plans;
  - Identify deliverables and quality assurance/review requirements;
  - Identify and track project change requests; and,
  - Document internal review and acceptance of deliverables.
- **Internal Review of Project Work:**
  - Review by senior staff and all appropriate technical experts of preliminary or draft product or other work completed; and,
  - Revision of preliminary or draft product or other work completed based on results on internal review.
- **Client Review of Project Work:**
  - Client Review (or delegated contractor) of preliminary or draft product or other work completed; and,
  - Revision and finalization of product or completion of work.
- **Signatures on Final Reports:**
  - Person responsible for preparing the report; and,
  - Project director responsible for approving the report.

All changes to the work plan, methodology, and scope of the project were subject to approval by the Client.

The quality-sensitive elements applicable to this project, and how they are accomplished, are indicated below:

- a) **Data Gathering** (i.e., extraction of relevant information from technical documents): Qualified Arcadis staff were involved in the selection and evaluation of data, in collaboration with CNL.
- b) **Data Analysis** (e.g., COPC screening): Data analysis was performed by qualified staff and underwent internal review.
- c) **Report Preparation** (including addressing and incorporating review comments): Reports were prepared by qualified staff and underwent internal review as well as review by CNL staff knowledgeable of the G1WF.
- d) **Record keeping:** With respect to document control, the project made use of:
  - A standardized file-naming structure;
  - Centralized file storage on the secure server; and,
  - Signoff sheets for deliverables prior to transmission.

# Appendix A

## Concordance Table

## APPENDIX A – Concordance Table

This ERA was prepared in accordance with the requirements of CSA Standard N288.6-22: *Environmental risk assessments at Class I nuclear facilities and uranium mines and mills* (CSA 2022b). The following table presents how the sections of the present ERA align with the ERA contents suggested in CSA N288.6-22 (CSA 2022b). Clauses 0 to 3 have not been included because they do not contain requirements. To remain brief, section numbers (and their topics) have been included rather than reproducing complete text from the standard. See N288.6-22 (CSA 2022b) for the full text.

Environmental Risk Assessment for the Gentilly-1 Waste Facility

**Table A-1: Concordance Table for CSA N288.6:22 - Environmental Risk Assessments at Class I Nuclear Facilities and Uranium Mines and Mills**

Section #	Topic	CSA N288.6 Requirement (see Note 1)	G1WF ERA Section
4	<b>Environmental risk assessment objectives and report format</b>	As described in Clause 0.1.1, an ERA of a nuclear facility is a systematic process used to identify, quantify, and characterize the risk posed by contaminants and physical stressors in the environment on biological receptors, including the magnitude and extent of the potential effects associated with the facility. The objectives of an ERA are to evaluate the risk to relevant human and non-human biota receptors resulting from exposure to contaminants and stressors related to a site and its activities, and to recommend further action or assessment based on the results.	Goals, Objectives and Scope (1.2)
4.1	Environmental risk assessment objectives		
4.2	Environmental risk assessment report format		
5	<b>Environmental risk assessment framework, tiers, and timelines</b>	The framework for an ERA at a nuclear facility should encompass the following technical components: (a) problem formulation; (b) exposure assessment; (c) toxicity/effects assessment; and (d) risk characterization.	Organization of Report (1.3), and TOC for more details
5.1	Framework		
5.2	Tiers of assessment		
5.3	Risk assessment updates		
6	<b>Human health risk assessments</b>		
6.1	General	Clause 6 outlines the recommended components of HHRAs involving both non-radiological and radiological contaminants and physical stressors. HHRAs comprise the following components: (a) problem formulation; (b) exposure assessment; (c) toxicity assessment; and (d) risk characterization.	See below
6.2	Problem formulation		
		See details in CSA N288.6	Radiological HHRA Problem Formulation (3.1) Non-Radiological HHRA Problem Formulation (5.1)

Environmental Risk Assessment for the Gentilly-1 Waste Facility

Section #	Topic	CSA N288.6 Requirement (see Note 1)	G1WF ERA Section
6.3	Exposure assessment	See details in CSA N288.6	HHRA Exposure Assessment (3.2 and 5.2)  Note that all radionuclides and chemicals are screened out (per Section 3.1.2), but brief information is still presented in this and subsequent sections.  Noise (physical stressor) is carried through the HHRA (Sections 5.1 and 5.4)
6.4	Toxicity assessment	See details in CSA N288.6	HHRA Effects / Toxicity Assessments (3.3 and 5.3)
6.5	Risk characterization	See details in CSA N288.6	HHRA Risk Characterization (3.4 and 5.4)
7	<b>Ecological risk assessments</b>	Clause 7 outlines the recommended components of EcoRAs for contaminants and physical stressors. All EcoRAs, irrespective of the tier of assessment, comprise the following components:	See below
7.1	General	(a) problem formulation; (b) exposure assessment; (c) effects assessment; and (d) risk characterization.	
7.2	Problem formulation	See details in CSA N288.6	EcoRA Problem Formulation (4.1 – Radiological EcoRA 6.1 – Non-Radiological EcoRA)  Assessment and Measurement Endpoints – Radiological EcoRA (4.1.1)  Assessment and Measurement Endpoints – Non-Radiological EcoRA (6.1.1)
7.3	Exposure assessment	See details in CSA N288.6	EcoRA Exposure Assessment (4.2 and 6.2)

Environmental Risk Assessment for the Gentilly-1 Waste Facility

Section #	Topic	CSA N288.6 Requirement (see Note 1)	G1WF ERA Section
7.4	Effects assessment	See details in CSA N288.6	EcoRA Effects /Toxicity Assessments (4.3 and 6.3)
7.5	Risk characterization	See details in CSA N288.6	EcoRA Risk Characterization (4.4 and 6.4)
<b>8</b>	<b>Evaluation of uncertainty</b>	Clause 8 provides guidance on methods for evaluating uncertainty that are applicable to both HHRAs and EcoRAs. For each stage of the risk assessment (i.e., problem formulation, exposure assessment, toxicity/effects assessment, and risk characterization) the important uncertainties shall be evaluated qualitatively or semi-quantitatively and discussed in the ERA report.	See below
8.1	General		
8.2	Identifying and evaluating uncertainty		
8.3	Probabilistic risk assessment	See details in CSA N288.6	Radiological HHRA – Uncertainties (3.5) Radiological EcoRA – Uncertainties (4.5) Non-Radiological HHRA – Uncertainties (5.5) Non-Radiological EcoRA – Uncertainties (6.5)
<b>9</b>	<b>Risk-based recommendations</b>	Risk-based recommendations are an important outcome of an ERA and are useful for the development of risk management and/or remediation plans and for EMP optimization. Risk-based recommendations should be based on the results of the HHRA and the EcoRA.	Conclusions and Recommendations (7.0)
9.1	General		
9.2	Recommendations for monitoring		

Environmental Risk Assessment for the Gentilly-1 Waste Facility

Section #	Topic	CSA N288.6 Requirement (see Note 1)	G1WF ERA Section
9.3	Recommendations for risk management or remediation	See details in CSA N288.6	Conclusions and Recommendations (7.0)
<b>10</b>	<b>Quality assurance and quality control</b>	Quality assurance (QA) activities are performed to monitor, document, and control the quality of the ERA process (e.g., planning, data gathering, data management, data analysis, report preparation, and record keeping) on a continual basis.	Quality Assurance and Quality Control (9.0)
10.1	-		
10.2	-	All aspects of the ERA process shall have appropriate QA and QC. QA/QC requirements for the ERA should be specified prior to conducting the ERA. The QA/QC requirements should be established to verify that the ERA is adequately addressing environmental issues and producing accurate results, and to identify any deficiencies requiring corrective action.	See Clause 10.1 above
10.3	-	Any data used in the ERA process that have been collected as part of the EMP should meet the data quality specifications outlined in the EMP.	See Clause 10.1 above
<b>11</b>	<b>Periodic review of the ERA</b>	See details in CSA N288.6	See below
11.1	-		
11.2	-	The information identified in Clause 11.1 should be used to plan the update to the ERA so that the update addresses current issues using current environmental data and current science.	ERA Goals, Objectives and Scope (1.2)
11.3	-	The EMP should also be reviewed on a five-year cycle (as specified in CSA N288.4), following completion of an updated ERA to ensure that environmental monitoring is addressing the data needs identified in the latest ERA.	ERA Goals, Objectives and Scope (1.2)

# Appendix B

## **Bukhari (2024): Receptors, Exposure Pathways and Contaminants of Potential Concern for Gentilly-1 Waste Facility**

Environmental Risk Assessment for the Gentilly-1 Waste Facility

## **APPENDIX B – Bukhari (2024): Receptors, Exposure Pathways and Contaminants of Potential Concern for Gentilly-1 Waste Facility**



**Memo**

Receptors, Exposure Pathways and Contaminants of Potential Concern for Gentilly-1 Waste Facility  
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File No.:	61	509200	021	004
	Doc. Collection ID	Subject Index	Doc. Code	Serial No.

**Decommissioning and Environmental Remediation** **Non-Standard ID: SB-24-03**  
**Reactor Decommissioning** **Date: 2024/09/17**  
**G-1 & DP Decommissioning**

**To:** Carla De Waele  
**From:** Syed Bukhari  
**Cc:** Renee Silke, Laura Howat, Callie Stirling, Julie Therrien.  
**Subject:** Receptors, Exposure Pathways and Contaminants of Potential Concern for Gentilly-1 Waste Facility

**1. Introduction**

The Gentilly Nuclear Generating Station (NGGS) is a former nuclear power station located on the south shore of the St. Lawrence River in Bécancour, Québec, about 15 km east of Trois-Rivières and 100 km northeast of Montreal. The NGGS site hosts two permanently shut down nuclear reactors, Gentilly-1 Nuclear Generating Station (250 MWe), and Gentilly-2 Nuclear Generating Station (685 MWe). The NGGS site consists of 240 hectares of land, owned by Hydro-Québec, providing an exclusion zone having a radius of 914 m on land from the two reactors. The Gentilly-1 Nuclear Generating Station, now referred to as Gentilly-1 Waste Facility (G1WF), is owned by Atomic Energy of Canada Limited (AECL) and operated by Canadian Nuclear Laboratories (CNL), while the Gentilly-2 Nuclear Generating Station is owned by Hydro-Québec. The G1WF underlying land is occupied by AECL under an emphyteutic lease with Hydro-Québec.

The G1WF consists of a permanently shut down and partially decommissioned prototype Canada Deuterium Uranium (CANDU) Boiling Light Water (BLW) reactor (CANDU-BLW-250) and its associated structures. The G1WF has been maintained in Storage with Surveillance (SWS) state since its safe shutdown state achieved in 1986. CNL is now planning to execute decommissioning at the G1WF to remove all buildings and structures, therefore an amendment to the G1WF licence [1] is required to authorize SWS activities only. CNL has already submitted a Licence Amendment Application to the CNSC requesting to amend the G1WF licence to allow to proceed with execution of decommissioning [2].

## 2. Scope

The purpose of this memo is to identify and describe the receptors, exposure pathways, and considerations for Contaminants of Potential Concern (COPCs) for the G1WF which will be used in the preparation of the Environmental Risk Assessment (ERA) for the G1WF. This memo will cancel and supersede the 2018 version of the memo [3].

## 3. Definitions

Abiotic	Relating to the non-living parts of the environment such as air, rock, soil and water. Some abiotic components are topography, hydrology, drainage, climate, meteorology, and land-use patterns by members of the public [4].
Biota	All living organisms, including human beings [4].
Biotic	Relating to the living parts of the environment: plants, animals and microorganisms. Biotic components include any part of the environment considered important by the licensee, the general public, the scientific community, the Government of Canada, and any environmentally sensitive habitat [4].
Contaminant	Any nuclear or hazardous substance that has the potential to cause an adverse effect.  Note: Contaminant is also referred to as contaminant stressor [5].
Contaminant of Potential Concern	Any contaminant that has undergone screening and has been selected for evaluation in higher tiers of assessment [5].
Chemical Dose	The amount of a chemical that is taken in by a receptor.  Note: Chemical doses are often expressed as milligrams (amount) per kilogram (a measure of body weight) per day (a measure of time), for example, when people or biota eat or drink contaminated water, food, or soil [5].
Ecosystem	A geographic area where plants, animals, and other organisms, as well as weather and landscapes, work together to form a bubble of life [6].
Effect	The assessment of the risk and magnitude of benefits and harms associated with a specific exposure [7].
Effluent	A waterborne release of a hazardous or nuclear substance to the environment during normal operations [4].

Emission	An airborne release of a hazardous or nuclear substance to the environment during normal operations. An emission can include point sources, fugitive emissions, or area sources [4].
Environment	<p>The components of the Earth:</p> <ul style="list-style-type: none"> <li>• land, water, and air, including all layers of the atmosphere;</li> <li>• all organic and inorganic matter and living organisms; and</li> <li>• the interacting natural systems that include the components above [4].</li> </ul>
Environmental Risk Assessment	<p>An evaluation or analysis of risks associated with contaminants and physical stressors in the environment relevant to a facility.</p> <p>Note: The evaluation is undertaken to meet defined objectives, which can include risk-informed recommendations for risk management of the site or facility [5].</p>
Ingestion	The intake of material by humans or animals by way of the gastrointestinal system [5].
Member of the Public	A person who is not a Nuclear Energy Worker (NEW) [5].
Nuclear Energy Worker	A person who is required, in the course of the person's business or occupation in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there is a reasonable probability that the person may receive a dose of radiation that is greater than the prescribed limit for the general public [8].
Pathway	Route of a contaminant from source to receptor through one or more environmental media or compartments [5].
Physical Stressor	<p>A physical entity that has the potential to cause an effect in a receptor.</p> <p>Notes:</p> <p>1) Physical stressors can include removal or alteration of wildlife habitat, heat, intake and discharge of cooling and/or process water, noise, and incidental wildlife-vehicle interactions.</p> <p>2) Certain physical stressors, such as heat, can be treated as a contaminant [5].</p>
Radiological Dose	The amount of energy per unit mass from radioactivity that is absorbed by biological tissues, expressed in Gy. The effective dose is the sum of

the weighted equivalent radiation doses in all tissues and organs of the body, expressed in Sv [5].

Receptor	A biological entity that can be exposed to contaminants or physical stressors, and might be subject to associated effects [5].
Release	The movement of a contaminant or physical stressor beyond the physical control of a facility; it generally includes both air and liquid [5].
Risk	A representation of the potential for occurrence of effects due to exposure to a contaminant or stressor. The term is sometimes used in the strict sense of a probability of occurrence of an effect. It includes any measure of potential for occurrence [5].

#### 4. Identification of Receptors

##### 4.1 Human Health Risk Assessment Receptors

Human receptors for the G1WF Human Health Risk Assessment (HHRA) and Radiological Human Health Risk Assessment (RHHRA) were selected to align with those in Environmental Risk Assessment completed by Hydro-Québec for the Gentilly-2 unit located in GNGS site [9] and are based on the known current and likely future uses of the site and its surrounding area. Since the G1WF is located within the GNGS site, it shares the same surroundings in terms of populated locations and land usages, and therefore the human receptors chosen for the GNGS site are applicable.

The receptors selected for the G1WF HHRA and RHHRA include:

- Residential Receptor: A non-farm resident representing typical, full-time residents in the area surrounding the site. This group also includes seasonal exposure (e.g., cottagers).. The residential receptor obtains a large portion of their food from grocery stores. Residents are potentially located in several different communities in the area, e.g., municipality of Bécancour, Trois-Rivières, etc.
- Worker Receptor: Representing off-site worker receptors potentially located near Bécancour or Laprade.
- Farm Resident Receptor: Representing residents who are also farmers. Farm residents are more likely to consume their own crop or livestock, but still use grocery stores for a portion of their food.
- Hunter-Fisher Receptor: A resident presumed to reside near Bécancour, who consumes increased amounts of hunted game and fish obtained near the G1 site.

The receptor locations are based on proximity to the site (i.e., all locations are within 10 km from the site). As per CSA Standard N288.1-20 [10], the receptor locations include the following three age categories:

- Adult
- Child (10 year old)
- Infant (1 year old)

The only people expected to be present on site for extended periods of time are those that are classified as Nuclear Energy Workers (NEWs). The health and safety of NEWs is strictly regulated and monitored, and there are a number of health and safety programs/protocols in place for the site that apply to NEWs. Additionally, as described in CSA Standard N288.6-22 [5], assessment of NEWs is not typically incorporated into the risk assessments under the Standard.

#### **4.2 Ecological Risk Assessment Receptors**

A functioning ecosystem involves interactions of multiple species, and each species may respond differently to Contaminants of Potential Concern (COPCs), radiological contaminants and/or physical stressors. Thus, it is neither possible nor practical, to directly assess the risk for each individual species. The ecosystems at the site have, therefore, been divided into components (e.g., plants, invertebrates, birds, mammals, and fish). For birds, mammals, and fish, a limited number of species were selected from each of the component groupings to be representative receptors of the entire component. For plants and invertebrates, individual species were not selected but rather these receptors were defined at the component level (e.g., terrestrial plants, soil invertebrates, aquatic plants, zooplankton, and benthic invertebrates), as per recommendations in N288.6-22 (clause 7.2.3.3) [5].

Ecological receptors for the G1WF Ecological Risk Assessment (EcoRA) and Radiological Ecological Risk Assessment (REcoRA) were selected in consideration of the following criteria:

- Species and habitats observed on the G1WF site as documented in previous environmental studies.
- Representation of all major plant and animal groups present on the Site (e.g., bird species with terrestrial and aquatic habitat, soil and benthic invertebrates, etc.).
- Receptors that reflect the interests of the facility, regulatory agencies, local First Nations and community stakeholders.
- Potential for exposure (i.e., diet, habitat preferences and behaviours that make the species likely to contact the COPCs).
- Receptors that play important roles in community structure and function (e.g., top predators and major herbivores).
- Inclusion of the various trophic levels (e.g., primary producer, herbivore, carnivore) for species that could potentially use the site.
- Receptors that have cultural or socio-economic significance.
- The availability of information on the receptor, including exposure-related and ecotoxicological data.
- Species of conservation status (e.g., vulnerable, threatened, or endangered species).

The following terrestrial and aquatic components and receptors are selected for the G1WF EcoRA and REcoRA:

- Terrestrial Plants
- Soil Invertebrates
- Benthic Invertebrates
- Zooplankton
- Waterfowl
- Great Blue Heron
- Large-mouth Bass
- Northern Pike
- Aquatic Plants
- Perch
- Carp

## **5. Identification of Exposure Pathways**

### **5.1 Human Health Exposure Pathways for Chemicals and Physical Stressors**

For the G1WF HHRA, the following chemical exposure pathways are considered for the human receptors:

- Inhalation of ambient air and dust (represented by air concentrations predicted at the site property boundary).
- Consumption of drinking water (represented by shallow residential wells or post-treatment water from the local water treatment plants).
- Consumption of contaminated food (e.g., fish, plants, and animals)
- Incidental ingestion of water (e.g., while swimming or boating)
- Incidental ingestion of soil
- Incidental ingestion of sediment
- Dermal uptake from contact with water/sediment/soil

For the G1WF HHRA, exposure to facility noise is the only physical stressor identified for exposure to human receptors.

### **5.2 Ecological Exposure Pathways for Chemicals and Physical Stressors**

For the G1WF EcoRA and REcoRA, following chemical exposure pathways are considered for the mammal and bird receptors, as applicable:

- Inhalation of dust
- Ingestion of soil
- Dermal contact with soil
- Ingestion of terrestrial plants
- Ingestion of soil invertebrates
- Ingestion of prey
- Ingestion of surface water

- Dermal contact with surface water
- Ingestion of fish
- Ingestion of sediment
- Dermal contact with sediment
- Ingestion of aquatic plants
- Ingestion of benthic invertebrates

For the G1WF EcoRA and REcoRA, following chemical exposure pathways are considered for the terrestrial plants and soil invertebrate receptors, as applicable:

- Direct contact with soil
- Direct contact with groundwater

For the G1WF EcoRA and REcoRA, following chemical exposure pathways are considered for the aquatic receptors, as applicable:

- Direct contact with surface water
- Direct contact with sediment

Ecological receptors at the G1WF site may be subject to physical stressors such as:

- Noise
- Bird Strikes
- Vehicle-wildlife collisions

### **5.3 Radiological Human Health Exposure Pathways**

For the G1WF RHHRA, the following exposure pathways are considered, as applicable:

- Air inhalation
- Air immersion
- Water ingestion
- Water immersion
- Soil ingestion (incidental)
- Soil external (ground shine)
- Terrestrial animal ingestion
- Terrestrial plant ingestion
- Aquatic animal ingestion
- Aquatic plant ingestion
- Sediment ingestion (incidental)
- Sediment external
- Gamma radiation

### **5.4 Radiological Ecological Exposure Pathways**

For the G1WF REcoRA, the following exposure pathways are considered for terrestrial biota:

- Consumption of contaminated foods and water
- Air immersion (exposure from gaseous radionuclides in the air, primarily noble gases).

- Ground shine (exposure from radioactive particulate on the ground, primarily gamma emitters such as Cs-137).

For the G1WF REcoRA, the following exposure pathways are considered for aquatic biota:

- Consumption of contaminated foods and water
- Water immersion (primarily gamma emitters such as Cs-137)
- Sediment (exposure from radioactive particulate in sediment, primarily gamma emitters such as Cs-137)

## 6. Identification of Contaminants of Potential Concern

The COPCs are contaminants which have undergone a screening assessment and have been identified for evaluation in higher tiers of assessment. The COPCs may be of potential concern, based on the current or predicted future concentrations in the environment. The contaminants relevant to the G1WF site characteristics which are listed in this section come from *Gentilly-1 Waste Facility Effluent Monitoring Plan* [11], a supplemental study [12] and G1WF Bounding Analysis document [13]. This section identifies the radiological and chemical parameters associated with the G1WF and environmental concentrations on site that will be screened to determine whether these parameters are COPCs.

### 6.1 Chemicals and Physical Stressors for Human Health Risk Assessment

The following chemicals are identified for consideration in St. Lawrence River water [14][15]:

- Mercury,
- Organochlorines including Polychlorinated biphenyls (PCBs), Dioxins, and Furans,
- Pesticides such as DichloroDiphenylTrichloroethane (DDT), Aldrin, Dieldrin, Toxaphene, and Mirex are often grouped as legacy contaminants,
- Organic wastewater contaminants including Personal Care Products, and
- Pharmaceuticals such as Hormones, Steroids, Analgesics, Antibiotics, Stimulants, and Antidepressants.

Groundwater chemical analysis conducted in the area showed a presence of a suite of heavy metals (e.g., iron, zinc, copper, lead, and cadmium), total phosphorus, ammonia nitrogen, nitrites, nitrates, sulphates, bicarbonates, chlorides, and fecal coliforms [16][17][18].

Hazardous substances identified in the G1WF that have the potential to impact the surrounding environment include asbestos insulation on piping and on mechanical insulation, lead-based paint on the structures, lead wool used to seal wall openings, lead-containing batteries, PCBs in fluorescent light ballasts, mercury in fluorescent and high intensity lights, and silica in poured concrete floors and concrete block walls. Therefore, identified hazardous substances in the G1WF including lead, mercury, and PCBs. These are also considered as chemical COPCs for ecological receptors (See Section 0).

There is only physical stressor for the G1WF which is noise. The noise levels at the G1WF site are comparable to the surrounding area designated as an industrial area. The proposed work activities at the G1WF will not be scheduled outside of normal working hours in the area.

## 6.2 Chemical and Physical Stressors for Ecological Risk Assessment

The following sources of chemicals are under consideration for terrestrial ecological receptors:

- Soil COPCs (receptors: terrestrial plants, soil invertebrates, mammals, and birds)
- Shallow groundwater COPCs (receptor: terrestrial plants)
- Surface water COPCs (receptors: mammals and birds)
- Sediment COPCs (receptors: mammals and birds)

The following contaminants are under consideration for all ecological receptors:

- Surface water contaminants including lead, mercury, and PCBs
- Sediment contaminants including lead, mercury, and PCBs

Lead, mercury, and PCBs are also considered as contaminants in soil and shallow groundwater for uptake by terrestrial receptors.

The physical stressors include noise, vehicle-wildlife impact, and bird strikes. The noise levels are comparable to the surrounding area designated as an industrial area. The proposed work activities will not be scheduled outside of normal working hours in the area. The vehicle-wildlife impacts are negligible due to driving or heavy machinery activities being isolated to the project footprint, and employee travel to the work area is conducted on Hydro-Québec property. The bird strike collisions are monitored and reported as part of the Environmental Protection Program, and there have been no reported collisions or deaths at the G1WF due to the lack of windows at the facility. Ongoing mitigation measures and reporting will continue as part of the CNL Environmental Protection Program as the project continues.

## 6.3 Radiological Human Health Risk Assessment

The following are the primary radionuclides associated with systems/components present within the G1WF and are under consideration as COPCs for the RHHA:

- Heat Transport System and Moderator System – Co-60 and Cs-137 [13]
- Reactor Core – Ni-63, Co-60, Eu-152, and Fe-55 [13]
- Turbine Building Systems and Components – Ni-63, Fe-55, Cs-137, Co-60, Eu-152, Eu-154, Sb-125, Nb-94, and C-14 [13]
- Groundwater Pumping System Effluent – H-3, Gross alpha, and Gross beta [12]

## 6.4 Radiological Ecological Risk Assessment

The radionuclides which are under consideration for the assessment of exposure to terrestrial biota include:

- Tritium (H-3)
- Carbon-14
- Cesium-137 (representing gross beta/gamma radionuclides)

The radionuclides which are under consideration for the assessment of exposure to aquatic biota include:

- Tritium (H-3)
- Carbon-14

- Cobalt-60
- Cesium-137 (representing gross beta/gamma radionuclides)

## 7. References

- [1] *Waste Facility Decommissioning Licence, Gentilly-1 Waste Facility*, WFDL-W4--331.00/2034, 61-508760-13-000-0005, Revision 0, 2019 February.
- [2] *Application for Licence Amendment to Proceed with Execution of Decommissioning at the Gentilly-1 Waste Facility*, 61-CNNO-24-0008-L, 2024 July 17.
- [3] *Receptors, Exposure Pathways and Contaminants of Potential Concern for Gentilly-1 Waste Facility*, 61-509200-021-000-0003, Revision 0, 2018 October.
- [4] *Glossary of CNSC Terminology*, CNSC REGDOC-3.6, 2023 February.
- [5] *Environmental risk assessments at nuclear facilities and uranium mines and mills*, CSA N288.6-22, 2022.
- [6] [Ecosystem \(nationalgeographic.org\)](https://www.nationalgeographic.org).
- [7] [Definition of Effect in Research](#)
- [8] *Nuclear Safety and Control Act* (S.C. 1997, c. 9).
- [9] *Résultats de la surveillance de l'environnement des installations de Gentilly-2, Rapport annuel 2022*, Rapport technique G2-RT-2023-00518-001. Version Finale. Avril 2023.
- [10] *Guidelines for modelling radionuclide environmental transport, fate, and exposure associated with the normal operation of nuclear facilities*, CSA N288.1-20, 2020.
- [11] *Gentilly-1 Waste Facility Effluent Monitoring Plan*, 61-509200-PLA-001, Revision 1, 2021 October.
- [12] Memo from M. Audet to M. Vickerd, *Results of Sampling Effluent Streams from CNL's Prototype Reactor Decommissioning Sites*, 3640-509000-021-000, 2016 March.
- [13] *Bounding Accident Analysis for the Phase 3 Decommissioning of the Gentilly-1 Waste Facility*, 61-01320-ASD-001, Revision 0, 2020 February.
- [14] *Biological and chemical contaminants as drivers of change in the Great Lakes-St. Lawrence river basin*, Emily R. Cornwell *et al.*, *Journal of Great Lakes Research Supplement* 41 September 1 (2015) 119-130.
- [15] Tracking down pharmaceutical pollution in surface waters of the St. Lawrence River and its major tributaries, Marc-Antonie Vaudreuil *et al.*, *Science of the Total Environment* 912 (2024) 168680.
- [16] *Overview of the State of the St. Lawrence 2019, St. Lawrence Action Plan 2011-2026*, *Environment & Climate Change Canada*, Québec's ministère de l'Environnement et de la Lutte contre les changements climatiques), Québec's ministère des Forêts, de la Faune et des Parcs, Parks Canada, Fisheries and Oceans Canada, and Stratégies Saint-Laurent, Legal deposit – Bibliothèque et Archives nationales du Québec, 2020, Catalogue no: En154-53/2020E-PDF, ISBN: 978-0-660-35905-2.

- [17] *Chemical dynamics of the "St. Lawrence" riverine system:  $\delta D_{H_2O}$ ,  $\delta^{18}O_{H_2O}$ ,  $\delta^{13}C_{DIC}$ ,  $\delta^{34}S_{sulphate}$ , and dissolved  $^{87}Sr/^{86}Sr$* , Chao Yang *et al.*, *Geochimica et Cosmochimica Acta*, Vol. 60, No. 5, pp. 851-866, 1996.
- [18] *Sediment Contamination in the St. Lawrence River Along the Cornwall, Ontario Waterfront*, Lisa A. Richman *et al.*, *J. Great Lakes Res.* 27(1):60–83, Internat. Assoc. Great Lakes Res., 2001.

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