ONTARIO POWER GENERATION

Report

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2023 PICKERING NUCLEAR GROUNDWATER MONITORING PROGRAM RESULTS

2023 Pickering Nuclear Groundwater Monitoring Program Results

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Revision Summary

Revision Number	Date	Comments
000	2023-04-02	Initial Issue

Land Acknowledgement

The lands and waters on which the Pickering Nuclear Generating Station (PNGS) is situated are within the traditional and treaty territory of the Williams Treaties First Nations, which includes Curve Lake First Nation, Hiawatha First Nation, Alderville First Nation, Chippewas of Beausoleil First Nation, Chippewas of Georgina Island First Nation, Chippewas of Rama First Nation, and the Mississaugas of Scugog Island First Nation.

The PNGS is within the territory of the Gunshot Treaty and the Williams Treaties of 1923. The Gunshot Treaty Rights were reaffirmed in 2018 in a settlement with Canada and the Province of Ontario.

To acknowledge the treaty and traditional territory, is to recognize the rights of the First Nations. It is to recognize the history of the land, predating the establishment of the earliest European colonies. It is also to acknowledge the significance for the Indigenous peoples who lived and continue to live upon it, to acknowledge the people whose practices and spiritualties are tied to the land and water and continue to develop in relation to the territory and its other inhabitants today.

ALDERVILLE FIRST NATION | BEAUSOLEIL FIRST NATION | CURVE LAKE FIRST NATION | GEORGINA ISLAND FIRST NATION | HIAWATHA FIRST NATION | SCUGOG ISLAND FIRST NATION | RAMA FIRST NATION

Executive Summary

Pickering Nuclear Generating Station (PNGS) has a mature and robust groundwater monitoring program in place to address the following three primary objectives:

- Objective 1: Monitor changes to on-site groundwater quality to ensure timely detection of inadvertent releases to groundwater;
- Objective 2: Ensure there are no adverse off-site impacts from PNGS groundwater; and
- Objective 3: Confirm predominant on-site groundwater flow characteristics at the PNGS site.

The findings in 2023 with respect to the above objectives are:

- Objective 1:
    - Groundwater concentrations in the vicinity of Units 1 and 8 had increases in tritium concentration. Tritiated groundwater around Unit 1 is expected to migrate south and west, collect within actively pumped sumps, and then managed through monitored pathways. Additionally, concentrations of tritium in downgradient locations are not inferred to impact groundwater end-use. Increased tritium concentrations in groundwater were observed within the vicinity of Unit 8. Tritium concentrations in groundwater downgradient of Unit 8 remain below risk-based evaluation criteria and monitoring will continue within these locations. The remaining groundwater data collected from the system structures and components indicate tritium concentrations are consistent with results for previous years and fluctuations associated with ongoing operations or represent increases that occur because of the expected migration of tritium associated with historical releases to groundwater and that are limited over time and space.
    - The results for the remediation approach of natural attenuation of petroleum hydrocarbons present in Units 1 to 4 Standby Generators (SG-A), SG-A Overflow area, Units 5 to 8 Standby Generators (SG-B), Emergency Power Generators (EPG), and EPG3 areas are consistent with historical results.
- Objective 2: Tritium concentrations within the site boundary wells and shoreline wells are stable and are within historical ranges with some slightly increased concentrations. Off-site effects of tritium in groundwater to Lake Ontario are not observed.
- Objective 3: The predominant groundwater flow patterns remain unchanged in 2023 from the recent years' interpretations.

1.0 INTRODUCTION

Ontario Power Generation (OPG) Pickering Nuclear Generating Station (PNGS) has a mature and robust annual groundwater monitoring program in place. The program examines the chemical, radiological, and physical characteristics of the groundwater beneath the site.

The following three primary objectives are addressed by specific objectives detailed in the N288.7-compliant PNGS Groundwater Protection Plan (GWPP) and Groundwater Monitoring Program (GWMP) (Ecometrix, 2023a):

Objective 1: Monitor changes to on-site groundwater quality to ensure timely detection of inadvertent releases to groundwater:

- Tritium concentrations in groundwater near system structures and components (SSCs).
- Dissolved iron concentrations in groundwater at East and West Landfills. Will be addressed in the 2024 groundwater monitoring program due to biennial sampling.
- Petroleum hydrocarbon (PHC) concentrations in groundwater at Units 1 to 4 Standby Generators (SGs, or SG-A), Units 5 to 8 SGs (or SG-B), Emergency Power Generators (EPG), and EPG3. Only Units 1 to 4 SGs are addressed in the 2023 groundwater monitoring program. The remaining locations are addressed in the 2024 groundwater monitoring program due to biennial sampling.
- PHC concentrations in groundwater at Fukushima Diesel Generators and Standby Boiler will be addressed in the 2024 groundwater monitoring program due to biennial sampling.

Objective 2: Ensure there are no adverse off-site impacts from PNGS groundwater:

- Tritium concentrations in groundwater in Perimeter Wells - monitor tritium in site perimeter wells to establish tritium concentrations at the PNGS site boundaries and to confirm no adverse off-site impacts.

Objective 3: Confirm predominant on-site groundwater flow characteristics at the PNGS site:

- Hydraulic Head Measurements - provide head measurements in selected monitoring wells to confirm the groundwater flow conditions across the PNGS site and to support the interpretation of constituent migration in groundwater.

The groundwater sampling and monitoring program conducted in 2023 followed the Sampling and Analysis Plan (SAP) for 2023 (OPG, 2023). This report presents groundwater data collected at PNGS for the period from January 1st to December 31st, 2023.

1.1 Summary of Hydrogeological Characteristics at the PNGS

Eight hydrostratigraphic units (HUs) have been identified beneath PNGS through historical assessments. Of the eight HUs, four main groundwater flow systems have been identified for the site:

- Shallow/Water Table (HU 1-3);
- Intermediate Overburden (HU 6);
- Deep Overburden (HU 7); and
- Deep Bedrock (HU 8).

HUs 4 and 5 are not always observed, and where they are observed, are generally thin and grouped into the shallow groundwater system. The shallow groundwater system is an aquifer, and the intermediate overburden and bedrock groundwater flow systems are considered to be aquitards. The deep overburden groundwater system may represent an aquifer. Groundwater migration into this HU from overlying HUs is considered to be limited due to the low permeability of the till materials in HU 6.

2.0 2023 PROGRAM DESIGN

The groundwater monitoring program design is detailed in the PNGS GWPP and GWMP (Ecometrix, 2023a). The N288.7-compliant 2023 SAP was developed to meet the relevant components of the objectives listed above.

Groundwater quality results are provided in Appendix A.

2.1 Objective 1 Methodology

2.1.1 Tritium Concentrations in Groundwater Near SSCs

In 2023, as per the SAP, groundwater samples were collected from 88 sampling locations, including monitoring wells, foundation drains, sumps, and groundtubes. Figure 1 shows the locations that were included within the 2023 SAP. Most of the locations sampled are near the operating reactors. Refer to Section 6.0 of this report for details on the sampling nomenclature used in the groundwater program.

The 2023 SAP specified the sampling locations and frequency (e.g., quarterly, annually) of sampling tritium concentrations in groundwater at each location.

Groundwater samples analyzed for tritium were collected from the following key areas in 2023:

- Unit 1 to 4 Reactor Buildings (RBs);
- Unit 5 to 8 RBs;
- Irradiated Fuel Bays (IFBs) for Units 1 to 4 and Units 5 to 8; and
- Upgrading Plant Pickering (UPP).

Water levels were collected in each monitoring well prior to the collection of samples by OPG technicians. Following measurement of the water level and prior to sample collection, each monitoring well was purged to remove standing water, ensuring that the groundwater collected had a quality representative of subsurface conditions. Collected samples were analyzed for tritium concentrations by the OPG PNGS Chemistry Laboratory.

The groundwater data generated from the sampling program was subsequently analyzed to either support previous conclusions, identify changes in groundwater quality (trends) including improvements, or demonstrate no significant change. Sample results of groundwater tritium concentrations for Objective 1 are presented in Appendix A (Table A-1, Table A-2, Table A-3, and Table A-4).

2.1.2 PHC concentrations in groundwater at Units 1 to 4 SGs, Units 5 to 8 SGs, EPG and EPG3

A monitored natural attenuation program (MNA) was implemented in the SG-A, SG-A Overflow area, and SG-B areas in 2011, following remedial activities. MNA programs are long-term because hydrocarbon mass attenuation occurs through volatilization, dissolution, and natural microbial degradation processes. Groundwater monitoring results in these three areas have, in the past, been reported under separate cover. The MNA program for these areas was incorporated into the GWMP developed for the site in 2019. Since that time, the results of the MNA programs in these areas are discussed in the annual report (this report) for PNGS. The SG-A area is monitored annually and is discussed further in this report. The other two areas (SG-B and SG-A overflow tank area) are monitored biennially and will be discussed following the 2024 monitoring program.

In 2023, as per the SAP and the GWMP (OPG, 2023), six groundwater wells were monitored quarterly (Q1-Q4) for water levels and petroleum hydrocarbon free-phase product thickness near the U1–4 SGs. If free-phase product was present in the wells, the thickness of the product and depth to water were the only measurements taken. If free-phase product was present in the wells, thickness of the product and depth to water were the only measurements taken. If free-phase product was not present, groundwater samples were collected for analysis of PHCs including benzene, toluene, ethylbenzene and xylenes (BTEX), PHC Fractions 1-4 (PHC F1 to PHC F4), and dissolved iron. Figure 2 shows the locations of the six wells that were monitored in 2023.

Product thicknesses for SG-A are presented in Table A-5 (Appendix A).

2.2 Objective 2 Methodology

The 2023 SAP included the sampling of monitoring well clusters at the site boundary to confirm that there are no adverse off-site impacts from PNGS groundwater. Boundary wells are located across the entire site in directions upgradient or cross-gradient to the SSCs and provide spatial information on background groundwater quality conditions. Shoreline wells are also monitored downgradient to the SSCs to assess off-site impacts to groundwater quality. Figure 3 shows the locations of the site perimeter wells. Analytical results for monitoring wells sampled at the PNGS perimeter are presented in Table A-6 (Appendix A)

The methodology for groundwater collection, analysis, and data evaluation in the perimeter wells was the same as what is described above for Objective 1.

2.3 Objective 3 Methodology

Groundwater flow interpretations for PNGS were first established in 2002. On an annual basis, the GWMP requires that a set of water levels be collected from several groundwater monitoring wells at the site over a short period of time (days). The intent of the program is to verify that groundwater flow conditions, which are the basis for interpreting the migration of constituents in groundwater, have not changed and that OPG continues to have a sound understanding of groundwater flow patterns at the site. In the third quarter (Q3) of 2023, water level readings were collected from monitoring well locations across the site over a period of eight days (September 12 to 20, 2023). The data was subsequently used to calculate the groundwater elevation at each monitoring well. The resulting groundwater elevations and the average daily mean Lake Ontario water levels collected between October 1 and October 31, 2023 (IJC, 2024) were used to generate groundwater elevation contours, from which groundwater flow directions are inferred.

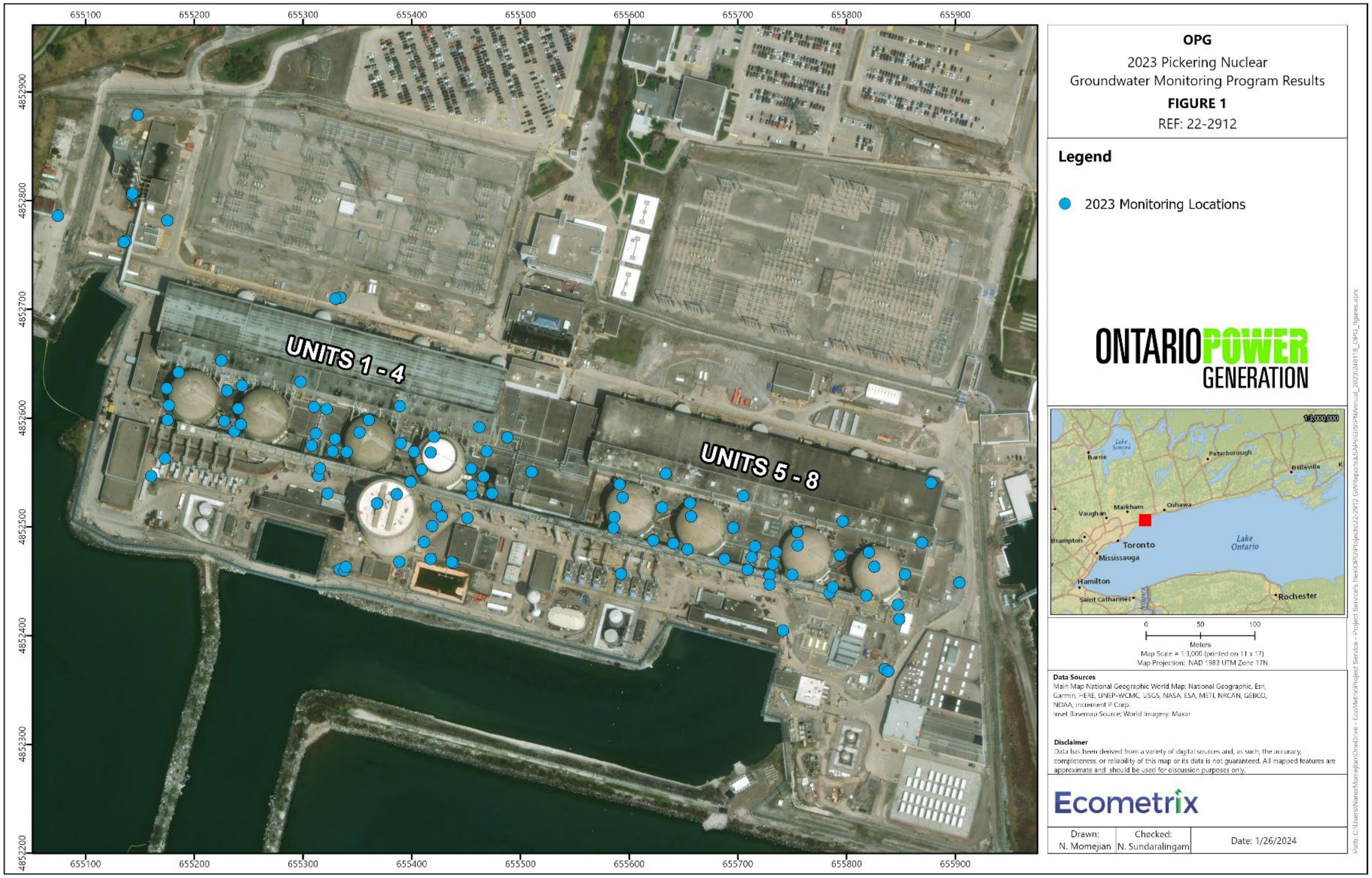


Figure 1: 2023 Tritium Monitoring Locations for Objective 1

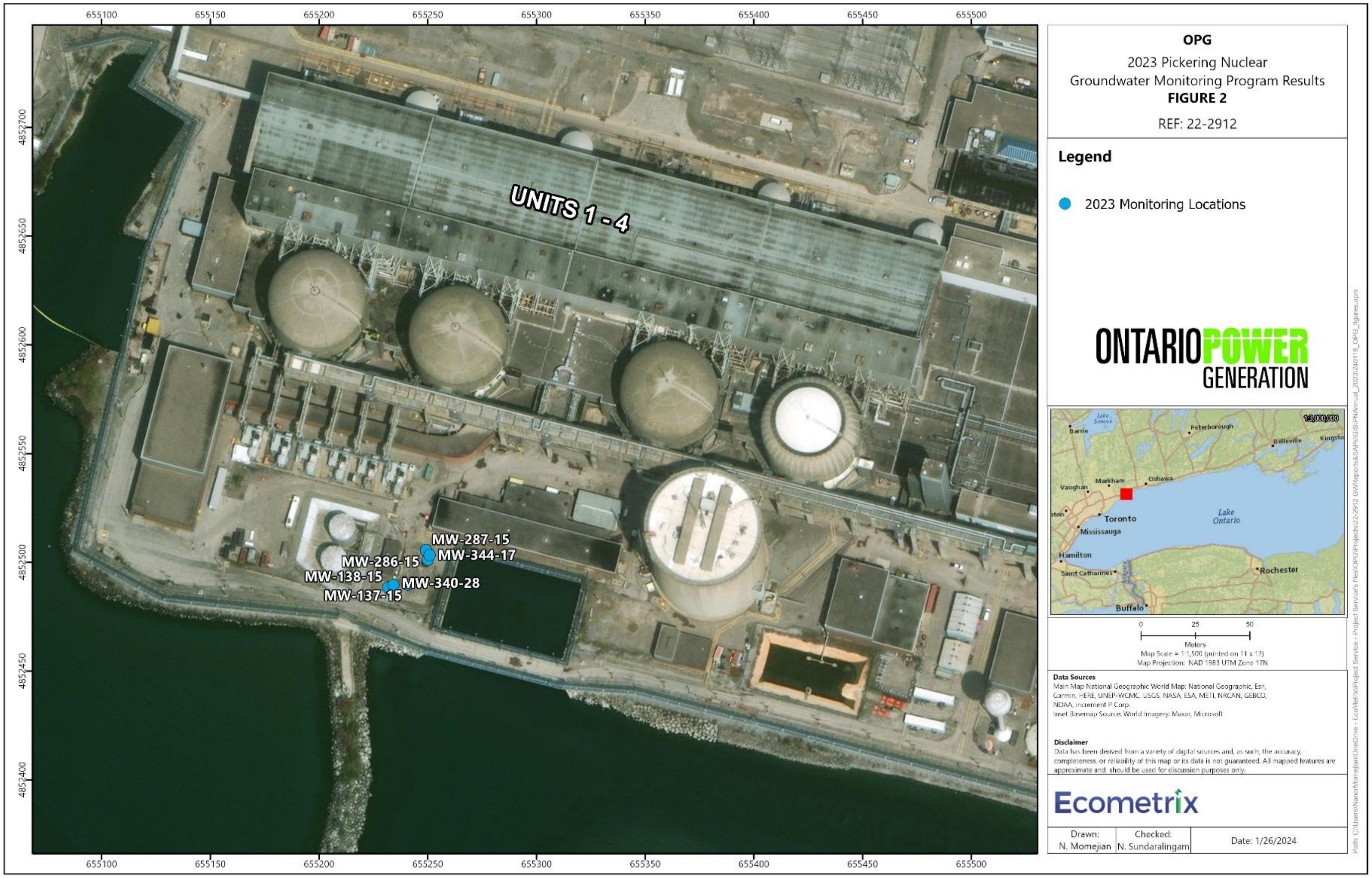


Figure 2: 2023 PHC, BTEX, and Dissolved Iron Monitoring Locations for Objective 1 - SG-A, SG-B, and SG-A Overflow Tank Area, EPG and EPG3

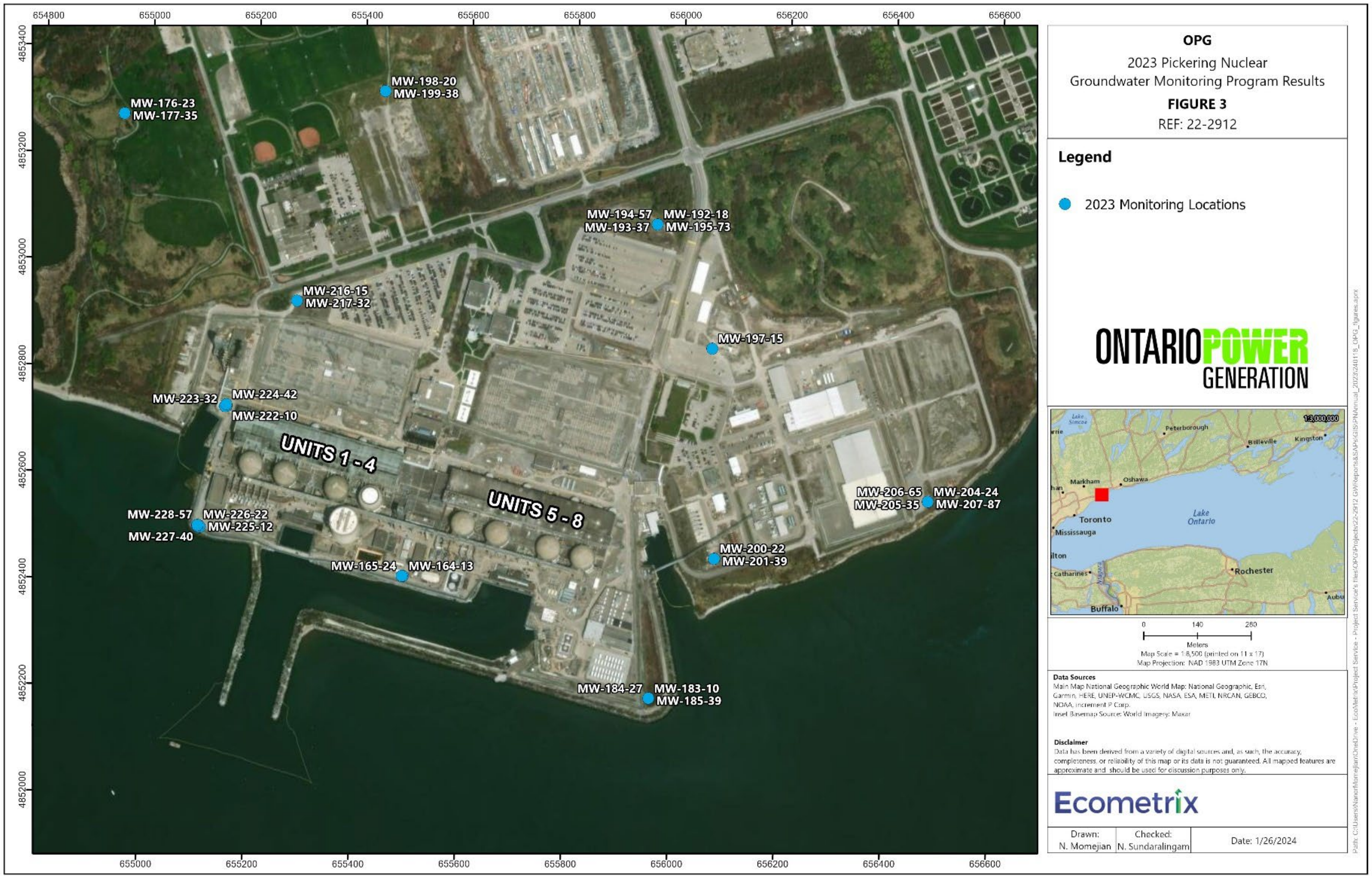


Figure 3: 2023 Monitoring Locations for Objective 2

3.0 2023 PROGRAM RESULTS

3.1 Objective 1 Results

3.1.1 Tritium Concentrations in Groundwater Near SSCs

In 2023, an increase in tritium concentrations was noted within the groundwater near Unit 1. Tritiated groundwater around Unit 1 is expected to migrate south and west, collect within actively pumped sumps, and then managed through site operations. Additionally, concentrations of tritium in downgradient locations are not inferred to impact groundwater end-use. An increase in tritium concentrations was also noted in groundwater within the vicinity of Unit 8. Tritium concentrations in groundwater downgradient of Unit 8 remain below risk-based evaluation criteria and monitoring will continue within these locations. The remaining groundwater data collected from the areas surrounding SSCs at PNGS indicate that tritium concentrations in groundwater have remained, overall, consistent with results for previous years, and are otherwise within the range of expected fluctuations resulting from ongoing operations or represent the expected movement of historical tritium releases to groundwater. Further discussion is provided in the sections below.

3.1.1.1 Unit 1 to 4 Reactor Building Area Overview

The 2023 groundwater sampling results within the area of Units 1 to 4 are presented in Table A-1 (Appendix A). The majority of the monitoring wells in this area are sampled quarterly. Figure 4 to Figure 6 display the distributions of maximum annual tritium concentrations within the vicinity of Units 1 to 4 area and Units 1 to 4 IFBs in HU 1-3, HU 6, and HU 7.

Key sampling locations are discussed in further detail below, by specific area.

Figure 4: 2023 Annual Maximum Tritium Concentrations within HU 1-3, Units 1 to 4, and IFB-A

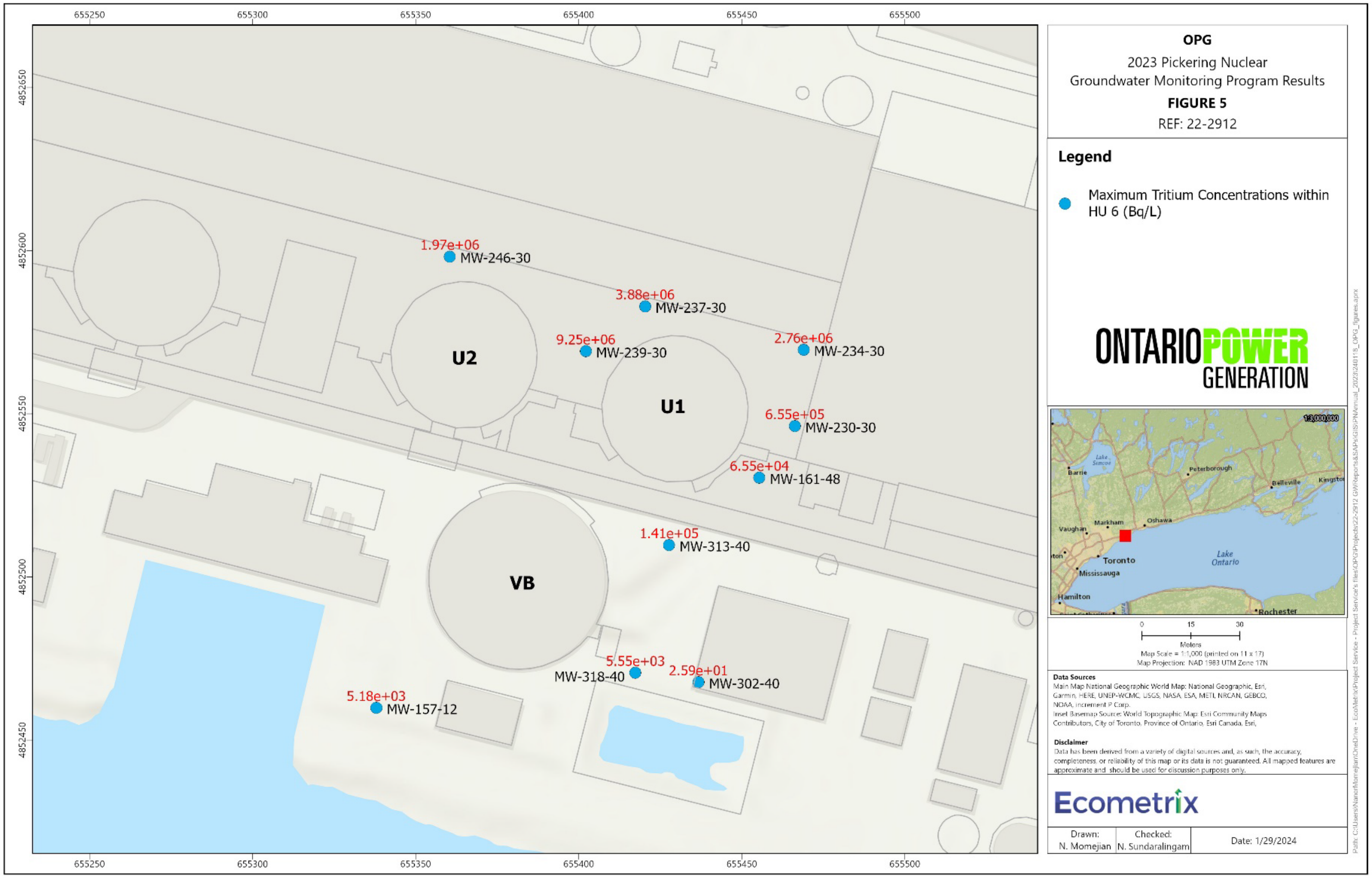


Figure 5: 2023 Annual Maximum Tritium Concentrations within HU 6, Units 1 to 4, and IFB-A

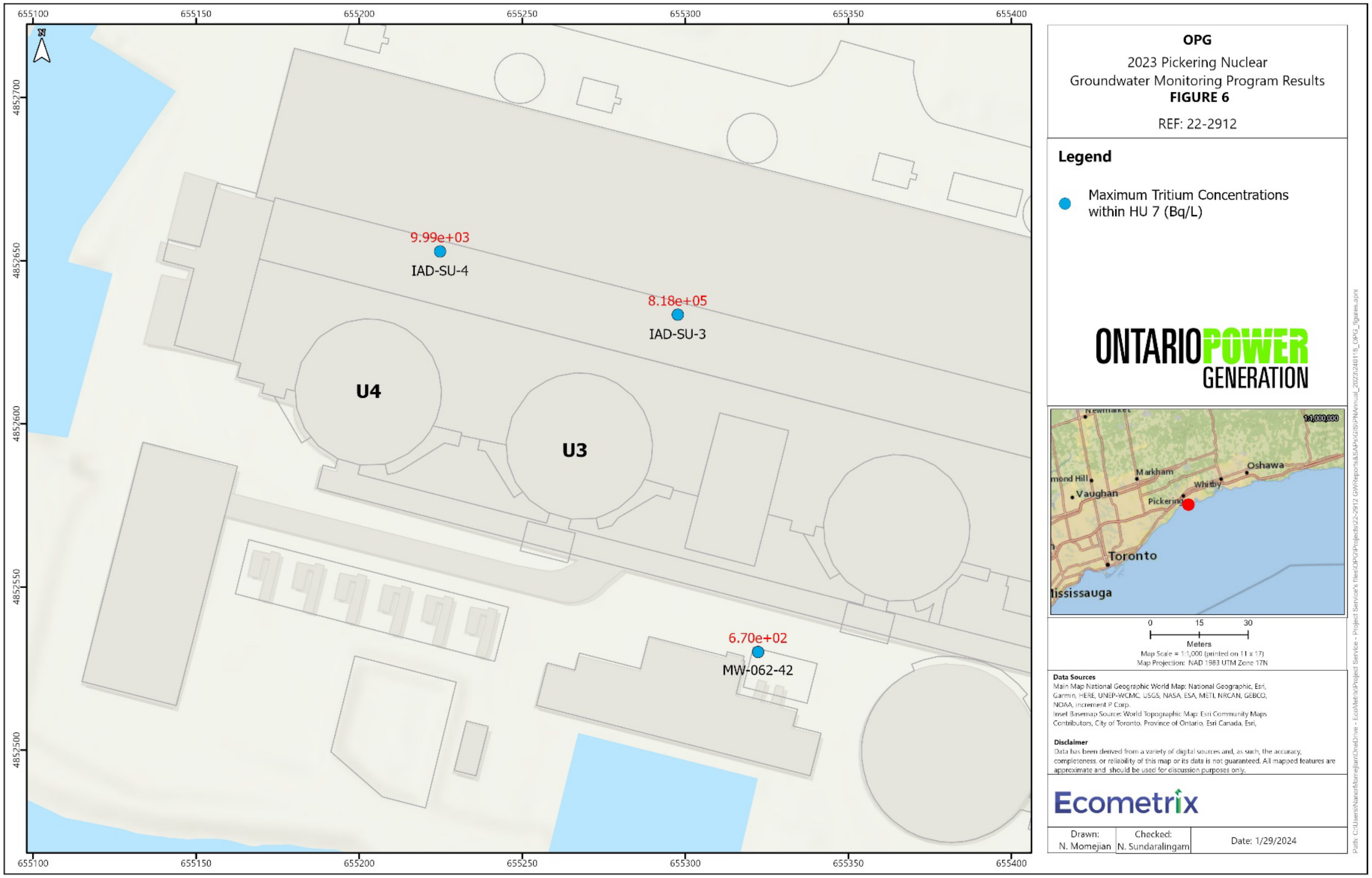


Figure 6: 2023 Annual Maximum Tritium Concentrations within HU 7, Units 1 to 4, and IFB-A

Unit 1 and 2 Area

Tritium concentrations within the ground tube (U1-RBFD-3), several monitoring wells towards the south-southeast of Unit 1 (MW-270-20, MW273-20, MW-313-40, MW-315-15, MW-320-20 and MW-321-15), and the Vacuum Building Ramp Sump (VBRS) were consistent with concentrations measured during previous years.

Two heavy water leaks were identified on October 20, 2023 at Unit 1, and another was identified on November 21, 2023 due to a faulty pump gasket which was repaired on the same day. The increased tritium concentrations observed within the south-southeastern monitoring wells and ground tube may be attributed to this leak. Concentrations have begun to decrease at MW-313-40 and MW-320-20 towards Q3 and Q4 2023. Based on the historical migration of a heavy water leak in 2020, this tritiated groundwater plume is expected to migrate south towards the VBRS, which acts as a hydraulic sink and collects a portion of groundwater in the Unit 1 and 2 areas (Ecometrix, 2023b). Additionally, groundwater in the area of Unit 1 is also known to migrate north towards the actively pumped Turbine Axillary Bay (TAB) foundation drains and west towards Units 1-4 IFBs (Ecometrix, 2020b). This northwestern migration of tritiated groundwater is demonstrated by slightly increased tritium concentrations in 2023 from MW-243-29 compared to recent historical results. Tritiated groundwater is collected at these actively pumped locations and discharged via a monitored pathway. Monitoring will continue at these monitoring wells to characterize the migration of tritiated groundwater. Tritiated groundwater migrating to the west towards the IFBs and TAB foundation drains and south to the VBRS is depicted in Figure 7.

Tritium concentrations in remaining wells and ground tubes within the vicinity of Units 1 and 2 remained within historical ranges reflective of routine operations. Graphs 1 to 9 display tritium concentrations over time at U1-RBFD-3, MW-270-20, MW273-20, MW-313-40, MW-315-15, MW-320-20, MW-321-15, and the VBRS.

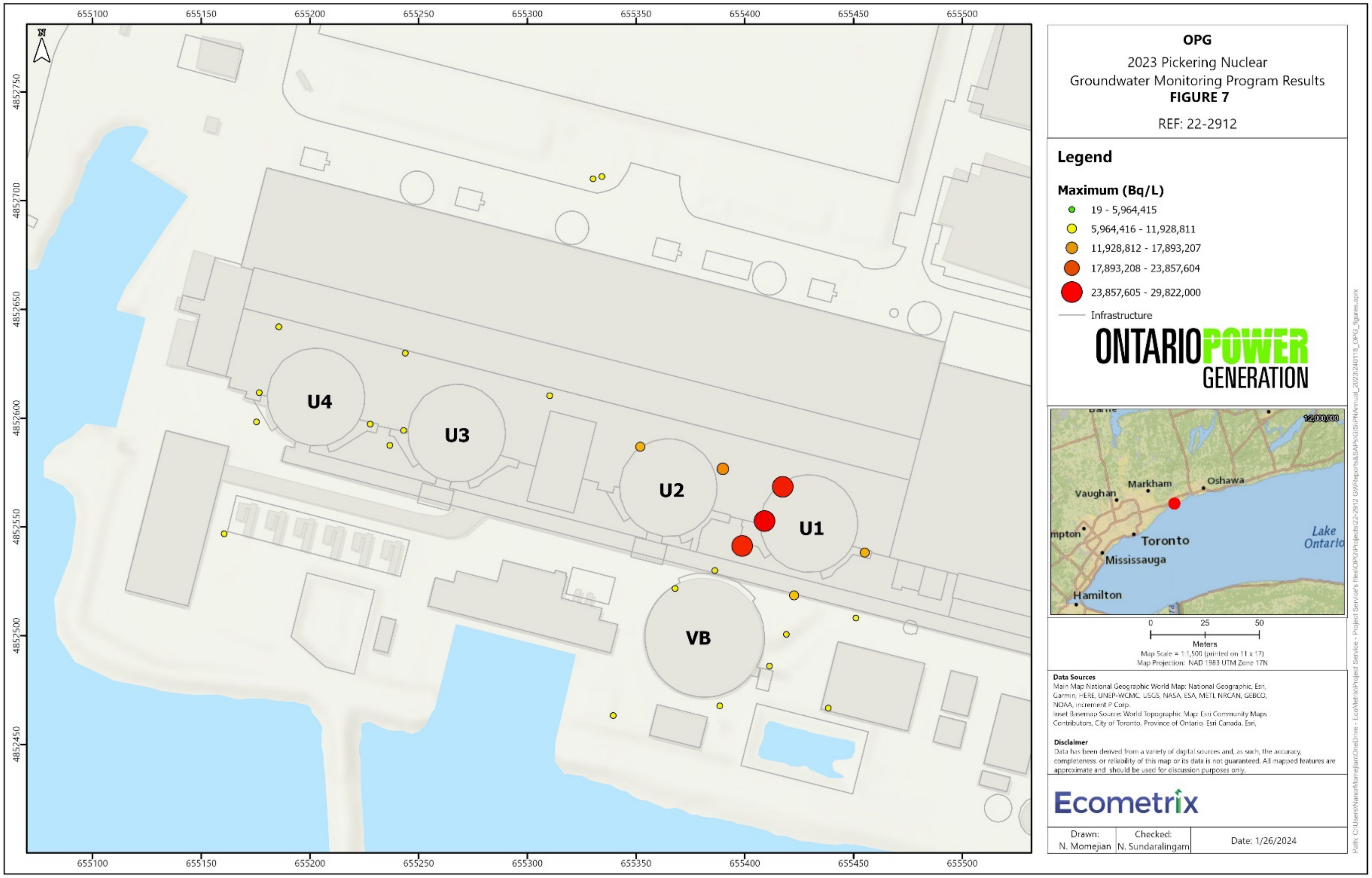
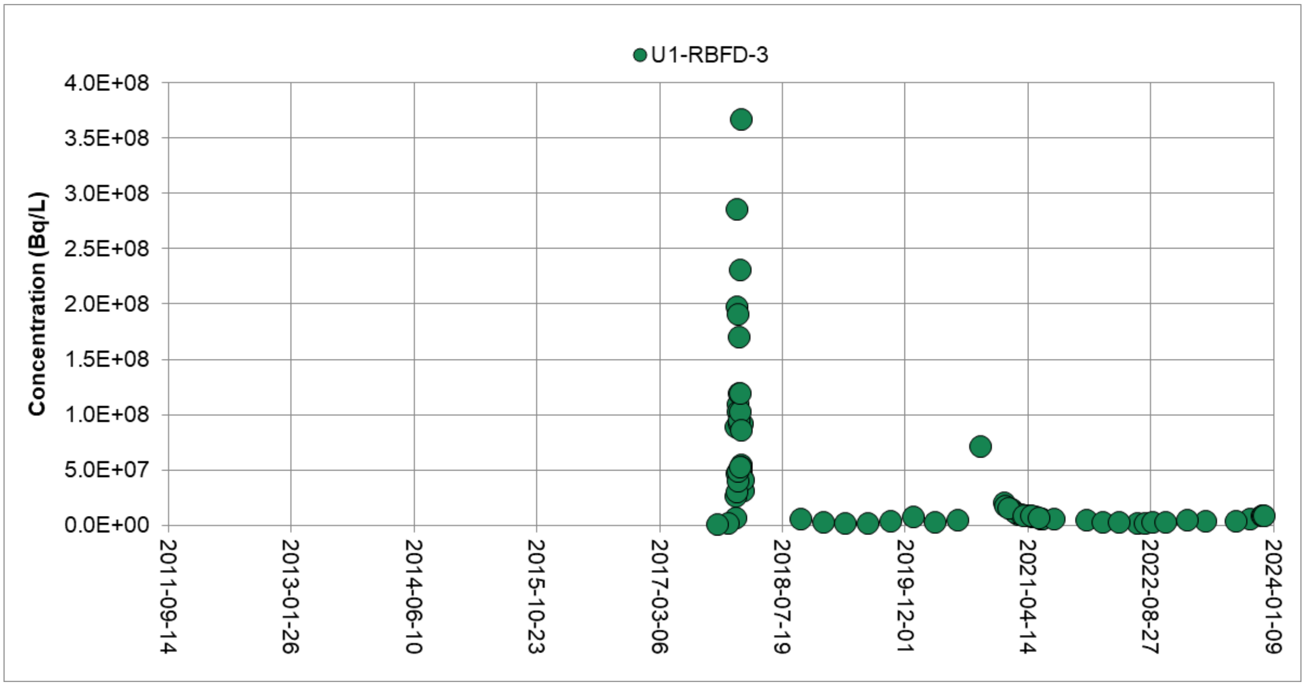
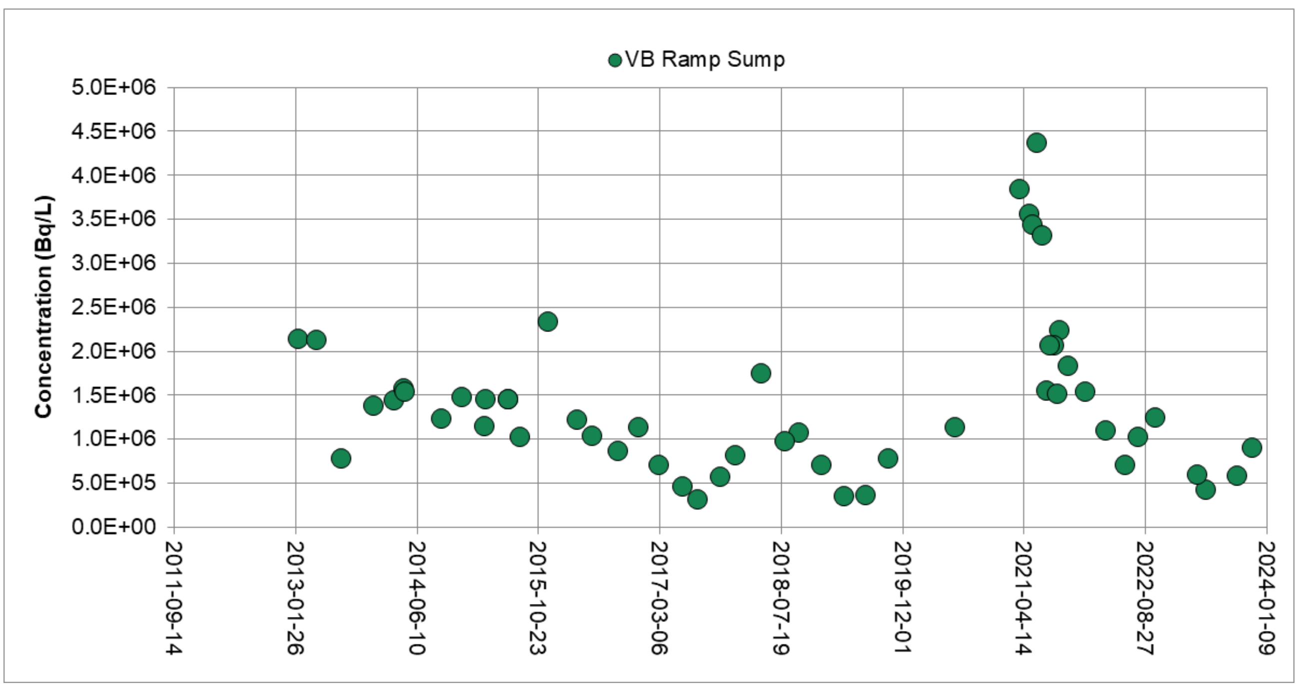


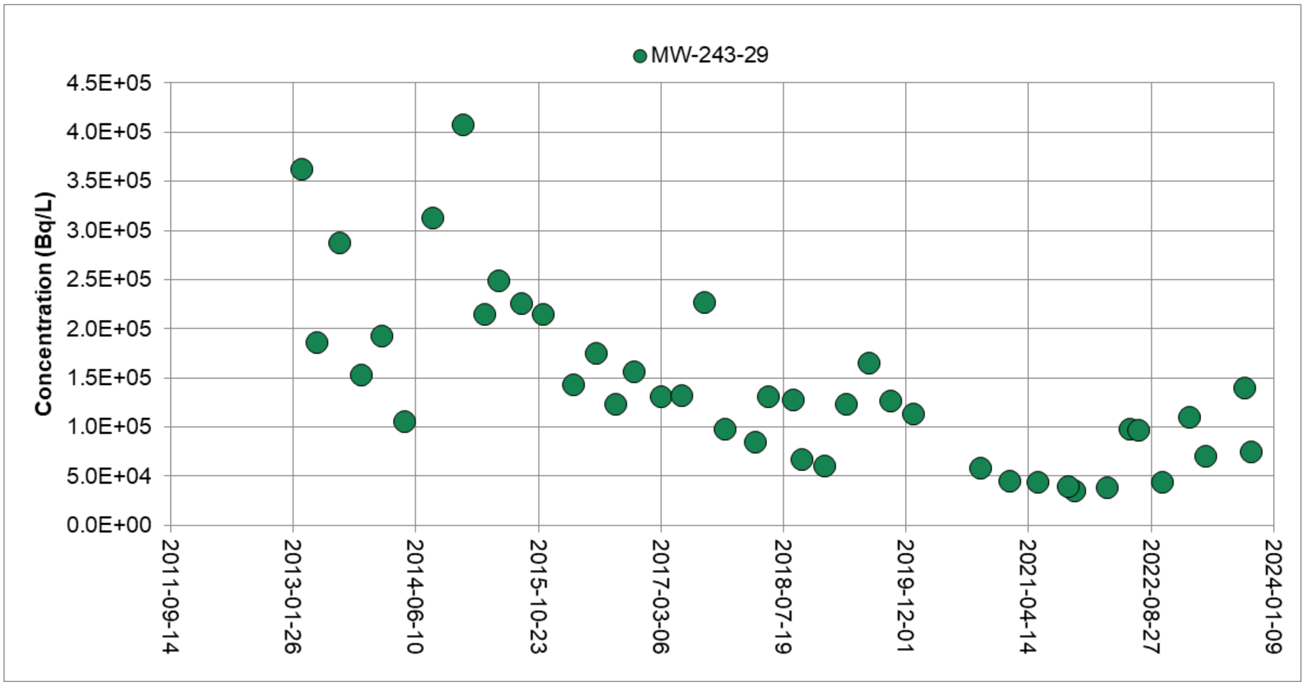
Figure 7: Maximum Tritium Concentrations in 2023 Showing Tritiated Groundwater Migration to TAB Drains and VBRS



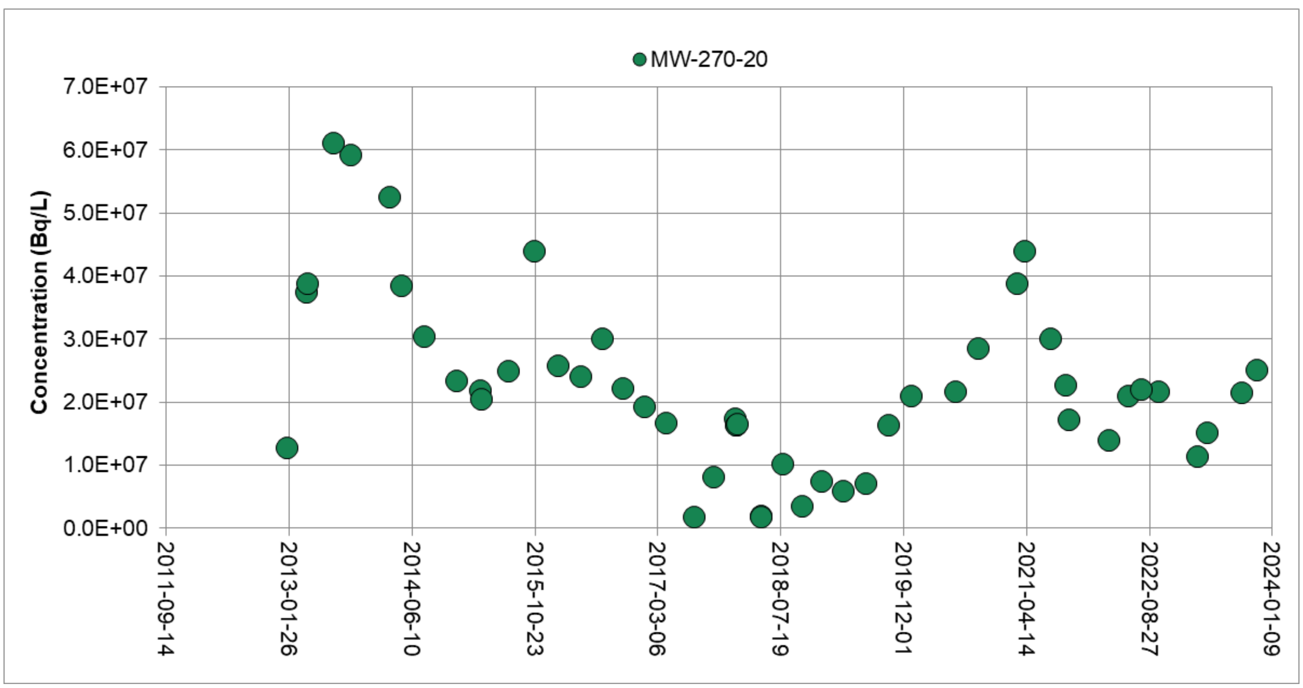
Graph 1: U1-RBFD-3 Tritium Data



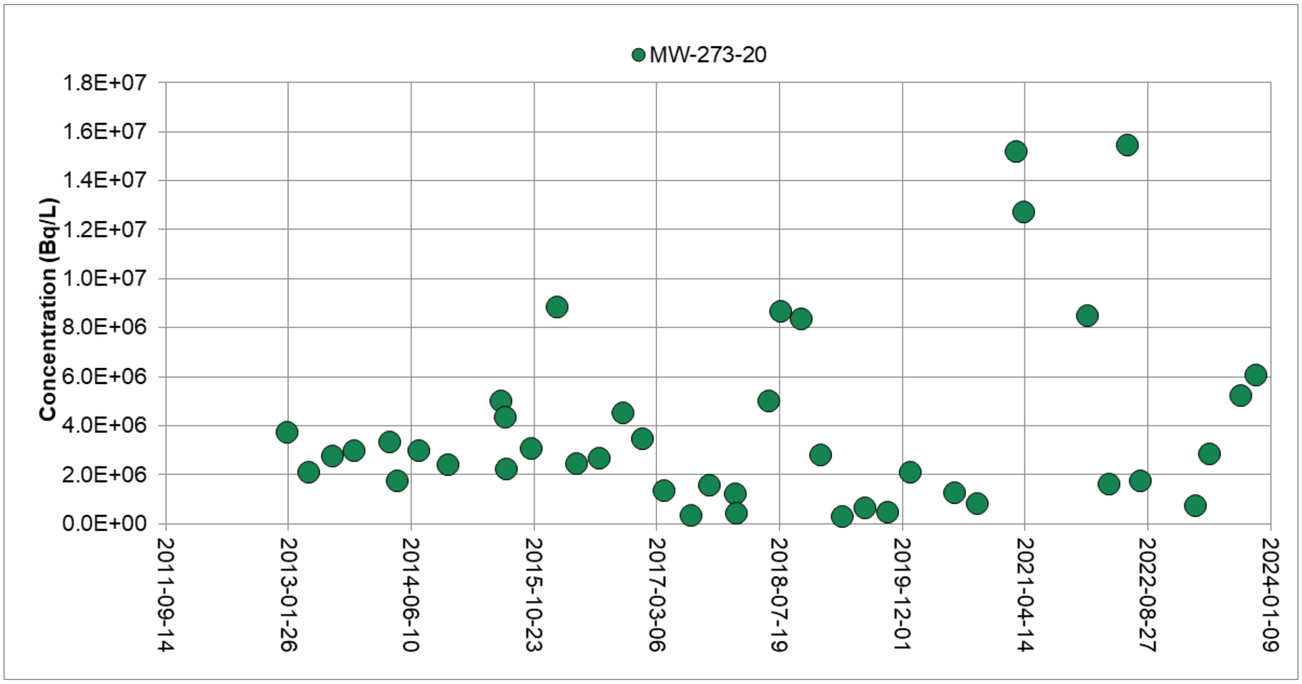
Graph 2: VBRS Tritium Data



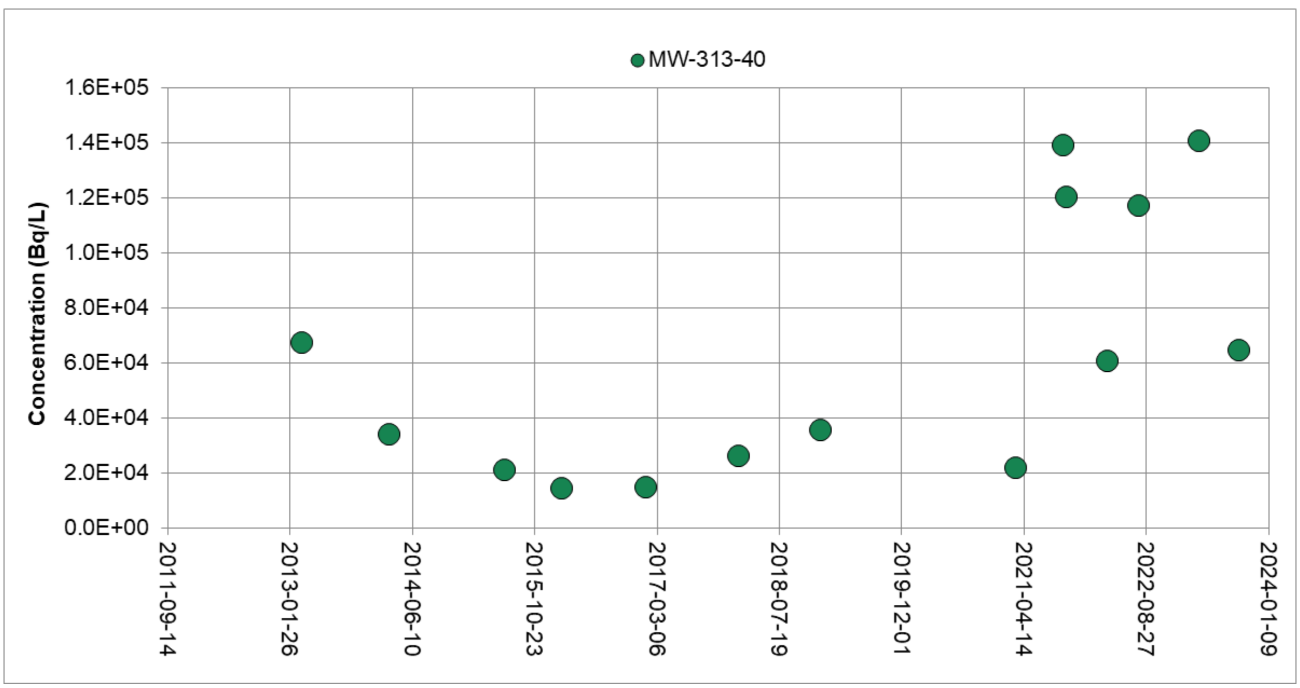
Graph 3: MW-243-29 Tritium Data



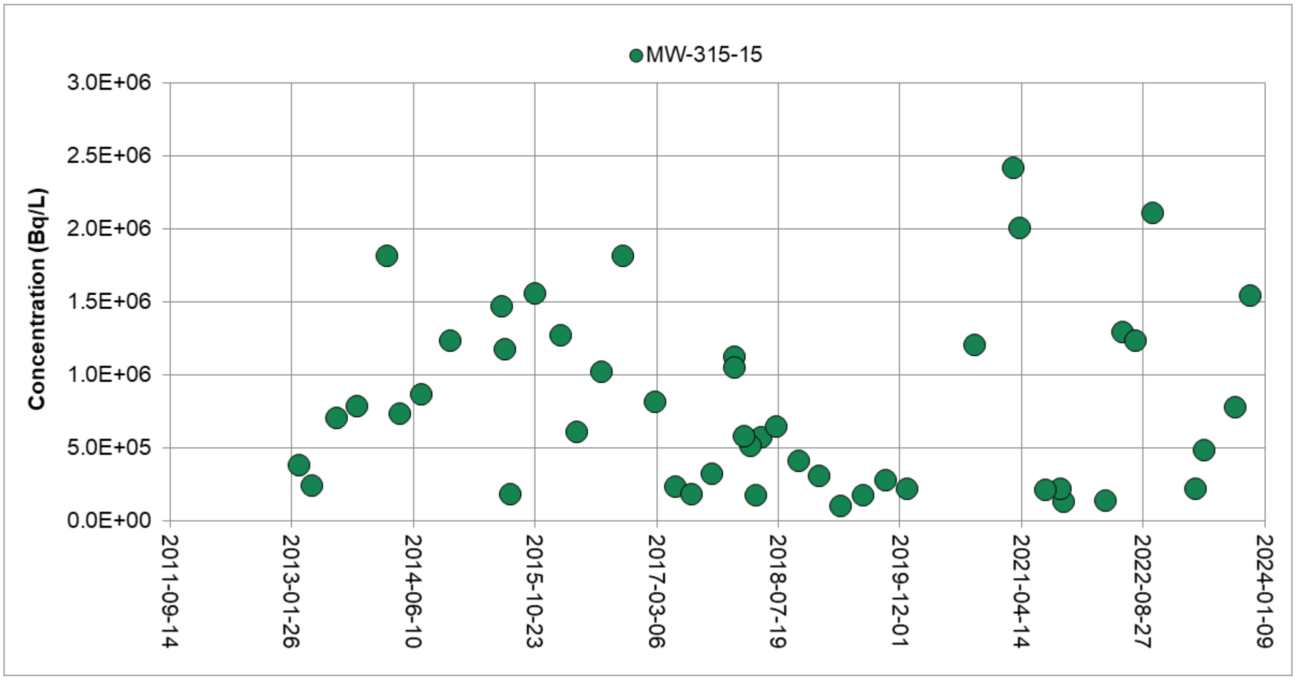
Graph 4: MW-270-20 Tritium Data



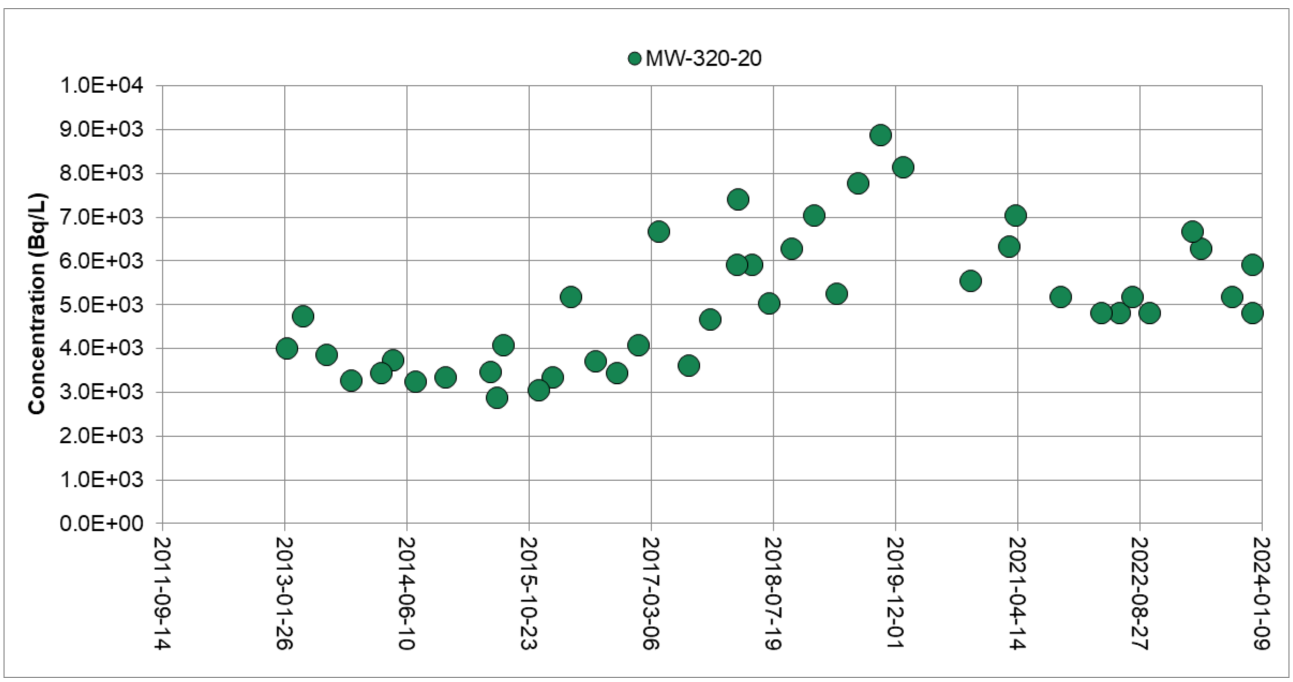
Graph 5: MW-273-20 Tritium Data



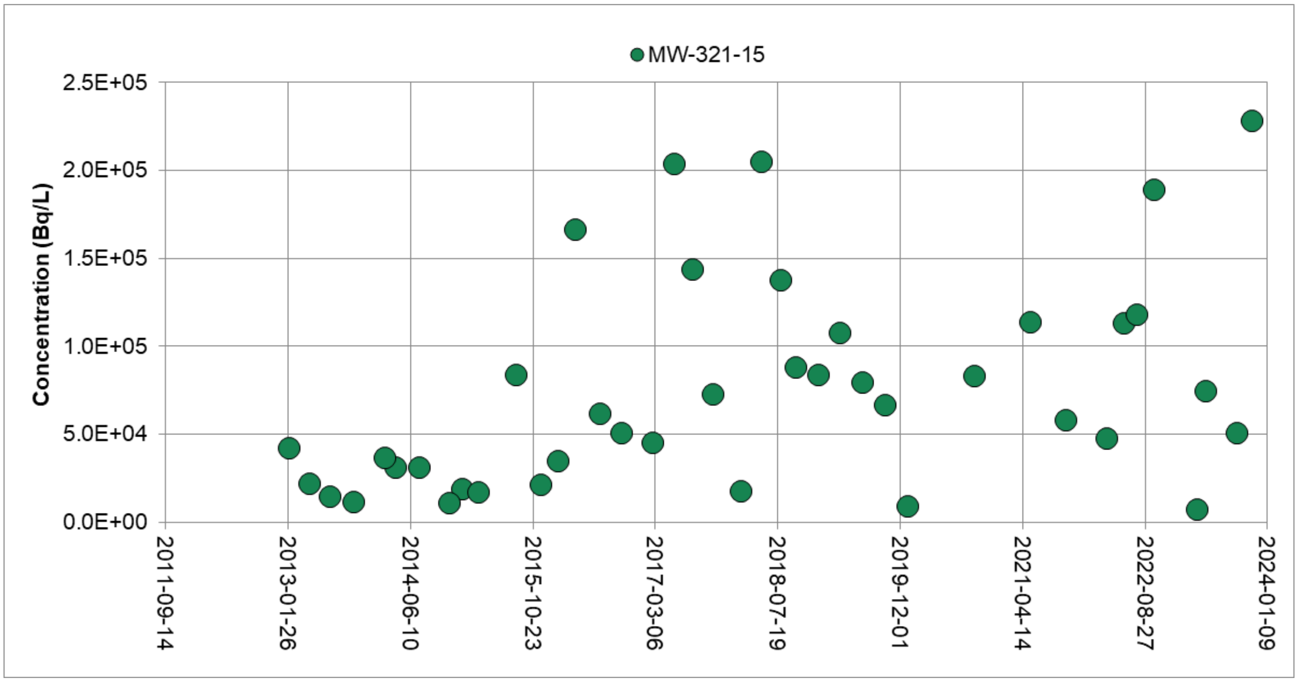
Graph 6: MW-313-40 Tritium Data



Graph 7: MW-315-15 Tritium Data



Graph 8: MW-320-20 Tritium Data

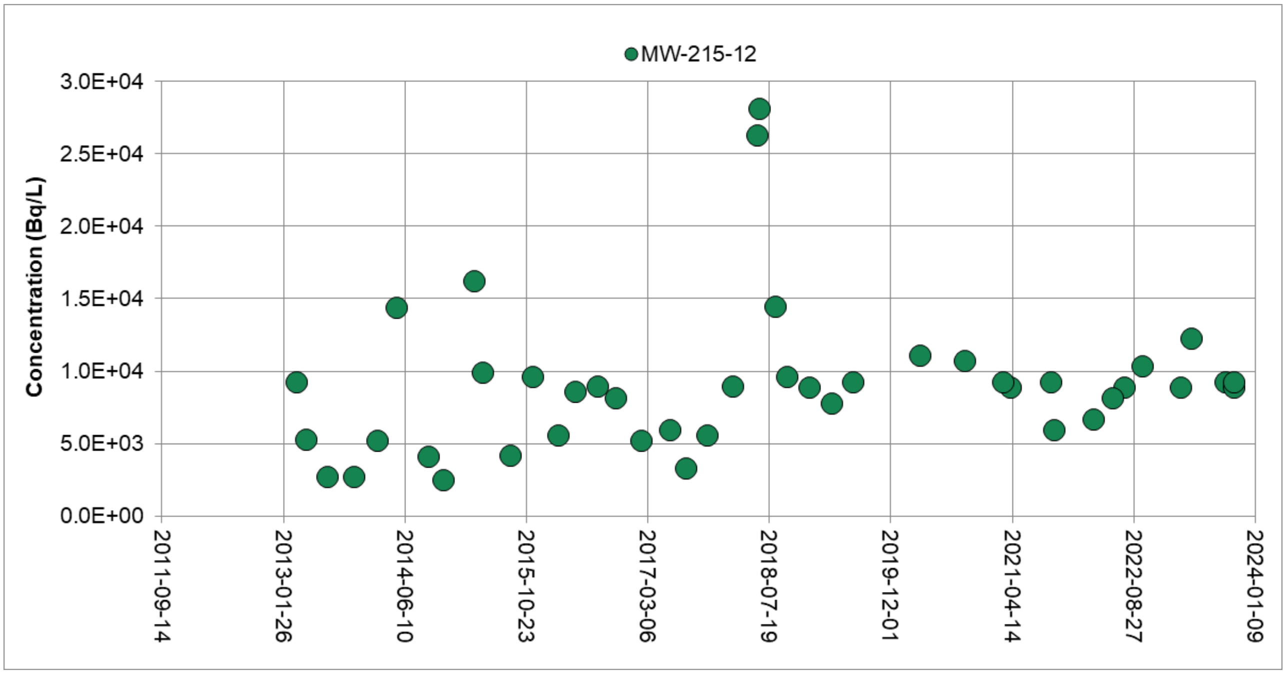


Graph 9: MW-321-15 Tritium Data

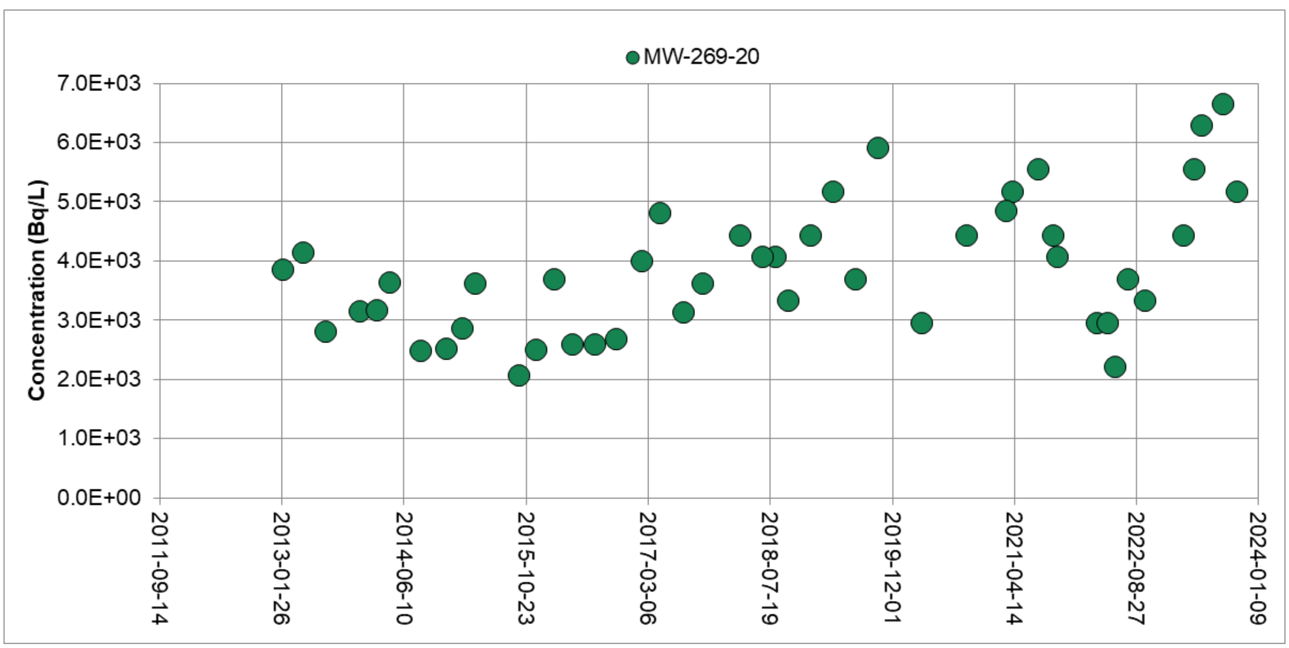
Unit 3 and 4 Area

In the Unit 3 and 4 areas, tritium concentrations at MW-269-20 (within the vicinity of Unit 4) experienced a slight fluctuation in 2023. The remaining tritium concentrations from monitoring wells and RB ground tubes near Unit 3 and 4 were within ranges that reflect routine operations at the site and were generally demonstrating decreasing, stable, or no trends. Monitoring will continue at these locations to observe the fluctuations in tritium within groundwater.

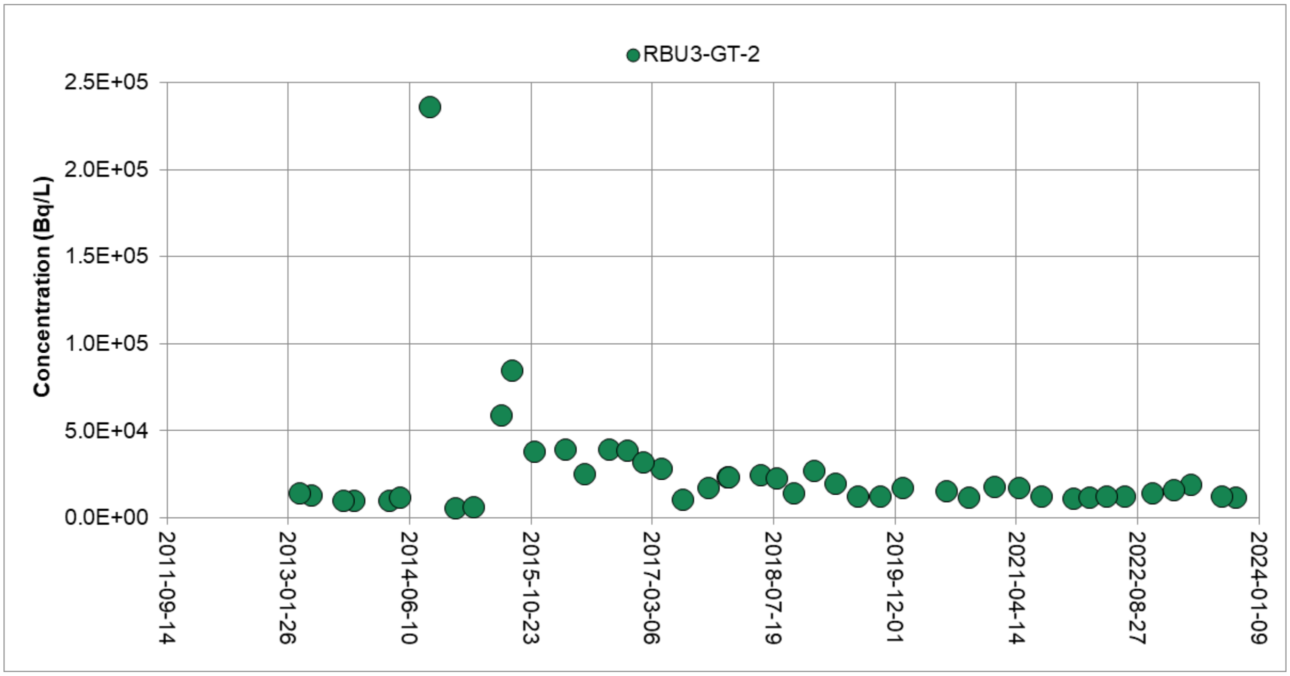
Graphs 10 to 13 illustrate the results for selected monitoring wells and ground tubes within the vicinity of Unit 3 and Unit 4.



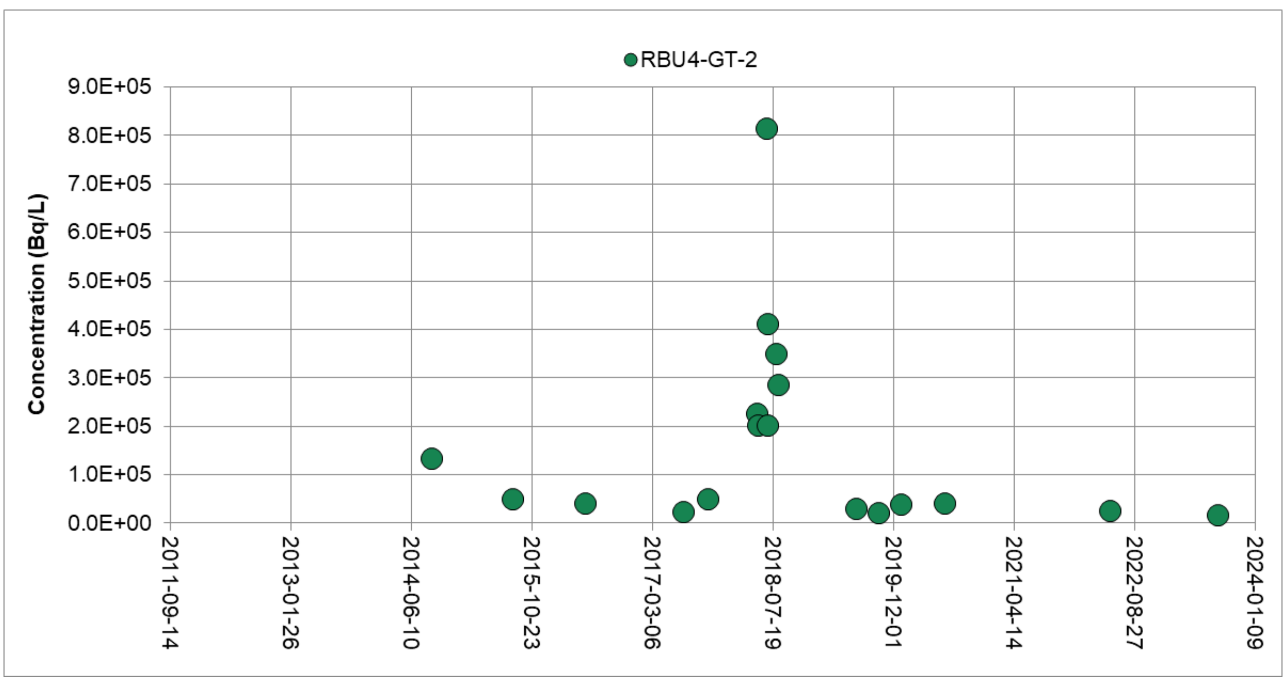
Graph 10: MW-215-12 Tritium Data



Graph 11: MW-269-20 Tritium Data



Graph 12: RBU3-GT-2 Tritium Data



Graph 13: RBU4-GT-2 Tritium Data

3.1.1.2 Unit 5 to 8 Reactor Building Area Overview

The 2023 groundwater sampling results in the area of Units 5 to 8 are presented in Table A-2 (Appendix A). Distributions of the annual maximum tritium concentrations in the area of Units 5 to 8 within HU1-3, HU 6, and HU 7 are presented in Figure 8 to Figure 10, respectively.

Key sampling locations are discussed in further detail below by specific area.

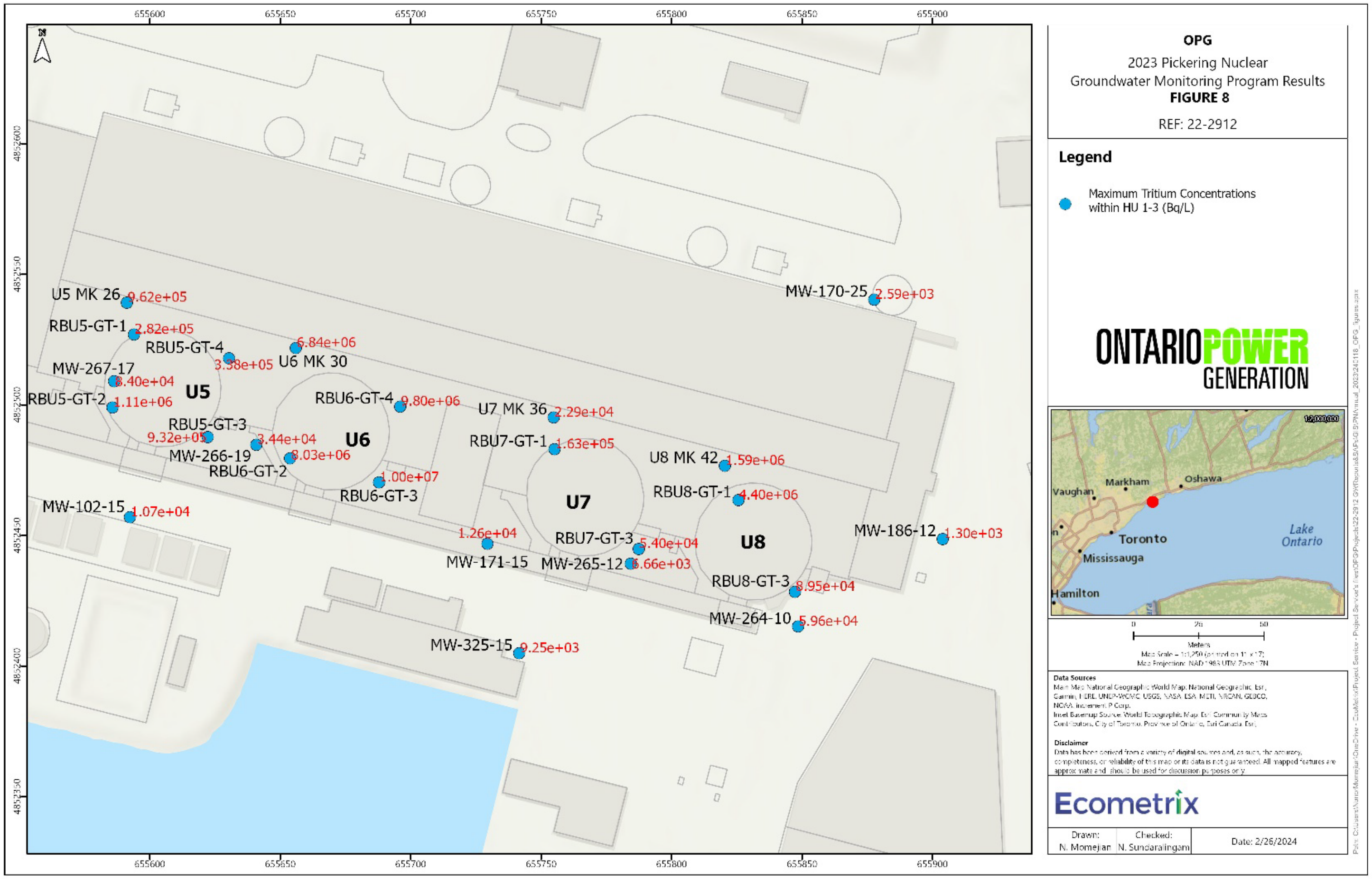


Figure 8: 2023 Annual Maximum Tritium Concentrations in HU 1-3, Unit 5 to 8, and IFB-B

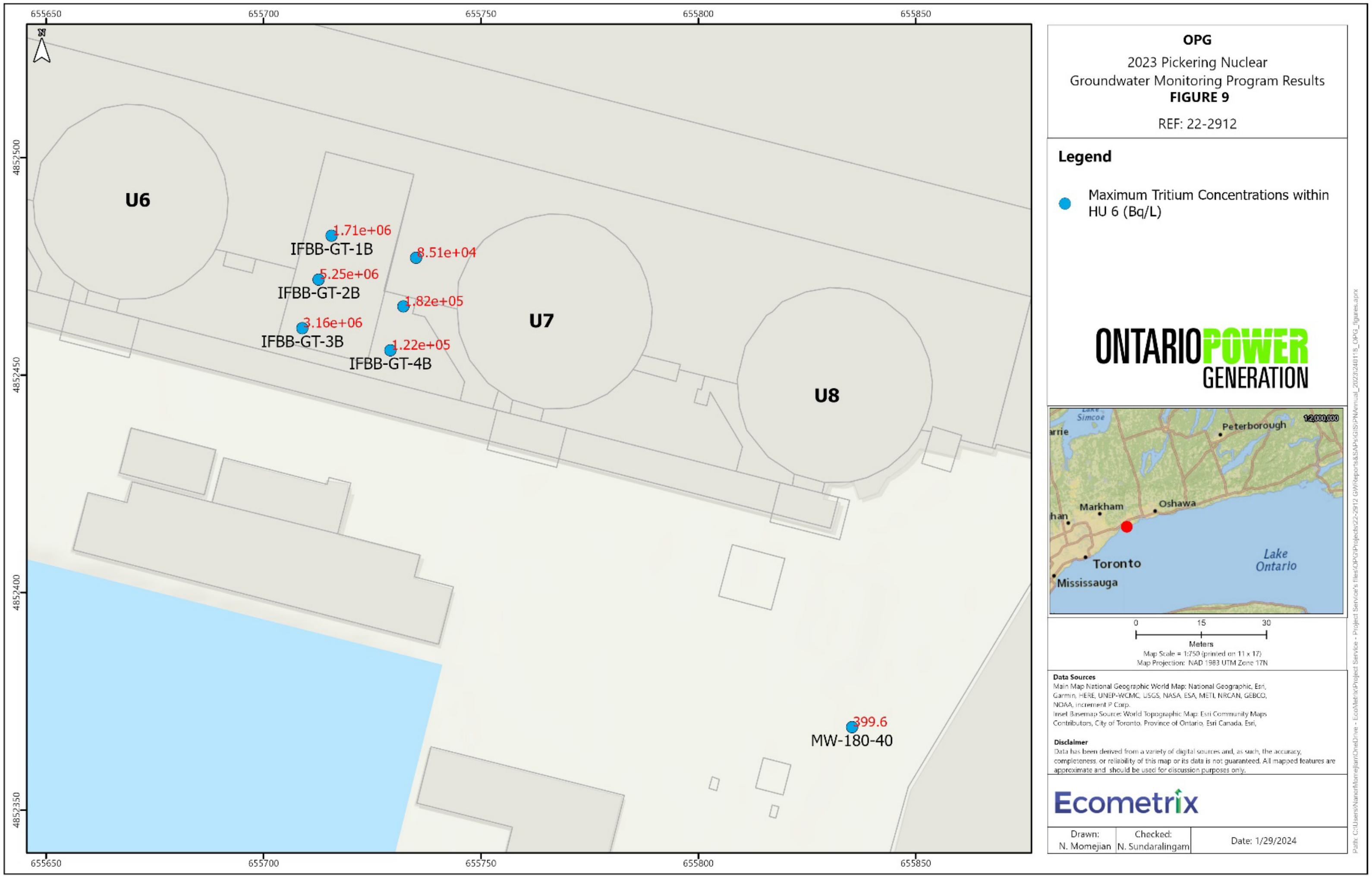


Figure 9: 2023 Annual Maximum Tritium Concentrations in HU 6, Unit 5 to 8, and IFB-B

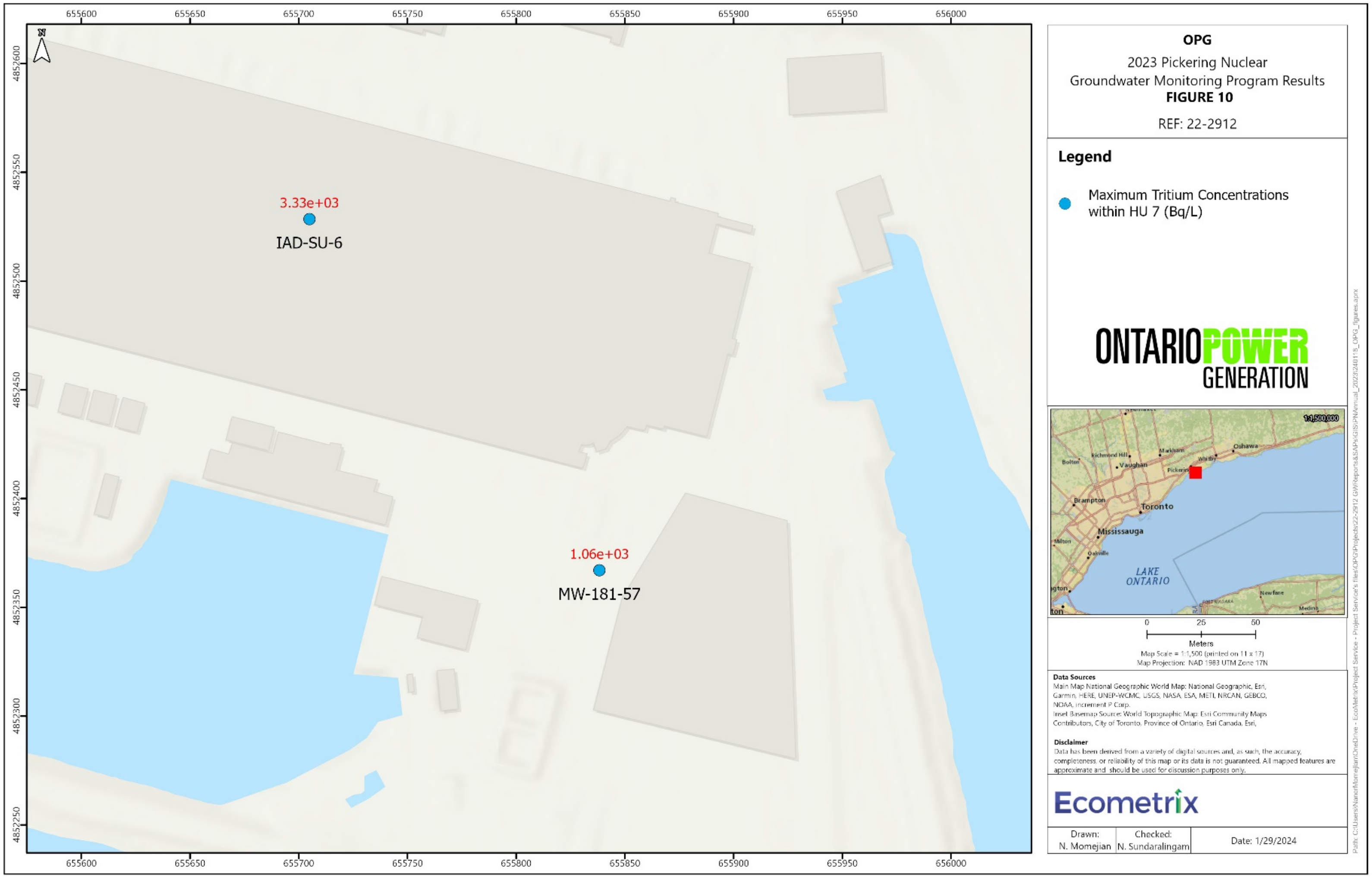
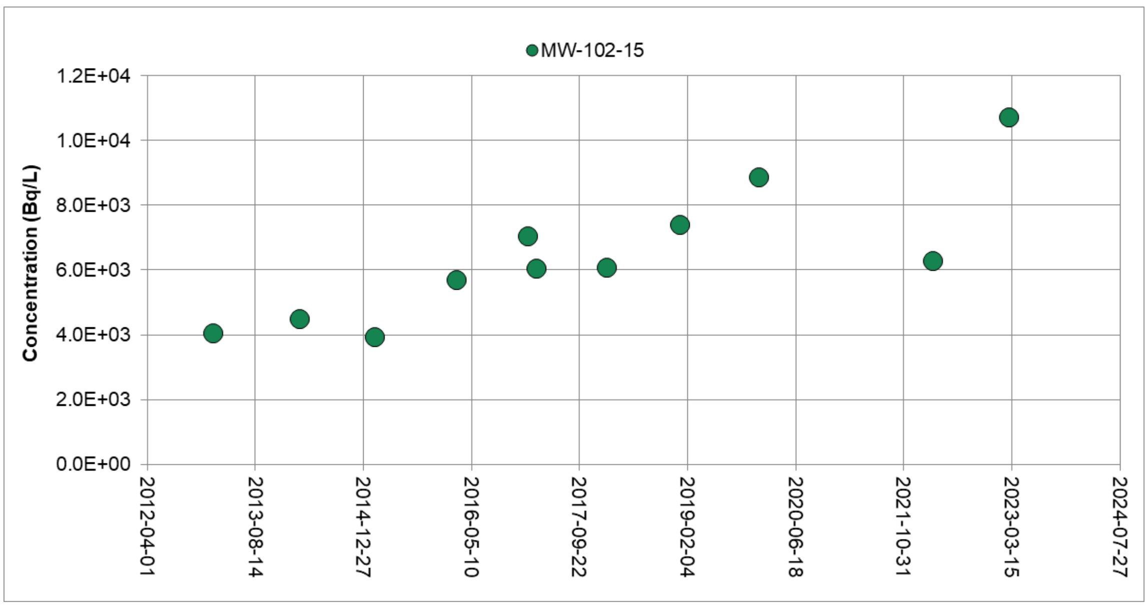


Figure 10: 2023 Annual Maximum Tritium Concentrations in HU 7, Unit 5 to 8

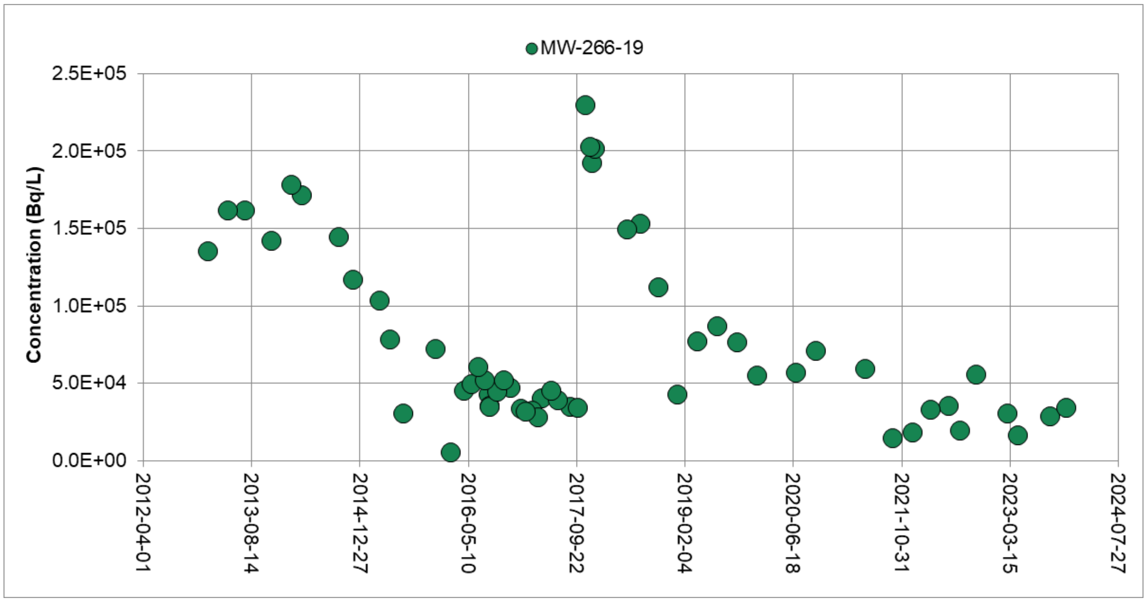
Unit 5 and Unit 6 Area

An increase in tritium concentrations was measured from MW-102-15, located south downgradient of Unit 5 and 6. However, concentrations at this well are still several orders of magnitude below the risk-based evaluation criteria applicable for the site. As such, off-site impacts to end-use are not expected based on the 2023 tritium concentrations. Further monitoring is in progress to evaluate tritium concentrations in groundwater at this well. Tritium concentrations within the remaining ground tubes, RB foundation drain sumps, and monitoring wells are within historical concentrations reflective of routine operations. Groundwater in these locations will continue to be monitored.

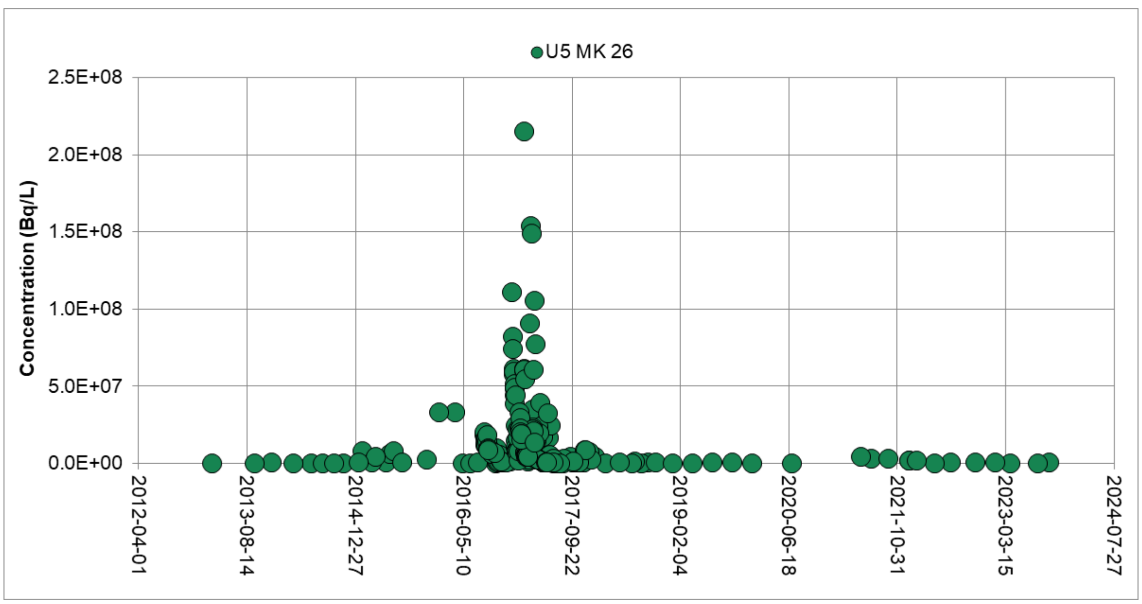
Graphs 14 to 21 present data from MW-102-15, the Unit 5 and 6 RB foundation drains, selected groundtubes (RBU5-GT-1 to RBU5-GT-4), and MW-267-17.



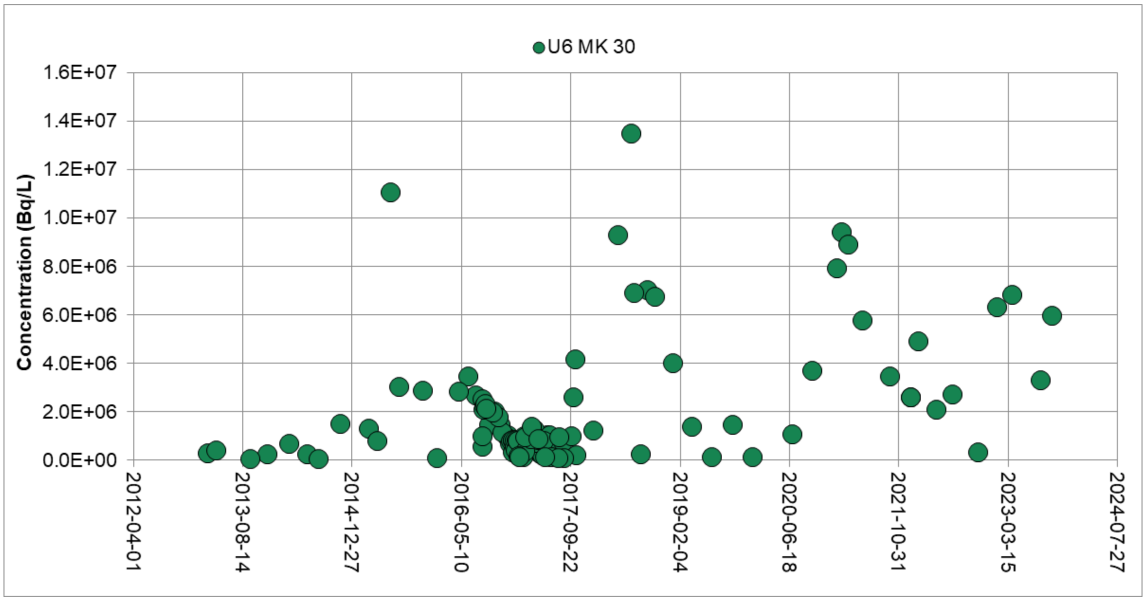
Graph 14: MW-102-15 Tritium Data



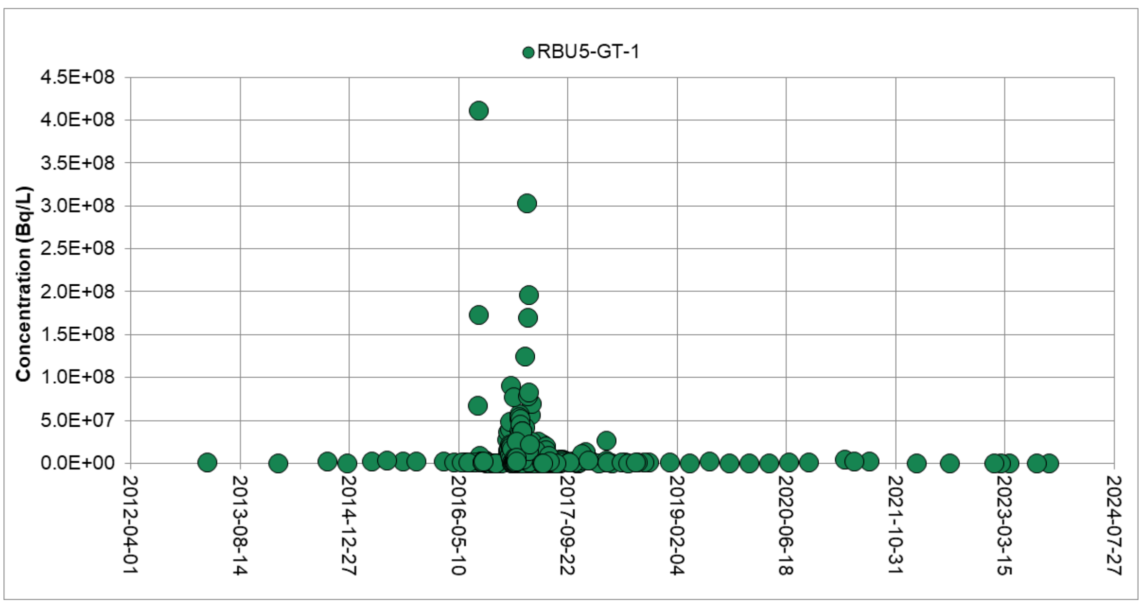
Graph 15: MW-266-19 Tritium Data



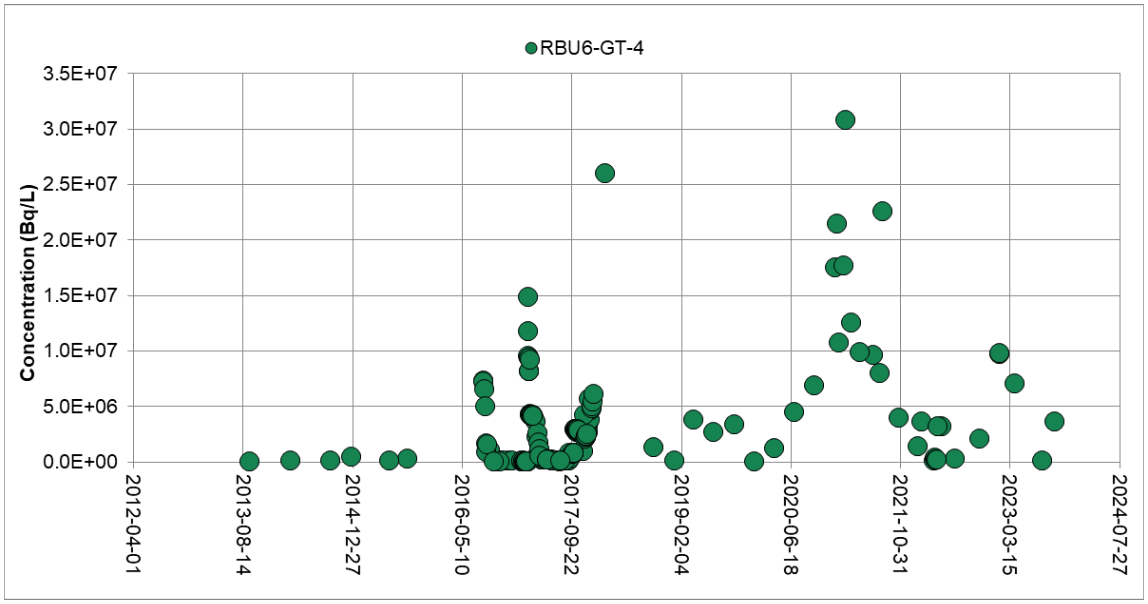
Graph 16: U5 MK26 Tritium Data



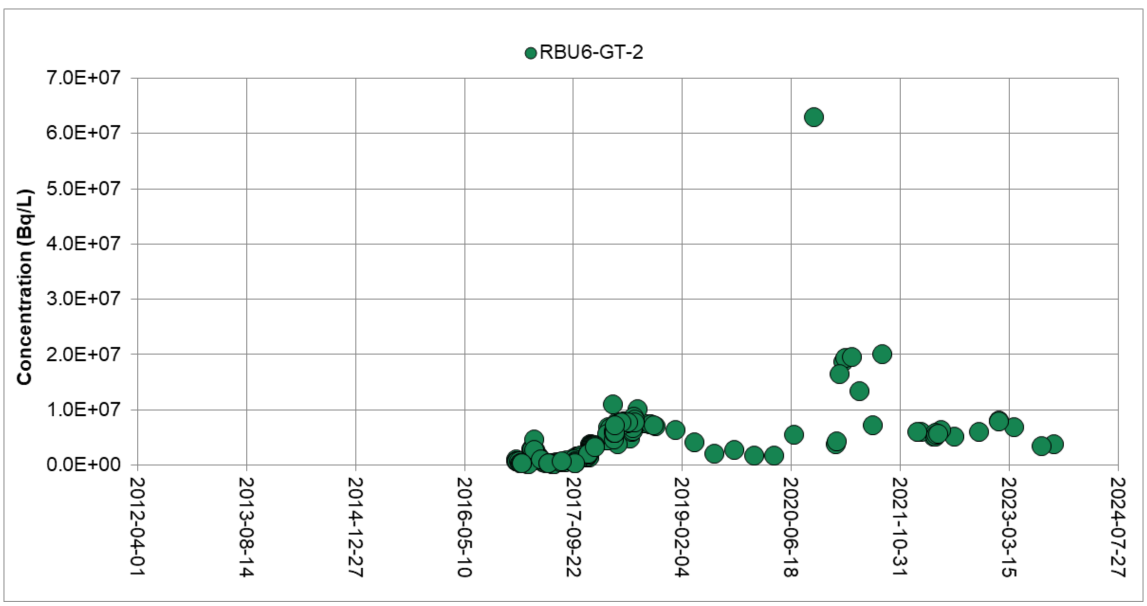
Graph 17: U6 MK30 Tritium Data



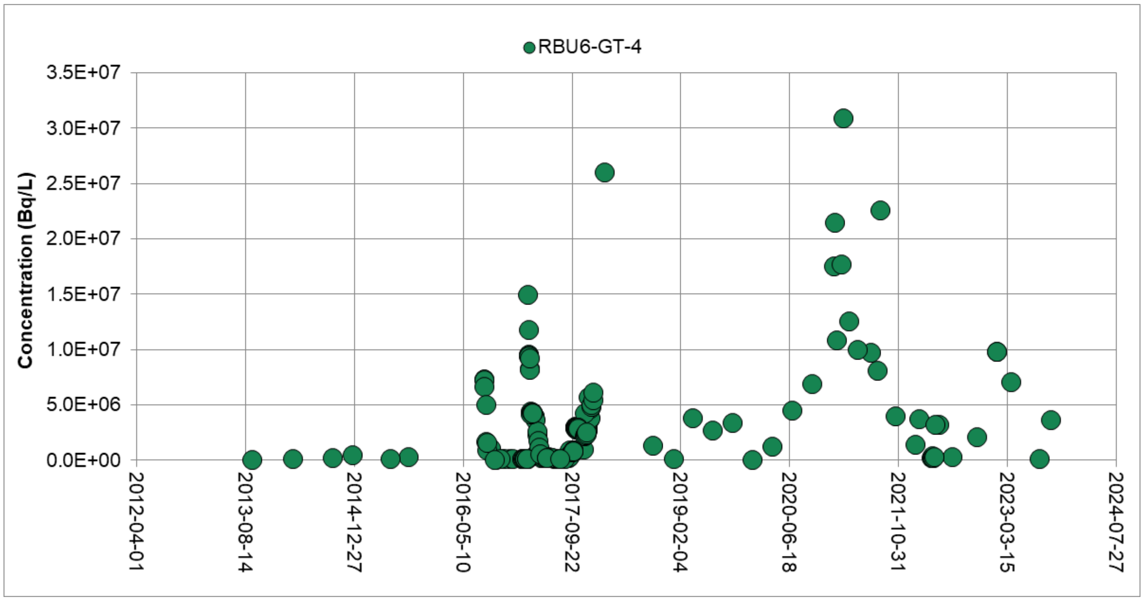
Graph 18: RBU5-GT-1 Tritium Data



Graph 19: RBU5-GT-4 Tritium Data



Graph 20: RBU6-GT-2 Tritium Data

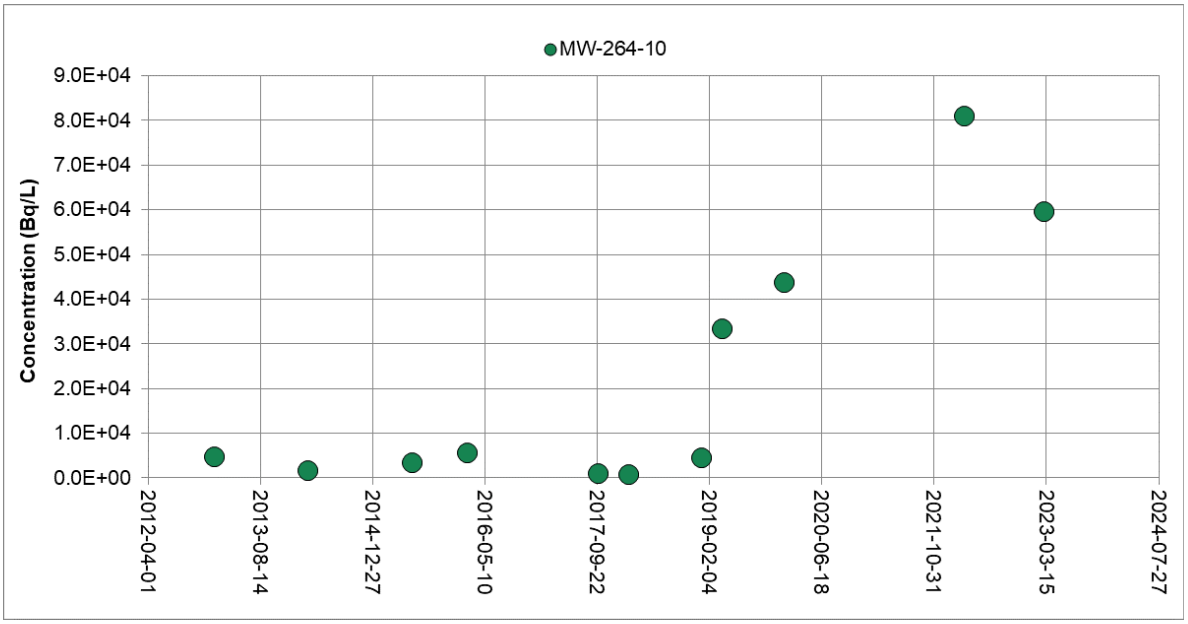


Graph 21: RBU6-GT-4 Tritium Data

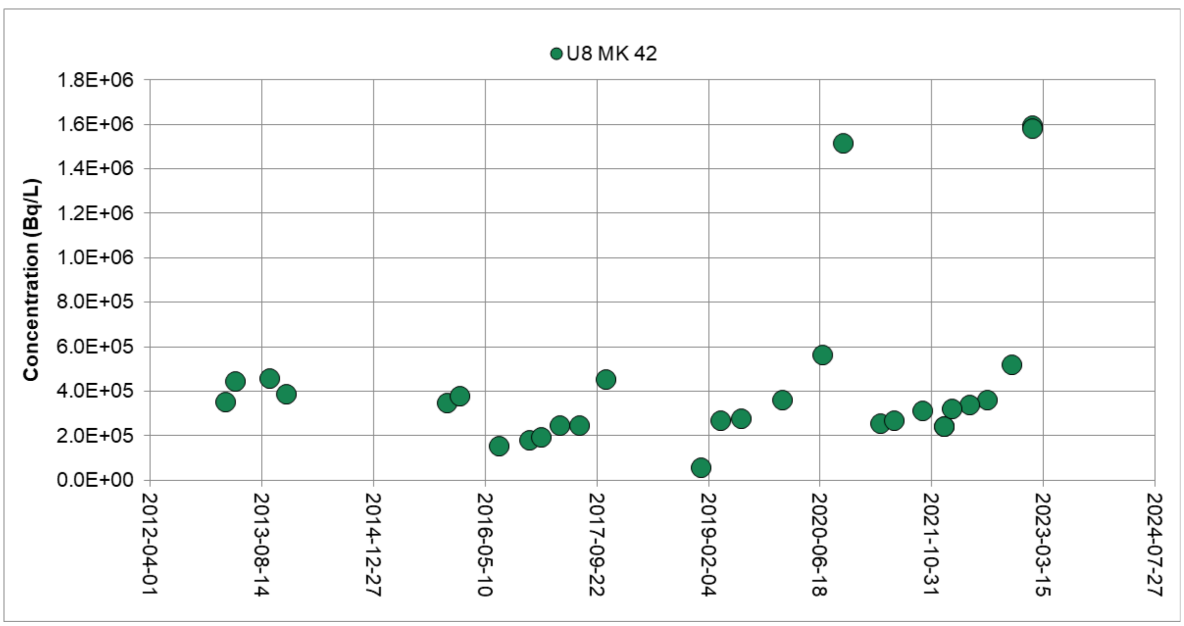
Unit 7 and 8 Area

In 2023, an increase in tritium concentrations was noted in monitoring well MW-264-10, located southeast of Unit 8. Samples collected in MW-264-10 in Q1 2024 indicate that the tritium concentration had returned to 2019 ranges. Slightly elevated concentrations were also observed at RB foundation drain sump U8 MK 42. The tritium concentrations from the Unit 7 and 8 ground tubes as well as the remaining wells monitored within the Unit 7 and 8 area remain within a range considered to reflect fluctuations associated with routine operations. Groundwater in the Unit 8 area will continue to be monitored. Tritium concentrations in groundwater downgradient of Unit 8 (MW-180-40, MW-181-57, MW-183-10, MW-184-27, and MW-185-39) have increased in 2023 compared to 2022; however, concentrations are several orders of magnitude below the numerical evaluation criteria for the site and groundwater at the shoreline is not expected to pose a risk to groundwater end-uses.

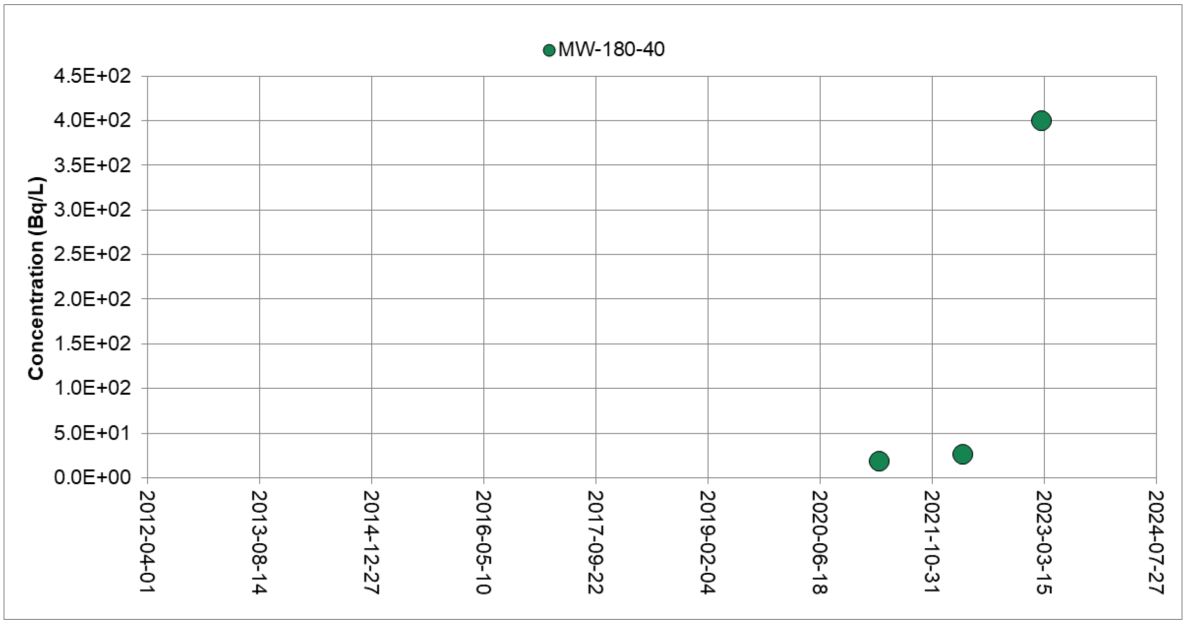
Graphs 22 to 25 illustrate the data for RBU7-GT-1, RBU7-GT-3, U7 MK36, MW-265-12, and MW-325-15.



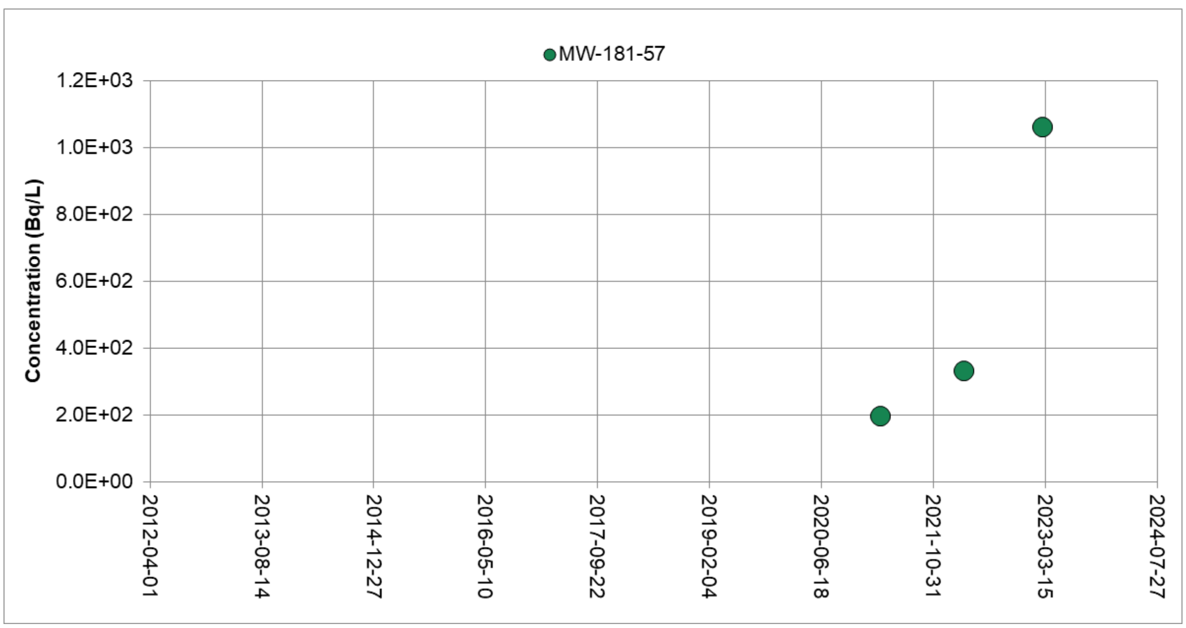
Graph 22: MW-264-10 Tritium Data



Graph 23: U8 MK42 Tritium Data



Graph 24: MW-180-40 Tritium Data



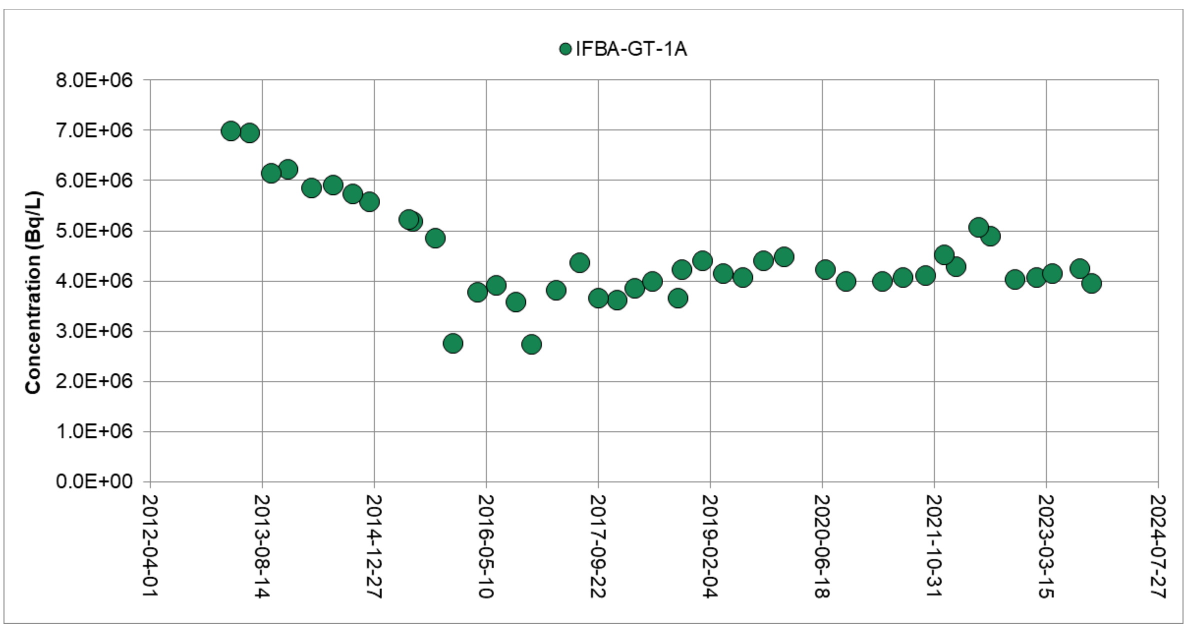
Graph 25: MW-181-57 Tritium Data

3.1.1.3 Irradiated Fuel Bay Areas

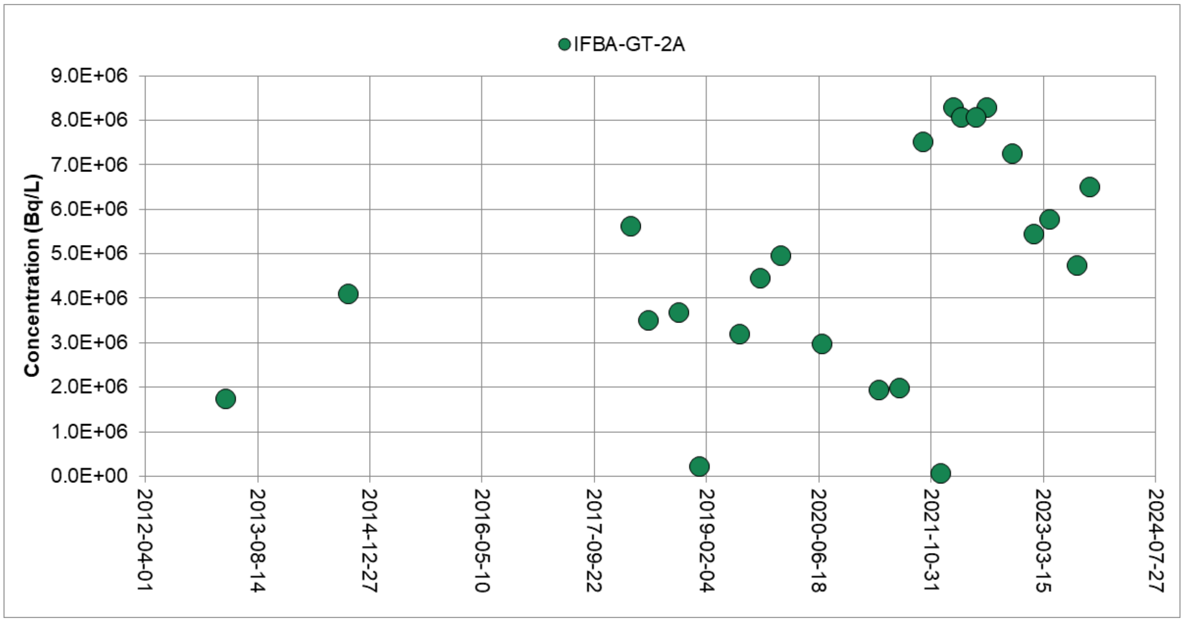
IFB-A

In 2023, the eastern groundtubes (IFBA-GT-1A and IFBA-GT-2A) showed higher tritium concentrations compared to IFBA-GT-4A and IFBA-GT-5A to the west. Monitoring wells MW-244-18 and IFBA-GT-2A in the vicinity of the IFBs, demonstrated increasing trends. Increased tritium concentrations within the eastern IFBs and MW-244-18 are expected as groundwater in the Unit 1 area migrates towards the Units 1 to 4 IFB-A and TAB foundation drains, in addition to the VBRS. The increased tritium concentrations are interpreted as the western edge of the tritium plume associated with the 2020 heavy water release originating in the Unit 1 area, extending towards the IFB-A, and may continue to increase for a period to reflect the migrating tritiated groundwater plume from the spill identified in November 2023. Groundwater in the protected area eventually flows north towards the low-lying TAB sumps, which are eventually discharged via a monitored pathway.

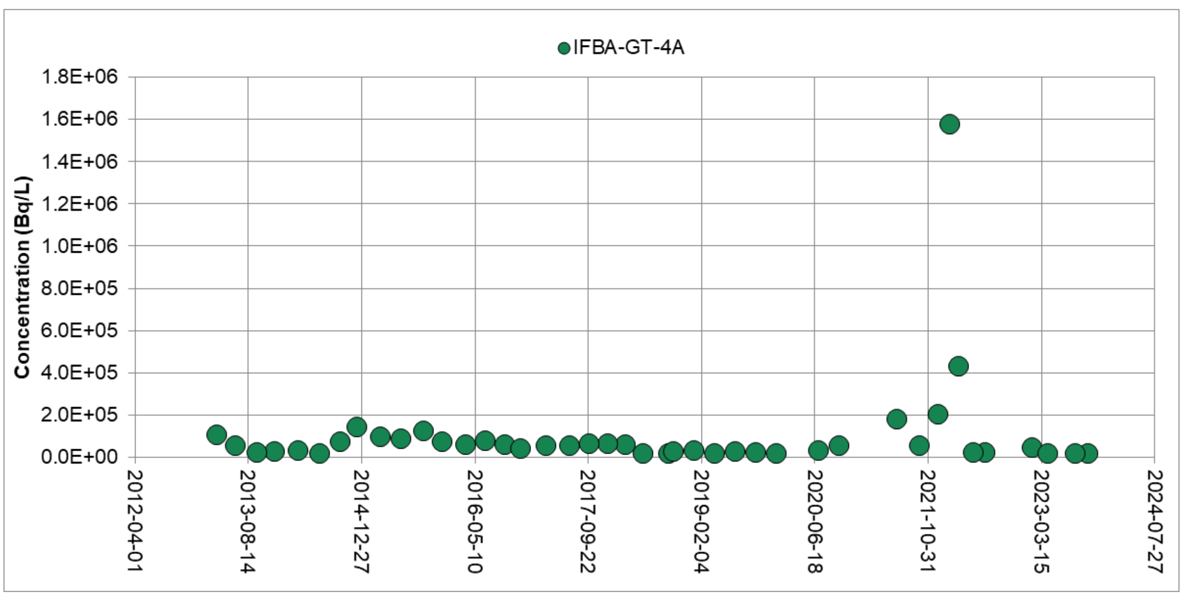
Tritium concentrations over time for the IFB-A ground tubes and MW-244-18 are presented in Graph 26 to 30. The 2023 tritium sample results are presented in Table A-3 (Appendix A). Figure 11 and Figure 12 also display the annual maximum tritium distributions of Unit 1 to 4 IFBs in HU 1-3 and HU 6, respectively.



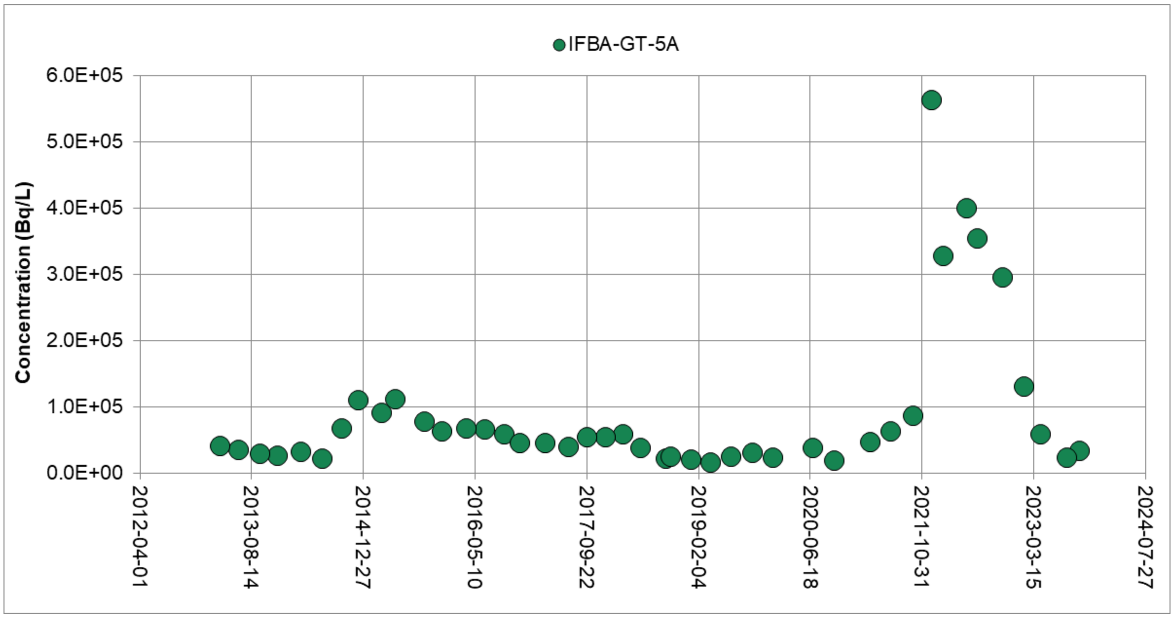
Graph 26: IFBA-GT-1A Tritium Data



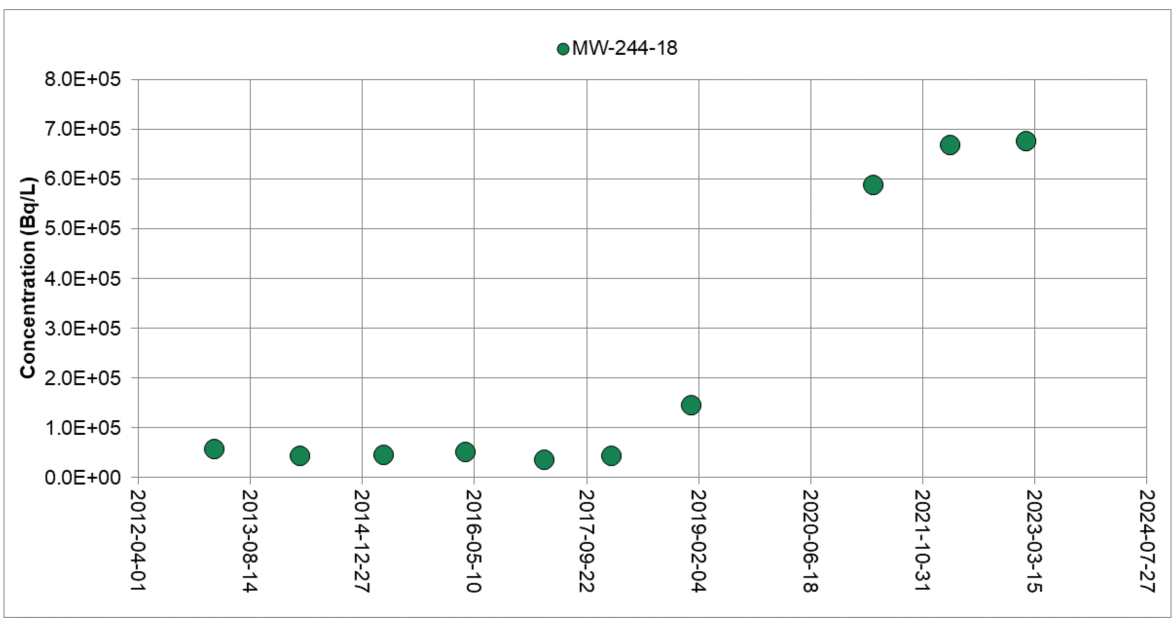
Graph 27: IFBA-GT-2A Tritium Data



Graph 28: IFBA-GT-4A Tritium Data



Graph 29: IFBA-GT-5A Tritium Data



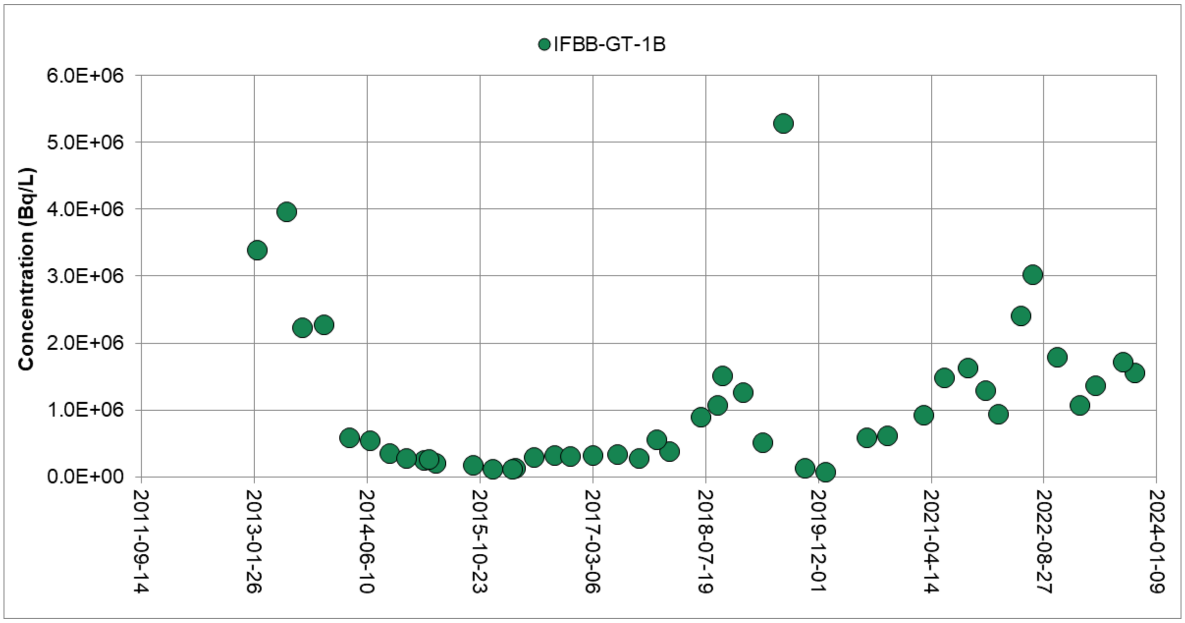
Graph 30: MW-244-18 Tritium Data

IFB-B

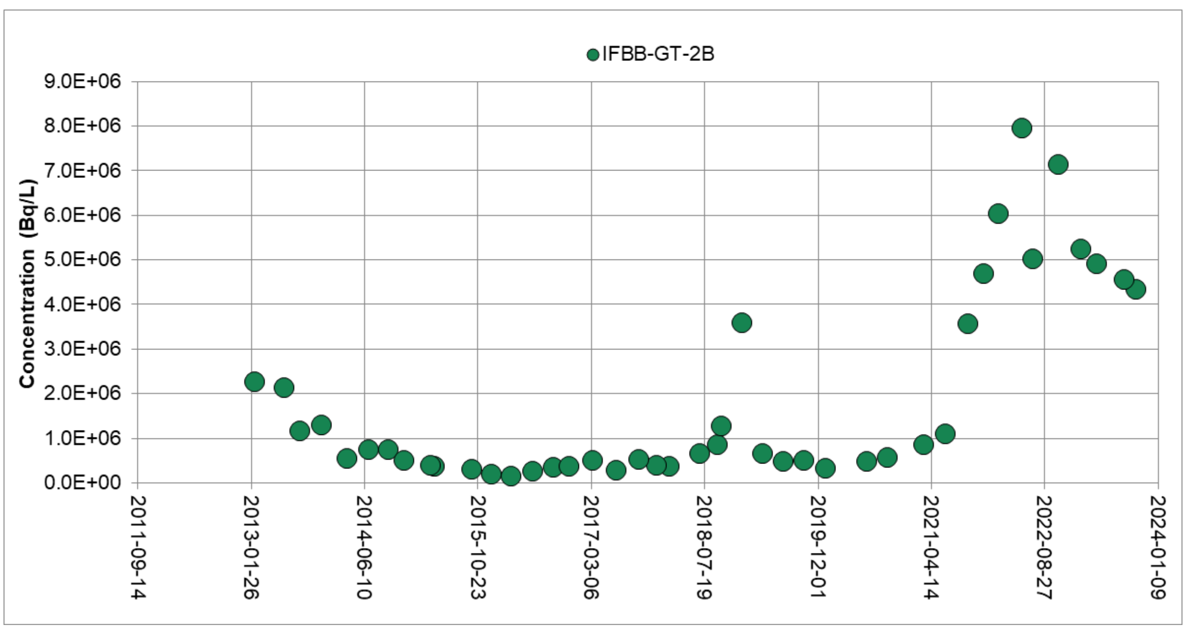
The groundwater results collected from sampling locations in the Irradiated Fuel Bay area located between Units 6 and 7 (IFB-B) are described below.

In 2023, tritium concentrations in the western groundtubes (IFBB-GT-1B, IFBB-GT-2B, and IFBB-GT-3B) decreased relative to 2022. Monitoring wells MW-171-15 and MW-172-25 located further south of Units 5-8 continued to show tritium concentrations within historical ranges reflective of routine operations. In addition, tritium concentrations in each of the eastern groundtubes (IFBB-GT-4B, IFBB-GT-5B, and IFBB-GT-6B) demonstrate decreasing or stable trends. A review of the available groundwater flow conditions suggests groundwater moves from Unit 6, beneath the IFB-B area and ultimately towards the TAB inactive drainage (IAD) sumps. The recent increases in tritium concentrations in the western groundtubes within the IFB-B area are likely related to the elevated concentrations observed in Unit 5 and 6 groundtubes. However, the tritium concentrations within the western IFB-B groundtubes are still within historical range. Groundwater quality in this area will continue to be monitored.

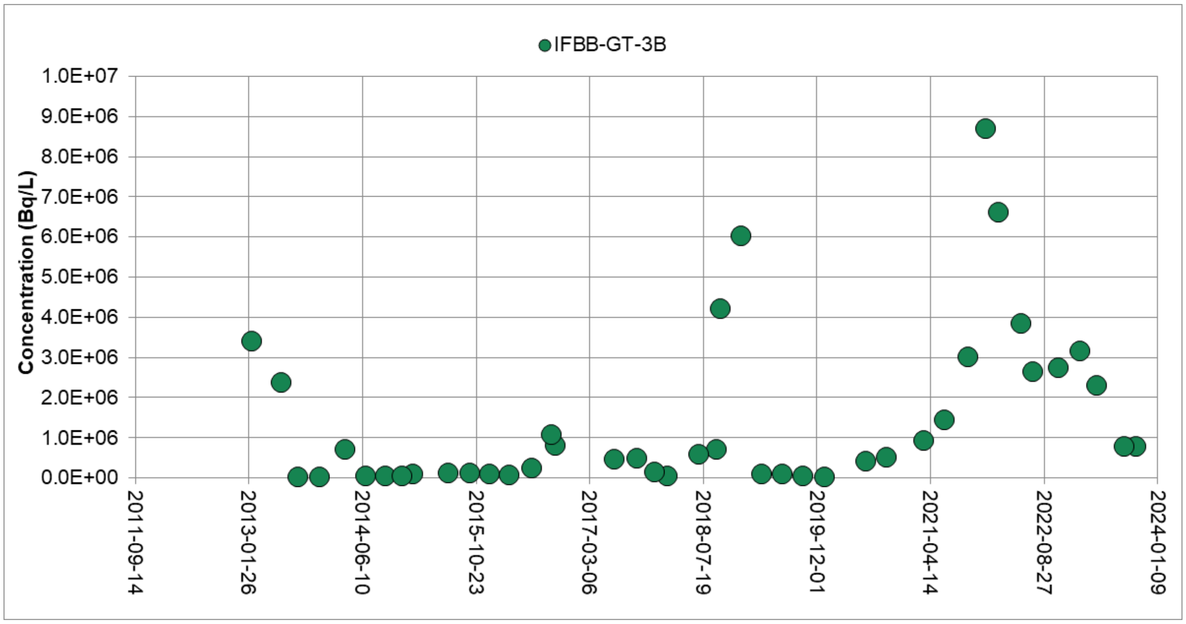
Tritium concentrations over time for the IFB-B groundtubes and monitoring wells are presented in Graphs 31 to 36. The 2023 tritium sample results are presented in Table A-3 (Appendix A). Figure 13 also displays tritium distributions of the Unit 5 to 8 IFBs in HU 6.



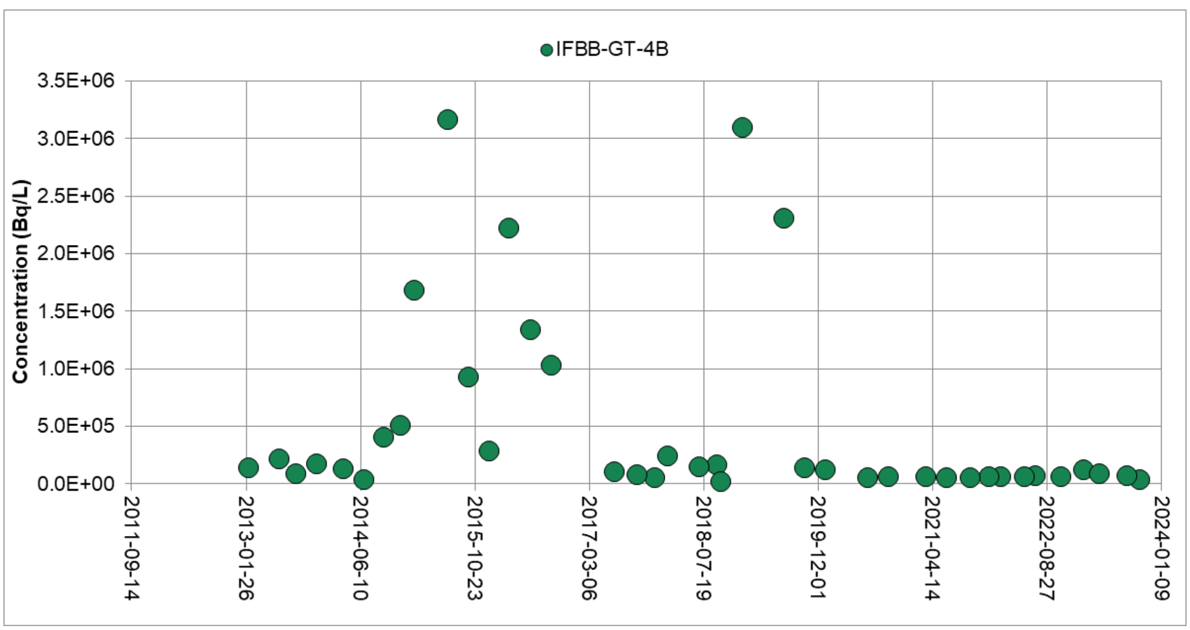
Graph 31: IFBB-GT-1B Tritium Data



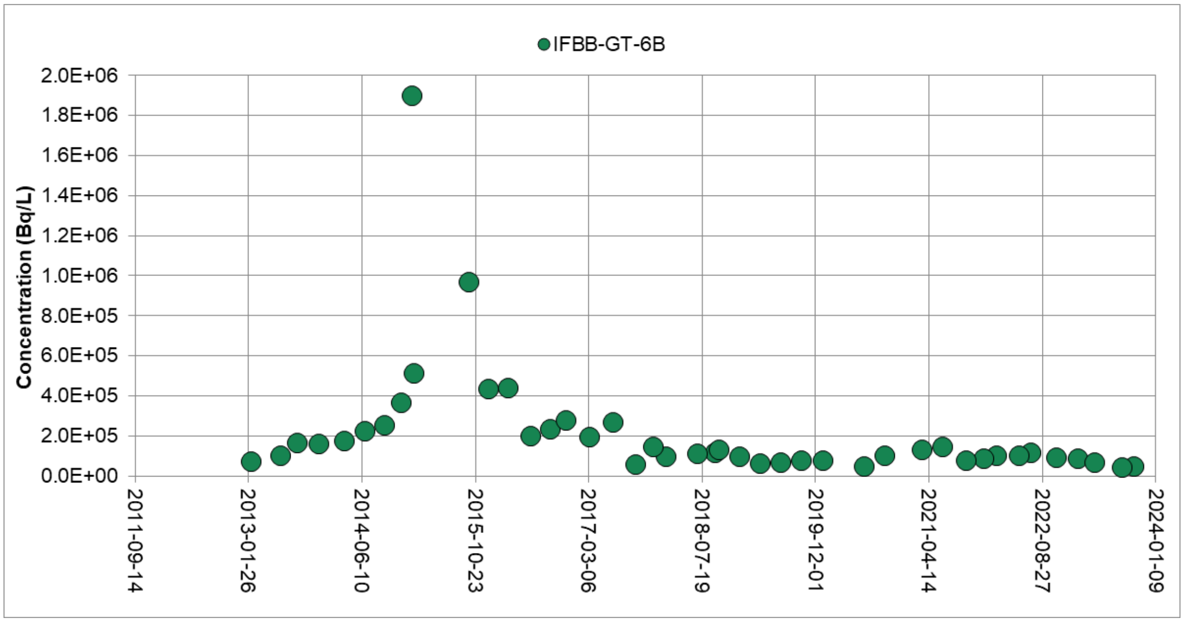
Graph 32: IFBB-GT-2B Tritium Data



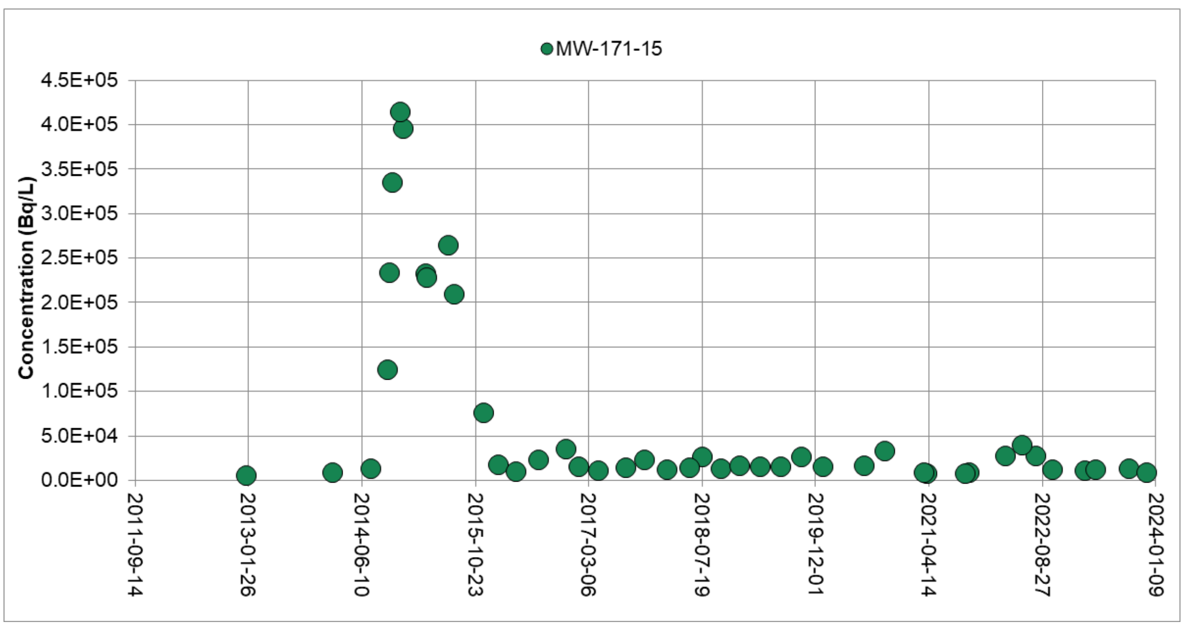
Graph 33: IFBB-GT-3B Tritium Data



Graph 34: IFBB-GT-4B Tritium Data



Graph 35: IFBB-GT-6B Tritium Data



Graph 36: MW-171-15 Tritium Data

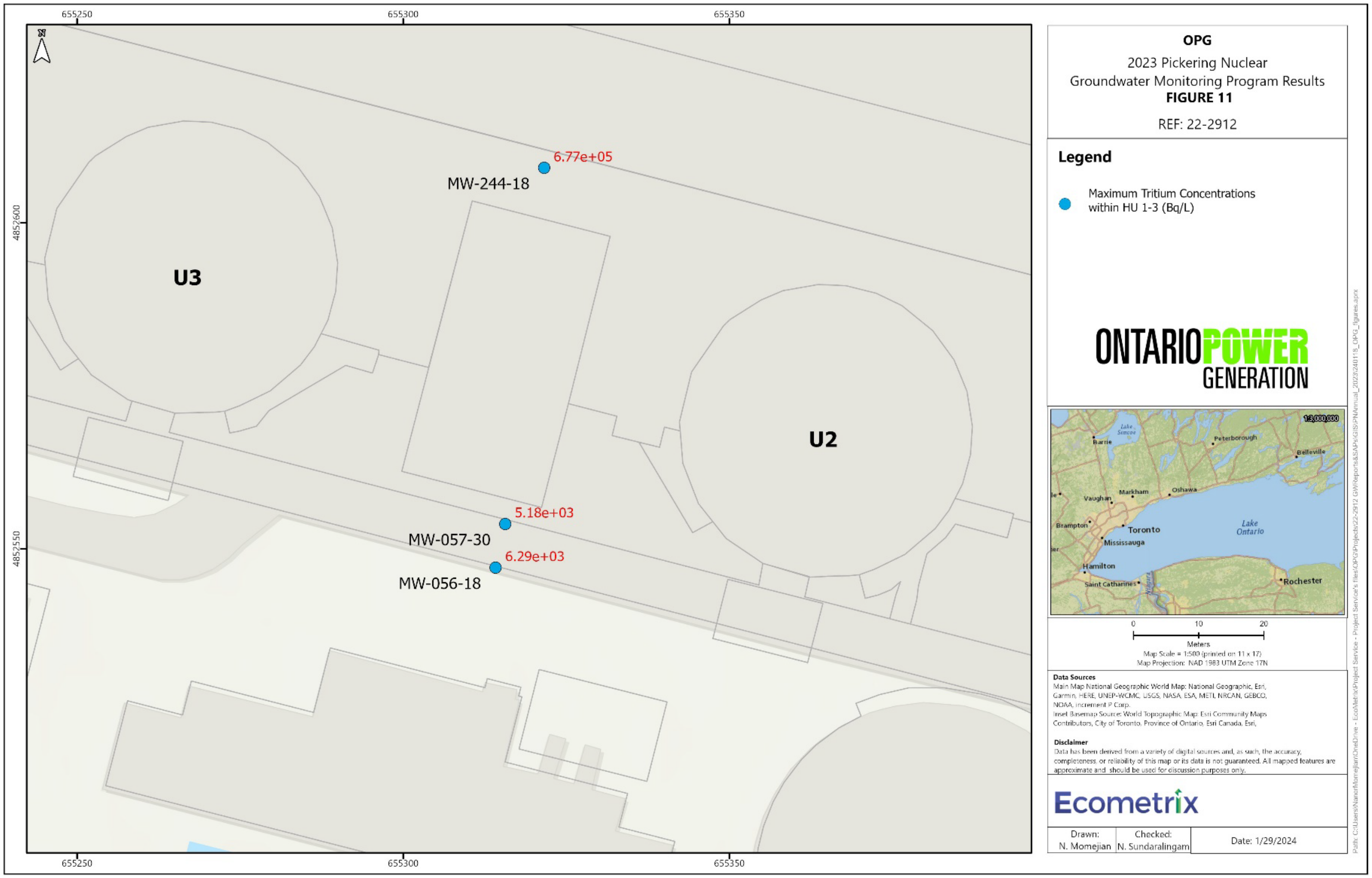


Figure 11: 2023 Annual Maximum Tritium Concentrations at IFB-A in HU 1-3

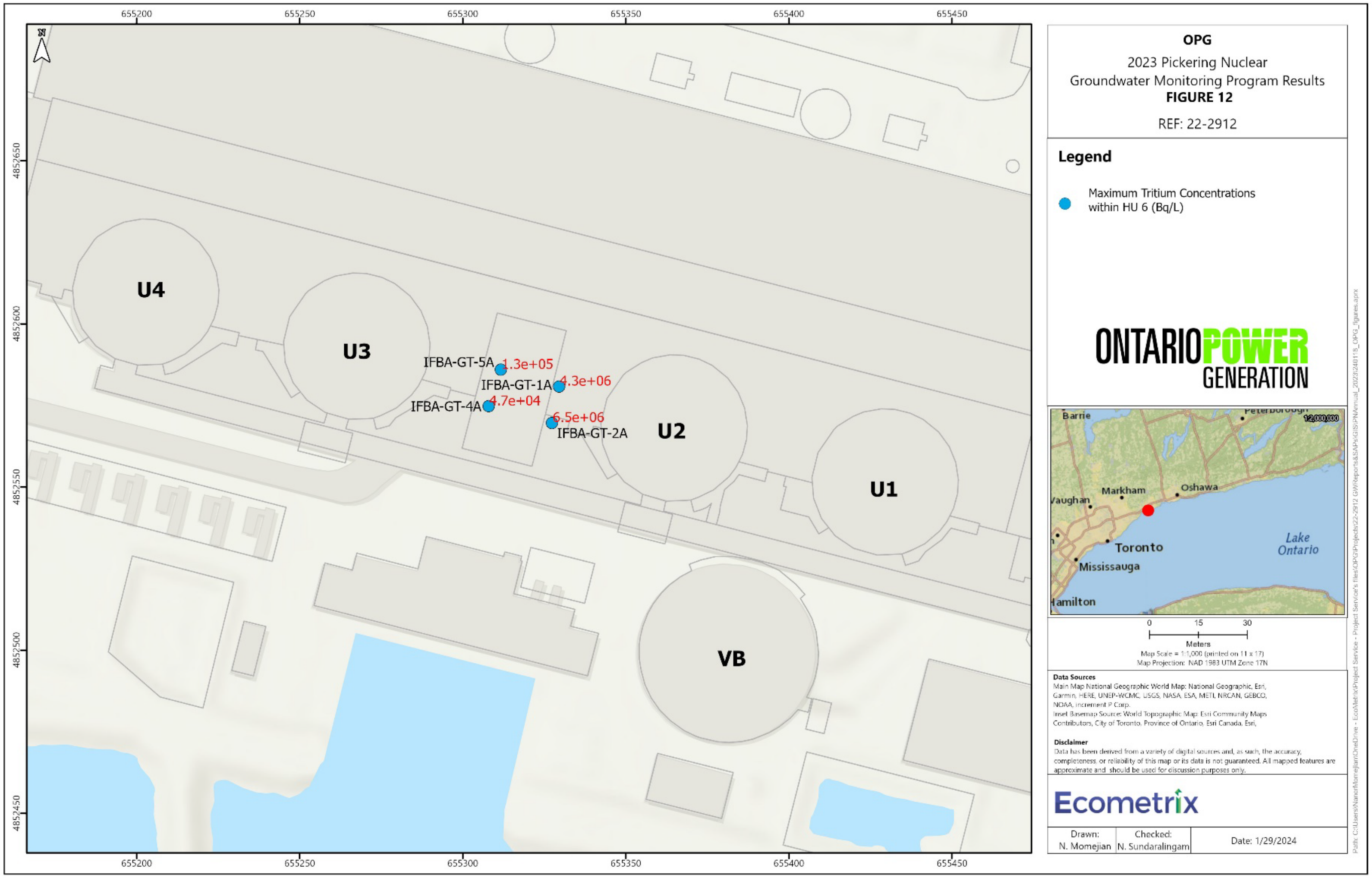


Figure 12: 2023 Annual Maximum Tritium Concentrations at IFB-A in HU 6

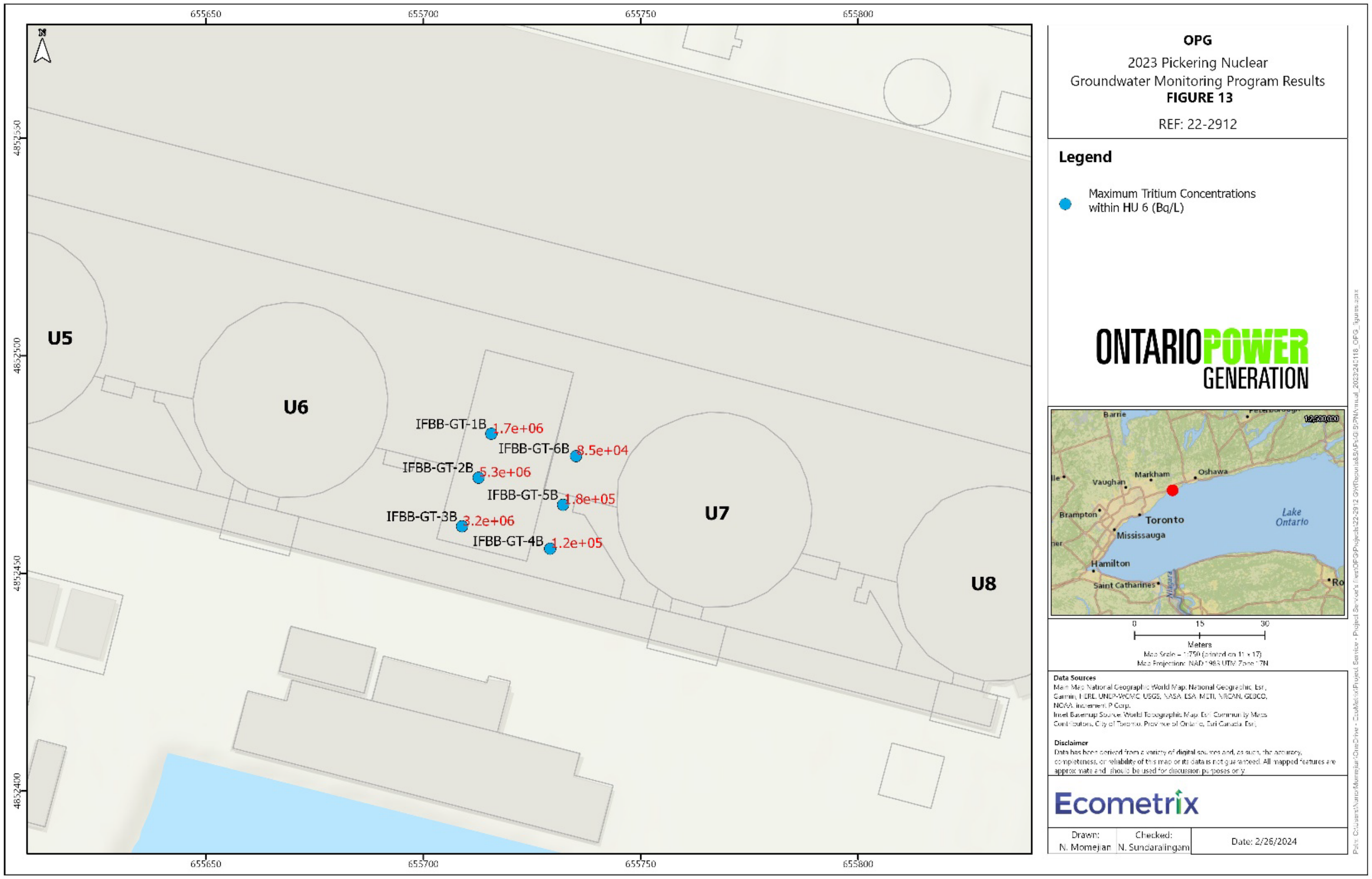
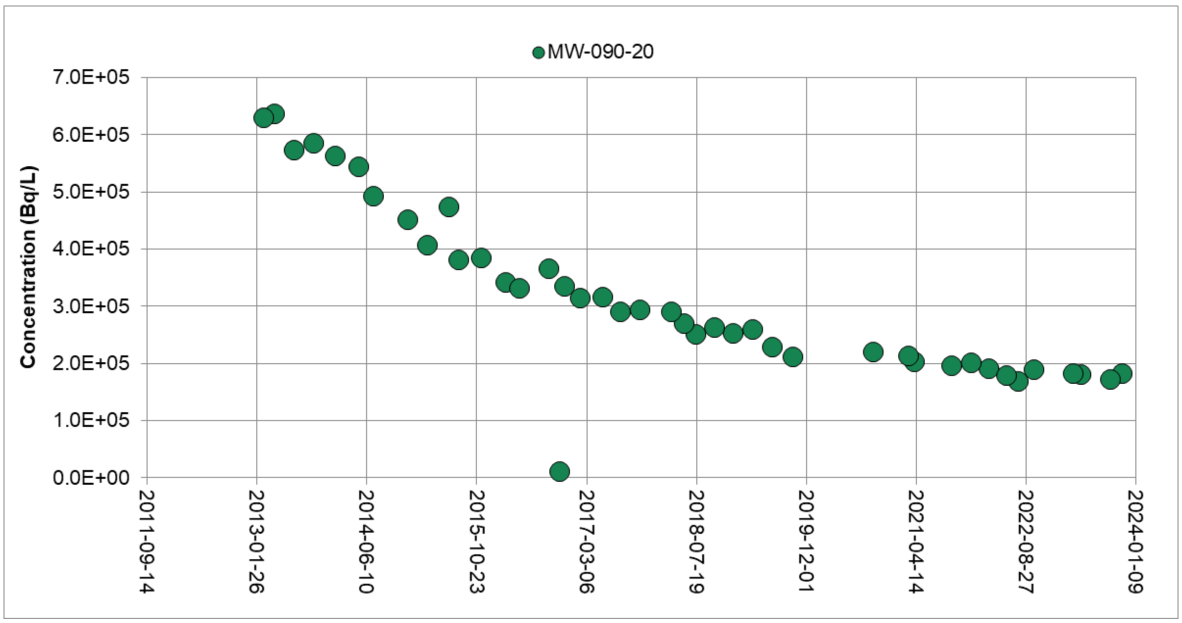


Figure 13: 2023 Annual Maximum Tritium Concentrations at IFB-B in HU 6

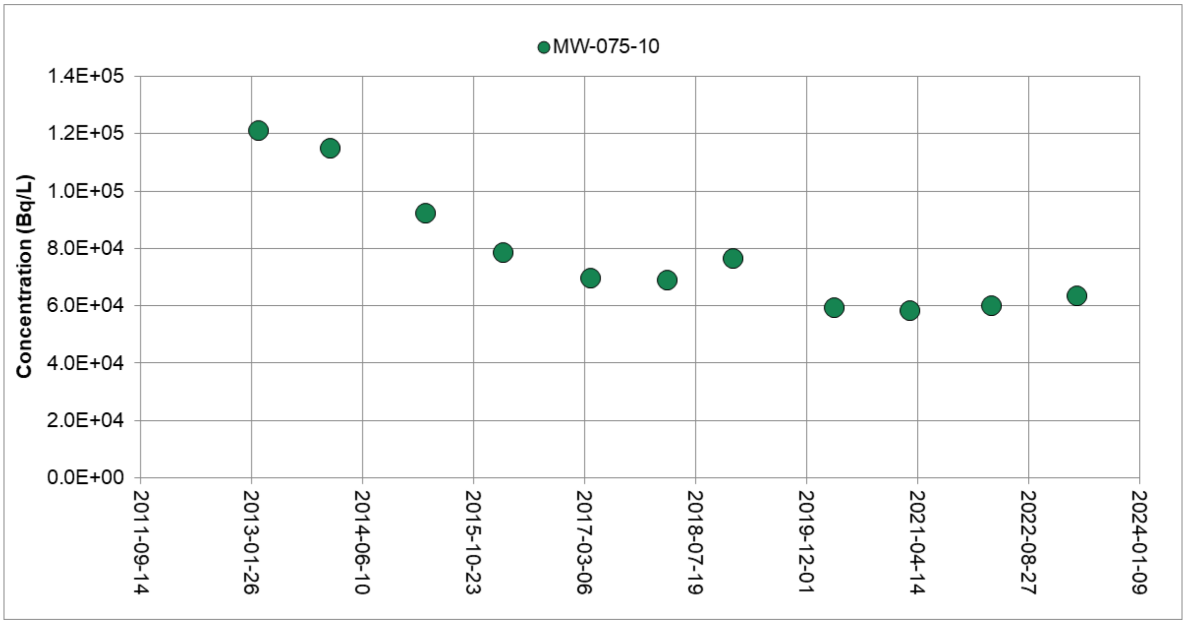
3.1.1.4 Upgrading Plant Pickering Area

In 2023, tritium concentrations in this area continued to decrease or appeared stable.

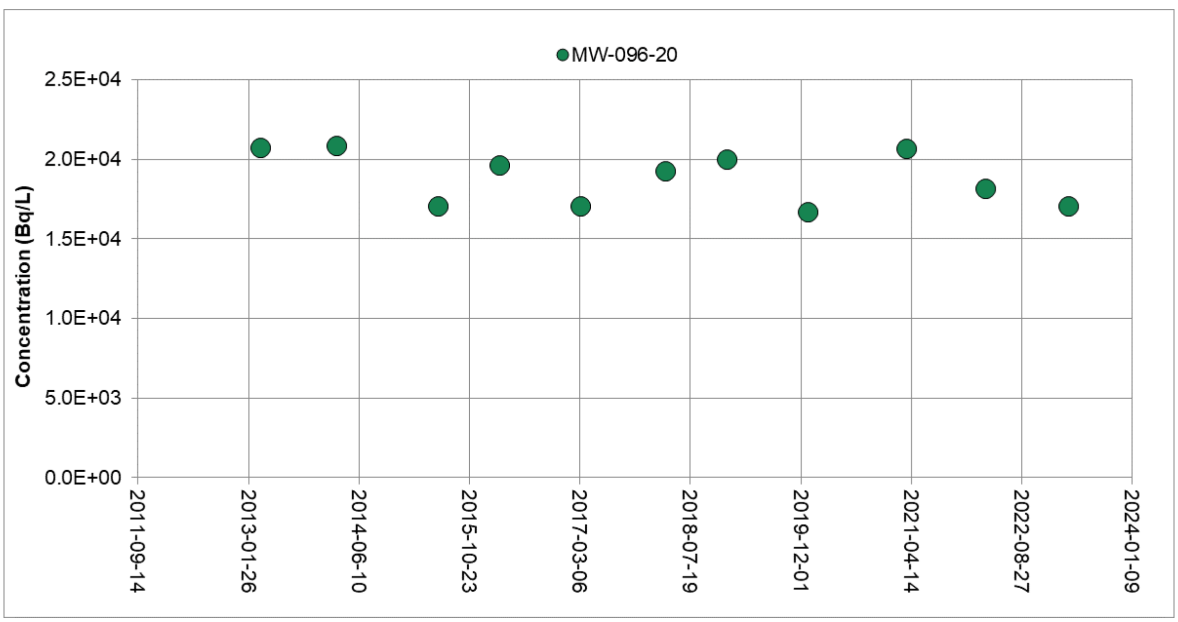
Tritium concentrations in groundwater over time for the UPP area are presented in Graph 37 to 39. The 2023 sample results for tritium concentrations in groundwater at the locations sampled in the UPP area are presented in Table A-4 (Appendix A). Figure 14 and Figure 15 display the annual maximum tritium concentration distributions within HU 1-3 and HU 6 in the UPP area.



Graph 37: MW-090-20 Tritium Data



Graph 38: MW-075-10 Tritium Data



Graph 39: MW-096-20 Tritium Data

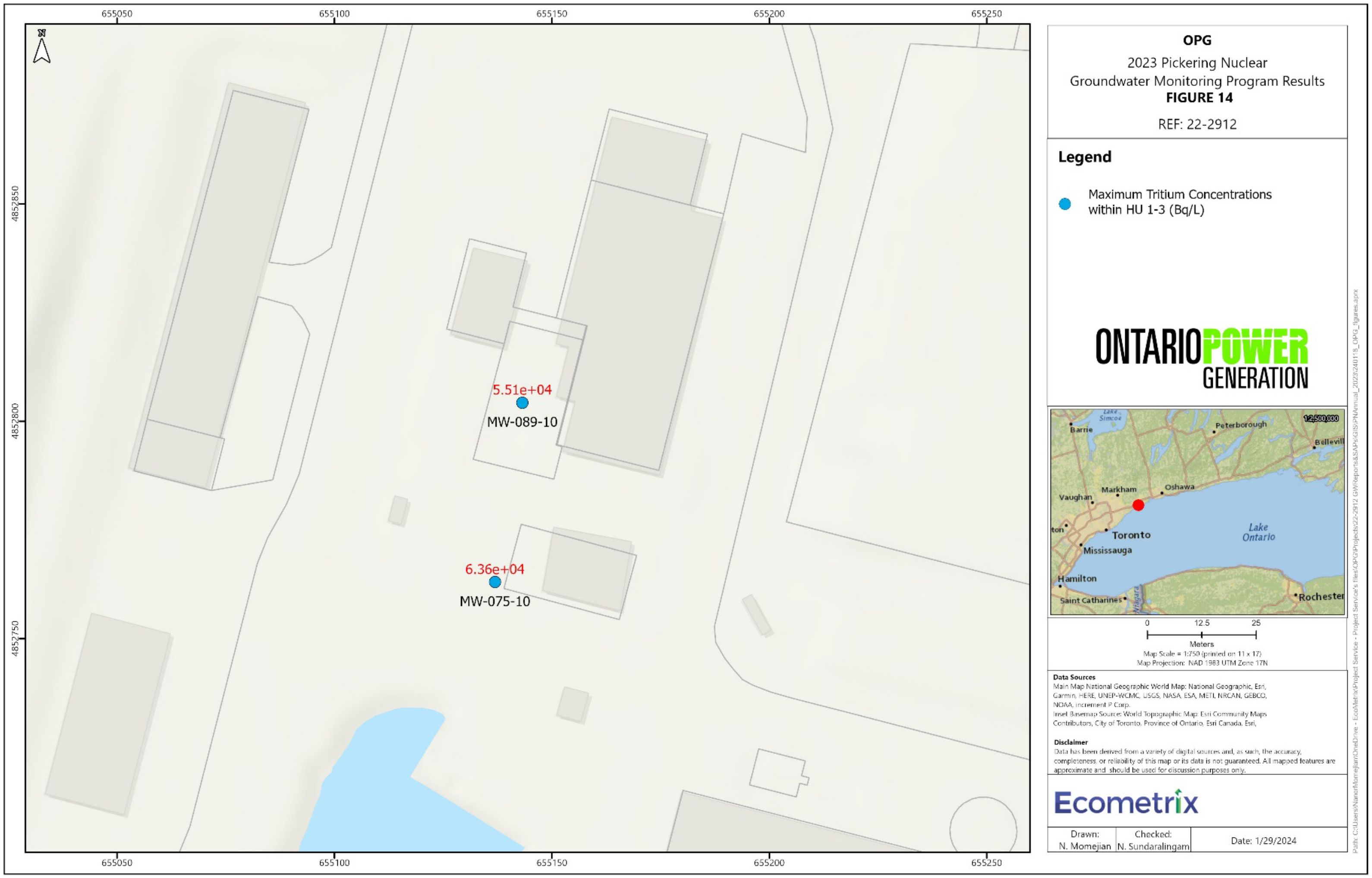


Figure 14: 2023 Annual Maximum Tritium Concentrations in HU 1-3, UPP

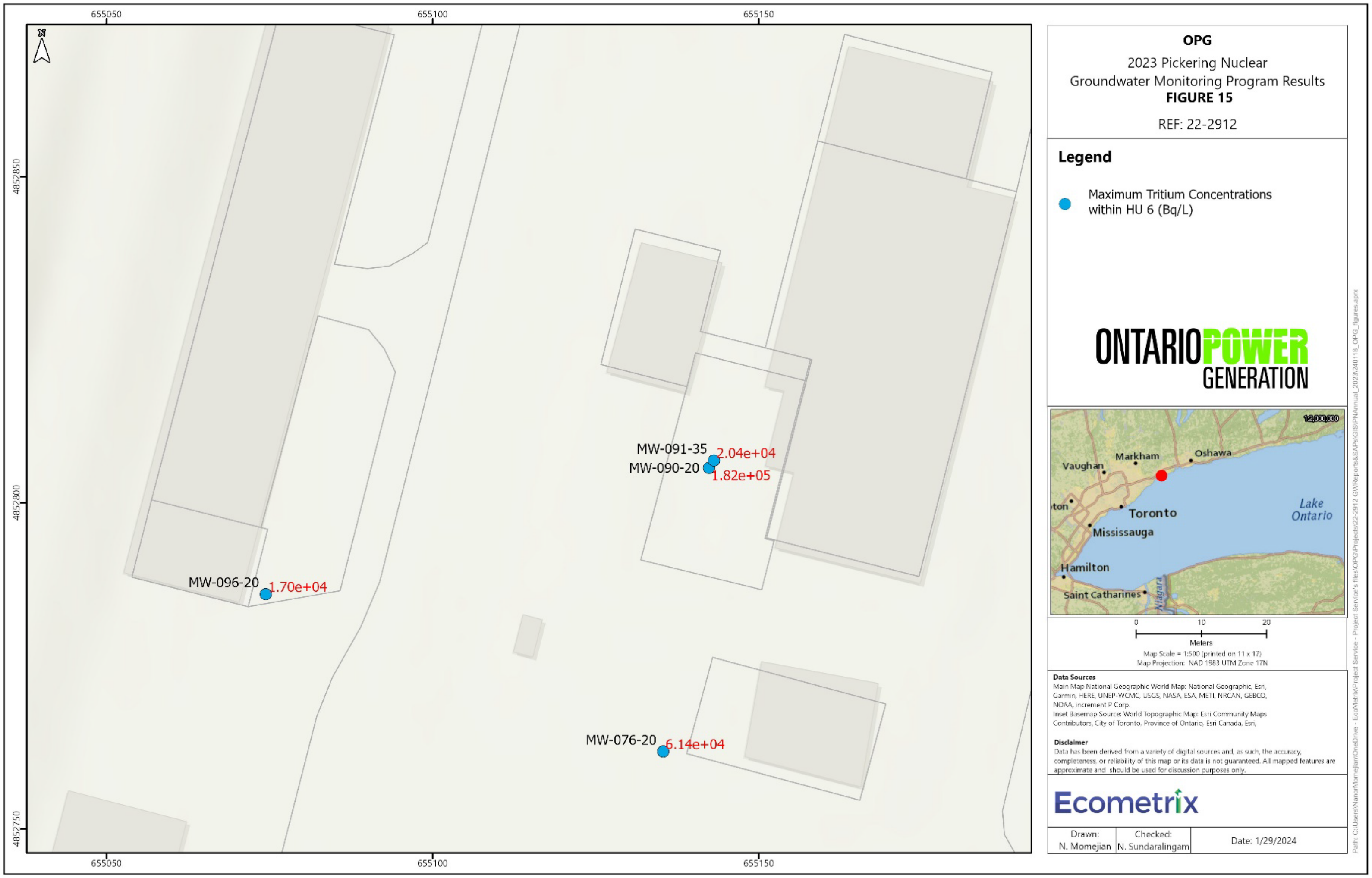


Figure 15: 2023 Annual Maximum Tritium Concentrations in HU 6, UPP

3.1.2 PHC Concentrations in Groundwater at Units 1 to 4 SG, Units 5 to 8 SG, EPG, and EPG3

In 2023, six monitoring wells were monitored within the vicinity of U1-4 SGs. The monitoring wells were monitored for groundwater/fuel oil product levels. Product was present in all wells monitored in 2023. The 2023 product thickness measurements were consistent with historical monitoring results in recent years. Free phase product thicknesses are reported in Table A-5 (Appendix A).

3.3 Objective 2 Results

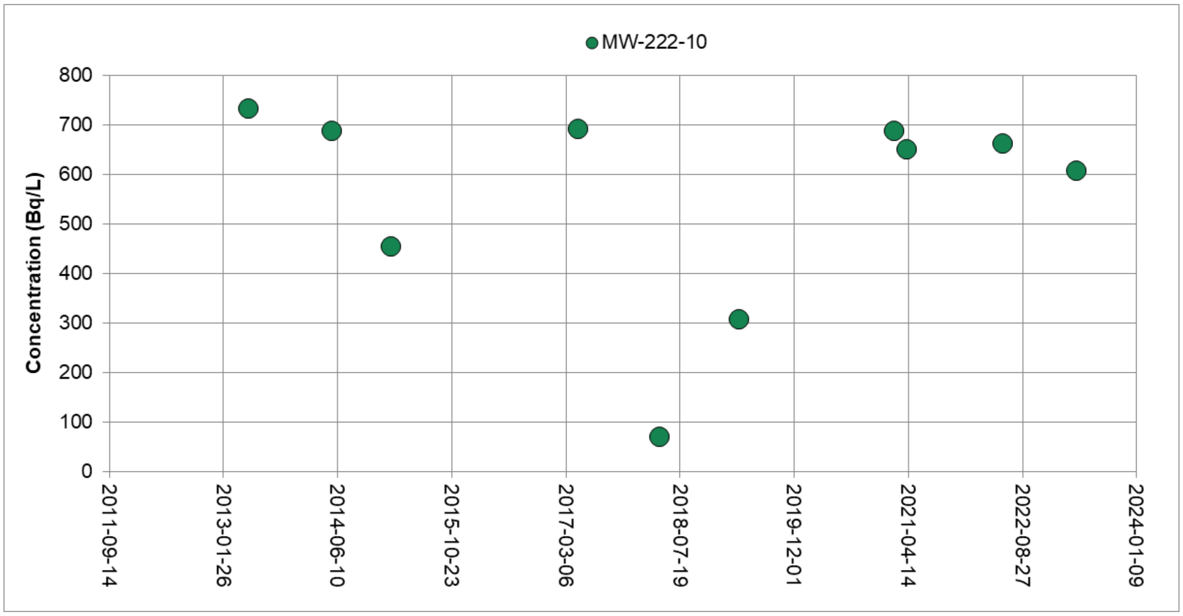
3.3.1 Site Perimeter Overview

Monitoring wells MW-183-10 and MW-185-39 are located in the southeastern corner of the PNGS. The tritium concentration at MW-183-10 has increased compared to previous years; however, the overall concentrations remain low (below 1,000 Bq/L) and the concentration in 2023 has decreased compared to previous years. The 2023 tritium concentration at MW-185-39 was also increased compared to recent years; however, concentrations remain low (below 1,000 Bq/L). There are no known sources, spills, or leaks that would contribute to these increases. Monitoring frequency will be increased from annual to quarterly to gather additional data for these monitoring wells.

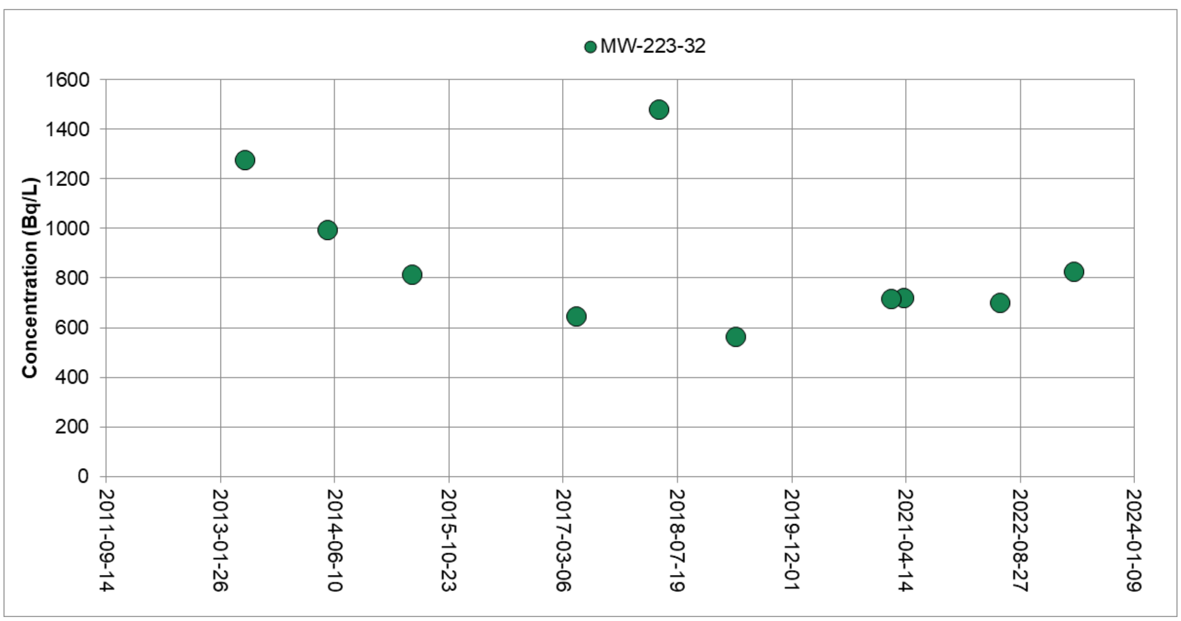
Monitoring well MW-164-13, located south of the PNGS, had slightly increased 2023 tritium concentrations compared to recent years; however, an increasing trend was not observed. Monitoring will continue at this location.

The remaining boundary and shoreline wells demonstrate either a decreasing trend, no trend, or stable trend. Overall, tritium concentrations in all boundary and shoreline wells at the site perimeter remain substantively below groundwater evaluation criteria, demonstrating no potential for off-site impacts from tritium in groundwater at PNGS.

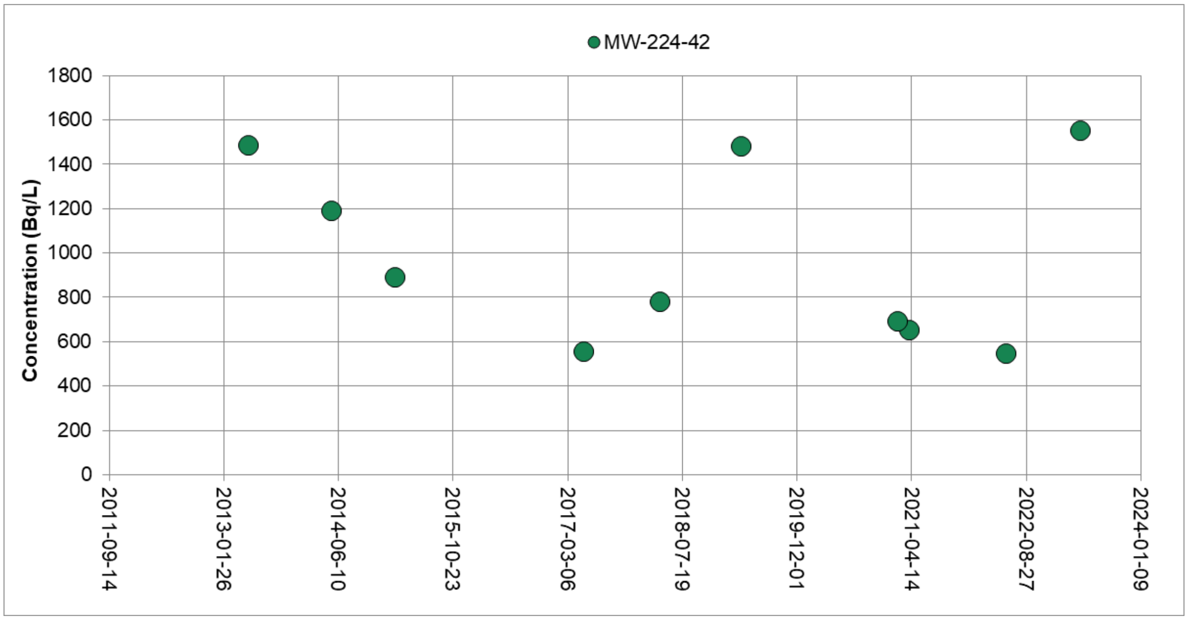
Table A-6 (Appendix A) summarizes the tritium concentrations at each of the perimeter wells, and the annual maximum tritium concentrations within HU1-3, HU 6, and HU 7 are in Figure 16 to Figure 18, respectively. Tritium results within MW-223-32, MW-224-42, MW-183-10, MW-185-39, and remaining shoreline wells are shown below in Graphs 40 to 49.



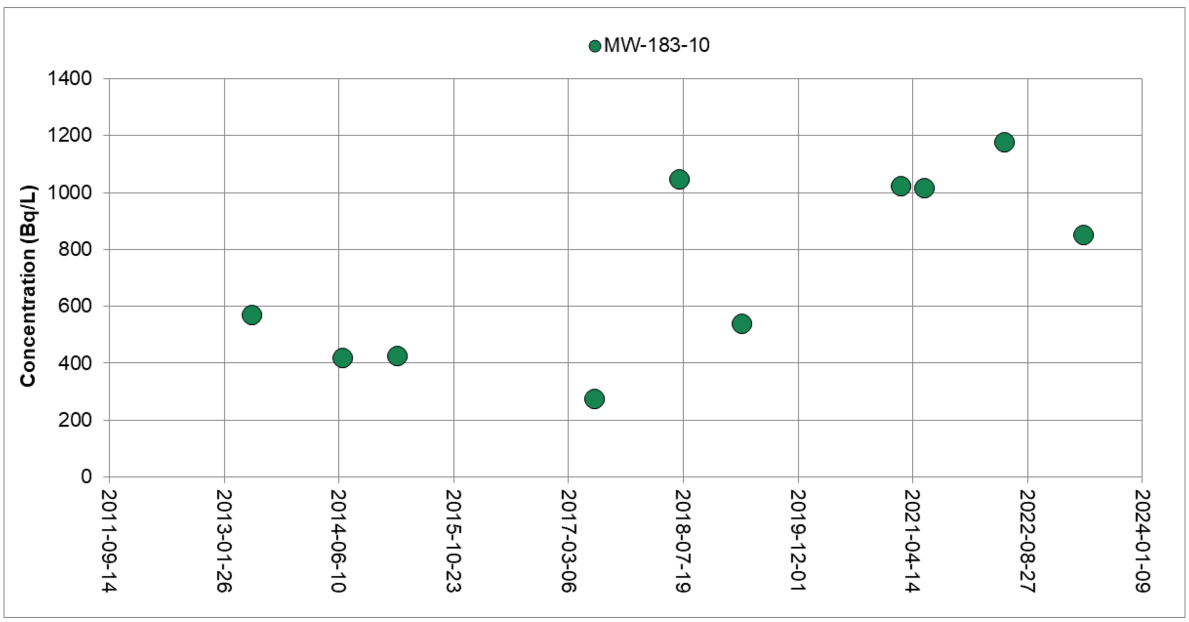
Graph 40: MW-222-10 Tritium Data



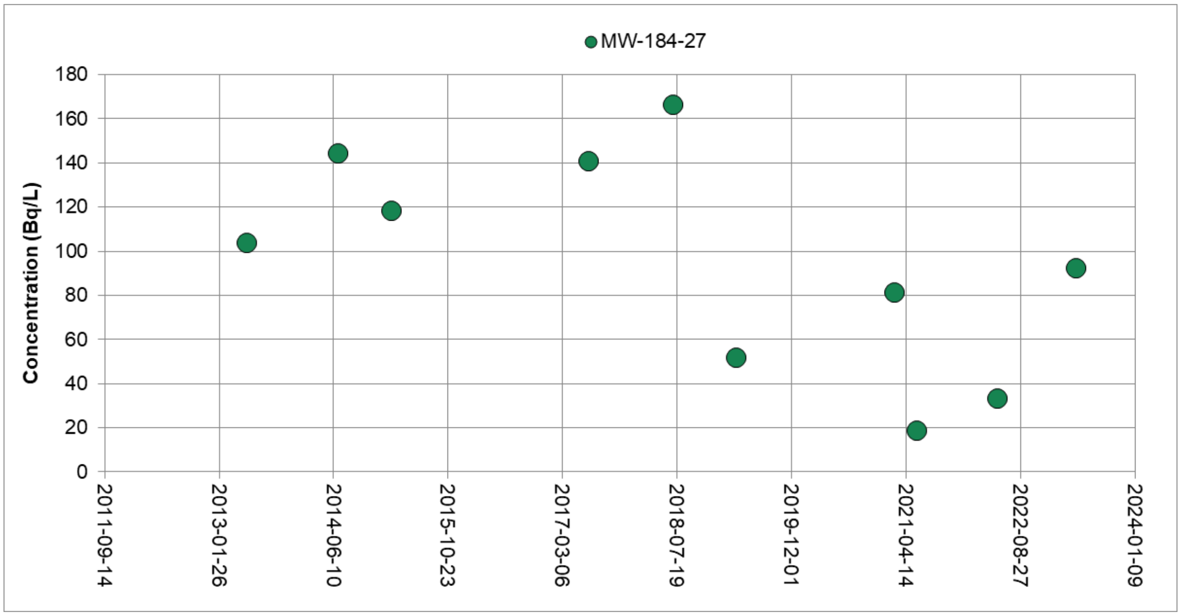
Graph 41: MW-223-32 Tritium Data



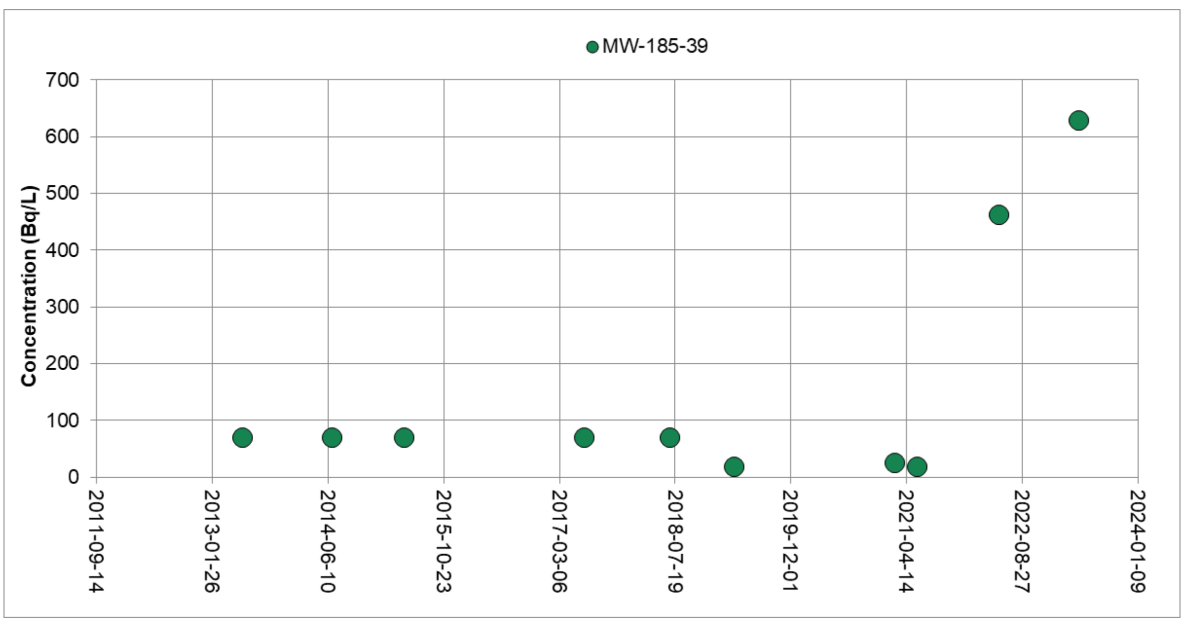
Graph 42: MW-224-42 Tritium Data



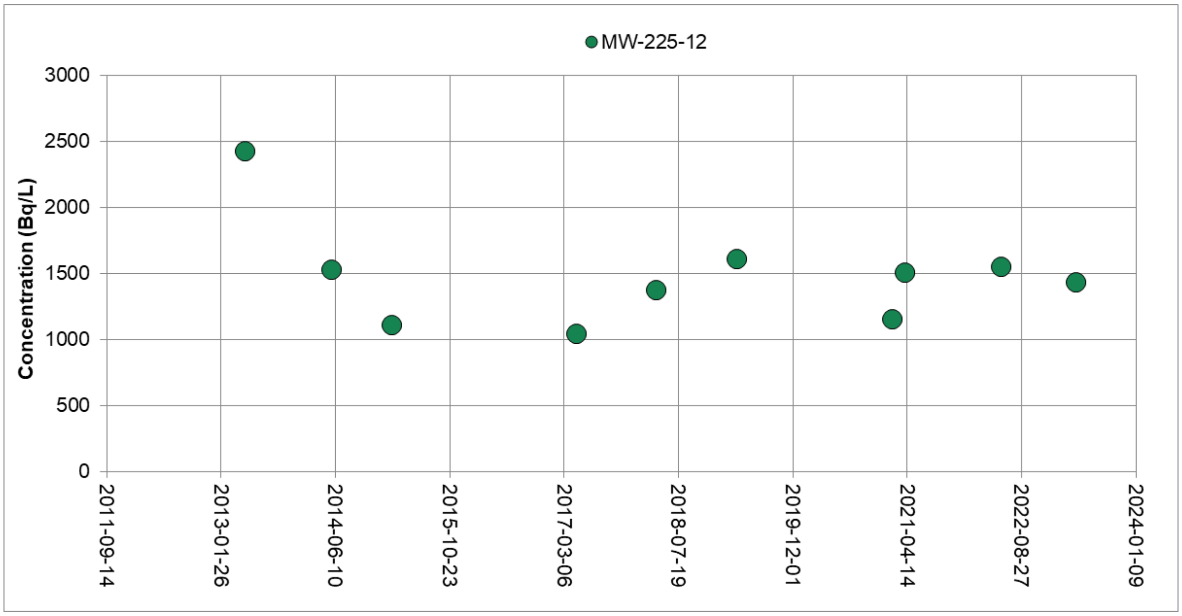
Graph 43: MW-183-10 Tritium Data



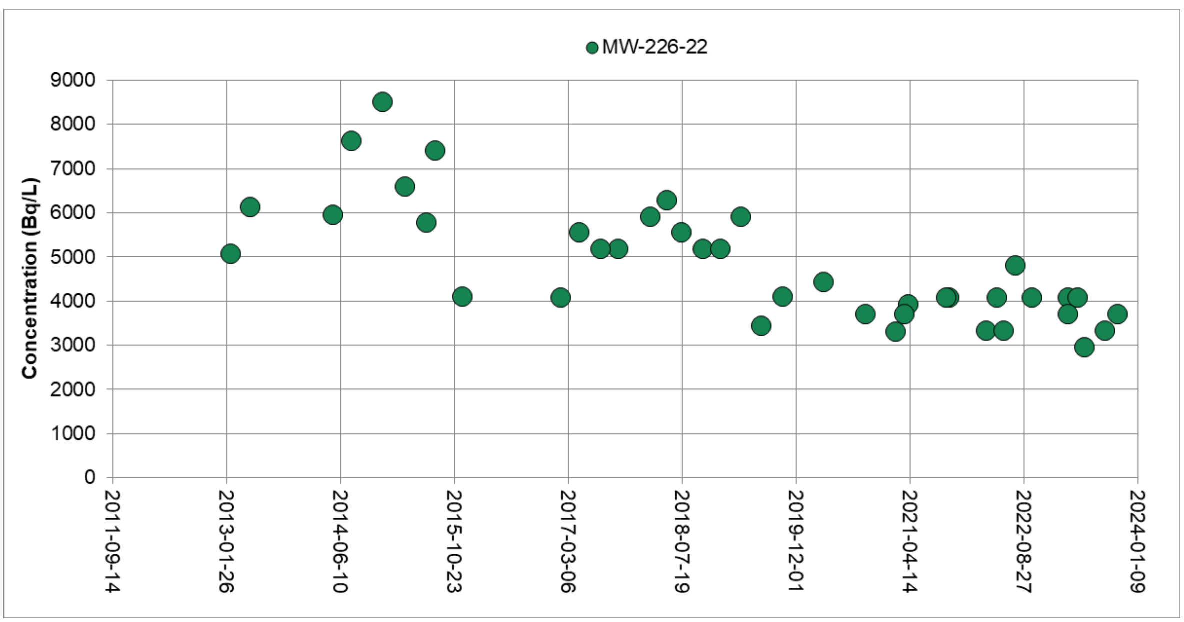
Graph 44: MW-184-27 Tritium Data



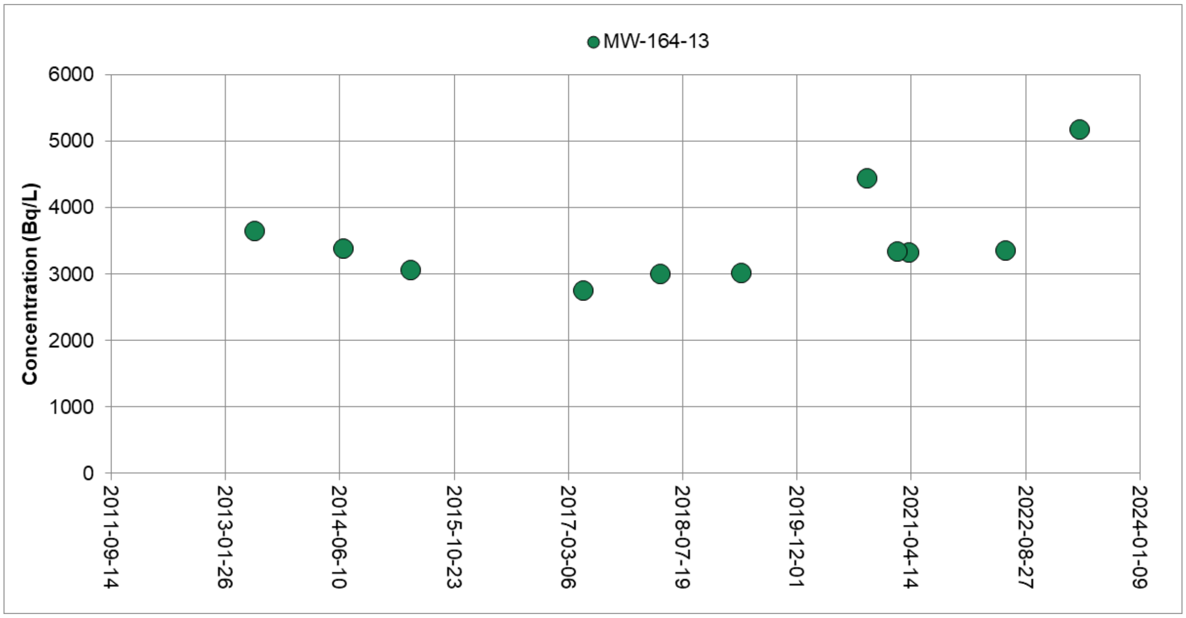
Graph 45: MW-185-39 Tritium Data



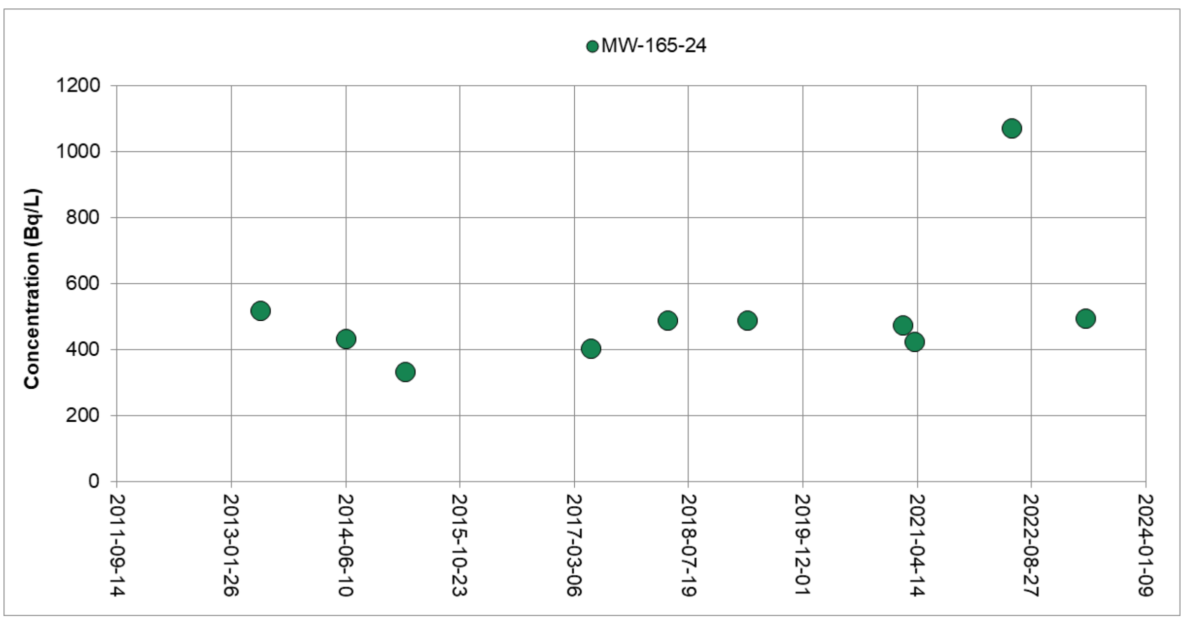
Graph 46: MW-225-12 Tritium Data



Graph 47: MW-226-22 Tritium Data



Graph 48: MW-164-13 Tritium Data



Graph 49: MW-165-24 Tritium Data

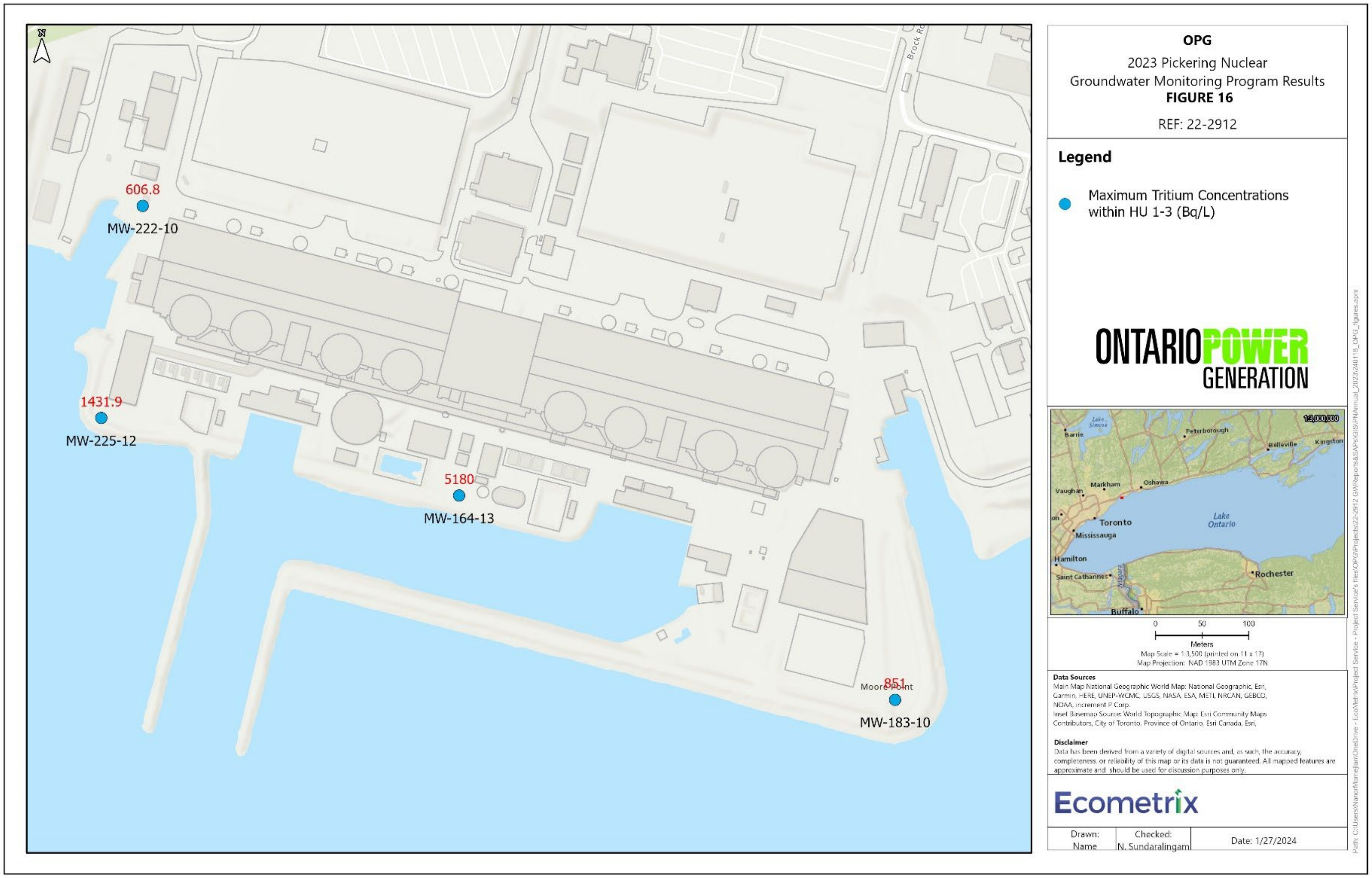


Figure 16: 2023 Annual Maximum Tritium Concentrations in HU 1-3, Site Perimeter

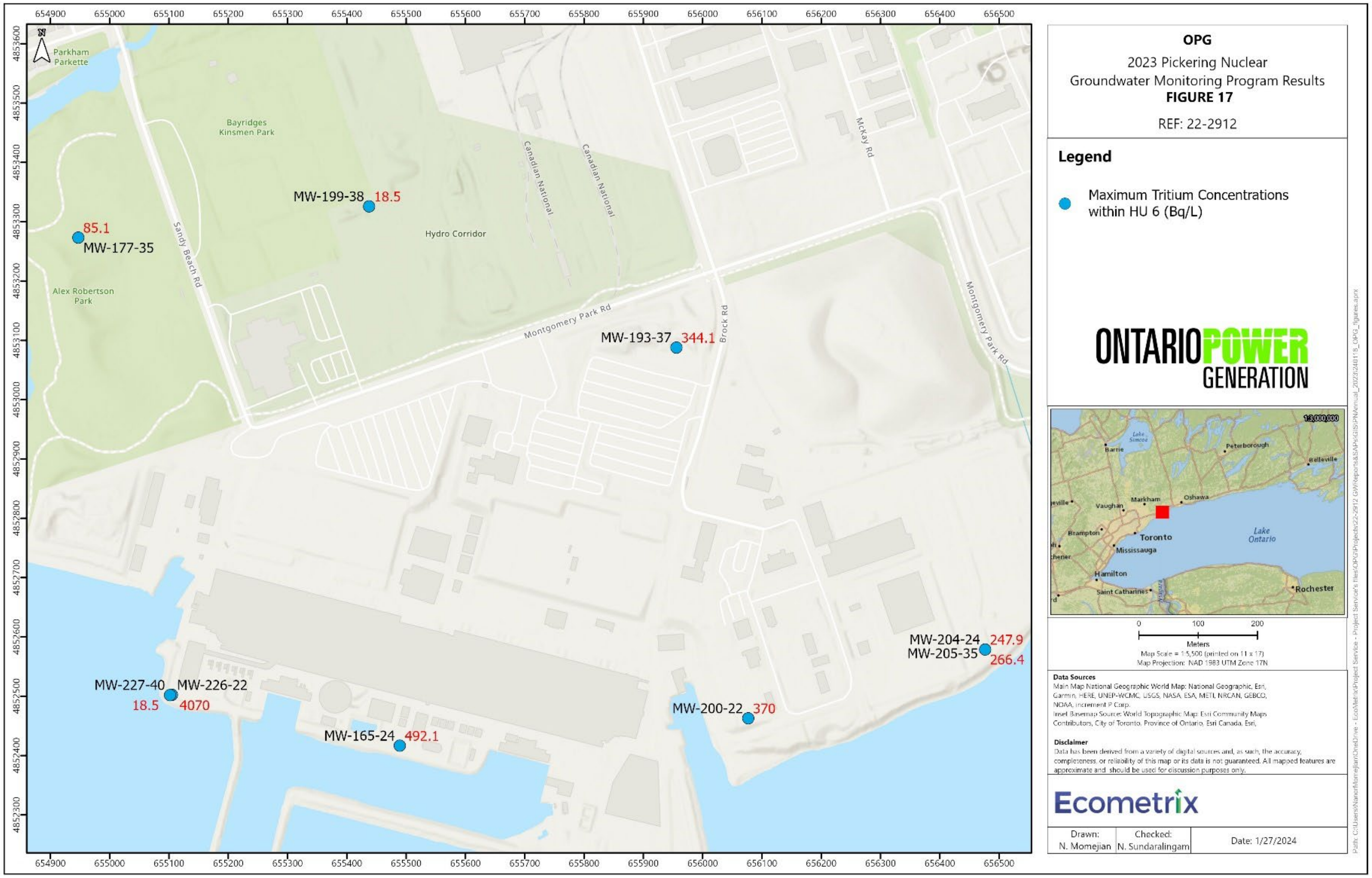


Figure 17: 2023 Annual Maximum Tritium Concentrations in HU 6, Site Perimeter

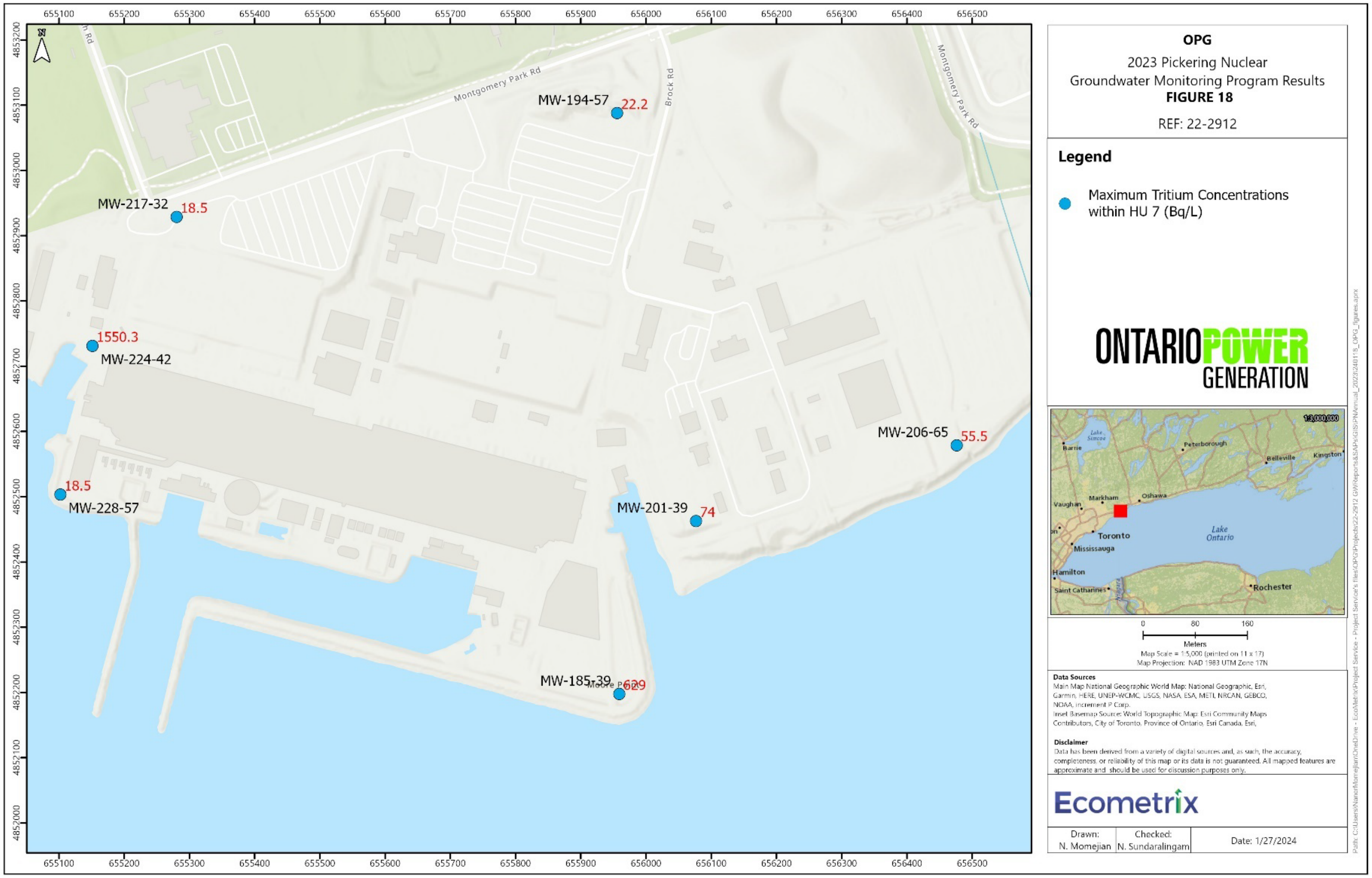


Figure 18: 2023 Annual Maximum Tritium Concentrations in HU 7, Site Perimeter

3.4 Objective 3 Results

3.1.3 Overview of Groundwater Flow Direction

The groundwater flow directions inferred for HUs beneath the PNGS from hydraulic head data collected in 2023 are consistent with historical interpretations.

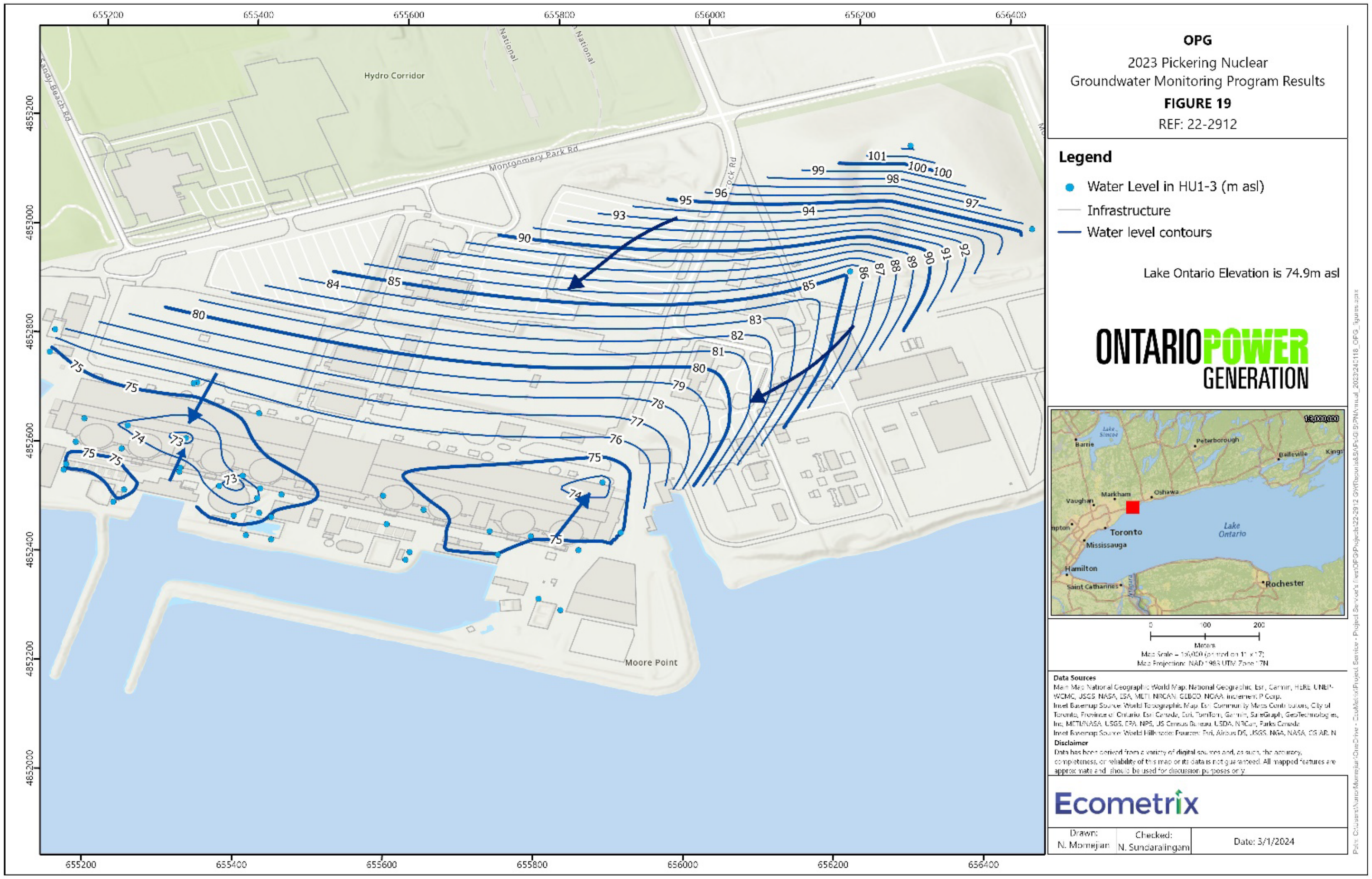
In the shallower groundwater table (HU 1-3; Figure 19), the East Landfill (northeast of the PNGS) remains the major local recharge area with groundwater flowing generally from the landfill towards the station buildings to the southwest, and towards the Lake Ontario in the south.

Closer to the reactor units, groundwater flow directions are more complex due to subsurface structures and active pumping in the TAB foundation drains and VBRS. The general groundwater flow direction is interpreted to be south-southwest towards the lake, with influence from the pumping activities around the reactors. Groundwater within the vicinity of Units 1 to 4 is inferred to migrate towards the TAB and IFB-A. In the Units 5 to 8 area, groundwater is generally inferred to migrate towards the TAB. The TAB foundation drains collect groundwater and terminate in the TAB IAD sumps associated with each reactor unit. These sumps also collect other station process water. The water collected in the IAD sumps is eventually discharged via a monitored pathway.

Groundwater within the area of Units 1 and 2 in HU 1-3 is interpreted to migrate towards the VBRS. As mentioned above, the VBRS acts as a hydraulic sink, diverting a portion of groundwater in Unit 1 and 2 areas towards the VBRS.

Water levels collected from wells installed within HU 6 and HU 7 are generally consistent with historical values. Thus, no change in the historically inferred groundwater flow directions in these units, towards Lake Ontario, is suggested.

Overall, the groundwater monitoring completed in 2023 was sufficient to determine groundwater flow conditions at the site and support the understanding of the migration of chemical and radiological constituents in groundwater throughout the site.



Note: Groundwater contours were developed using water level measurements collected between October 1 to 31, 2023. The Lake Ontario elevation used to determine groundwater contours were determined from an average of daily mean water elevations between October 1 to 31, 2023 (IJC, 2024).

Figure 19: 2023 Q4 Shallow (HU 1-3) Groundwater Elevation Contours

4.0 2023 PROGRAM QUALITY ASSURANCE/QUALITY CONTROL

The Quality Assurance and Quality Control measures for the groundwater monitoring program encompass all activities in field sample collection, laboratory analysis, and laboratory quality control. The objective is to provide confidence in the interpretation of the PNGS groundwater monitoring data through a systematic and documented process.

4.1 Quality Assurance Programs for Laboratories

The PNGS Chemistry Laboratory performs laboratory activities according to a documented quality assurance program.

4.2 Quality Control Results

Field duplicate samples were collected at a prescribed frequency to measure sampling and analytical performance.

Over the 2023 sampling programs, 46 field duplicate samples were collected. The results and calculated relative percent differences (RPD) to understand the sampling precision, are presented in Table A-7 (Appendix A). Forty-two of the forty-six calculated RPDs were below 20 percent as recommended in the PNGS GWMP. In general, the duplicate samples were deemed of acceptable quality, demonstrating that the field techniques and the analytical methods employed by the laboratories were reproducible and reliable.

5.0 SUPPLEMENTARY STUDIES AND AUDITS

The Auxiliary Irradiated Fuel Bay (AIFB) is located to the west of the SG-A Overflow Area. The AIFB structure consists of an inner and an outer tank and stores active materials as well as cooling and purification components. During a routine inspection, a leak of the inner tank was identified and repairs are in progress. Water leaking into the interspaces of the inner and outer tank is captured and recirculated back into the inner tank. Water within the tank system represents a potential tritium source to groundwater.

Samples were collected and analysed for tritium from MW-117-14 and MW-141-15, located west of the AIFB, in Q2 to Q4 2023. The sample results are presented in Table A-8 (Appendix A). Tritium concentrations in groundwater were within the expected range of background in shallow groundwater within vicinity of Units 1 to 4. Samples were also collected from MW-117 and MW-141 in Q2 2023 and analysed for cesium-137, an indicator parameter for a heavy water leak within the AIFB, and samples were below detection. Monitoring for tritium will continue at these locations.

Monitoring wells MW-225-12 to MW-229-70 are located south along the shoreline downgradient of the AIFB (Table A-6; Appendix A). Tritium concentrations within all wells demonstrated decreasing or stable trends, are several orders of magnitude below the tritium evaluation criteria for the site and are not expected to post a risk to groundwater end-uses at these wells.

6.0 NOMENCLATURE OF SAMPLING LOCATIONS

Sampling Location Type	Identifier	Explanation of Nomenclature
Monitoring Well	MW-*XXX*-*YY*	*XXX* represents a unique identifier *YY* represents the depth of the monitoring well in feet
Reactor Building Foundation Drainage Groundtube	RBU*X*-GT-*Y*	*X* represents the unit associated with the groundtube *Y* represents the position (1 is northwest, 2 is southwest, 3 is southeast, 4 is northeast)
Reactor Building Foundation Drainage Sump	U*X* MK *YY*	*X* represents the unit associated with the sump *Y* is a unique identifier
Irradiated Fuel Bay Groundtube	IFBA-GT-*X*A IFBB-GT-*X*B	*X* is a unique identifier
TAB Foundation Drainage	IAD-SU-*X*-*Y*	*X* represents the unit associated with the foundation drainage *Y* represents the orientation of the drainage line (1 is north and 2 west)
TAB Inactive Drainage Sump	IAD-SU-*X*	*X* represents the unit associated with the sump

7.0 ACRONYMS

AIFB	Auxiliary Irradiated Fuel Bay
Bq/L	Becquerel per Litre
BTEX	Benzene / Toluene / Ethylbenzene / Xylene
CSA	Canadian Standards Association
EPG	Emergency Power Generator
GWMP	Groundwater Monitoring Program
GWPP	Groundwater Protection Plan
HU	Hydrostratigraphic Unit
IAD	Inactive Drainage
IFB	Irradiated Fuel Bay

MECP	Ministry of Environment, Conservation and Parks
MNA	Monitored Natural Attentuation
OPG	Ontario Power Generation Inc.
PHC	Petroleum Hydrocarbon
PNGS	Pickering Nuclear Generating Station
RB	Reactor Building
RPD	Relative Percentage Difference
SAP	Sampling and Analysis Plan
SG	Standby Generator
SSC	Systems Structures and Components
TAB	Turbine Auxiliary Bay
UPP	Upgrading Plant Pickering
VBRS	Vacuum Building Ramp Sump
VOC	Volatile Organic Compound

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IJC, 2024. International Lake Ontario-St. Lawrence River Board- Lake Ontario Daily Mean Water Levels 2021-2023 [WWW Document]. Int. Jt. Comm. Int. Lake Ont.-St Lawrence River Board. January.

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Appendix A: Tables A-1 to A-9

Table A-1: Units 1 to 4, Vacuum Building Areas and Units 1 to 4 Turbine Auxiliary Bays

Monitoring Location	Frequency	Analysis Parameter	HU	Q1 (Bq/L)	Q2 (Bq/L)	Q3 (Bq/L)	Q4 (Bq/L)
IAD-SU-1	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-1-1	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-1-2	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-2	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-2-1	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-2-2	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-3	Quarterly	Tritium	HU 7	22940	N/A	N/A	817700
IAD-SU-3-1	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-3-2	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-4	Quarterly	Tritium	HU 7	7400	9990	4070	4070
IAD-SU-4-1	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-4-2	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
MW-064-21	Annual	Tritium	HU 1-3	N/A	--	--	--
MW-157-12	Annual	Tritium	HU 6	5180	--	--	--
MW-158-34	Annual	Tritium	HU 1-3	111	--	--	--
MW-161-48	Quarterly	Tritium	HU 6	65120	65490	61790	61050
MW-209-13	Annually	Tritium	HU 1-3	4514	--	--	--
MW-210-30	Annually	Tritium	HU 1-3	470	81	--	--
MW-215-12	Quarterly	Tritium	HU 1-3	8880	12210	9250	9250
MW-230-30	Quarterly	Tritium	HU 6	640100	654900	606060	505420
MW-234-30	Quarterly	Tritium	HU 6	2756500	2464200	2603320	2268840
MW-237-30	Quarterly	Tritium	HU 6	3885000	3848000	3513150	3439150
MW-239-30	Quarterly	Tritium	HU 6	9250000	9250000	8259880	8233240
MW-240-26	Annual	Tritium	HU 1-3	<18.5	--	--	--
MW-242-25	Quarterly	Tritium	HU 1-3	258630	484700	413660	341880
MW-243-29	Quarterly	Tritium	HU 1-3	109890	70670	139490	75110
MW-246-30	Quarterly	Tritium	HU 6	1857400	1968400	1747880	1686460
MW-247-35	Annual	Tritium	HU 6	N/A	--	--	--
MW-251-5	Quarterly	Tritium	HU 1-3	N/A	N/A	N/A	N/A
MW-255-12	Quarterly	Tritium	HU 1-3	N/A	N/A	N/A	308210
MW-257-5	Quarterly	Tritium	HU 1-3	N/A	N/A	N/A	N/A
MW-260-25	Quarterly	Tritium	HU 1-3	662300	365560	369630	525400
MW-261-25	Quarterly	Tritium	HU 1-3	61050	199800	32190	31080
MW-269-20	Quarterly	Tritium	HU 1-3	4440	6290	6660	5180
MW-270-20	Quarterly	Tritium	HU 1-3	11359000	15101920	21460000	25086000
MW-273-20	Quarterly	Tritium	HU 1-3	721500	2860100	5217000	6068000
MW-301-15	Quarterly	Tritium	HU 1-3	8140	7770	8140	8140
MW-302-40	Annual	Tritium	HU 6	26	--	--	--
MW-313-40	Semi-Annual	Tritium	HU 6	140600	--	64750	--
MW-315-15	Quarterly	Tritium	HU 1-3	220150	488400	777000	1546600
MW-318-40	Quarterly	Tritium	HU 6	4440	3700	5550	3700
MW-320-20	Quarterly	Tritium	HU 1-3	6660	6290	5180	4810
MW-321-15	Quarterly	Tritium	HU 1-3	7030	74740	50320	227920
RBU2-GT-1 or GT-2	Quarterly	Tritium	HU 1-3	6475000	2911900	1968400	7659000
RBU2-GT-1 or GT-2	Quarterly	Tritium	HU 1-3	N/A	N/A	N/A	N/A
RBU2-GT-3 or GT-4	Quarterly	Tritium	HU 1-3	N/A	N/A	N/A	N/A
RBU2-GT-3 or GT-4	Quarterly	Tritium	HU 1-3	12728000	2930400	4144000	10323000
RBU3-GT-1 or GT-2	Quarterly	Tritium	HU 1-3	N/A	N/A	N/A	N/A
RBU3-GT-1 or GT-2	Quarterly	Tritium	HU 1-3	15910	19240	12580	11470
RBU3-GT-3 or GT-4	Quarterly	Tritium	HU 1-3	N/A	N/A	N/A	N/A
RBU3-GT-3 or GT-4	Quarterly	Tritium	HU 1-3	N/A	N/A	N/A	N/A
RBU4-GT-1 or GT-2	Quarterly	Tritium	HU 1-3	N/A	N/A	N/A	N/A
RBU4-GT-1 or GT-2	Quarterly	Tritium	HU 1-3	N/A	N/A	15540	N/A
RBU4-GT-3 or GT-4	Quarterly	Tritium	HU 1-3	N/A	N/A	21830	N/A
RBU4-GT-3 or GT-4	Quarterly	Tritium	HU 1-3	N/A	N/A	N/A	N/A
U1-RBFD-1	Quarterly	Tritium	HU 1-3	26344000	5217000	19573000	26344000
U1-RBFD-2	Quarterly	Tritium	HU 1-3	28638000	29822000	22052000	27676000
U1-RBFD-3	Quarterly	Tritium	HU 1-3	4440000	3082100	3922000	8361260
U1-RBFD-4	Quarterly	Tritium	HU 1-3	N/A	N/A	N/A	N/A
VB Ramp Sump	Quarterly	Tritium	HU 1-3	603100	429200	584600	906500

Note:
"--" - Sample not required
N/A - Sample was not collected

Table A-2: Units 5 to 8 and Units 5 to 8 Turbine Auxillary Bays

Monitoring Location	Frequency	Analysis Parameters	HU	Q1 (Bq/L)	Q2 (Bq/L)	Q3 (Bq/L)	Q4 (Bq/L)
IAD-SU-5	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-5-1	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-5-2	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-6	Quarterly	Tritium	HU 7	3330	518	233.1	3330
IAD-SU-6-1	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-6-2	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-7	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-7-1	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-7-2	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-8	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-8-1	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
IAD-SU-8-2	Quarterly	Tritium	HU 7	N/A	N/A	N/A	N/A
MW-102-15	Annual	Tritium	HU 1-3	10730	--	--	--
MW-170-25	Annual	Tritium	HU 1-3	2590	--	--	--
MW-180-40	Annual	Tritium	HU 6	400	--	--	--
MW-181-57	Annual	Tritium	HU 7	1062	--	--	--
MW-186-12	Annual	Tritium	HU 1-3	1299	--	--	--
MW-264-10	Annual	Tritium	HU 1-3	59570	--	--	--
MW-265-12	Annual	Tritium	HU 1-3	6660	--	--	--
MW-266-19	Quarterly	Tritium	HU 1-3	30710	16650	28490	34410
MW-267-17	Quarterly	Tritium	HU 1-3	64380	48470	20720	83990
MW-325-15	Annual	Tritium	HU 1-3	9250	--	--	--
RBU5-GT-1	Quarterly	Tritium	HU 1-3	177600	243090	234580	281940
RBU5-GT-2	Quarterly	Tritium	HU 1-3	1106300	614200	540200	518000
RBU5-GT-3	Quarterly	Tritium	HU 1-3	932400	632700	577200	540200
RBU5-GT-4	Quarterly	Tritium	HU 1-3	337810	288230	220150	267140
RBU6-GT-1	Quarterly	Tritium	HU 1-3	N/A	N/A	N/A	N/A
RBU6-GT-2	Quarterly	Tritium	HU 1-3	8029000	6919000	3422500	3848000
RBU6-GT-3	Quarterly	Tritium	HU 1-3	10027000	9620000	346690	728900
RBU6-GT-4	Quarterly	Tritium	HU 1-3	9805000	7067000	133570	3618600
RBU7-GT-1 or GT-2	Quarterly	Tritium	HU 1-3	162800	64750	75480	75480
RBU7-GT-3 or GT-4	Quarterly	Tritium	HU 1-3	54020	42180	34040	33300
RBU8-GT-1 or GT-2	Quarterly	Tritium	HU 1-3	4403000	33300	63640	32930
RBU8-GT-3 or GT-4	Quarterly	Tritium	HU 1-3	66230	89540	39590	21460
U5 MK 26	Quarterly	Tritium	HU 1-3	392200	221630	160950	962000
U6 MK 30	Quarterly	Tritium	HU 1-3	6327000	6845000	3293000	5957000
U7 MK 36	Quarterly	Tritium	HU 1-3	22940	13320	N/A	10360
U8 MK 42	Quarterly	Tritium	HU 1-3	1594700	N/A	N/A	N/A

Note:
"--" - Sample not required
N/A - Sample was not collected

Table A-3: Units 1 to 8 Irradiated Fuel Bays

Monitoring Location	Frequency	Analysis Parameters	HU	Q1 (Bq/L)	Q2 (Bq/L)	Q3 (Bq/L)	Q4 (Bq/L)
Unit 1-4 IFB							
MW-056-18	Semi-Annual	Tritium	HU 1-3	6290	--	5550	--
MW-057-30	Quarterly	Tritium	HU 1-3	N/A	N/A	5180	4440
MW-062-42	Quarterly	Tritium	HU 7	670	--	--	--
MW-244-18	Annual	Tritium	HU 1-3	677100	--	--	--
IFBA-GT-1A	Quarterly	Tritium	HU 6	4070000	4144000	4255000	3959000
IFBA-GT-2A	Quarterly	Tritium	HU 6	5439000	5772000	4736000	6490540
IFBA-GT-4A	Quarterly	Tritium	HU 6	46620	18500	19980	18500
IFBA-GT-5A	Quarterly	Tritium	HU 6	131350	58830	23310	33670
Unit 5-8 IFB							
MW-171-15	Quarterly	Tritium	HU 1-3	11100	11470	12580	8140
MW-172-25	Semi-Annual	Tritium	HU 1-3	19980	--	5550	--
IFBB-GT-1B	Quarterly	Tritium	HU 6	1065600	1361600	1713100	1554000
IFBB-GT-2B	Quarterly	Tritium	HU 6	5254000	4921000	4551000	4329000
IFBB-GT-3B	Quarterly	Tritium	HU 6	3159800	2308800	791800	784400
IFBB-GT-4B	Quarterly	Tritium	HU 6	122100	86950	74000	40700
IFBB-GT-5B	Quarterly	Tritium	HU 6	182040	132460	134310	104340
IFBB-GT-6B	Quarterly	Tritium	HU 6	85100	67710	41810	46990

Note:
"--" - Sample not required
N/A - Sample was not collected

Table A-4: Upgrading Plant Pickering

Monitoring Location	Frequency	Analysis Parameters	HU	Q1 (Bq/L)	Q2 (Bq/L)	Q3 (Bq/L)	Q4 (Bq/L)
Unit 1-4 IFB							
MW-056-18	Semi-Annual	Tritium	HU 1-3	6290	--	5550	--
MW-057-30	Quarterly	Tritium	HU 1-3	N/A	N/A	5180	4440
MW-062-42	Quarterly	Tritium	HU 7	670	--	--	--
MW-244-18	Annual	Tritium	HU 1-3	677100	--	--	--
IFBA-GT-1A	Quarterly	Tritium	HU 6	4070000	4144000	4255000	3959000
IFBA-GT-2A	Quarterly	Tritium	HU 6	5439000	5772000	4736000	6490540
IFBA-GT-4A	Quarterly	Tritium	HU 6	46620	18500	19980	18500
IFBA-GT-5A	Quarterly	Tritium	HU 6	131350	58830	23310	33670
Unit 5-8 IFB							
MW-171-15	Quarterly	Tritium	HU 1-3	11100	11470	12580	8140
MW-172-25	Semi-Annual	Tritium	HU 1-3	19980	--	5550	--
IFBB-GT-1B	Quarterly	Tritium	HU 6	1065600	1361600	1713100	1554000
IFBB-GT-2B	Quarterly	Tritium	HU 6	5254000	4921000	4551000	4329000
IFBB-GT-3B	Quarterly	Tritium	HU 6	3159800	2308800	791800	784400
IFBB-GT-4B	Quarterly	Tritium	HU 6	122100	86950	74000	40700
IFBB-GT-5B	Quarterly	Tritium	HU 6	182040	132460	134310	104340
IFBB-GT-6B	Quarterly	Tritium	HU 6	85100	67710	41810	46990

Note:
"--" - Sample not required
N/A - Sample was not collected

Table A-5: Units 1 to 4 SG, Product thicknesses

Year	Quarter	Standby Generator A					
		MW-137-15	MW-138-15	MW-286-15	MW-287-15	MW-340-28	MW-344-17
2011	Q1	ND	ND	ND	-	ND	ND
	Q2	ND	ND	ND	-	ND	ND
	Q3	ND	0.051	ND	-	ND	ND
	Q4	0.082	0.002	0.120	-	0.028	0.019
2012	Q1	0.003	ND	0.001	-	0.035	ND
	Q2	0.180	0.005	0.105	-	0.010	0.070
	Q3	0.100	0.030	0.002	-	0.021	ND
	Q4	0.005	0.050	0.033	-	0.022	ND
2013	Q1	0.002	0.001	0.037	-	0.002	ND
	Q2	0.004	ND	0.068	-	ND	ND
	Q3	ND	ND	0.225	-	ND	ND
2014	Q2	0.130	0.007	0.095	-	ND	0.002
	Q3	0.100	0.001	0.1	-	0.001	0.001
	Q4	0.145	0.020	0.103	-	ND	0.008
2015	Q2	0.135	ND	0.023	-	ND	0.012
	Q3	ND	ND	ND	-	ND	ND
	Q4	0.2	ND	0.137	-	ND	0.047
2016	Q2	0.193	ND	0.194	-	ND	ND
2018	Q2	0.249	0.053	0.372	-	0.492	0.009
	Q3	0.311	ND	ND	-	0.404	ND
	Q4	0.001	0.807	ND	-	0.19	ND
2020	Q3	ND	0.078	ND	-	ND	ND
	Q4	0.195	0.38	ND	-	0.060	ND
2021	Q1	0.256	0.086	0.208	0.084	0.114	0.08
	Q2	0.168	0.268	0.082	ND	0.012	0.058
	Q3	0.028	0.001	0.084	0.001	0.102	0.005
	Q4	0.104	0.017	0.180	ND	0.002	0.002
2022	Q1	0.15	0.003	0.224	0.001	0.008	0.003
	Q1 Supplementary	0.12	-	0.11	-	-	-
	Q2	0.068	0.005	0.117	0.001	0.084	0.059
	Q3	0.121	0.042	0.125	ND	0.074	0.086
	Q4	0.132	0.322	0.088	0.001	0.073	0.049
2023	Q1	0.045	0.0001	0.087	0.0001	0.063	0.0004
	Q2	0.108	0.001	0.147	0.001	0.057	0.069
	Q3	0.114	0.001	0.108	0.001	0.015	0.023
	Q4	0.125	0.005	0.098	0.001	0.057	0.01

Notes:
"--": product thickness was not measured
"ND" : No detectable product

Table A-6: Site Perimeter Wells

Monitoring Well	Frequency	Analysis Parameters	HU	Q1 (Bq/L)	Q2 (Bq/L)	Q3 (Bq/L)	Q4 (Bq/L)
Boundary Wells							
MW-176-23	Annual	Tritium	HU 5	--	22	--	--
MW-177-35	Annual	Tritium	HU 6	--	85	--	--
MW-185-39	Annual	Tritium	HU 7	--	629	--	--
MW-192-18	Annual	Tritium	HU 5	--	289	--	--
MW-193-37	Annual	Tritium	HU 6	--	344	--	--
MW-194-57	Annual	Tritium	HU 7	--	22	--	--
MW-195-73	Annual	Tritium	HU 8	--	<18.5	--	--
MW-197-15	Annual	Tritium	HU 5 / HU 6	--	781	--	--
MW-198-20	Annual	Tritium	HU 5 / HU 6	--	185	--	--
MW-199-38	Annual	Tritium	HU 6	--	<18.5	--	--
MW-200-22	Annual	Tritium	HU 6	--	370	--	--
MW-201-39	Annual	Tritium	HU 7	--	74	--	--
MW-204-24	Annual	Tritium	HU 6	--	248	--	--
MW-205-35	Annual	Tritium	HU 6	--	266	--	--
MW-206-65	Annual	Tritium	HU 7	--	56	--	--
MW-207-87	Annual	Tritium	HU 8	--	<18.5	--	--
MW-216-15	Annual	Tritium	HU 5 / HU 6	--	196	--	--
MW-217-32	Annual	Tritium	HU 7	--	<18.5	--	--
MW-224-42	Annual	Tritium	HU 7	--	1550	--	--
MW-227-40	Annual	Tritium	HU 6	--	<18.5	--	--
MW-228-57	Annual	Tritium	HU 7	--	<18.5	--	--
MW-229-70	Annual	Tritium	HU 8	--	<18.5	--	--
Shoreline Wells							
MW-164-13	Annual	Tritium	HU 1-3	--	5180	--	--
MW-165-24	Annual	Tritium	HU 6	--	492	--	--
MW-225-12	Annual	Tritium	HU 1-3	--	1432	--	--
MW-226-22	Quarterly	Tritium	HU 6	4070	4070	3330	3700
MW-183-10	Annual	Tritium	HU 1-3	--	851	--	--
MW-184-27	Annual	Tritium	HU 5 / HU 6	--	93	--	--
MW-222-10	Annual	Tritium	HU 1-3	--	607	--	--
MW-223-32	Annual	Tritium	HU 6 / HU 7	--	825	--	--

Notes:
"--" - Sample not required

Table A-7: Tritium Quality Control Results, Duplicate Samples and Relative Percent Differences (RPD)

Location	Sample Date	Units	Sample Values		RPD (%)
			Duplicate	Primary	
IAD-SU-3	04-Oct-2023	Bq/L	815110	817700	0.3
IAD-SU-4	05-Apr-2023	Bq/L	11470	9990	13.8
	08-Aug-2023	Bq/L	4810	4070	16.7
	04-Oct-2023	Bq/L	4070	4070	0.0
IAD-SU-6	04-Apr-2023	Bq/L	562	518	8.2
	08-Aug-2023	Bq/L	215	233	8.3
	04-Oct-2023	Bq/L	3330	3330	0.0
IFBB-GT-1B	31-Jan-2023	Bq/L	1061900	1065600	0.3
	12-Apr-2023	Bq/L	1346800	1361600	1.1
	11-Aug-2023	Bq/L	1753800	1713100	2.3
	04-Oct-2023	Bq/L	1583600	1554000	1.9
MW-056-18	09-Mar-2023	Bq/L	5920	6290	6.1
MW-057-30	07-Sep-2023	Bq/L	4440.0	5180.0	15.4
	07-Nov-2023	Bq/L	4440.0	4440.0	0.0
MW-090-20	30-Mar-2023	Bq/L	180930	182410	0.8
	03-May-2023	Bq/L	182410	180930	0.8
	14-Sep-2023	Bq/L	165390	172420	4.2
	07-Nov-2023	Bq/L	176120	182410	3.5
MW-161-48	09-Mar-2023	Bq/L	61420	65120	5.8
	03-May-2023	Bq/L	63640	65490	2.9
	17-Aug-2023	Bq/L	62160	61790	0.6
	07-Nov-2023	Bq/L	58830	61050	3.7
MW-170-25	02-Mar-2023	Bq/L	4070	2590	44.4
MW-192-18	25-Apr-2023	Bq/L	285	289	1.3
MW-197-15	25-Apr-2023	Bq/L	751	781	3.9
MW-222-10	20-Apr-2023	Bq/L	655	607	7.6
MW-226-22	09-Mar-2023	Bq/L	3700	4070	9.5
	20-Apr-2023	Bq/L	4070	4070	0.0
	17-Aug-2023	Bq/L	3330	3330	0.0
	12-Oct-2023	Bq/L	3700	3700	0.0
MW-242-25	01-Feb-2023	Bq/L	261220	258630	1.0
	06-Apr-2023	Bq/L	473600	484700	2.3
	12-Sep-2023	Bq/L	432900	413660	4.5
	11-Oct-2023	Bq/L	336330	341880	1.6
MW-301-15	28-Mar-2023	Bq/L	8140	8140	0.0
	03-May-2023	Bq/L	5920	7770	27.0
	06-Sep-2023	Bq/L	9250	8140	12.8
	27-Nov-2023	Bq/L	8880	8140	8.7
U6 MK 30	09-Aug-2023	Bq/L	3059900	3293000	7.3
U7 MK 36	25-Jan-2023	Bq/L	23680	22940	3.2
	04-Apr-2023	Bq/L	13320	13320	0.0
	03-Oct-2023	Bq/L	10360	10360	0.0
VB Ramp Sump	28-Mar-2023	Bq/L	599400	603100	0.6
	03-May-2023	Bq/L	392200	429200	9.0
	06-Sep-2023	Bq/L	580900	584600	0.6
	07-Nov-2023	Bq/L	880600	906500	2.9

Table A-8: Supplemental Study

Monitoring Location	Frequency	Analysis Parameter	Units	HU	Q1	Q2	Q3	Q4
MW-117-14	Supplemental Study	Tritium	Bq/L	HU 1-3	--	4440	3700	3700
		Cesium-137	µCi/kg		--	<1.43E-4	--	--
MW-141-15		Tritium	Bq/L	HU 1-3	--	3330	2220	2590
		Cesium-137	µCi/kg		--	<1.69E-4	--	--

Note:
"--" - Sample not required