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Title:
2022 WESTERN WASTE MANAGEMENT FACILITY GROUNDWATER PROGRAM RESULTS

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2022 Western Waste Management Facility Groundwater Program Results

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Revision Summary

Revision Number	Date	Comments
000	2023-08-15	Initial issue.
001	2023-12-06	Removed typos in the document.

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Land Acknowledgement

OPG acknowledges that the Western Waste Management Facility is located on the traditional territory of the Chippewas of Saugeen First Nation and the Chippewas of Nawash Unceded First Nation, collectively known as the Saugeen Ojibway Nation, and are the traditional keepers of the land. The area is also home to many diverse First Nations, Inuit and Métis peoples and as a company, we remain committed to fostering positive and mutually beneficial relationships with Indigenous people and communities across Ontario.

Executive Summary

The Western Waste Management Facility (WWMF) and the Radioactive Waste Operations Site 1 (RWOS1) have a mature and robust groundwater protection program. The groundwater monitoring aspect of the program is in place to address the following three primary goals:

- Monitor changes to on-site groundwater quality to ensure timely detection of inadvertent releases to groundwater;
- Ensure no adverse off-site impacts from groundwater beneath the WWMF and RWOS1; and
- Confirm predominant on-site groundwater flow characteristics at both sites.

The findings in 2022 with respect to the monitoring program include the following:

- The groundwater data collected from around the systems, structures and components indicate tritium concentrations are:
 - consistent with results for previous years and expected fluctuations associated with ongoing operations, or
 - where tritium concentrations have been elevated above background conditions historically, they are generally showing improvement (decreased concentrations). Increases in tritium concentrations in groundwater are occurring in a small number of wells; the increases are understood to be associated with historical conditions and do not represent inadvertent releases.
- Tritium concentrations within the site perimeter wells are low (at background values), stable, and far below values that would indicate potential risks to off-site water quality and use beneath the WWMF or RWOS1.
- The predominant groundwater flow patterns remain unchanged in 2022 from interpretations in recent years.

Overall, the groundwater monitoring completed in 2022 was sufficient to determine groundwater flow conditions at the site and support the understanding of the migration of tritium in groundwater beneath the WWMF and RWOS1.

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1.0 INTRODUCTION

The Western Waste Management Facility (WWMF) and Radioactive Waste Operations Site 1 (RWOS1) are located at the Bruce Nuclear site, within the municipality of Kincardine in the County of Bruce. The WWMF and RWOS1 are each situated at an approximate distance of 1.1 km from the east shore of Lake Huron, near the Village of Tiverton between Kincardine (south) and Port Elgin (north). The WWMF is licensed by the CNSC as a class 1B Nuclear Facility to manage and store radioactive waste from Ontario Power Generation’s (OPG’s) and Bruce Power’s nuclear generating station. The RWOS1 is located approximately 660 meters southwest relative to the WWMF and operates under a Waste Nuclear Substance Licence.

Ontario Power Generation’s WWMF and RWOS1 have 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 objectives for the groundwater monitoring program are documented in the N288.7-compliant WWMF and RWOS1 Groundwater Protection Plan (GWPP) and Groundwater Monitoring Program (GWMP) (Ecometrix, 2022a):

- Objective 1: monitor tritium concentrations in groundwater near Low-Level Storage Buildings (LLSBs), Steam Generator Storage Building (SGSB), and the Retube Waste Container Storage Building (RWCSB) within the WWMF to ensure timely detection of inadvertent releases to groundwater;
- Objective 2: monitor tritium concentrations in groundwater beneath the RWOS1 to ensure timely detection of inadvertent releases to groundwater;
- Objective 3: establish and monitor background tritium concentrations in groundwater at the WWMF;
- Objective 4: confirm the predominant on-site groundwater flow characteristics beneath the WWMF and RWOS1; and
- Objective 5: monitor tritium concentrations in groundwater on the perimeter of the WWMF and RWOS1 in the direction of groundwater flow (“Downgradient Perimeter”) to confirm no adverse off-site impacts to groundwater quality.

The location of the WWMF is shown in Figure 1 and the RWOS1 is shown in Figure 2. Within the WWMF, the LLSBs, SGSB and RWCB are shown in Figure 3, along with other infrastructure including the Used Fuel Dry Storage building. Stages 1, 3 and 3E are discussed as well in this report, which pertain to the trenches, tile hole inground container and Quadricell area, which are shown in Figure 3.

The groundwater sampling and monitoring program conducted in 2022 followed the Sampling and Analysis Plan (SAP) for 2022 (Ecometrix, 2022c). This report presents groundwater data collected at WWMF for the period from January 1st to December 31st, 2022.

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Figure 1: WWMF Site Boundary

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Figure 2: RWOS1 Site Boundary

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Figure 3: WWMF Site Buildings and Structures

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1.1 Summary of Hydrogeological Characteristics at the WWMF and RWOS1

Seven hydrostratigraphic units (HUs) have been identified beneath the WWMF and RWOS1 through historical assessments. Of the seven HUs, three main groundwater flow systems have been identified for the site:

- HU 1-3: Perched/Shallow Water Table, comprised of fill, native sand and silt till
- HU 4: Middle Sands Aquifer (MSA)
- HU 7: Limestone/Dolostone Bedrock

Surficial fill materials at the site (HU1) are unsaturated and lie above the water table. The underlying sands (HU2) are silty and frequently contain gravel and are unsaturated or partially to fully saturated, depending on the location. Underlying the sands is a weathered till unit of clayey to sandy dense subglacial silt till with interbeds of fine to coarse sand, and fine to coarse gravel (HU3). The HU4 consists of beds of silty fine sand to well-sorted sand with occasional gravel layers and some silt till interbeds and represents an aquifer. The HU5 shares similar characteristics to HU3 but this deeper till is less weathered and more competent. The basal sand unit (HU6) is discontinuous as well and where it occurs, HU6 and HU7 form one aquifer unit.

Between HU1-3, HU4 and HU7, groundwater flow is generally vertical to subvertical, downwards, through the fine-grained till units (Ecometrix, 2022b).

At the RWOS1, overburden beneath the western portion of the site consists of till overlying dolostone bedrock, and overburden beneath the eastern portion of the site consists of sand and lesser till overlying bedrock. The monitoring wells in the eastern portion of the site where native sands extend approximately 4-6 metres from the ground surface to bedrock. Groundwater is encountered at the sand/bedrock interface. The groundwater monitored is considered to represent a single unconfined hydrostratigraphic unit, and best aligns with HU2.

1.2 Subsurface Drainage System at the WWMF and discharge infrastructure

Inside the WWMF fenced area, groundwater and surface water are collected by several engineered drainage systems. The surface drainage system captures runoff from precipitation and discharges collected water to the South Railway Ditch (SRD).

The sub-surface drainage system at the WWMF includes drains and sumps associated with building foundations, tile holes or trenches. Buildings with subsurface drainage systems include the LLSBs (#2 to 10, #11 to 14), SGSB, RWCSB and the Used Fuel Dry Storage building. The LLSB #1 does not have a subsurface drainage system.

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Water collected by the subsurface drainage systems is directed to either the south railway ditch (SRD) or the stormwater management pond. The SRD and stormwater management pond are shown in Figure 3. Monitoring of the groundwater quality collected by the subsurface drainage is part of the GWMP for the WWMF, Objective 1.

2.0 2022 PROGRAM DESIGN

The groundwater monitoring program design is detailed in the WWMF GWPP and GWMP (Ecometrix, 2022a). The N288.7-compliant 2022 SAP (Ecometrix, 2022c) was developed to meet the relevant components of the objectives listed above.

In 2022, as per the SAP, groundwater samples were collected from fifty-nine (59) sampling locations in total, including groundwater monitoring wells and subsurface drainage structures. Sample results of the groundwater quality monitoring are provided in Appendix A.

The 2022 SAP specified the sampling locations and the frequency of sampling tritium concentrations in groundwater at each location (e.g., semi-annually or annually).

Water levels were measured before the collection of groundwater samples for analysis of tritium concentrations 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 groundwater representative of the conditions in the hydrostratigraphic unit was sampled. Collected samples were analyzed for tritium concentrations by the OPG Chemistry Laboratory.

The groundwater data generated from the sampling program was subsequently analyzed to support previous conclusions, identify trends, reflect improvements and/or to demonstrate no significant change in tritium concentrations concerning historical values. Refer to Section 6.0 of this report for details on the sampling naming/location nomenclature used in the groundwater program.

2.1 Objective 1 – Tritium near LLSBs, SGSB and RWCSB within the WWMF

Included within Objective 1 are the following areas of the site and systems, structures and components (SSCs):

- LLSBs #1 to #10;
- LLSBs #11 to #14, SGSB and RWCSB; and
- Trenches, Tile Holes, Quadricells and Inground Containers (ICs).

Figure 4 shows the locations of groundwater wells and subsurface structures in which groundwater quality was monitored for Objective 1.

Sample results for tritium concentrations related to Objective 1 are presented in Appendix A (Table A-1a, Table A-1b, Table A-2a, Table A-2b, Table A-3a and Table A-3b).

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2.2 Objective 2 – RWOS1

In 2022, groundwater quality was monitored in five groundwater monitoring wells at the RWOS1. Figure 5 shows the locations of the wells monitored for this objective. Sample results for tritium concentrations in groundwater related to Objective 2 are presented in Appendix A (Table A-4).

2.3 Objective 3 – Background Tritium Concentrations at WWMF

In 2022, six locations were monitored to establish background tritium concentrations in groundwater at the WWMF. Figure 6 shows the groundwater wells monitored for this objective. Sample results for tritium concentrations in groundwater related to Objective 3 are presented in Appendix A (Table A-5).

2.4 Objective 4 – Annual Snapshot of Hydraulic Head Measurements

Groundwater flow interpretations for the WWMF and RWOS1 were developed in the WWMF GWMP and GWPP (Ecometrix, 2022c). On an annual basis, the GWMP requires that a set of water levels be collected from all wells at RWOS1 and a subset of the wells in the groundwater well network at the WWMF over a short period of time (days). The intent of this “snapshot” 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 Q4, water level readings were collected from monitoring wells across the site on December 6, 2022. The data was subsequently used to calculate the groundwater elevation at each monitoring well and generate water elevation contours, from which groundwater flow directions are inferred. Groundwater flow directions are interpreted to be perpendicular to and downgradient across the contour lines.

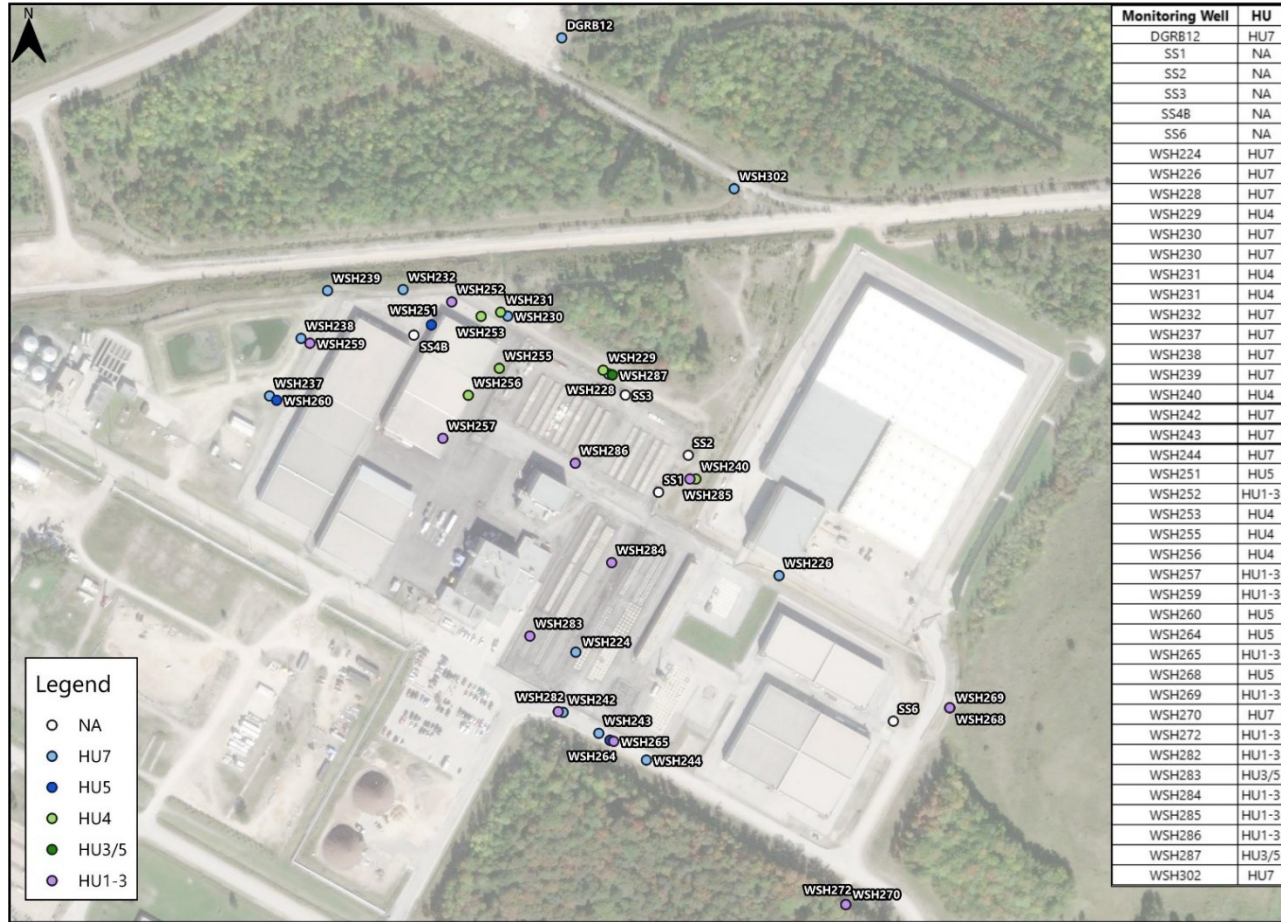
2.5 Objective 5 – Downgradient Perimeter Groundwater Monitoring

In 2022, groundwater quality was monitored in seven groundwater wells located on the perimeter of the WWMF. Locations monitored for this objective are shown in Figure 7. Sample results of groundwater tritium concentrations for Objective 5 are presented in Appendix A (Table A-6).

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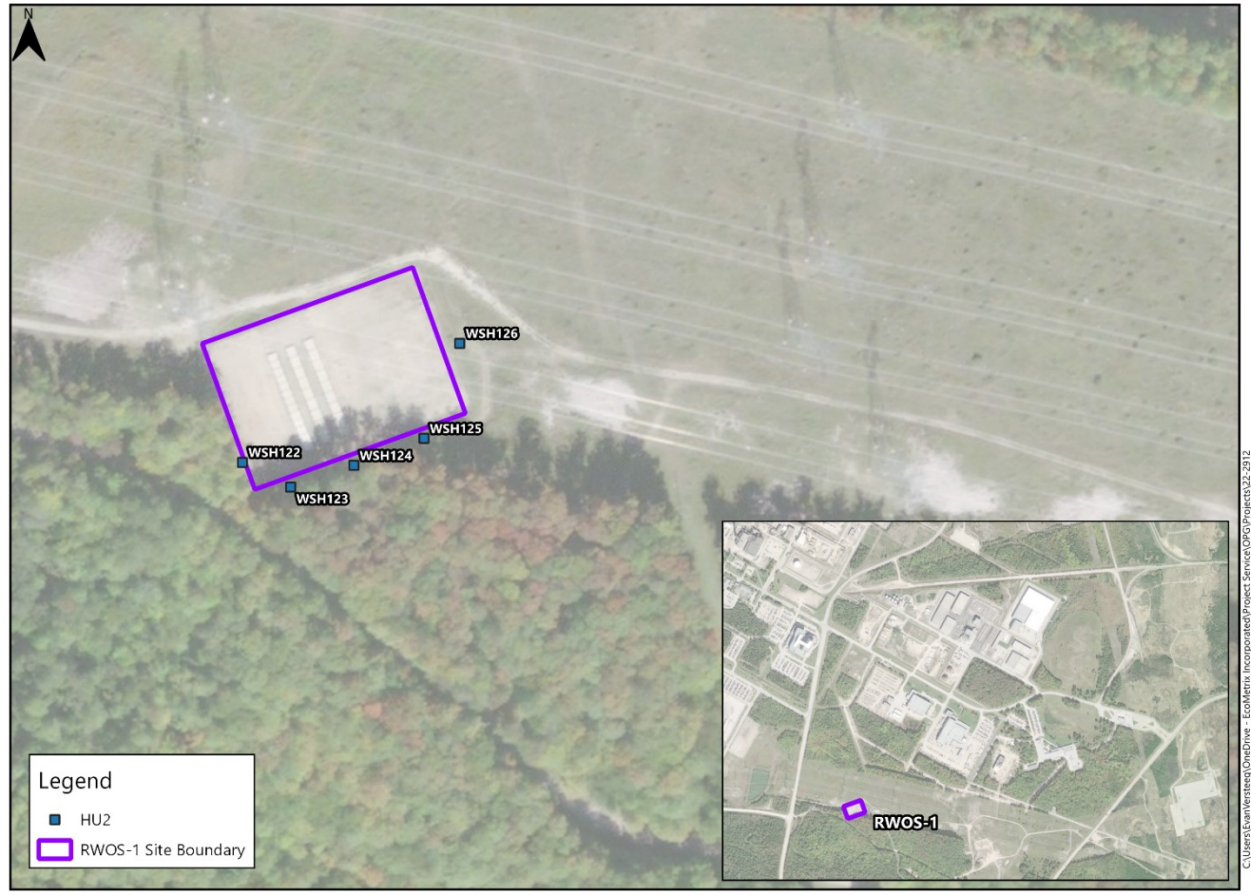


Figure 4: 2022 Monitoring Locations – Objective 1

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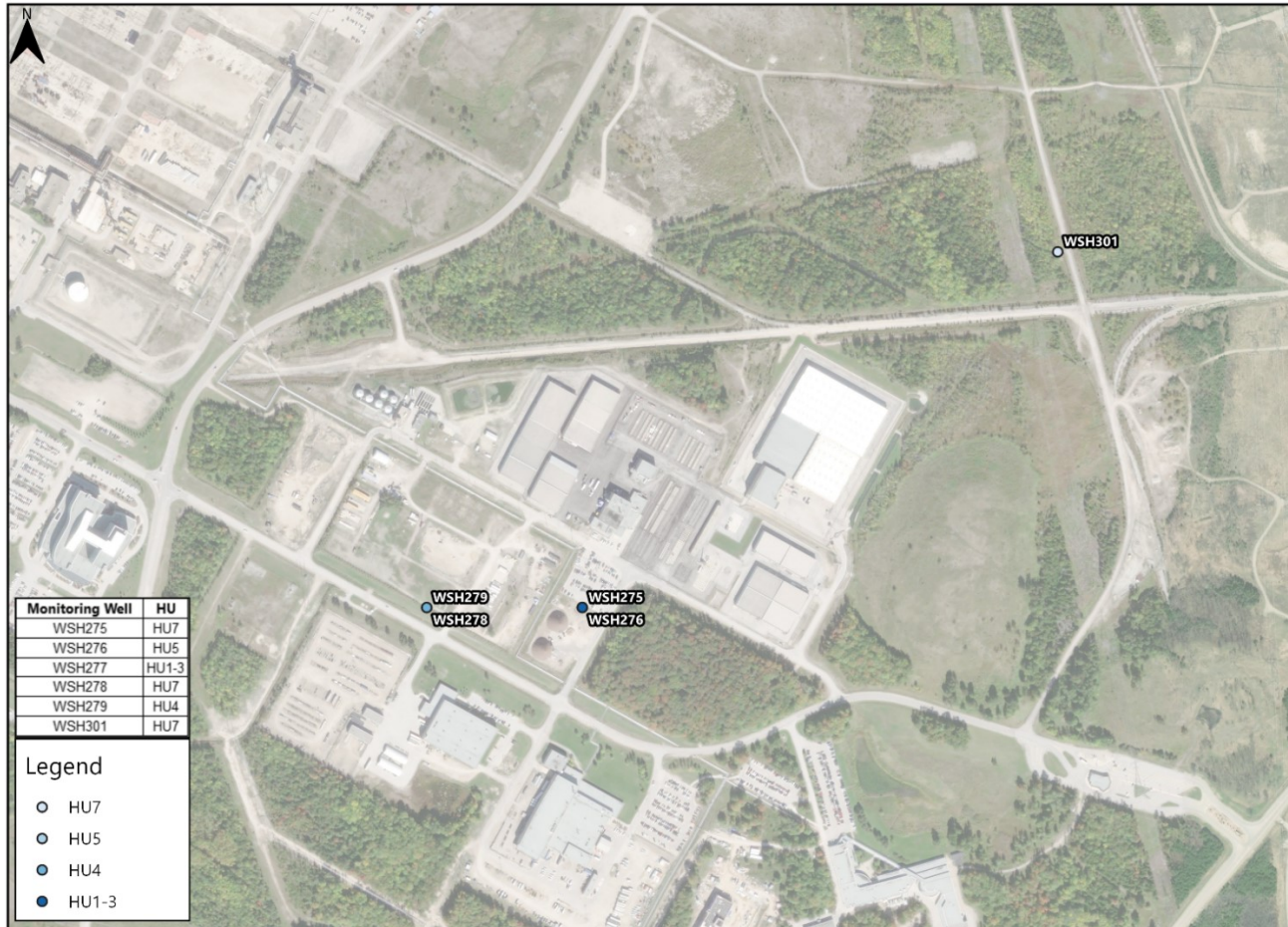
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Figure 5: 2022 Monitoring Locations – Objective 2, RWOS1

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Figure 6: 2022 Monitoring Locations – Objective 3, Background Tritium Concentrations at the WWMF

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Figure 7: 2022 Monitoring Locations – Objective 5, Downgradient Perimeter Wells at the WWMF

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3.0 2022 PROGRAM RESULTS

3.1 Objective 1 Results – Tritium near SSCs at the WWMF

In 2022, the groundwater data collected from the areas surrounding SSCs at the WWMF indicate that tritium concentrations in groundwater have remained, overall, consistent with results for previous years and within the ranges of expected fluctuations resulting from ongoing routine operations, or represent the expected movement of well characterized and understood tritium releases to groundwater. Further discussion is provided in the sections below.

The frequency of sampling of the subsurface drainage is monthly. The frequency of sampling of groundwater monitoring wells has been specified based on groundwater conditions at the locations being sampled. Semi-annual sampling is the most frequent and biennial sampling is the least frequent.

3.1.1 LLSBs #1 to #10

Within the LLSB #1 to #10 area, the primary point source (or, SSC) of tritium to groundwater is tritiated water vapour that originates from the stored waste within the LLSBs. Tritium that condenses on the internal and external surfaces of the LLSBs and surrounding asphalt surfaces has the potential to migrate to the subsurface via sumps or pervious surfaces. In recent years, and including in 2022, conditions with respect to tritium concentrations in groundwater in this area are, for the most part, decreasing over time or are stable and not showing changes over time.

Maximum tritium concentrations in groundwater, in all HUs beneath the LLSB #1 to #10 area, in 2022 are shown in Figure 8. Tritium concentrations are highest to the north of LLSBs #1 to #5 in the subsurface drainage, SS4B, and in monitoring wells WSH251, WSH253, and WSH 231 installed in the MSA.

Tritium concentrations in groundwater to the west of the LLSBs #1 to #10, in monitoring wells WSH237, WSH238 and WSH239 (all in HU-7), WSH259 (HU1-3) and WSH260 (HU5) are stable or decreasing, as shown in Graph 1 for WSH259. These wells are located in the inferred upgradient groundwater flow direction to the LLSBs #1 to #10 (see Objective #4, Section 2.4) and tritium concentrations in these wells represent background conditions in those HUs within this area of the site. Tritium concentrations in groundwater are also at background levels in well WSH232, screened in bedrock immediately to the north of LLSBs #1 to #10.

North and east of LLSBs #1 to #5, maximum concentrations of tritium in groundwater are measured in the subsurface drainage, monitored at SS4B. Tritium concentrations in SS4B have decreased over time and stabilized to values between approximately 10,000-20,000 Bq/L in the past five years, as shown in Graph 3. In 2022, tritium concentrations in SS4B

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ranged from 11,500 Bq/L (May) to 24,400 Bq/L (February), with an annual average concentration of about 16,000 Bq/L (Graph 3 and Table A-1b).

Downgradient, tritium concentrations elevated above background values are observed in the shallow till/fill material and in the MSA, which is encountered at relatively shallow depths within the LLSBs #1 to #10 area. Maximum tritium concentrations in groundwater within the shallow fill/till were 18,200 Bq/L in 2022 (WSH252), which is aligned with annual average values of tritium in the subsurface drainage. Within the MSA, maximum tritium concentrations were observed in WSH253 in 2022, as they have been historically; tritium concentrations in this well have been stable in recent years (Graph 2). Further downgradient, tritium concentrations in WSH231 are decreasing steadily (Graph 4). To the west of the LLSBs, tritium concentrations are stable or stabilizing to concentrations of approximately 3,000 Bq/L in monitoring wells WSH255, WSH256, and WSH257, as shown in Graph 5 for WSH255.

Tritium concentrations in the underlying unweathered till (HU5) and bedrock aquifer (HU7) to the northeast of LLSBs #1 to #5 show tritium concentrations above background levels, reflecting natural downward vertical gradients between the MSA and the deeper groundwater units across the WWMF (Ecometrix, 2022b). Tritium concentrations in the deeper till at WSH251 are decreasing (Graph 6), with a maximum value in 2022 of 1680 Bq/L. In bedrock (HU7), monitoring well WSH230 is clustered with MSA well WSH231 (HU4). Tritium concentrations in the bedrock hydrostratigraphic unit at WSH230 are increasing, as shown in Graph 7, with a maximum concentration of 678 Bq/L in 2022 which is approximately one order of magnitude lower than the concentrations in the overlying MSA at WSH231 (maximum concentration in 2022 of 9390 Bq/L; Figure 4). Low levels of tritium are migrating to the northwest in the groundwater in bedrock (HU7).

The extent of migration of tritium further downgradient in HU7 is being monitored in wells WSH302 and DGRB-12. Tritium concentrations in well WSH302 are at background levels. Tritium concentrations were only available for DGRB-12 in 2022. The measured tritium value of 110 Bq/L is elevated to a limited extent above expected background concentrations in HU7 beneath the LLSBs #1 to #10.

The data in 2022 confirms that groundwater conditions continue to improve overall, with respect to tritium concentrations north and east of LLSBs #1 and #5. Tritium continues to migrate downwards in groundwater from shallow groundwater to the bedrock hydrostratigraphic unit. The extent of tritium migration in HU7 will continue to be monitored. Monitoring of additional downgradient perimeter wells as part of Objective 5 (Section 2.5) demonstrates that tritium concentrations in the perimeter wells remain substantively below groundwater evaluation criteria and confirm that the potential for adverse effects to water quality off-Site beyond the WWMF site boundaries is low to negligible.

Groundwater quality in this area will continue to be monitored.

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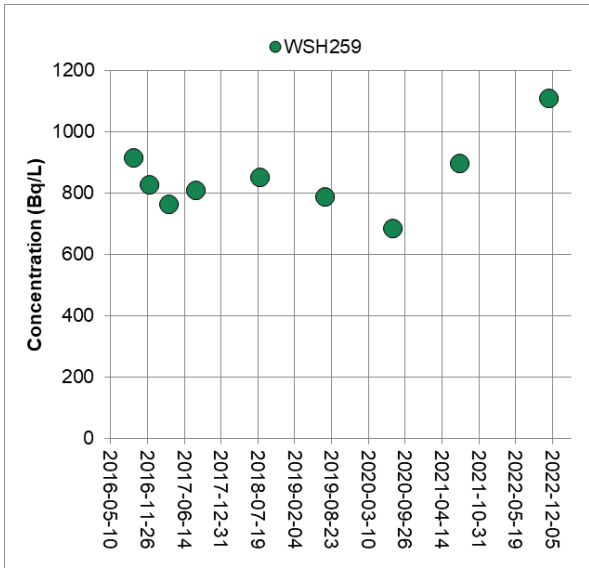


Figure 8: 2022 Maximum Tritium Concentrations – Objective 1, LLSB #1 to #10

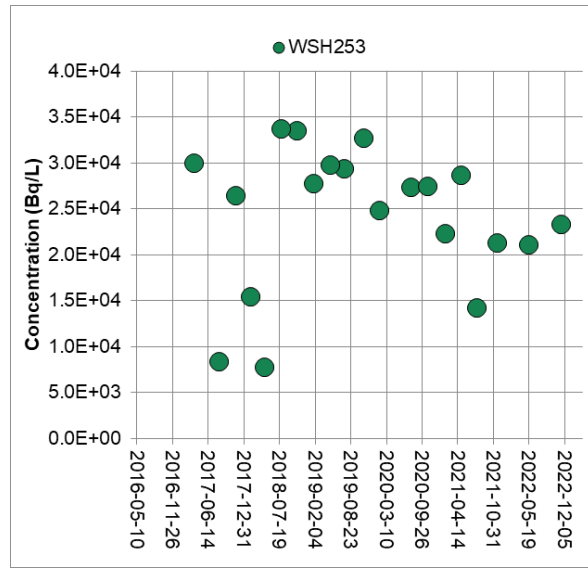
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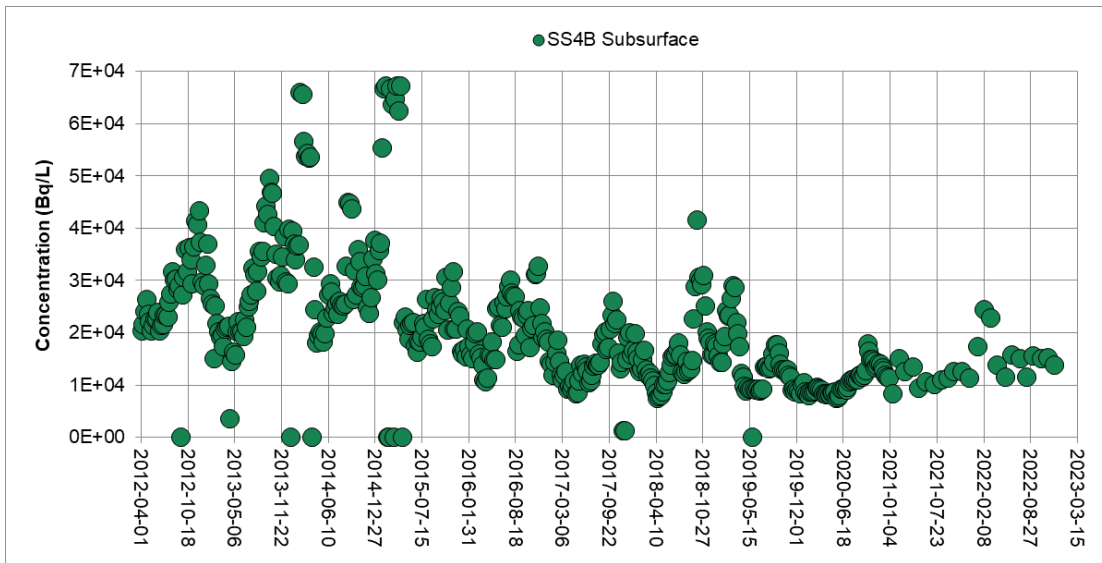
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Graph 1: WSH259 Tritium Data



Graph 2: WSH253 Tritium Data

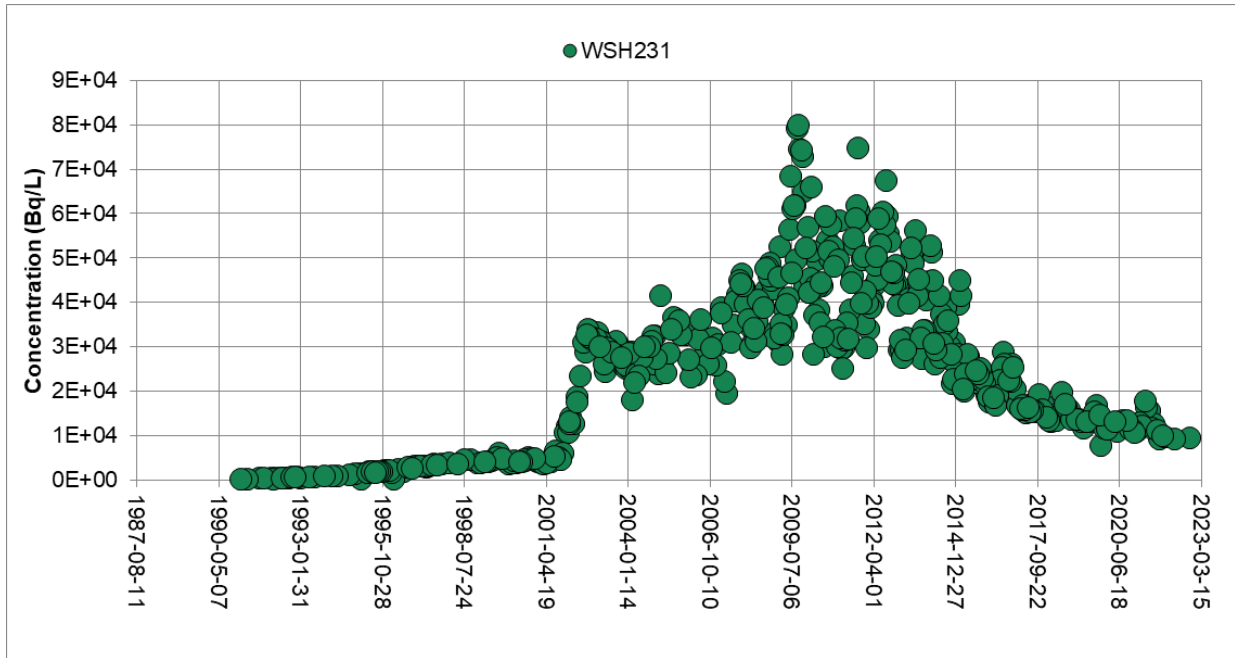


Graph 3: SS4B Tritium Data

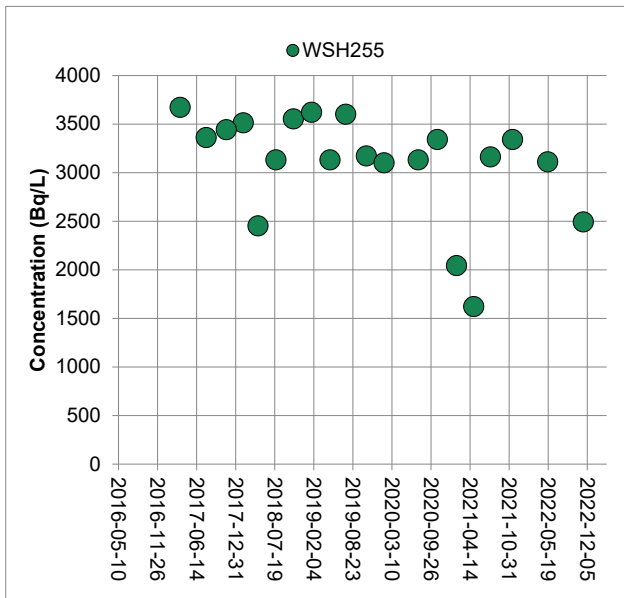
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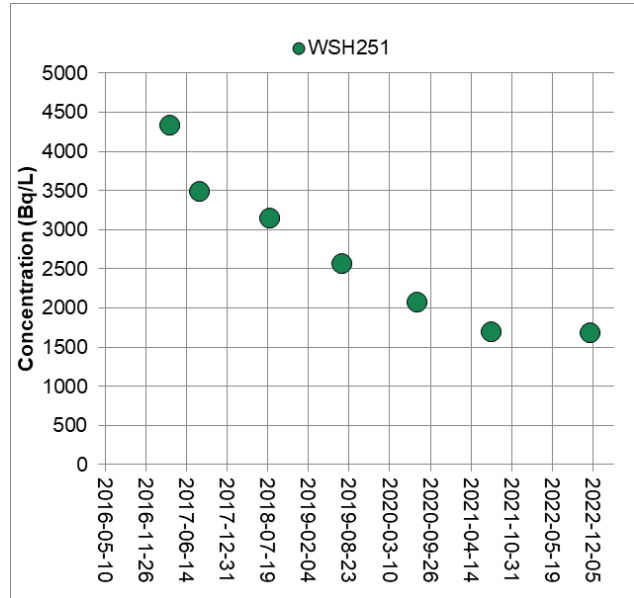
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Graph 4: WSH231 Tritium Data



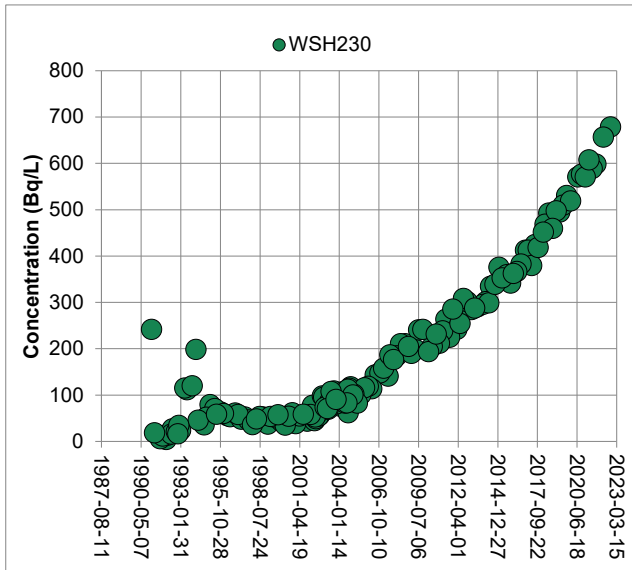
Graph 5: WSH255 Tritium Data



Graph 6: WSH251 Tritium Data

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Graph 7: WSH230 Tritium Data

3.1.2 LLSBs #11 to #14, SGSB and RWCSB

LLSBs #11 to #14, SGSB and RWCSB are in the southeast corner of the WWMF. Maximum tritium concentrations are shown spatially in Figure 9. The MSA is not present beneath this portion of the WWMF. The groundwater monitoring network includes monitoring wells installed in shallow groundwater (HU1-3), deeper till (HU5) and bedrock (HU7). Subsurface drainage collected in this area is monitored at SS6. Historical results in this area suggest that uncontrolled releases of tritium from the LLSBs #11 to #14, the SGSB or the RWCSB to groundwater have not occurred (Ecometrix, 2022b).

Tritium concentrations in groundwater and subsurface drainage in this area in 2022 are summarized in Tables A2-a and A2-b, respectively.

Tritium concentrations in the subsurface drainage, measured at SS6, have fluctuated since the LLSBs were put into service in 2010, and are considered to result from operational activities (e.g., waste loadings, sump pump outs, etc.,). Maximum tritium concentrations in subsurface drainage at SS6 were observed in 2015, with values decreasing again since that time, and concentrations demonstrate no trend in recent years (Graph 8). In 2022, tritium concentrations in SS6 ranged from 1270 Bq/L (February) to 6370 Bq/L (March) with an average annual value of 4699 Bq/L (Appendix A, Table A-2b).

In 2022, groundwater flow conditions (Section 2.4) were consistent with historical conditions, from south to north in HU1-3 and HU7. Tritium concentrations are at background levels upgradient of the SSCs in both HU1-3 (WSH272) and HU7 (WSH270). Tritium concentrations in HU7 are at background levels downgradient of the SSCs. Tritium concentrations in

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groundwater near the SSCs are measured in HU1-3 and HU5 in wells WSH269 and WSH268, respectively. In well WSH269, tritium concentrations are elevated above background levels, with a maximum tritium concentration in 2022 of 544 Bq/L in Q2. Tritium concentrations fluctuate in WSH269 but are not increasing (Graph 9). In the deeper till (WSH268), concentrations are at background levels.

The temporal behaviour of tritium in WSH269 indicates that routine operational activities associated with the LLSBs #11 to #14 are influencing water quality near the SSCs to a limited extent, but an uncontrolled release has not occurred. Groundwater quality in the deeper groundwater is not influenced by operational activities.

Groundwater quality in this area will continue to be monitored.

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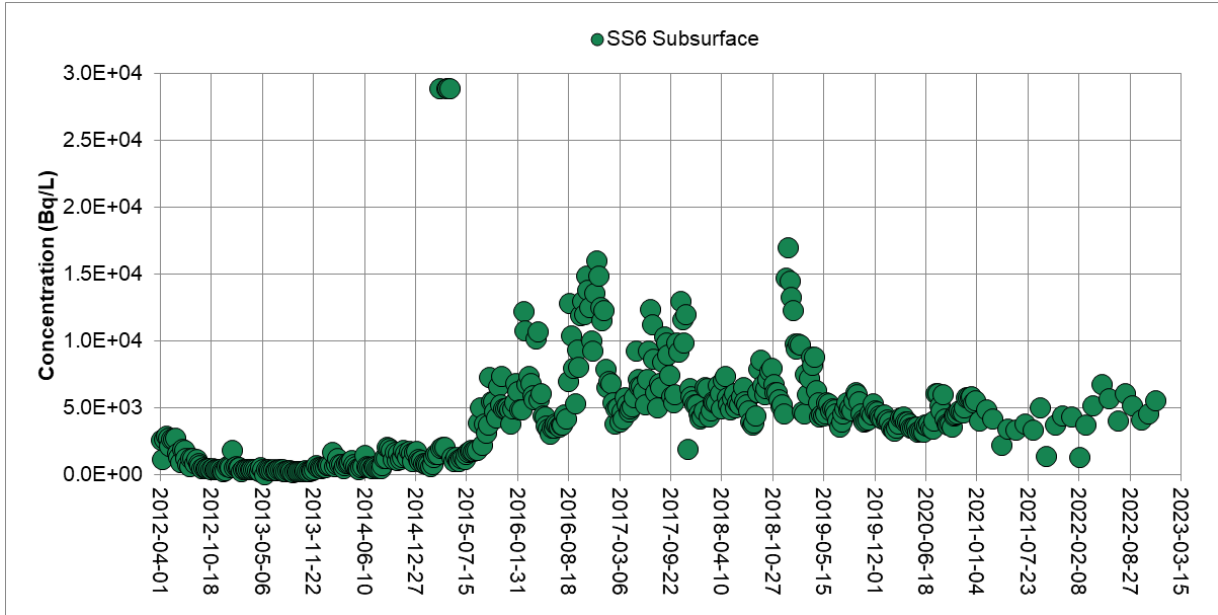


Figure 9: 2022 Maximum Tritium Concentrations – Objective 1, LLSB #11 to #14, SGSB and RWCS

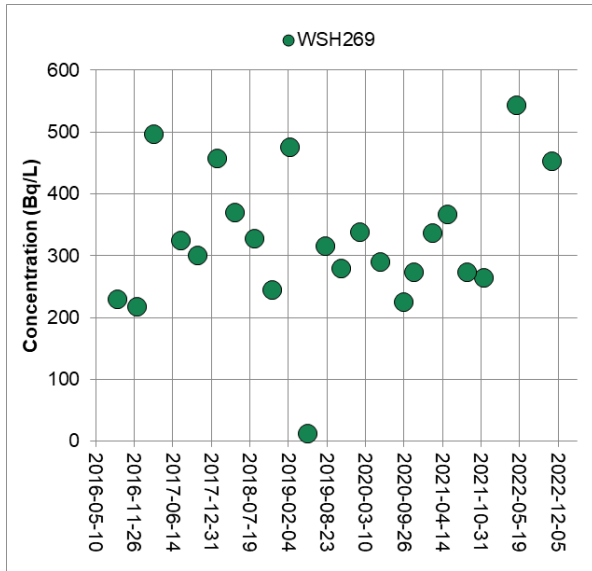
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Graph 8: SS6 Tritium Data



Graph 9: WSH269 Tritium Data

3.1.3 Trenches, Tile Holes, ICs and Quadricells

The area containing the trenches, tiles holes, ICs and Quadricells is in the central portion of the WWMF. In this area, tritium concentrations in groundwater and subsurface drainage are

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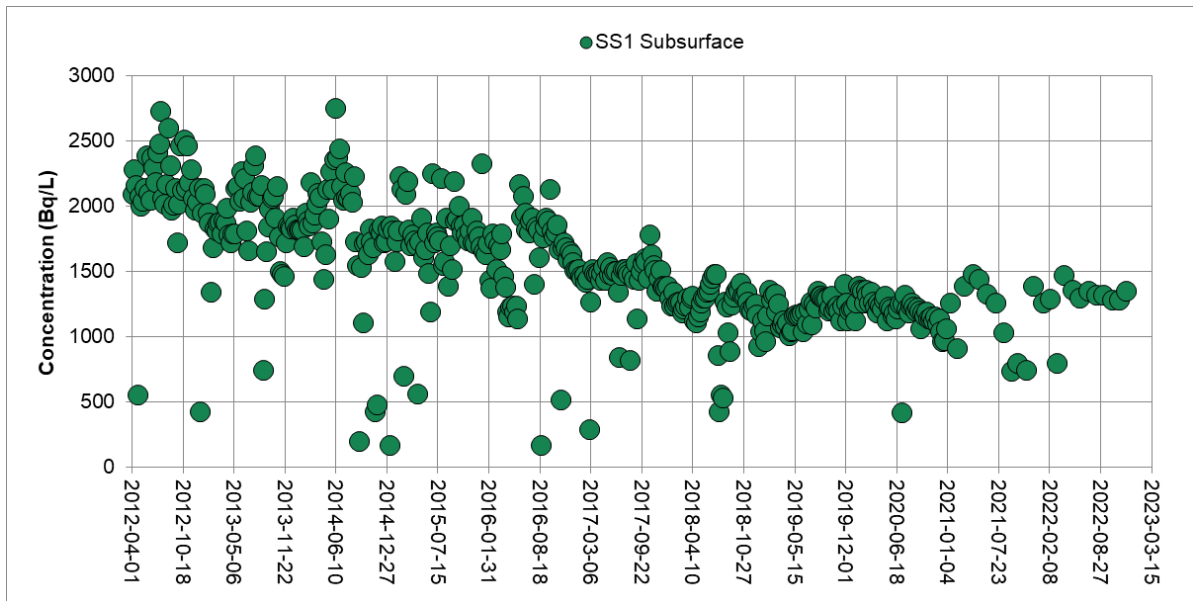
influenced by the ingress of groundwater into and egress of water out of waste structures, and primarily from the Tile Holes and Trenches in Stages 1 and 3 (Ecometrix, 2022b).

The subsurface drainage in the central part of the WWMF is collected from around the:

- Stage 1 Tile Holes (TH101 to TH180) and Trenches (TRH3 to TRH6), and sampled at SS1;
- remaining Tile Holes and Trenches (TRH7 to TRH10), and sampled at SS2; and
- Stage 3 and 3E Trenches, and sampled at SS3.

Tritium concentrations in groundwater and subsurface drainage in this area in 2022 are summarized in Appendix A, Tables A3-a and A3-b, respectively. Maximum tritium concentrations in 2022 are shown spatially in Figure 10.

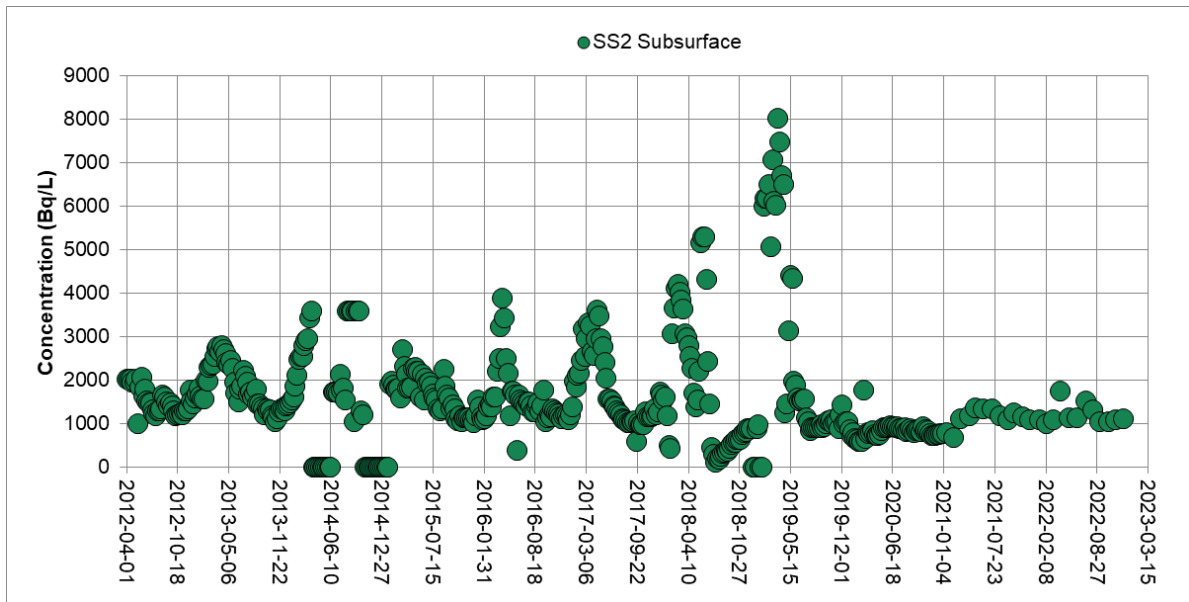
Tritium concentrations in subsurface drainage since 2012 are shown in Graph 10 for SS1, Graph 11 for SS2 and Graph 12 for SS3. Tritium concentrations have fluctuated temporally but have decreased overall. Maximum and annual average tritium concentrations measured at SS1, SS2, and SS3 in 2022 were 1470 Bq/L and 1281 Bq/L, 1760 Bq/L and 1199 Bq/L, and 4630 Bq/L and 1789 Bq/L, respectively (Graphs 10 to 12 and Table A-3b).



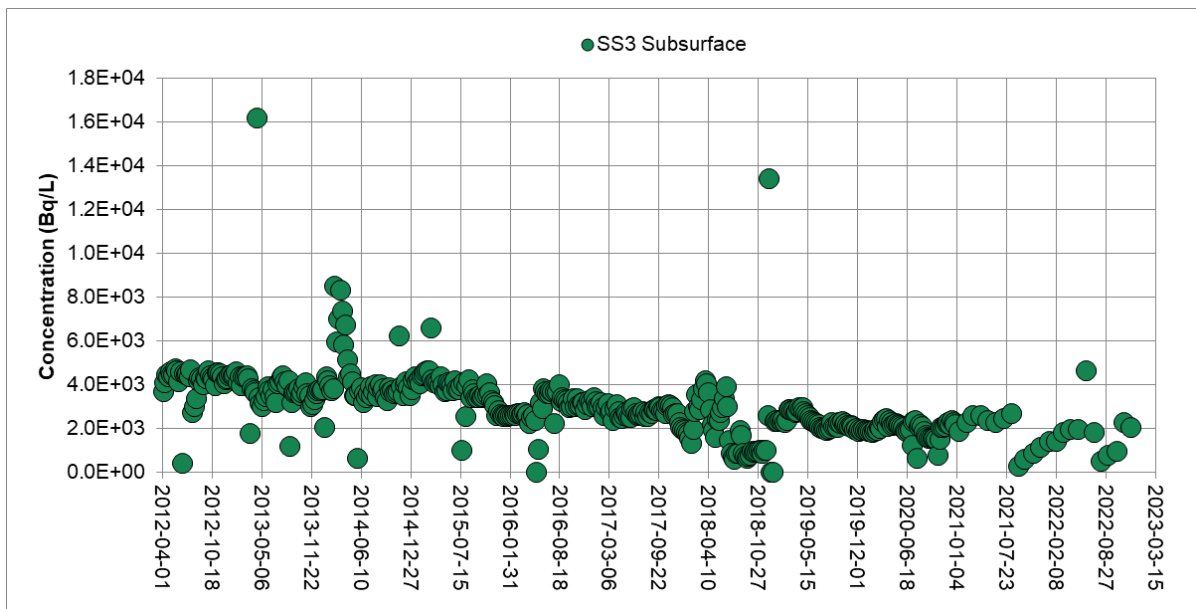
Graph 10: SS1 Tritium Data

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Graph 11: SS2 Tritium Data



Graph 12: SS3 Tritium Data

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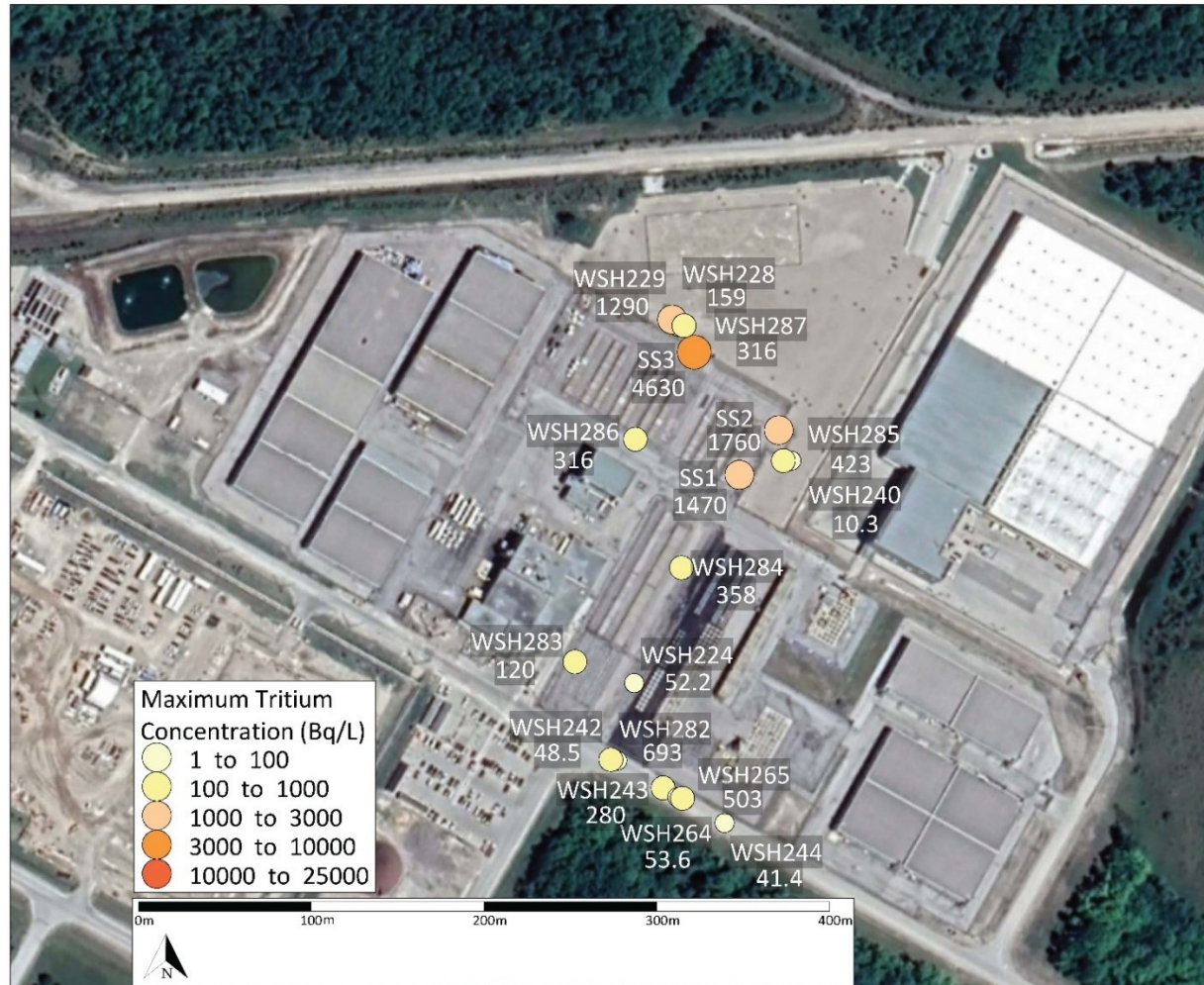


Figure 10: 2022 Maximum Tritium Concentrations – Objective 1, Trenches Tile Holes, Inground Containers and Quadricells

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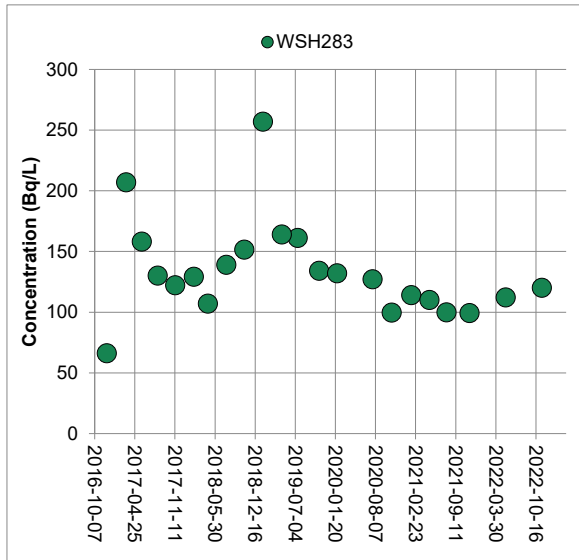
Over this central portion of the WWMF, groundwater is inferred to flow, generally from south of the ICs, tile holes and Quadricells to the north, in both HU1-3 and HU7 (Section 2.4). However, the groundwater flow directions are understood to be more complex in the southeastern portion of this area, where mounding of groundwater in the area around WSH224 has been noted (Jensen, 1996). There is also a groundwater divide in the HU1-3 south of the ICs, tile holes and Quadricells. The MSA is interpreted to be present beneath the majority of this area and is for the most part overlain by several metres of fill/till material (Ecometrix, 2022b). Groundwater flow in the MSA is interpreted to be to the east (Section 2.4).

Across this entire central portion of the site, tritium concentrations in HU1-3 are at or close to background conditions and indicate that routine operations contribute low levels of tritium to groundwater in this area. Wells monitoring tritium concentrations in HU1-3 include: WSH265, WSH282, WSH283, WSH284, WSH285, and WSH286. Monitoring well WSH287 is screened deeper in the till (HU5/8). Tritium concentrations in these wells are, for the most part, stable, as is shown for WSH283 in Graph 13. The highest tritium concentrations in HU1-3 in the central area of the site are observed within and near the Stage 1 Trenches, Tile Holes, ICs and Quadricells. At well WSH284, maximum concentrations in February 2017 (608 Bq/L) and again in January 2019 (594 Bq/L), with concentrations decreasing to background levels between these times (Graph 14). Improving conditions are demonstrated by gradually decreasing tritium concentrations such as WSH265 (Graph 15). East of the Stage 3 trenches, tritium concentrations are increasing very gradually in well WSH285 (Graph 16). Tritium concentrations in that well are still within the range of concentrations observed in the wells south of the ICs, tile holes and Quadricells and the slow increase is considered related to routine operational conditions and not an inadvertent release.

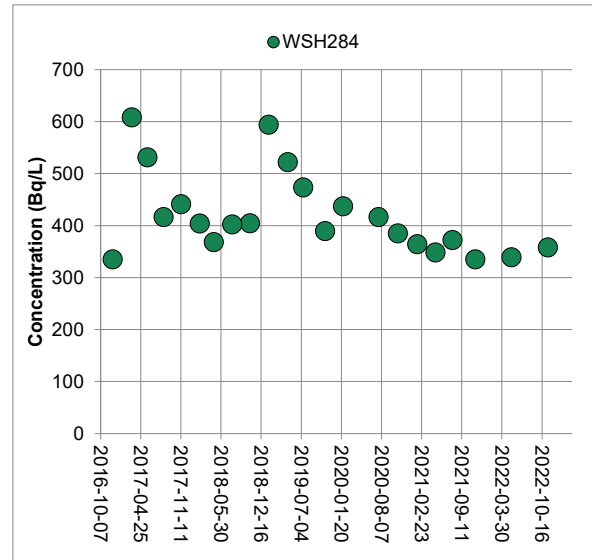
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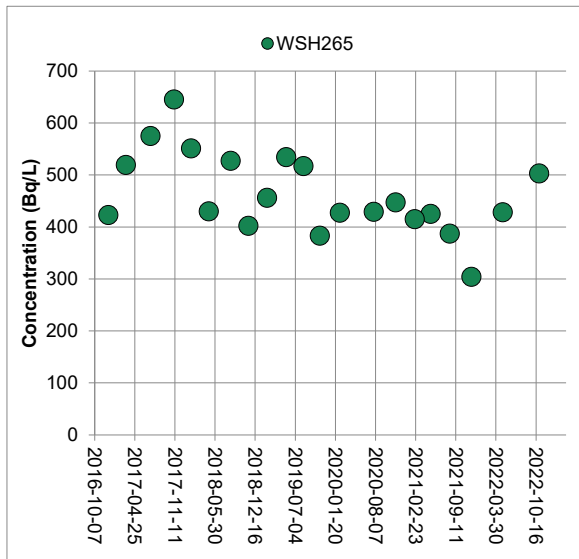
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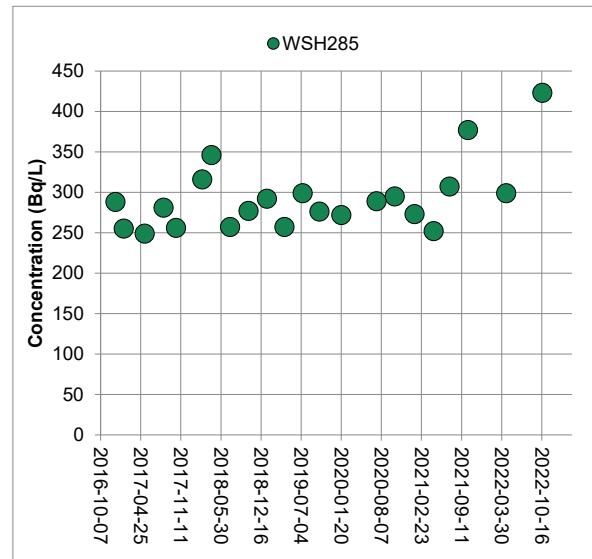
Graph 13: WSH283 Tritium Data



Graph 14: WSH284 Tritium Data



Graph 15: WSH265 Tritium Data



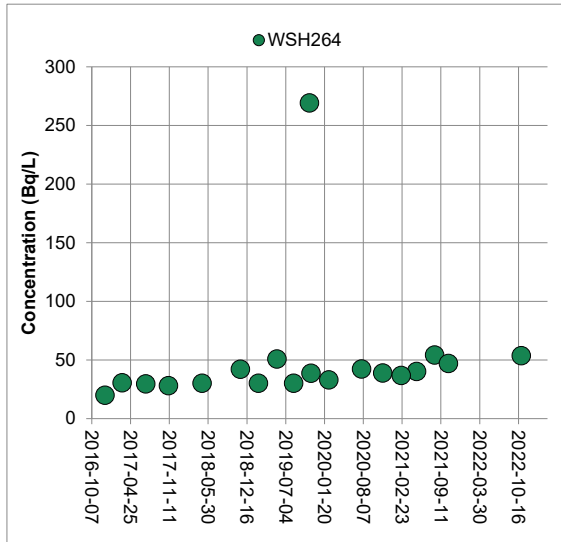
Graph 16: WSH285 Tritium Data

In deeper groundwater, tritium concentrations in the central part of the site are discussed for wells to the south, close to the Stage 1 trenches, tile Holes, ICs, and Quadricells separately from conditions to the north, within the Stage 3 and 3E trenches. South of the ICs, tile holes and Quadricells and nested with wells in HU1-3 are deep till and bedrock monitoring wells, being WSH264 (HU5), WSH242 (HU7), WSH243 (HU7) and WSH244 (HU7). Tritium concentrations in WSH264 are showing a very gradual increase over time, as shown in Graph 17, but remain at background levels. Tritium concentrations in bedrock at WSH243 and

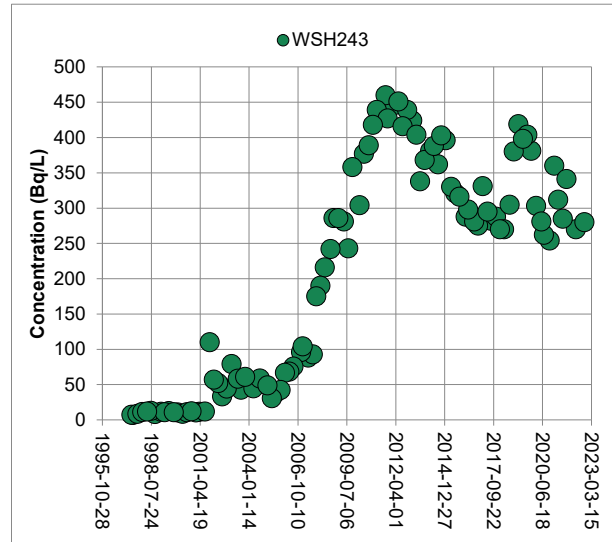
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WSH244 are stable and at background levels. In well WSH243, tritium concentrations have historically been and continue to be elevated above background levels, with a maximum concentration of 280 Bq/L in 2022. Tritium levels in this well have decreased from an overall maximum value in September 2011 (460 Bq/L; Graph 18). The source contributing to elevated tritium in this well is not known, but low tritium concentrations in groundwater in the deep till (WSH264) in this area suggest that the sources to the shallow groundwater and to bedrock are different/separate.



Graph 17: WSH264 Tritium Data



Graph 18: WSH243 Tritium Data

North of the Stage 3E trenches, tritium concentrations in the MSA and bedrock hydrostratigraphic units are monitored at locations WSH229 (HU4) and WSH228 (H7). East of the Stage 3 trenches, the MSA is monitored at location WSH240 (HU4). Tritium concentrations in WSH229 have been increasing over time, with concentrations fluctuating around 1000 Bq/L since 2021 (Graph 19). Because tritium concentrations in shallow groundwater in the overlying till (monitored at WSH287) are at background values, it is considered possible that tritium concentrations in the MSA at WSH229 reflect tritium migration from beneath the LLSBs #1 to #10, consistent with the inferred groundwater flow direction in the MSA to the east (Section 2.4). Further to the east in well WSH240 (HU4), tritium concentrations remain at background levels (Graph 20).

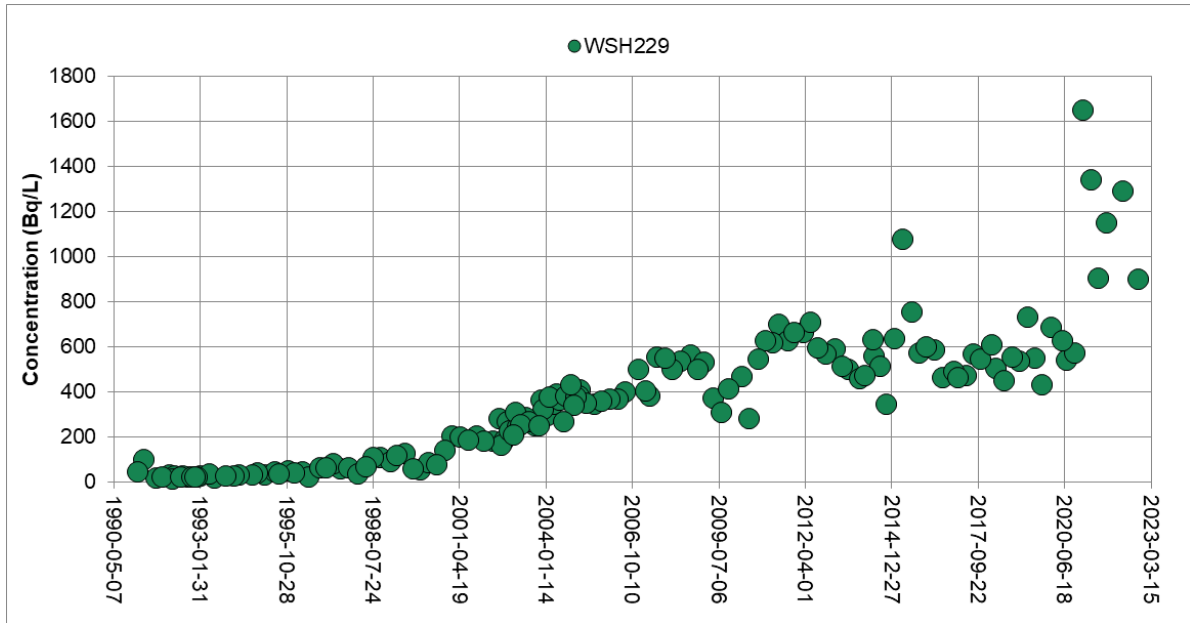
Tritium concentrations in the bedrock well in this area, at WSH228, show a different temporal behaviour, as shown in Graph 21. Concentrations in this well reached a maximum value of 518 Bq/L in 1999 and have been decreasing since that time. Maximum concentrations in WSH228 in 2022 were 159 Bq/L. The earlier source of tritium concentrations in this location is unknown and may have been related to the trenches. The persistence of low concentrations of tritium in groundwater in this well may indicate influence from the interconnectedness of the upper bedrock with the MSA.

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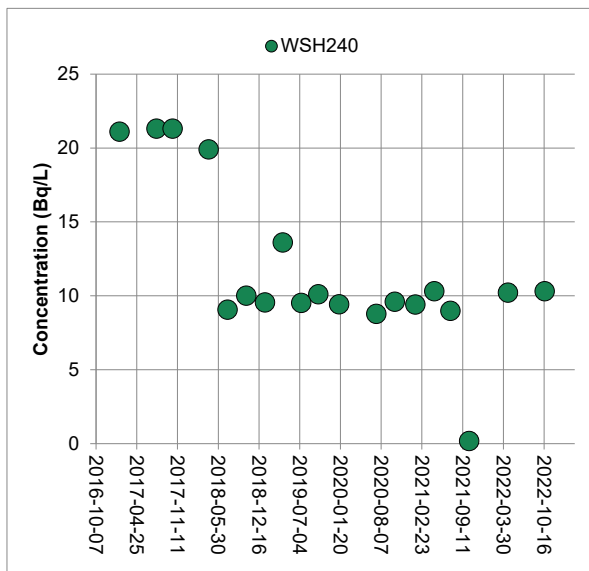
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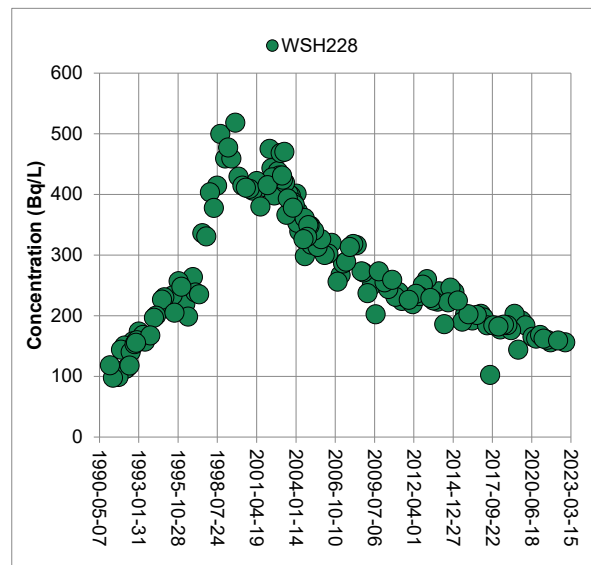
Groundwater quality in this area will continue to be monitored.



Graph 19: WSH229 Tritium Data



Graph 20: WSH240 Tritium Data



Graph 21: WSH228 Tritium Data

3.2 Objective 2 Results – RWOS1

In developing the GWPP for RWOS1, tritium concentrations in groundwater beneath the RWOS1 were determined to be comparable to those measured in precipitation (wet

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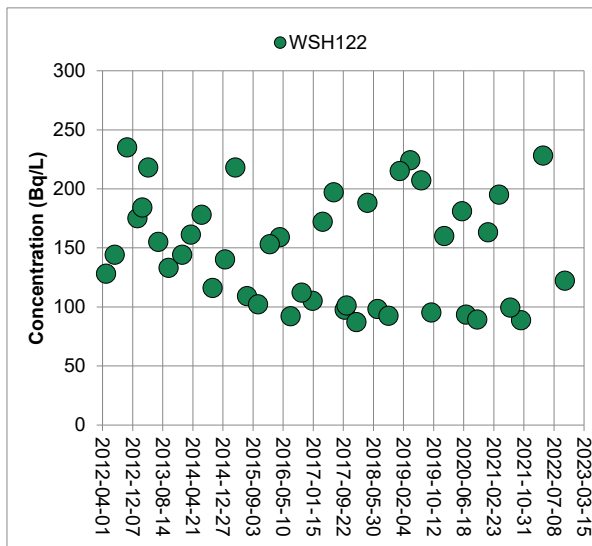
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deposition) and no localized tritium sources were identified (Ecometrix, 2022b). The potential for the influence of SSCs on groundwater at RWOS1 is considered low; new wastes have not been received at RWOS1 since the 1970s and some wastes were relocated in the 1990s and 2000s.

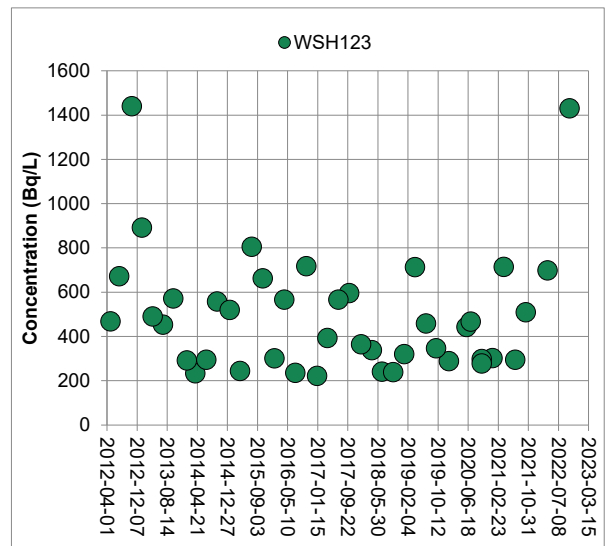
The frequency of sampling of groundwater monitoring wells in the RWOS1 wells is semi-annual. Maximum tritium concentrations in groundwater beneath the RWOS1 are shown in Figure 11.

Tritium concentrations in 2022 were within the historical range for all wells within the RWOS1. Fluctuations in tritium concentrations in RWOS1 wells are observed, as is shown for wells WSH122 and WSH123 over the last ten years in Graph 22 and Graph 23; however, the concentrations observed over time were stable. Fluctuations in tritium concentrations reflect fluctuations in tritium concentrations in precipitation (Ecometrix, 2022b).

As was concluded in the GWPP, there is no evidence of the influence of the SSCs on groundwater tritium concentrations at RWOS1. Groundwater will continue to be monitored in this area.



Graph 22: WSH122 Tritium Data



Graph 23: WSH123 Tritium Data

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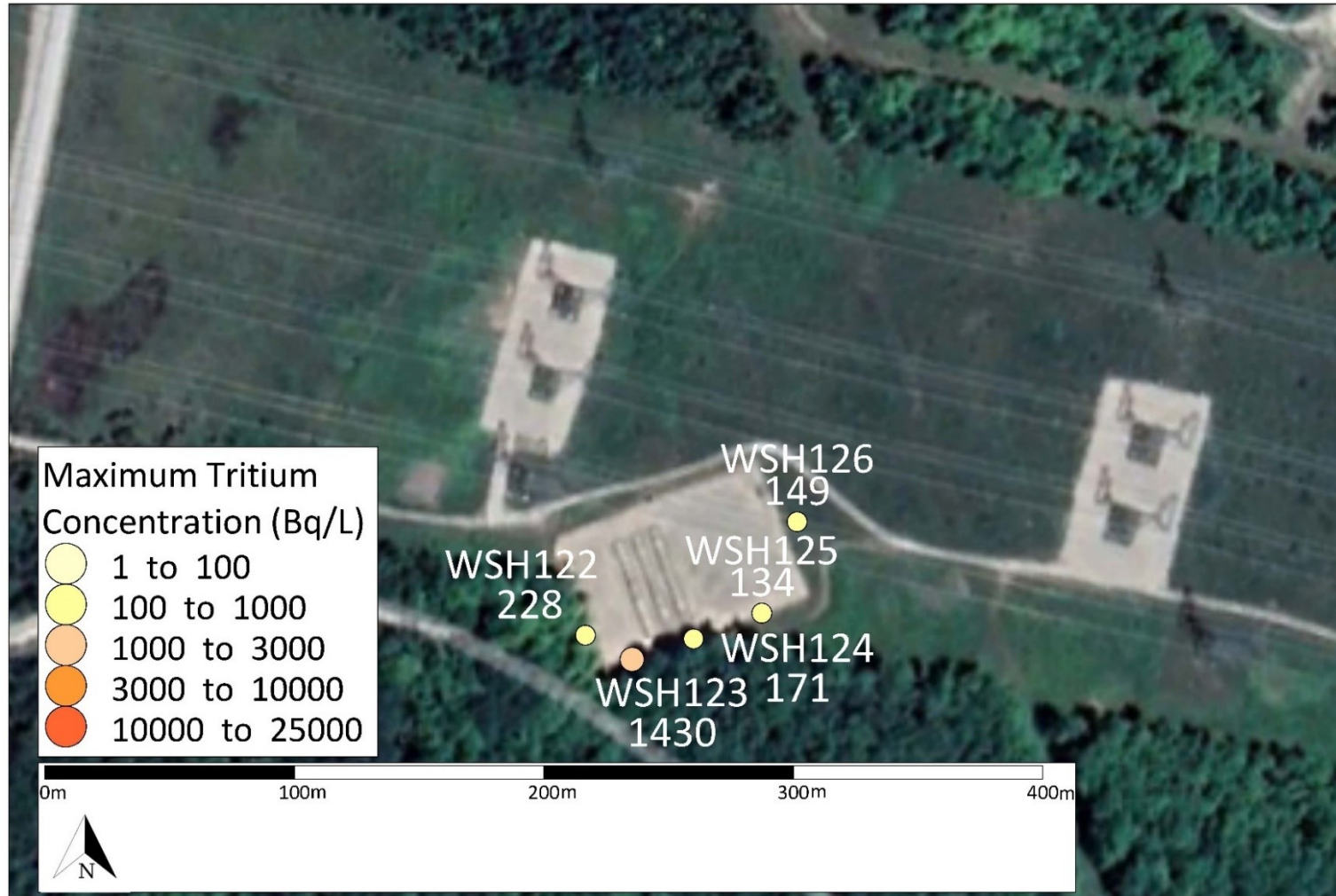


Figure 11: 2022 Maximum Tritium Concentrations – Objective 2, RWOS1

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3.3 Objective 3 Results – Background Tritium

Objective 3 was included as part of the GWMP to monitor tritium concentrations some distance from, the inferred upgradient or cross-gradient groundwater flow direction, from structures, systems, and components (SSCs). Tritium concentrations in wells meeting these criteria provide the means of identifying changes in background concentrations related to air emissions around the WWMF, to be considered in interpreting data downgradient of SSCs.

Background concentrations of tritium in groundwater for the WWMF are measured in groundwater monitoring wells located in the southwest portion of the site, in two wells clusters:

- WSH277(HU1-3), WSH276 (HU5) and WSH275 (HU7); and
- WSH279 (HU4) and WSH278 (HU7).

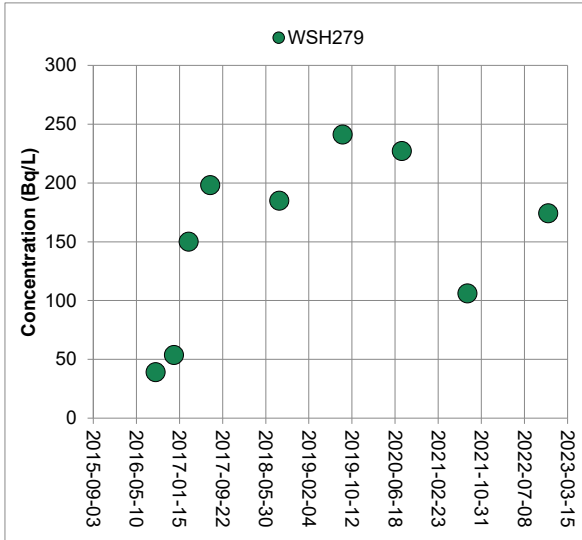
Background tritium concentrations are additionally monitored in WSH301, on OPG lands north of the WWMF.

Tritium concentrations in background wells are provided in Appendix A, Table A-5. Maximum tritium concentrations in background monitoring wells are shown in Figure 12. Tritium concentrations in the background wells are stable over time, indicating that they are not being influenced by SSCs. The temporal behaviour of tritium in monitoring wells WSH279 and WSH278 is shown as examples of background tritium concentrations over time in Graph 24 and Graph 25, respectively. Tritium concentrations are in the low 100s of Bq/L in groundwater in the upper fill/till (WSH279 and WSH277; (Appendix A, Table A-5) and at or below detection in the unweathered till (WSH276) and bedrock (WSH278, WSH275 and WSH301; Table A-5).

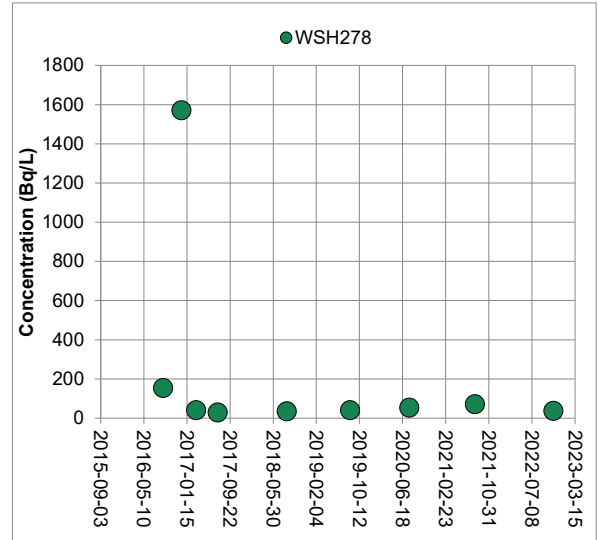
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Graph 24: WSH279 Tritium Data



Graph 25: WSH278 Tritium Data

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Figure 12: 2022 Maximum Tritium Concentrations – Objective 3, Background Monitoring Wells

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3.4 Objective 4 Results – Annual Snapshot of Hydraulic Head Measurements

The groundwater flow directions inferred for HUs beneath the WWMF and the RWOS1 from hydraulic head data collected in 2022 are consistent with historical interpretations.

Inferred groundwater flow directions in HU1-3 are shown in Figure 13. The flow directions are complex in this hydrostratigraphic unit, which is considered to reflect influences from the subsurface drainage infrastructure and the heterogeneous nature of the till/fill material. Groundwater in HU1-3 is inferred to discharge to the SRD and other drainage ditches on the WWMF (e.g., perimeter ditches in the laydown area), which ultimately discharge to Lake Huron (Ecometrix, 2022b).

Groundwater flow in the MSA is interpreted to flow east locally (Figure 14). Groundwater in the MSA also flows downward into the bedrock. Once in the bedrock, groundwater is inferred, from regional-scale water levels, to flow to Lake Huron (Ecometrix, 2022b). In the bedrock aquifer, groundwater is inferred to flow north towards Lake Huron, as shown in Figure 15.

Contours for the water table at RWOS1 are presented in Figure 16. Groundwater flow beneath the RWOS1 is inferred to flow southeast locally at the site. Ultimately, groundwater from beneath the RWOS1 is inferred, based on regional groundwater elevations in bedrock, to flow to the south towards Lake Huron (Ecometrix, 2022b).

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Figure 13: 2022 Q4 Shallow (HU 1-3) Groundwater Contours (December 12, 2022). Note: Elevations and contours are reported in metres above sea level (masl)

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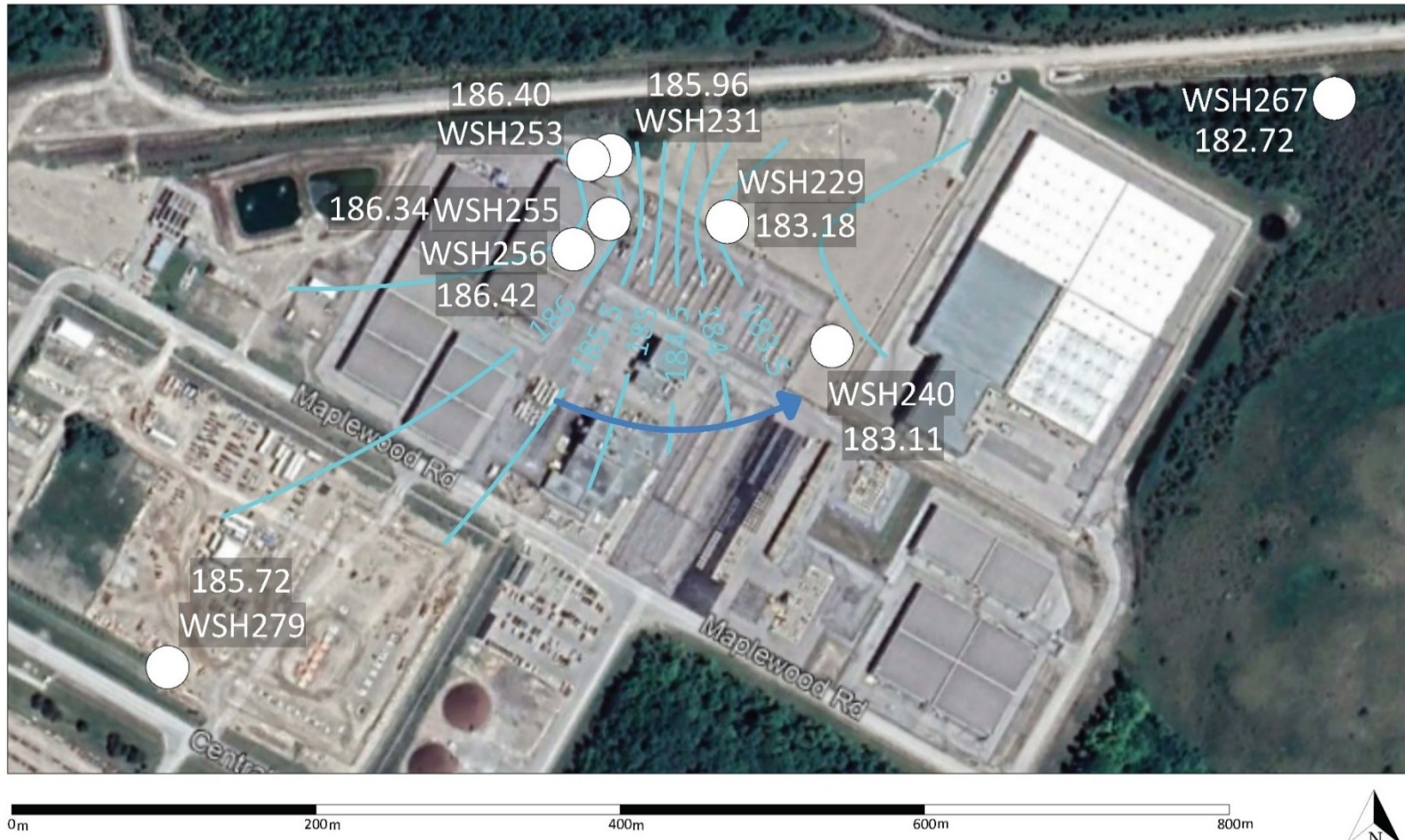


Figure 14: 2022 Q4 MSA (HU 4) Groundwater Contours (December 12, 2022). Note: Elevations and contours are reported in masl.

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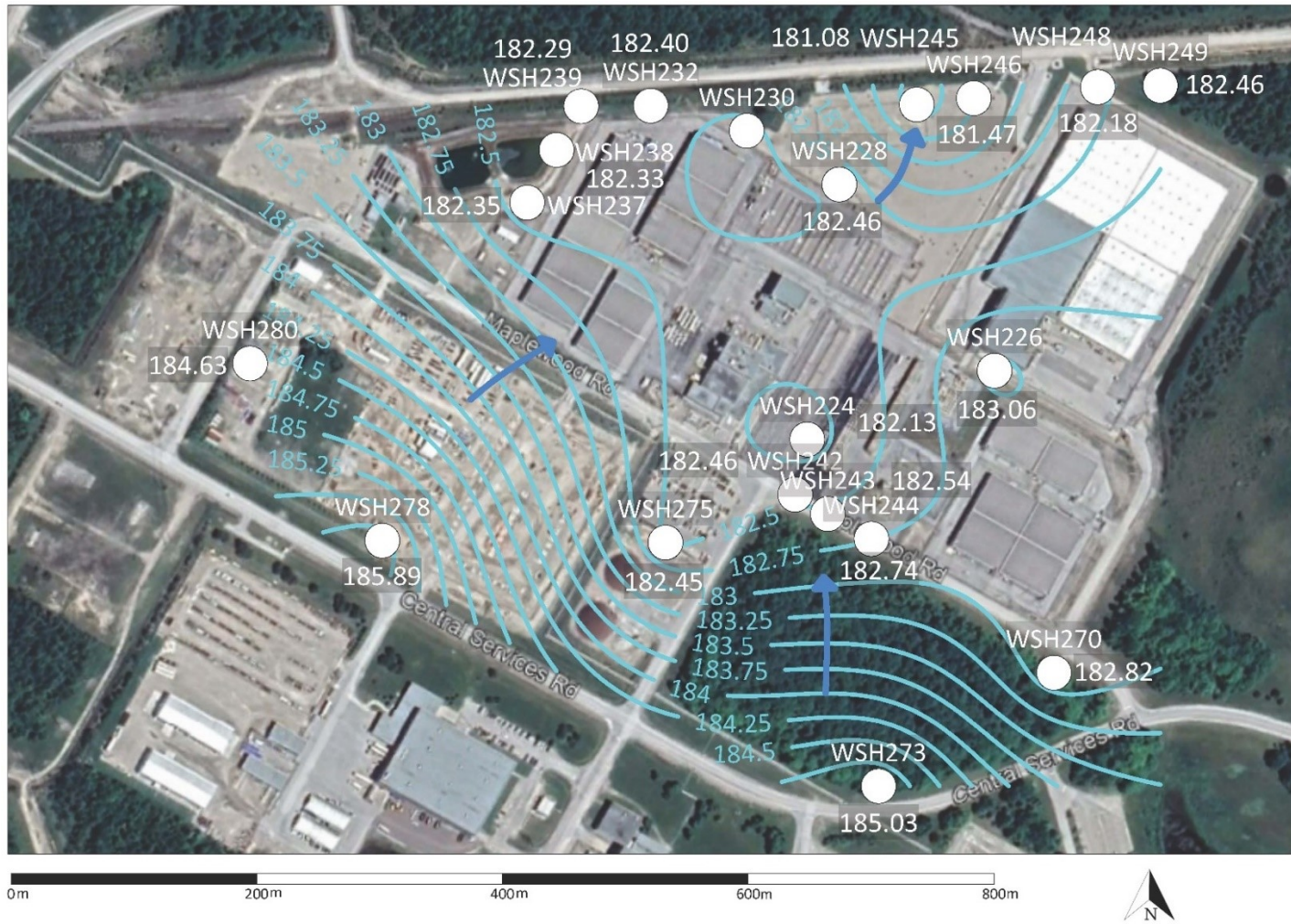


Figure 15: 2022 Q4 Bedrock (HU 7) Groundwater Contours (December 12, 2022). Note: Elevations and contours are reported in masl.

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Figure 16: 2022 Q4 (HU 2) Groundwater Contours at RWOS1 (December 12, 2022). Note: Elevations and contours are reported in masl.

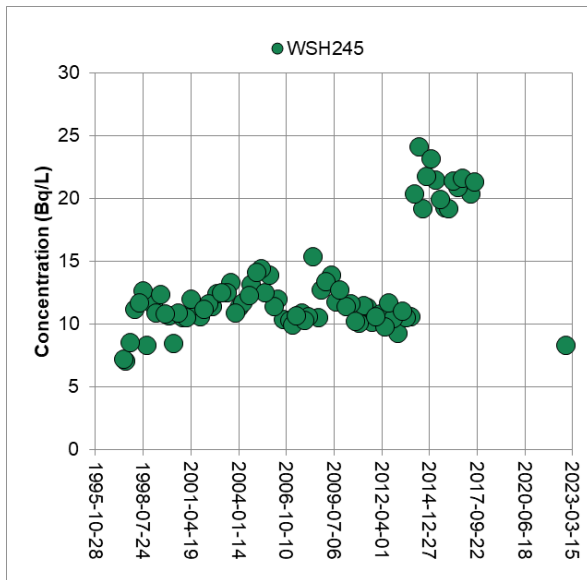
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3.5 Objective 5 Results – Downgradient Perimeter Groundwater Wells

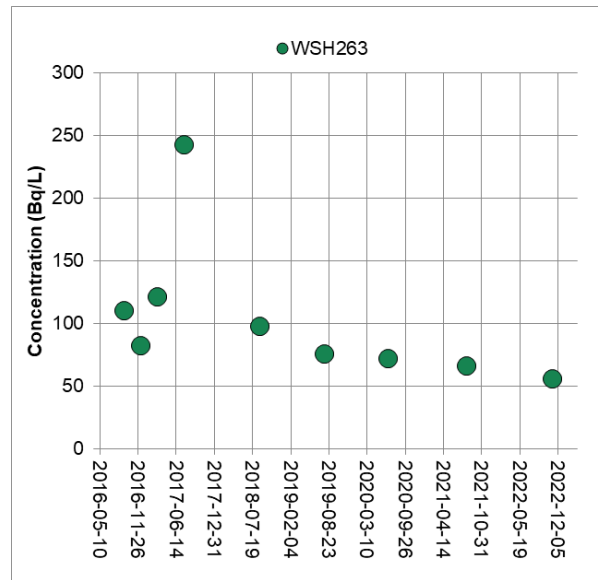
Groundwater quality along the perimeter of the WWMF in the inferred downgradient direction of groundwater flow in the middle sand and bedrock hydrostratigraphic units, HU4 and HU7, respectively, is monitored to provide timely data to evaluate whether human and ecological receptors associated with the groundwater end uses are protected. Tritium concentrations in these wells are compared to numeric groundwater evaluation criteria to identify any potential for off-site groundwater end uses. Groundwater end uses are off-site potable water wells and the discharge of groundwater from beneath the site to Lake Huron.

Tritium concentrations in perimeter wells WSH245 (HU7), WSH249 (HU5), WSH263 (HU5), WSH267 (HU4), WSH307 (HU7), DGRB12A (HU5) and DGRB14 (HU5) are provided in Table A-6. Maximum tritium concentrations in background monitoring wells are shown in Figure 17. Monitoring wells WSH 307, DGRB12A and DGRB14 are located north of the WWMF site boundary on OPG lands.

Tritium concentrations in the perimeter wells are stable as shown in Graph 26 for WSH245, or decreasing as shown in Graph 27 for WSH263. The results for the perimeter wells remain substantively below groundwater evaluation criteria and confirm that the potential for adverse effects to water quality off-Site beyond the WWMF site boundaries is low to negligible.



Graph 26: WSH245 Tritium Data



Graph 27: WSH263 Tritium Data

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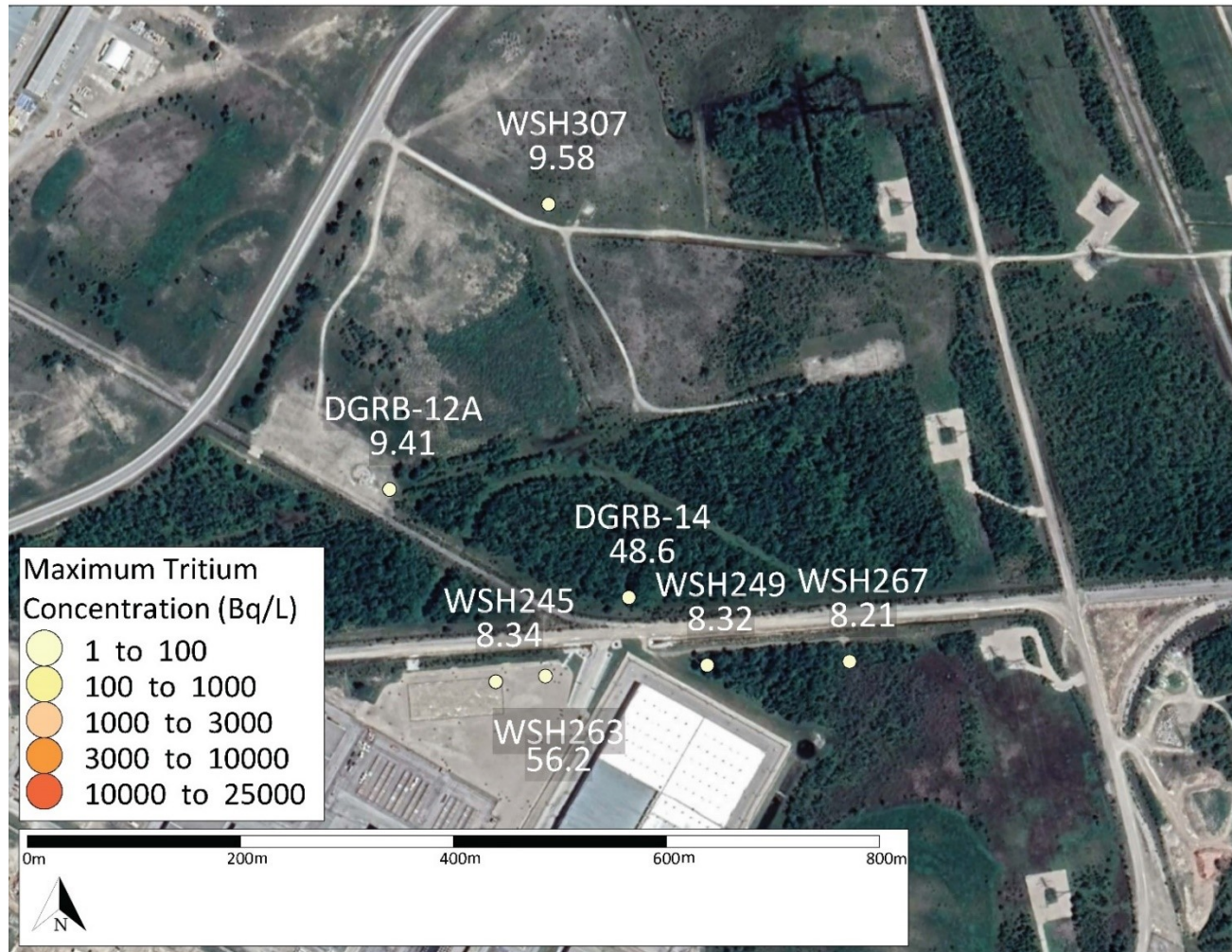


Figure 17: 2022 Maximum Tritium Concentrations – Objective 5, Downgradient Perimeter Monitoring Wells

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4.0 2022 QUALITY ASSURANCE AND QUALITY CONTROL

The Quality Assurance and Quality Control for the groundwater monitoring program encompasses all activities in field sample collection, laboratory analysis and laboratory quality control. The objective is to provide confidence in the interpretation of the WWMF and RWOS1 groundwater monitoring data through a systematic and documented process.

4.1 Quality Assurance Program for Laboratories

In 2022, water samples were submitted to the Bruce Power Health Physics Lab, which performs laboratory activities according to a documented quality assurance program.

4.2 Quality Control Results

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

In 2022, 12 field duplicate samples of tritium in groundwater were collected. To understand sampling precision, two data quality objectives were defined in the GWPP. The first objective is applied where concentrations of tritium being evaluated are greater than or equal to five times the detection limit and it is to achieve a relative percent difference (RPD) of 20% or less between the original and duplicate samples. The second objective is applied where the tritium concentrations being evaluated are less than five times the detection limit, and an absolute difference (AD) between the original and duplicate samples of less than two times the detection limit is to be achieved.

All sample and field duplicate pairs met the data quality objectives outlined above. The field technique and the laboratory's analytical methods employed were determined to be reproducible and reliable.

5.0 SUPPLEMENTARY STUDIES AND AUDITS

There were no supplementary studies related to the groundwater monitoring program at WWMF or RWOS1 initiated in 2022. There were no audits completed on the WWMF groundwater program in 2022.

6.0 NOMENCLATURE OF SAMPLING LOCATIONS

Sampling Location Type	Identifier	Explanation of Nomenclature
Groundwater Monitoring Well ("Water Sampling Hole")	WSHXXX or DGRB-XX	XXX or XX represents a unique identifier

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7.0 ACRONYMS AND UNITS

µCi/kg	Micro curie per Kilogram
Bq/L	Becquerel per Litre
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association
HU	Hydrostratigraphic Unit
LLSB	Low Level Storage Building
MW	Monitoring Well
OPG	Ontario Power Generation Inc.
QA/QC	Quality Assurance/Quality Control
RPD	Relative Percentage Difference
SAP	Sampling and Analysis Plan
SSC	Systems, Structures and Components
SGSB	Steam Generator Storage Building
RWCSB	Retube Waste Container Storage Building
WWMF	Western Waste Management Facility

8.0 REFERENCES

- Ecometrix, 2022a. Groundwater Protection and Monitoring Programs – CSA N288.7 Implementation at WWMF AND RWOS1. Report No. W-REP-07294-00002. October.
- Ecometrix, 2022b. Conceptual Site Model – CSA N288.7 Implementation at WWMF and RWOS1. Report No. W-REP-07294-00001. October.
- Ecometrix (Ecometrix Inc.), 2022c. 2022 Sampling and Analysis Plan, Western Waste Management Facility and RWOS1. July.
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- Jensen and Heystee (Ontario Hydro), 1987. BNPD Radioactive Waste Operations Site 1 and 2 Survey of Local Geologic and Hydrogeologic Conditions. Report No. 87126.
- Jensen (Ontario Hydro), 1996. BNPD RWO Site 2: Ground Water Monitoring Well Network Assessment. Report No. NK37- 03480–96006.

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Appendix A: Tables A-1 to A-7

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Table A-1a: 2022 Groundwater Results near LLSBs #1 to #10

Monitoring Location	Analysis Parameter	HU	Frequency	Q1 (Bq/L)	Q2 (Bq/L)	Q3 (Bq/L)	Q4 (Bq/L)
WSH230	Tritium	HU 7	Semi-Annual	--	656	--	678
WSH231	Tritium	HU4	Semi-Annual	--	9260	--	9390
WSH232	Tritium	HU7	Annual	--	--	--	8.4
WSH237	Tritium	HU7	Annual	--	--	--	10.7
WSH238	Tritium	HU7	Annual	--	--	--	1.06
WSH239	Tritium	HU7	Annual	--	--	--	10.5
WSH251	Tritium	HU5	Annual	--	--	--	1680
WSH252	Tritium	HU1-3	Annual	--	--	--	18200
WSH253	Tritium	HU4	Semi-Annual	--	21100	--	23300
WSH255	Tritium	HU4	Semi-Annual	--	3110	--	2490
WSH256	Tritium	HU4	Annual	--	--	--	2790
WSH257	Tritium	HU1-3	Annual	--	--	--	3490
WSH259	Tritium	HU1-3	Annual	--	--	--	1110
WSH260	Tritium	HU5	Annual	--	--	--	16.7
WSH302	Tritium	HU7	Annual	--	--	9.88	N/A
DGRB-12	Tritium	HU7	Annual	--	--	110	N/A

Note:

"--", Not required as per the WWMF GWMP

"N/A", Sample was not collected

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Table A-1b: 2022 Subsurface Drainage Results near LLSBs #1 to #10

Drainage ID	Analysis Parameter	Frequency	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SS4B Subsurface	Tritium	Monthly	17400	24400	22800	13800	11500	15700	15000	11600	15600	15100	15300	13900

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Table A-2a: 2022 Groundwater Results near LLSBs #11 to #14, SGSB and RWCSB

Monitoring Location	Analysis Parameter	HU	Frequency	Q1 (Bq/L)	Q2 (Bq/L)	Q3 (Bq/L)	Q4 (Bq/L)
WSH226	Tritium	HU7	Semi-Annual	--	9.13	--	9.67
WSH268	Tritium	HU5	Annual	--	--	--	9.98
WSH269	Tritium	HU1-3	Semi-Annual	--	544	--	453
WSH270	Tritium	HU7	Annual	--	--	--	8.48
WSH272	Tritium	HU1-3	Annual	--	--	--	295

Note:

"--", Not required as per the WWMF GWMP

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Table A-2b: 2022 Subsurface Drainage near LLSBs #11 to #14, SGSB and RWCSB

Drainage ID	Analysis Parameter	Frequency	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SS6 Subsurface	Tritium	Monthly	4330	1270	3690	5170	6730	5660	4060	6110	5200	4090	4530	5550

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Table A-3a: 2022 Groundwater Results near Trenches, Tile Holes, ICs and Quadricells

Monitoring Location	Analysis Parameter	HU	Frequency	Q1 (Bq/L)	Q2 (Bq/L)	Q3 (Bq/L)	Q4 (Bq/L)
WSH224	Tritium	HU7	Annual	--	--	--	52.2
WSH228	Tritium	HU7	Semi-Annual	--	159	--	156
WSH229	Tritium	HU4	Semi-Annual	--	1290	--	903
WSH240	Tritium	HU4	Semi-Annual	--	10.2	--	10.3
WSH242	Tritium	HU7	Semi-Annual	--	48.5	--	39
WSH243	Tritium	HU7	Semi-Annual	--	270	--	280
WSH244	Tritium	HU7	Annual	--	--	--	41.4
WSH264	Tritium	HU5	Annual	--	--	--	53.6
WSH265	Tritium	HU1-3	Semi-Annual	--	428	--	503
WSH282	Tritium	HU1-3	Semi-Annual	--	693	--	600
WSH283	Tritium	HU1-3	Semi-Annual	--	112	--	120
WSH284	Tritium	HU1-3	Semi-Annual	--	339	--	358
WSH285	Tritium	HU1-3	Semi-Annual	--	299	--	423
WSH286	Tritium	HU1-3	Semi-Annual	--	269	--	316
WSH287	Tritium	HU3/5	Semi-Annual	--	287	--	316

Note:

"--", Not required as per the WWMF GWMP

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Table A-3b: 2022 Subsurface Drainage near near Trenches, Tile Holes, ICs and Quadricells

Drainage ID	Analysis Parameter	Frequency	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SS1 Subsurface	Tritium	Monthly	1260	1290	794	1470	1360	1300	1350	1320	1320	1280	1280	1350
SS2 Subsurface	Tritium	Monthly	1090	1010	1090	1760	1140	1130	1530	1330	1050	1040	1100	1120
SS3 Subsurface	Tritium	Monthly	1420	1410	1830	1950	1980	4630	1820	490	772	975	2260	2040

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Table A-4: 2022 Groundwater Results near RWOS1

Monitoring Location	Analysis Parameter	HU	Frequency	Q1 (Bq/L)	Q2 (Bq/L)	Q3 (Bq/L)	Q4 (Bq/L)
WSH122	Tritium	HU2	Semi-Annual	--	228	--	122
WSH123	Tritium	HU2	Semi-Annual	--	698	--	1430
WSH124	Tritium	HU2	Semi-Annual	--	160	--	171
WSH125	Tritium	HU2	Semi-Annual	--	134	--	133
WSH126	Tritium	HU2	Semi-Annual	--	138	--	149

Note:

"--", Not required as per the WWMF GWMP

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Table A-5: 2022 Groundwater Results to Establish Background Concentrations at WWMF

Monitoring Location	Analysis Parameter	HU	Frequency	Q1 (Bq/L)	Q2 (Bq/L)	Q3 (Bq/L)	Q4 (Bq/L)
WSH275	Tritium	HU7	Annual	--	--	--	8.4
WSH276	Tritium	HU5	Semi-Annual	--	23.6	--	11.3
WSH277	Tritium	HU1-3	Annual	--	--	--	311
WSH278	Tritium	HU7	Annual	--	--	--	36.2
WSH279	Tritium	HU4	Annual	--	--	--	174
WSH301	Tritium	HU7	Annual	--	--	--	9.62

Note:

"--", Not required as per the WWMF GWMP

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Table A-6: 2022 Groundwater Results in Downgradient Perimeter Wells at WWMF

Monitoring Location	Analysis Parameter	HU	Frequency	Q1 (Bq/L)	Q2 (Bq/L)	Q3 (Bq/L)	Q4 (Bq/L)
WSH245	Regular	HU7	Annual	--	--	--	8.34
WSH249	Regular	HU7	Annual	--	--	--	8.32
WSH263	Regular	HU5	Annual	--	--	--	56.2
WSH267	Regular	HU4	Annual	--	--	--	8.21
WSH307	Regular	HU7	Annual	--	--	--	9.58
DGRB-12A	Regular	HU5	Annual	--	--	--	9.41
DGRB-14	Regular	HU5	Annual	--	--	--	48.6

Note:

"--", Not required as per the WWMF GWMP

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

Location	Sample Date	Sample Values (Bq/L)		RPD (%) ^a	Absolute Difference ^a
		Duplicate	Primary		
WSH123	08-Apr-2022	700	698	0.3	
	07-Oct-2022	1440	1430	0.7	
WSH229	22-Apr-2022	1310	1290	1.5	
	18-Oct-2022	878	903	2.8	
WSH249	24-Nov-2022	8.29	8.32		0.03
WSH252	25-Nov-2022	17600	18200	3.4	
WSH269	04-May-2022	557	544	2.4	
	01-Nov-2022	458	453	1.1	
WSH276	04-May-2022	37.4	23.6		13.8
	02-Nov-2022	11.4	11.3		0.1
WSH284	18-May-2022	333	339	1.8	
	15-Nov-2022	345	358	3.7	

Notes:

^a In the GWPP (Ecometrix 2022a), two data quality objectives were defined for sampling precision. Where the tritium concentrations are more than 5 times the detection limit (DL), a Relative Percent Difference (RPD%) is calculated. Where the tritium concentrations are within 5*DL, an absolute difference is calculated between the sample and duplicate tritium concentrations and the absolute difference must be less than 2*DL. The detection limit for tritium varies by sample. Review of the historical information suggests that the lowest DL is generally approximately 8 Bq/L. Thus, samples with tritium values less than 40 Bq/L in 2022 were evaluated using the absolute difference criterium. All samples met the data quality objectives.