SWAN HILLS TREATMENT CENTRE

2023 Environmental Monitoring Program

Annual Report

Executive Summary

Prepared by:
Veolia Waste Services Alberta Inc.

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1 INTRODUCTION

The Swan Hills Treatment Centre (SHTC) (Figure 1-1) provides comprehensive treatment and disposal capabilities for hazardous wastes. The SHTC is owned by the Alberta Government and was operated in 2023 by Veolia Waste Services Alberta Inc. (Veolia) under an operating contract with Alberta Infrastructure.

The SHTC is located approximately 17 kilometers northeast of the Town of Swan Hills, as shown in Figure 1-2.

Figure 1-1: **Swan Hills Treatment Centre**

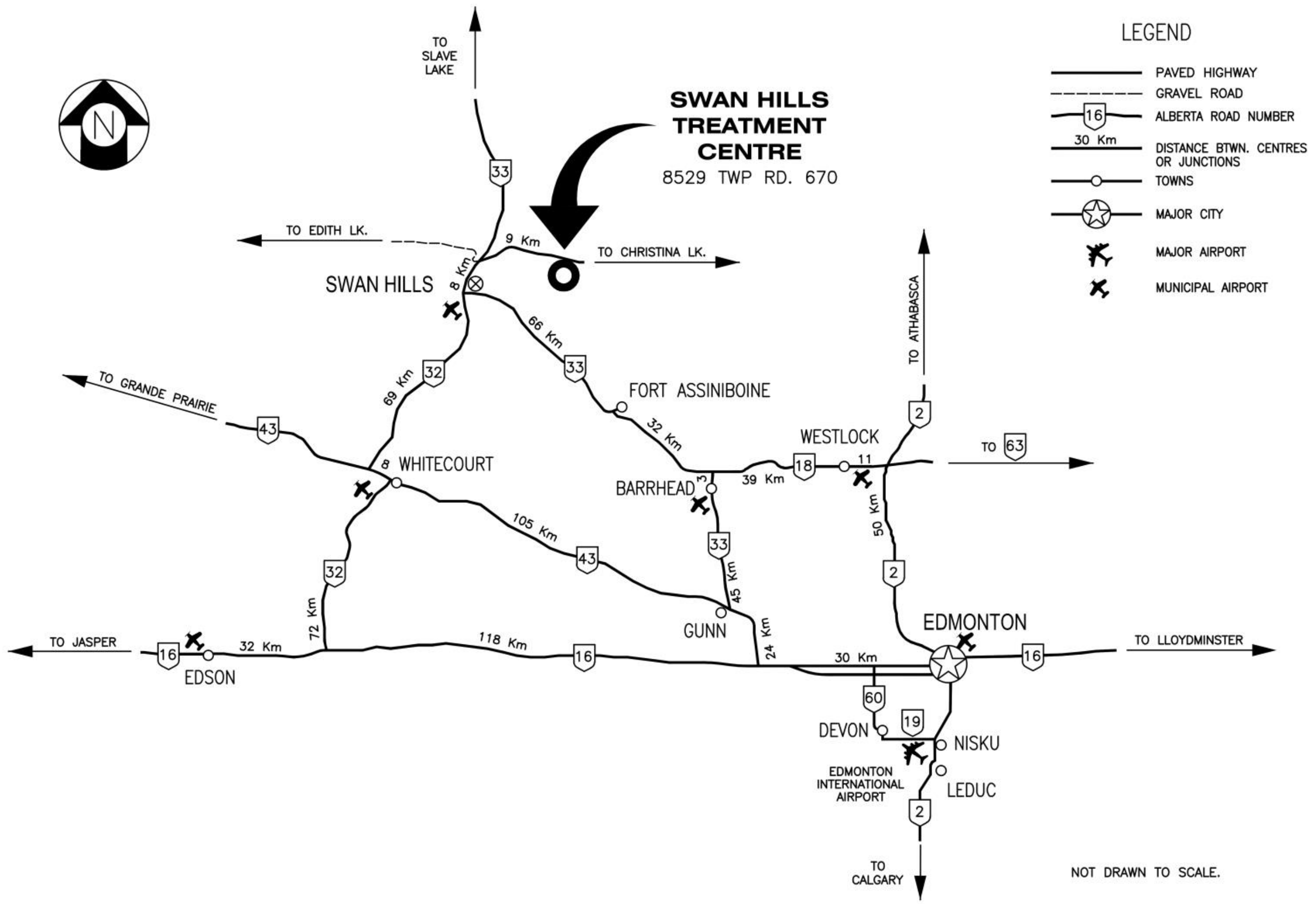

Figure 1-2: Site Location Map

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A thorough environmental baseline data collection program was initiated around the SHTC in 1985, two years before it officially commenced operation in 1987. This program has evolved into an extensive environmental monitoring program that provides early detection of potential environmental impacts associated with SHTC operations. The program includes the monitoring of meteorological, air quality, soils, groundwater, vegetation, wildlife, surface water, sediment, and fish. A human health risk assessment, based on consumption of fish from local lakes, is also performed annually.

Key environmental monitoring program (EMP) items include:

Source and On-site Monitoring

Extensive source and on-site monitoring are conducted annually in accordance with Approval 1744-03-00, as amended. Specific requirements include the following:

- Continuous process monitoring and monthly reporting for the following parameters: Waste Feed Rate, Combustion Temperature, Flue Gas Flow Rate and other key incinerator operating parameters.
- Continuous (on-line) monitoring and reporting of stack emissions including Oxygen (O_2) Carbon Dioxide (CO_2) Carbon Monoxide (CO), Oxides of Nitrogen (NO_X), Sulphur Dioxide (SO_2) Total Hydrocarbon (THC), Hydrogen Chloride (HCl) and Mercury[a].
- Regular manual stack surveys are performed to ensure that the total particulate, dioxin and furan TEQ, metals and destruction and removal efficiency (DRE) criteria are being achieved.
- Monthly monitoring of Carbon Adsorption Unit (CAU) stack emissions for THC and PCBs
- Containment of all surface water runoff in retention ponds for use as process water. Excess water is released only if it is necessary and must meet the off-site discharge limits.
- Ambient air is monitored for PCBs, Volatile Organic Compounds (VOCs), Total Suspended Particulate (TSP), and Fine Particulate[b] ($PM_{2.5}$) on the plant site and reported monthly (annually for VOCs).

[a] Continuous monitoring for Mercury is required by Approval 1744-03-00, as amended. A continuous analyzer installed in 2020 and operational commencing January 01, 2021. The new emission limit for Mercury (20 µg/m^3 maximum 24 hr rolling average) became effective January 01, 2023

[b] $PM_{2.5}$ monitoring commenced in July 2020

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- All spills and releases are reported immediately and cleaned up in accordance with the facility's Emergency Response Plan.
- An on-site Soil Management Plan is conducted in accordance with Alberta Environment and Protected Areas (AEPA) Soil Monitoring Directive The soil management program addresses on-site contamination in order to: protect workers at the facility; minimize off-site migration of contaminants; and decrease the cost of final site remediation.
- Groundwater Monitoring is conducted at 14 locations around the process area and landfills (upgradient and downgradient). Samples are obtained at three different depths (shallow till, intermediate till and the underlying sandstone) at most locations and results are reported annually.

Off-site Environmental Monitoring Program (EMP)

A comprehensive off-site environmental monitoring program is also conducted annually. This program was initiated two years prior to operation and includes a wide range of environmental receptors. Results are compared with pre-operational data and data collected at reference locations. In addition to reporting the results of the air monitoring and groundwater monitoring programs noted above, the program includes the following components:

- Soil – organic soils predominate in the Swan Hills area and the live moss layer is sampled and analyzed annually. The live moss layer provides information on contaminants accumulating in surface soils (2 – 3 years).
- Vegetation - Labrador tea is used as an indicator species based on its wide distribution in the Swan Hills region and its demonstrated ability to retain contaminants on its leaves. It provides annual data on contaminant deposition and distribution around the SHTC. Moss bags are used to monitor metals deposition and lichen health is assessed biannually.
- Wildlife – Red-backed Voles are considered an ideal indicator of potential impacts on wildlife receptors given their small home ranges, high reproduction potential, diet, and habitat. These characteristics provide the opportunity to assess both contaminant levels and population effects.
- Water Quality – local streams and surface water bodies are monitored annually to assess potential impacts on water quality.
- Sediment – many of the contaminants processed at the facility have low solubility in water and can be persistent in the environment. Sediment provides a sensitive media to monitor potential accumulation and impacts associated with these types of compounds.

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- Fish – can accumulate contaminants in their tissue and represent a potential pathway for human risk through consumption. Fish tissue is monitored for contaminant levels annually.
- Toxicology and Risk Assessment – Monitoring data are reviewed annually and a human health risk assessment is completed based on fish consumption from monitored lakes.

The monitoring program results are compiled annually and reviewed with regulatory authorities and regional stakeholders. The program is dynamic, and changes are made to the scope and methodology, as required, to maintain its effectiveness.

The environmental monitoring program has been rationalized to focus on a subset of the historic monitoring plots along with a more comprehensive analytical scope. To ensure potential issues are not overlooked, the program is expanded on a 5-year cycle to include both additional monitoring locations and chemical parameters/contaminants. Expanded monitoring has been conducted in 2004, 2009, 2014; and 2019. The 2024 program will also include expanded monitoring. In addition, a series of receptor-specific “triggers” that require additional data collection, were established and are reviewed annually to provide early response to address emerging trends or to respond to specific incidents.

The overall analytical scope of the environmental monitoring program includes PCB, PCDD/F, TEQ, and metals. Additional groups of compounds are added to the program during “Expanded” monitoring years. In the past, these have included Polycyclic Aromatic Hydrocarbons (PAHs), Semi-Volatile Organic Compounds (SVOCs), as well as inclusion of PCDD/F, metals, and VOCs in receptors not included in the annual program scope. To date, these additional analyses have not identified any potential issues that warrant annual surveillance.

- The most significant contaminants identified in the monitoring program include polychlorinated biphenyls (PCBs) and dioxins and furans (PCDD/F). Both include a range of congeners that exhibit slightly different characteristics (e.g. volatility, solubility and toxicity) based on the number and position of chlorine atoms in their structure. There are 209 different PCBs, 75 dioxins and 135 furans. The analytical procedures have been continually upgraded in the monitoring program and these compounds are analyzed using the most sophisticated and sensitive methods available. As a result, the program interprets the data as follows: PCBs are analyzed by high-resolution mass spectrometry that can identify individual PCB congeners. The term PCB denotes the total of all 209 potential congeners identified within the sample.
- Dioxins/Furans – these compounds are reported together because they are very similar and exhibit toxicity through a similar mechanism. However, the toxicity of individual dioxin/furan congeners varies significantly based on the location and number of chlorine atoms in its structure. The most

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toxic dioxin is 2,3,7,8 tetra-chloro dibenzodioxin (2,3,7,8 TCDD). The World Health Organization supports a methodology whereby the toxicity of this group of compounds can be interpreted by using Toxicity Equivalent Factors (TEFs) to calculate the overall toxicity relative to 2,3,7,8 TCDD. There are 7 dioxins and 10 furans that contribute to the toxicity associated with this group of chemicals. Each of the toxic congeners is multiplied by its respective TEF to establish the overall toxicity represented by the analytical result (i.e. PCDD/F TEQ).

- Toxic PCBs – twelve PCB congeners have been shown to exhibit similar toxicity as the toxic dioxins and furans. TEFs have been established for these congeners and the results are reported as PCB TEQ.
- Total TEQ – because toxic dioxins, furans and PCBs all exhibit their toxicity through the same mechanism, the combined toxicity of a sample is expressed as its Total TEQ. This simply represents the sum of the PCDD/F TEQ and the PCB TEQ results. Toxicity assessments conducted in this report are all conducted using Total TEQ.

The following provides an overview of SHTC operations and presents a summary of the results for both on-site and environmental monitoring programs conducted in 2023. The scope of individual monitoring components is presented along with any proposed changes for implementation in 2024. Detailed information including sampling and analytical methods, QA/QC procedures, statistical analysis and interpretation of results, supporting data and recommendations are all presented in the Annual Report.

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2 OPERATIONS

The Swan Hills Treatment Centre employs a variety of processes to treat hazardous waste. These include the following:

Incineration: The FBD Incinerator is the primary process unit with a capability of treating approximately 35,000 tonnes per year.

Physical/Chemical Treatment: Inorganic liquid wastes are treated through a variety of processes including neutralization, oxidation, reduction, phase separation and precipitation in the physical/chemical treatment plant.

Stabilization: The Stabilization plant treats heavy metal contaminated fly ash from the FBD Incinerator, by immobilizing the hazardous constituents in a cement-like matrix. The end product is an inert, non-hazardous solid.

The non-hazardous solid residues resulting from treatment are disposed in secure, onsite landfills and liquid residuals are sent to the onsite disposal well.

2.1 2023 Operations

The Swan Hills Treatment Centre has treated over 481,000 tonnes of commercial hazardous waste since commencing operations in 1987 (Figure 2-1). In 2023, approximately 1,850 tonnes of hazardous waste were treated including:

- 25 tonnes of PCBs
- 700 tonnes of Plant Generated, Decommissioning and Secondary Waste of which 90 tonnes were sent for off-site disposal/recycling
- 1,120 tonnes of Biomedical Waste (includes pharmaceuticals and expired medication)

The SHTC accepted all waste streams until May 31, 2021 and has moved to the base scope operation

The base scope allows for 1,500 tonnes of commercial waste (300 tonnes of high-level PCB waste and 1,200 tonnes of Alberta Biomedical & Pharmaceutical waste) to be processed each fiscal year (April – March).

Waste streams that have no alternate option for disposal or waste from special projects must be approved by Alberta Infrastructure through a change order.

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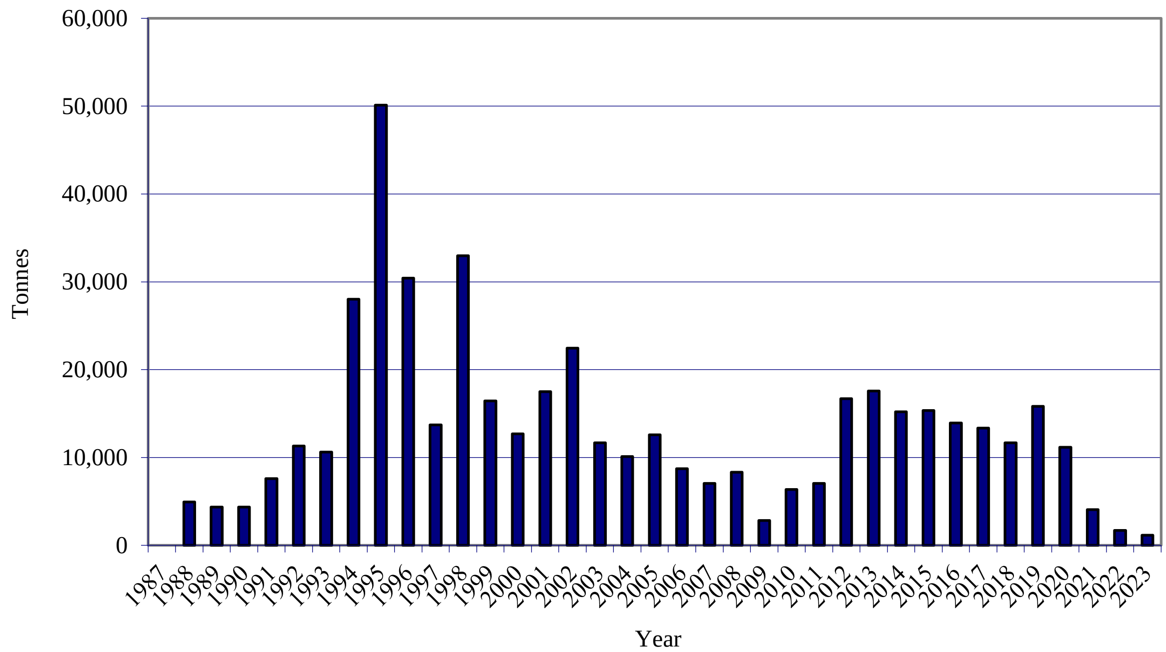

Figure 2-1: Commercial Waste Treatment Summary

Significant events and achievements in 2023 included the following:

- The FBD Incinerator was operational for approximately 5,300 hours between January 1 and December 31, 2023.
- There were two scheduled maintenance shutdowns of the FBD Incinerator from March 17-July 17 and October 10 to November 3.
  - The March 17-July 17 maintenance included: baghouse inspection & repair; flop gate inspection; replace shafts on backdraft damper for the lo NOx standard burner; ID fan oil change; deslagger inspection & repair. The startup was delayed due to the wildfire evacuation of the plant site from May 16-24. When preparing for the June 16 startup, discovered that a power bump had damaged the high voltage power conduit for incoming power. The shutdown was then extended to July 7 so that repairs could be made. Warmed up July 11, but had ID fan vibration issues and DCS communication failures that did not allow SHTC to go on waste feeds until July 17.

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  - The October 10- November 3 maintenance included: commissioning the mercury analyzer; removed control valves from gas scrubbing and cleaned them before sending them to the manufacturer to be repaired; the vent cap, wire rope, and air lines were inspected for wear and damage, the seal and brick integrity were assessed, and the metal was inspected; the feed gate assembly was inspected and repaired.

- Site improvements included: Water Treatment Plant decommissioning; size reduced and processed contaminated concrete from past projects; removed recyclable scrap metal from Plant site; Replaced the FBD blowdown line; replaced the Lab distillation unit, one of the boilers and the Penthouse roof; installed a new chlorine dosing system in the Pumphouse and replaced the domestic water pressure tank for the potable water system; completed underground firewater loop repairs; repaired the South Pond 1 caisson; completed Borrow Pit pump station upgrade with new pump and piping installed; and modified switches and servers for IT access; installed three air cannons on the Stabilization Plant Flyash Silo #2 to allow for smooth flow of flyash; and completed the construction of Landfill Cells A3 and B3.

- There was a significant amount of rainfall in 2023, particularly during the months of July and August. This required frequent transfers to proactively manage Pond water levels to prevent an uncontrolled release of water from South Pond 2 beyond the SHTC fence line. Despite these efforts it was still necessary to release excess surface water from South Pond 2 on two occasions. The issue of the dissolved molybdenum (DMo) being above the discharge limit (0.01 mg/L) was not present in these discharges. Since the facility stopped putting the leachate from the landfill cells into the PMP in early 2022 the dissolved molybdenum levels decreased in 2023. The facility will not request an increase to the discharge limit for molybdenum. Surficial soil samples were collected from this spillway in 2022 to establish a baseline for molybdenum and again in 2023 to monitor the molybdenum concentration. All soil samples have met the Tier 1 guideline of 4 mg/kg. The drainage channel will be sampled every year for a 3-year period (2022, 2023, and 2024) to determine if there are any short-term trends. If there is no change in molybdenum concentrations, will monitor every 5 years with the Soil Monitoring Program to ensure soil quality is not being affected.

2.2 2023 Manual Stack Surveys

The manual stack survey conducted October 3-4 and December 5-12, assessed incinerator performance while processing hazardous waste. The organics portion of the test will be redone on April 15-19, 2024

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since the testing performed in December 2023 exceeded the approval limit for total dioxin and furan toxic equivalent. The scope of the survey is based on the waste-specific requirements as noted in Table 2-1.

Table 2-1: 2023 Manual Stack Survey Results

Parameter	Operating Approval Limit	Result
Halogenated POHC[1]	100 mg/hr of POHC when halogenated POHC feed rate is ≤100 kg/hour	3.74 mg/hr
Total Particulate (dry @ 11% O_2)	20 mg/m^3	6.59 mg/m^3
PCDD/F TEQ[2,3,4] (dry @ 11% O_2)	80 pg/m^3	Average = 240 pg/m^3 Test 1 = 170 pg/m^3 Test 2 = 270 pg/m^3 Test 3 = 279 pg/m^3
Mercury (dry @ 11% O_2)	20 µg/m^3	21.1 µg/m^3
HCl (dry @ 11% O_2)	75 mg/m^3	0.011 mg/m^3
SO_2 (dry @ 11% O_2)	325 mg/m^3	<0.030 mg/m^3
CO (dry @ 11% O_2)	57 mg/m^3	<4.25 mg/m^3

[1] DRE – Primary Organic Hazardous Constituent
[2] PCDD/F TEQ – Dioxin/Furan Toxic Equivalent
[3] When analytical results were < Method Detection Limit (MDL), the MDL was used to calculate concentrations and emission results.
[4] The results of each test are listed to satisfy AEPA reporting requirements

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2.3 2023 Process Monitoring Activities

- Successful relative accuracy test audits (RATA) were performed on the continuous stack emission monitoring systems (CEMS) to verify the emission monitors are calibrated and reporting accurate data.
- Two cylinder gas audits (CGA) were performed in 2023.
- The CEMS Code (AEPA 2021[c]) requires that the CEMS and Quality Assurance Manual be audited on an annual basis. In 2023, Global Analyzer Systems Ltd. completed this audit on August 16-17.
- The Air Monitoring Directive, Chapter 5, Quality System (AEPA 2016[d]) requires that the Ambient Air Monitoring Quality Manual be audited every three years. In 2023, Global Analyzer Systems Ltd. completed this audit on August 16-17.
- The annual fugitive emission survey was conducted at the Organic Tank Farm. None of the components were found to be leaking.
- There were no vent cap releases were reported in 2023. The emergency vent cap is a safety device that prevents hot combustion gases from damaging the pollution control system in the event an emergency shutdown is required. An emergency shutdown is a controlled event that terminates waste feeds prior to implementing a sequence of steps (including vent cap openings) to ensure worker safety and equipment integrity is protected.
- Stack exhausts from buildings equipped with activated carbon air management systems are monitored, monthly, for PCBs and THC to evaluate the performance of the fugitive emission control systems. These include the Organic Tank Farm, Heated Storage Building and the FBD Incinerator Feed and Container Staging buildings. In 2023, there were no exceedances of the 6.0 $\mu g/m^3$ PCB limit or 500 ppm THC limits.
- The SHTC did not receive any air-related complaints in 2023.

[c] AEPA, 2021. "Continuous Emissions Monitoring System (CEMS) Code." Alberta Environmental and Protected Areas, Edmonton, AB, 111 pp.
[d] AEPA, 2016, "Air Monitoring Directive (AMD), Chapter 5, Quality System." Alberta Environmental and Protected Areas, Edmonton, AB, 19 pp.

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- The annual bottom hole survey and packer isolation test on the Deepwell were completed as per AER Approval 7742 confirming that the Class 1a injection well is in good mechanical condition. A successful Packer Isolation Test was performed August 21. The pressure survey was completed October 13-25. Since the well workover and acid stimulation in 2021, the injection flow rate was restored to over 30 m3/hr and has not deteriorated since. No mechanical repairs are required or anticipated in the upcoming operating year. The well and reservoir continue to operate under gravity injection, have surplus injection capability, and the well and reservoir should be able to handle the plant's disposal requirements for the near future and reservoir fill up is not a concern. At injection volumes of 50,000 m3/year (2019 - 2020 volume), it will take over 50 years to reach a reservoir pressure of 14,900 kPag (i.e., 120% of initial reservoir pressure). Temperature injection logs demonstrate gradual injectivity deterioration in the Winterburn Formation; however, the overall well injectivity remains high.

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3 ON-SITE MONITORING

On-site monitoring conducted at the SHTC includes ambient air and groundwater monitoring in accordance with requirements specified in Approval 1744-03-00, as amended. In addition, regular soils monitoring, and management programs are conducted in accordance with Alberta's Soil Monitoring Directive (AENV 2009[e]). Monitoring results and soil management program activities undertaken in 2023 are discussed in the following sections.

3.1 Ambient Air Monitoring

The ambient air monitoring program consists of monitoring PCB levels in ambient air at five locations, total suspended particulate (TSP) at two locations, fine particulate ($PM_{2.5}$) at three locations, and total hydrocarbons (THC) and volatile organic compounds (VOCs) at one location, as shown in Figure 3-1. One sampling site (E1) is located within the waste processing area, while the others are along the fenceline of the facility, or near the property boundary (Site 11). Ambient PCB, TSP, and $PM_{2.5}$ levels are obtained monthly and THC and VOC monitoring at the Organic Tank Farm (OTF) is conducted annually.

Meteorological data is collected continuously at the Air Quality Monitoring (AQM) Station (Site 11) located southeast of the SHTC as shown in Figure 3-1. The meteorological parameters of interest for ambient air monitoring include hourly average values for ambient temperatures at a 2 m height, wind velocity and direction at a 30 m height. The predominant wind directions in 2023 were from the northwest, west-northwest, west-southwest and southwest at 30m which is typical for the Swan Hills region (Veolia 2024[f]). Average wind speeds at the 30 m level were 17.2 km/hr, which are similar to observations from previous years. The average monthly temperature recorded at the AQM Station ranged between -8.4°C in February and 15.4°C in July and August.

Polychlorinated biphenyls (PCBs) sampling was conducted monthly with 100% data completeness in 2023. Ambient air PCB monitoring results at the SHTC for the period 2009-2023 are presented in Figure 3-2. Results are summarized below. Alberta has an occupational health objective for PCBs to protect workers but does not have an ambient air quality objective. To help place these results into perspective, the Alberta Occupational Health and Safety 8-hour exposure limit is 500,000 ng/m^3 (Aroclor 1254). In addition, some jurisdictions (e.g. Ontario), have established ambient air quality objectives. The Ontario 24-hour average and annual average ambient air quality objectives for PCBs are 150 ng/m^3 and 35 ng/m^3, respectively

[e] AENV, 2009. "Soil Monitoring Directive", Alberta Environment and Protected Areas, 32 pp
[f] Veolia, 2024. "2023 SHTC Meteorological Report", Veolia Waste Services Alberta Ltd., Swan Hills, AB, 30 pp

.
The following observations were noted:

- Individual site average PCB concentrations increased slightly at Site 1 but slightly decreased at all other sites, compared to 2022 annual averages.
- The average PCB concentration at Site E1 decreased from 12.58 ng/m3 to 7.85 ng/m3 between 2022 and 2023. The highest PCB concentration at Site E1 was 21.55 ng/m3 detected on May 2nd, 2023. The elevated result could be caused by elevated forest fire activity in the area at the time the sampling was done.
- The average fenceline PCB concentration (the average of sites 1, 2A, and 5A) was 1.12 ng/m3 which was lower than in 2022 (1.50 ng/m3). The highest fenceline 24-hour Average PCB concentration in 2023 was 1.89 ng/m3 measured on August 1st, 2023.
- Ambient PCB levels were lowest at Site 11 (New AQM). The average 24-hour concentration was 0.91 ng/m^3 and the maximum 24-hour level reported was 0.91 ng/m^3, which is the laboratory detection limit.
- Consistent with previous observations, PCB levels tended to be higher during the warm summer months.
- All 24-hour PCB measurements on plant site were well below the Occupational Health and Safety limit of 500,000 ng/m^3 (Aroclor 1254). No exceedances of Veolia's fenceline trigger level of 150 ng/m^3 were observed in 2023.

Total Suspended Particulate (TSP) sampling was conducted at two sites (Site 1 and Site 9, Figure 3-1) on the same monthly schedule as PCBs. There were exceedances of the Alberta Ambient Air Quality Objective for TSP (100 µg/m^3) for samples collected May 16, 2023 at Site 1 (172.5 µg/m^3) and Site 9 (185.2 µg/m^3) due to forest fires in the area. Samples collected May 30 were below 100 µg/m^3.

Fine Particulate ($PM_{2.5}$) sampling was conducted at three sites (Site 1, Site 5A, and Site 9, Figure 3-1) on the same monthly schedule as PCBs. No exceedances of the Alberta Environment Air Monitoring Directive 24-hour $PM_{2.5}$ ambient air quality objective of 29 µg/m^3 were measured at Site 1, Site 5A, or Site 9.

Volatile Organic Compounds (VOC) and Total Hydrocarbons (THC) sampling was conducted at the Organic Tank Farm (Site E1) once in 2023 as specified in the Approval. The total VOC and THC concentrations are presented in Table 3-1. There are no Approval limits for these parameters; however, both VOC and THC were below the monitoring program "trigger" values of 3 ppm and 5 ppm, respectively.

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Table 3-1: VOC and THC Results at Site E1 (2022)

Date	Average Temperature (°C)	Total VOC Concentration (ppm)	Total THC Concentration (ppm)
Trigger Limit	**n/a**	**3**	**5**
01-Nov-23	-0.5	0.016	2.50

The individual VOCs are summarized and compared to the Alberta Ambient Air Quality Objectives in Table 3-2.

Table 3-2: 2022 Site E1 VOC Canister Analysis Results Compared to the Alberta Ambient Air Quality Objective[g]

Parameter	Reporting Units	Objective	Reported Result
Hydrocarbons, Total (as Methane)	ppmv		2.5
1-Butene	ppmv		<0.10
Acetylene	ppmv		<0.08
cis-2-Butene	ppmv		<0.04
Ethane	ppmv		<0.1
Ethylacetylene	ppmv		<0.06
Ethylene	ppmv		<0.07
Isobutane	ppmv		<0.1
Isobutylene	ppmv		<0.1
Methane	ppmv		2.5
n-Butane	ppmv		<0.2
n-Propane	ppmv		<0.07
Propylene	ppmv		<0.1
Propyne	ppmv		<0.1
trans-2-Butene	ppmv		<0.09
1,1,1-Trichloroethane	ppbv		<0.02
1,1,2,2-Tetrachloroethane	ppbv		<0.02
1,1,2-Trichloroethane	ppbv		<0.02
1,1-Dichloroethane	ppbv		<0.02
1,1-Dichloroethylene	ppbv		<0.02
1,2,3-Trimethylbenzene	ppbv		<0.05
1,2,4-Trichlorobenzene	ppbv		<0.3
1,2,4-Trimethylbenzene	ppbv		<0.03
1,2-Dibromoethane	ppbv		<0.02
1,2-Dichlorobenzene	ppbv		<0.03
1,2-Dichloroethane	ppbv		<0.03
1,2-Dichloropropane	ppbv		<0.03
1,3,5-Trimethylbenzene	ppbv		<0.03
1,3-Butadiene	ppbv		1.90
1,3-Dichlorobenzene	ppbv		<0.4
1,4-Dichlorobenzene	ppbv		<0.4
1,4-Dioxane	ppbv		<0.5
1-Butene/Isobutylene	ppbv		1.81
1-Hexene/2-Methyl-1-pentene	ppbv		0.22
1-Pentene	ppbv		0.31
2,2,4-Trimethylpentane	ppbv		<0.02
2,2-Dimethylbutane	ppbv		<0.02
2,3,4-Trimethylpentane	ppbv		<0.02
2,3-Dimethylbutane	ppbv		<0.09
2,3-Dimethylpentane	ppbv		<0.02
2,4-Dimethylpentane	ppbv		<0.03
2-Methylheptane	ppbv		<0.02
2-Methylhexane	ppbv		<0.03
2-Methylpentane	ppbv		0.09
3-Methylheptane	ppbv		<0.03
3-Methylhexane	ppbv		<0.02
3-Methylpentane	ppbv		0.04
Acetone	ppbv	2,400 (1-hr)	3.1
Acrolein	ppbv	1.9 (1-hr) 0.17 (24-hr)	0.5
Benzene	ppbv	9.0 (1-hr)	0.25
Benzyl chloride	ppbv		<0.3
Bromodichloromethane	ppbv		<0.03
Bromoform	ppbv		<0.02
Bromomethane	ppbv		<0.02
Carbon disulfide	ppbv	10 (1-hr)	0.06

[g] AEPA, 2019. "Alberta Ambient Air Quality Objectives and Guidelines Summary", Alberta Environment and Parks, 6pp

Parameter	Reporting Units	Objective	Reported Result
Carbon tetrachloride	ppbv		0.06
Chlorobenzene	ppbv		<0.02
Chloroethane	ppbv		<0.02
Chloroform	ppbv		<0.02
Chloromethane	ppbv		0.72
cis-1,2-Dichloroethene	ppbv		<0.02
cis-1,3-Dichloropropene	ppbv		<0.03
cis-2-Butene	ppbv		0.14
cis-2-Pentene	ppbv		0.03
Cyclohexane	ppbv		<0.04
Cyclopentane	ppbv		<0.02
Dibromochloromethane	ppbv		<0.02
Ethanol	ppbv		1.9
Ethyl acetate	ppbv		<0.3
Ethylbenzene	ppbv	460 (1-hr)	<0.03
Freon-11	ppbv		0.22
Freon-113	ppbv		0.06
Freon-114	ppbv		<0.03
Freon-12	ppbv		0.58
Hexachloro-1,3-butadiene	ppbv		<0.3
Isobutane	ppbv		1.12
Isopentane	ppbv		0.54

Parameter	Reporting Units	Objective	Reported Result
Isoprene	ppbv		0.16
Isopropyl alcohol	ppbv		<0.3
Isopropylbenzene	ppbv		<0.04
m,p-Xylene	ppbv	530 (1-hr) 161 (24-hr)	0.05
m-Diethylbenzene	ppbv		<0.02
m-Ethyltoluene	ppbv		<0.03
Methyl butyl ketone	ppbv		<0.4
Methyl ethyl ketone	ppbv		<0.3
Methyl isobutyl ketone	ppbv		<0.3
Methyl methacrylate	ppbv		<0.08
Methyl tert butyl ether	ppbv		<0.03
Methylcyclohexane	ppbv		<0.02
Methylcyclopentane	ppbv		<0.05
Methylene chloride	ppbv		<0.3
n-Butane	ppbv		1.79
n-Decane	ppbv		<0.06
n-Dodecane	ppbv		<0.3
n-Heptane	ppbv		<0.04
n-Hexane	ppbv	5,960 (1-hr) 1,990 (24-hr)	0.09+
n-Nonane	ppbv		<0.04

Parameter	Reporting Units	Objective	Reported Result
n-Octane	ppbv		<0.02
n-Pentane	ppbv		0.32
n-Propylbenzene	ppbv		<0.06
n-Undecane	ppbv		<0.5
Naphthalene	ppbv		<0.3
o-Ethyltoluene	ppbv		<0.02
o-Xylene	ppbv	530 (1-hr) 161 (24-hr)	<0.03
p-Diethylbenzene	ppbv		<0.02
p-Ethyltoluene	ppbv		<0.04
Styrene	ppbv	52 (1-hr)	<0.04
Tetrachloroethylene	ppbv		0.04
Tetrahydrofuran	ppbv		<0.3
Toluene	ppbv	499 (1-hr) 106 (24-hr)	0.08
trans-1,2-Dichloroethylene	ppbv		<0.06
trans-1,3-Dichloropropylene	ppbv		<0.02
trans-2-Butene	ppbv		0.18
trans-2-Pentene	ppbv		0.04
Trichloroethylene	ppbv		<0.02
Vinyl acetate	ppbv		<0.3
Vinyl chloride	ppbv	51 (1-hr)	<0.02

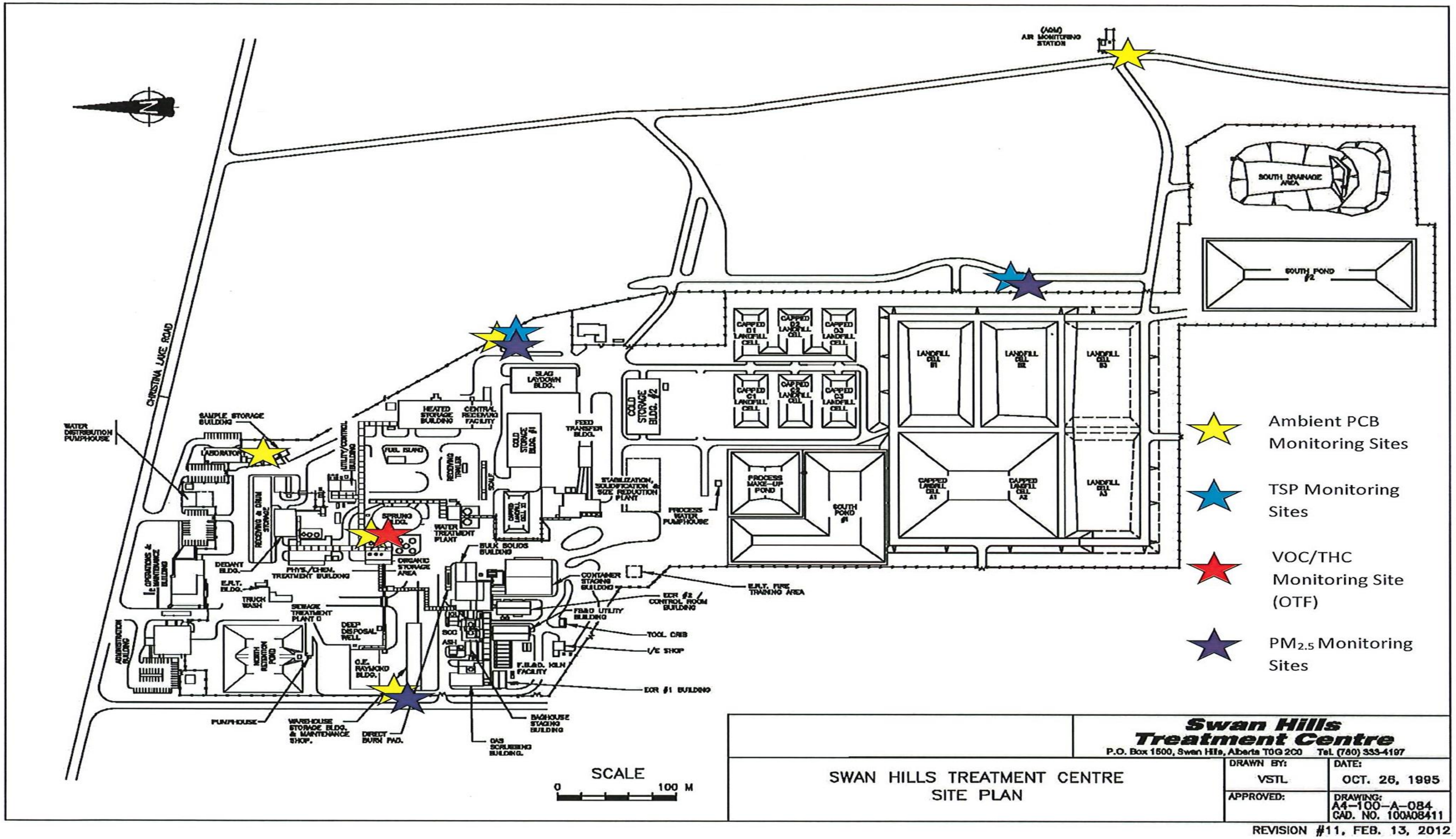


Figure 3-1: SHTC Site Plan Locations of Air Monitoring Stations

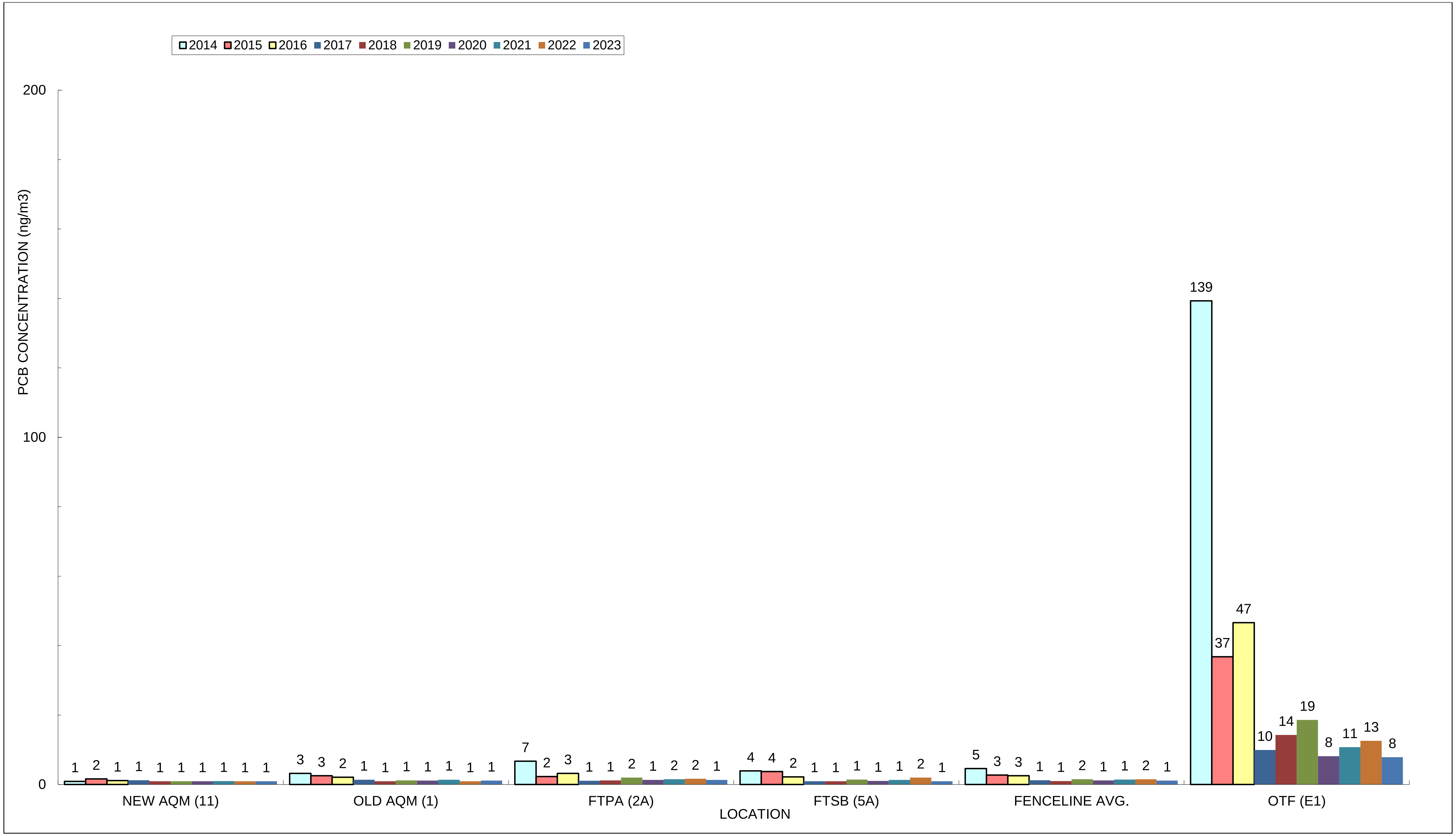


Figure 3-2: Ambient Air PCB Monitoring Results (2014-2023)

3.2 Soil Management Program

Alberta's Soil Monitoring Directive requires all industrial Approval holders to conduct on-site soil monitoring and management programs (if necessary) to address potential contamination resulting from operations. The first on-site Soil Monitoring Program (SMP) was completed in 1998 and subsequent SMPs have been completed every five years (2002, 2007, 2012, 2017, and 2019) in compliance with the Directive. Soil management programs (SMaPs) are undertaken to manage any identified on-site contamination to protect worker safety and minimize the potential for off-site migration.

Activities for the 2023 Soil Management Program were as follows:

- May 27 to 28, 2023 – Collected samples from the excavated B3 landfill cell to verify if acutely impacted soil required further excavation and landfill disposal. This sampling event also provided verification that the western extent of the impacted area had been fully excavated.
- June 29, 2023 – Collected samples from stockpiled excess soil generated during landfill construction. Only 2 of 30 samples collected from the soil stockpiles marginally exceeded the Tier 1 natural area guidelines for metals.
- September 12, 2023 – Collected soil samples from the discharge area. All soil samples met the guidelines for molybdenum.

3.3 Groundwater Monitoring

Three depth intervals are monitored. The shallow and intermediate intervals monitor groundwater in the surficial till deposits. The clay-till soils on the plant site are approximately 10 metres thick, and have very low hydraulic conductively, providing a significant barrier for contaminant migration via a groundwater pathway. The sandstone interval wells monitor the groundwater in the Paskapoo Formation between 50 and 70 metres Below Ground Surface (mBGS). This zone provides a useable groundwater aquifer and the SHTC is the only local groundwater user.

The groundwater flow in the shallow and intermediate intervals is generally to the east at an estimated velocity of 0.11 metres per year (m/yr) for the shallow till and 0.018 m/yr for the deeper till (intermediate interval wells). Based on historical result, groundwater flow in the sandstone interval is typically to the south at an estimated velocity of approximately 15.56 m/yr.

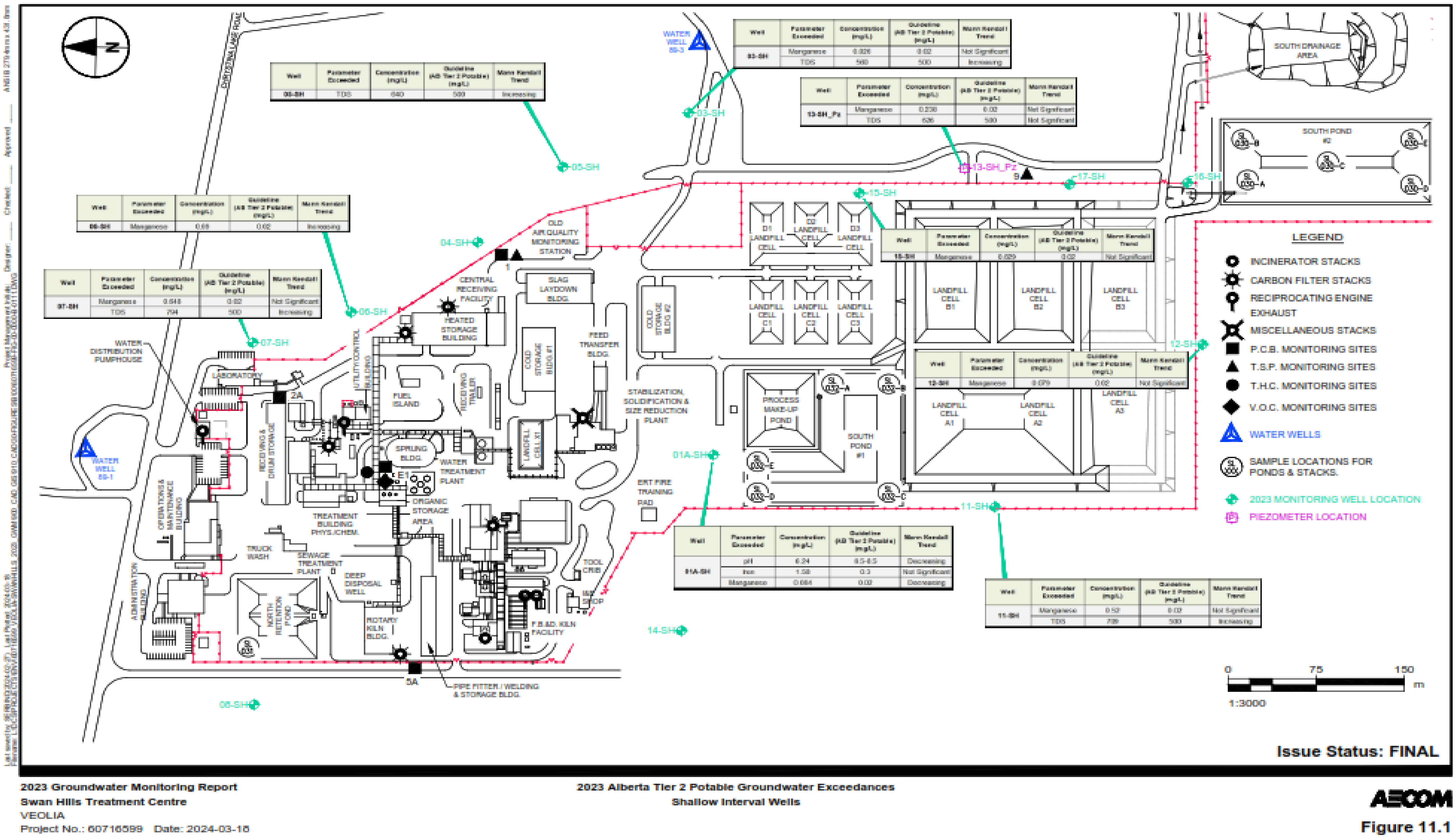
The following presents the key findings of the 2023 groundwater monitoring program. The specific locations are referenced by the well location number and its depth interval with the following designations (SH=Shallow, IN=Intermediate, SS=Sandstone). Well locations and notable results are presented in Figures 3-3 – 3-5:

Based on the 2023 groundwater monitoring, the following conclusions can be made:

- Petroleum hydrocarbon (BTEX, PHC F1) concentrations were below the laboratory detection limit for all wells sampled in 2023.
- Polychlorinated Biphenyl (PCB) Aroclor and total PCB concentrations were below the laboratory detection limit for all wells sampled in 2023.
- Adsorbable Organic Halogen (AOX) results were below the laboratory detection limit for all select wells tested except for 13-SH. This is the first time a concentration above detection limit has been recorded. Future sampling events will be examined to determine if concentrations above detection remain.
- Nine of the wells completed in the till interval (shallow and intermediate wells) have Total Dissolved Solids (TDS) concentrations above the Alberta Tier II Potable Groundwater Guidelines. For eight wells these concentrations are consistent with baseline and/or historical observations, as well as expected TDS concentrations for a till lithology. For one well (11-IN), the concentration is the highest seen in the well since it was drilled. The result was confirmed by the laboratory. 2024 results will be examined to determine if this increase remains.
- Manganese concentrations exceeding the Alberta Tier II Potable Groundwater Guideline were observed in all monitoring wells except 03-IN, 04-SH, 05-SH, 08-SH, 08-IN, 13-IN, 14-SH, 16-SH, and 17-SH. Manganese concentrations have been measured since the 1990s and have typically exceeded the guideline in both up-gradient and down-gradient wells; therefore, it is likely naturally occurring. Manganese concentrations above the Alberta Tier II Potable Guideline for Commercial/Industrial Land Use (0.02 milligrams per litre; mg/L) in till are of little concern since this source is not capable of supporting a potable water supply.
- Elevated iron and manganese concentrations may be a result of biological activity. Orange and black residues and/or oxidation was noted on several bladder pumps and tubing during well maintenance in May 2014. Iron reducing bacteria (IRB) tests from 2015 confirmed the presence of anaerobic iron related and enteric bacteria in monitoring wells 01A-SH, 01A-IN, 04-IN, 04-SS, 07-SH, 07-IN, and 16-SH.
- The elevated chloride concentrations in 07-SH may be caused by infiltration of run-off containing road salt from the adjacent parking lot and road. Increasing chloride trends are observed in 01A-SH and 07-SH. Monitoring well 07-SH is located in a low-lying area adjacent to a road while 01A-SH is located on the plant site. Monitoring well 17-SH had an increase in chloride concentration in 2015 compared to historical results, but the level is well below the guideline and has been falling in the following years.

Monitoring wells 05-SH and 13-SH have increasing trends but both are an order of magnitude below the guideline.

- Monitoring well MW-01A:
  - The TDS and major ion groundwater chemistry of 01A-SH and 01A-IN appears to be affected by rain and surface water infiltration.
  - High Dissolved Organic Carbon (DOC) concentrations may be a result of the composition of the engineered fill, as well as activity at the ERT Fire Training Pad. The high DOC probably results in anaerobic conditions in the monitoring well. It is noted that no Aroclor PCBs or petroleum hydrocarbons were detected in this well, thus the elevated DOC concentrations are from other compounds.
  - Sulphur odour and reduced pH in 01A-SH indicates the presence of sulphur reducing bacteria that is confirmed by the results of the sulphate reducing bacteria (SRB)
- Figures 3-3 to 3-5 show the groundwater sample locations and exceedances.



Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
05-SH	TDS	640	500	Increasing

Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
06-SH	Manganese	0.65	0.02	Increasing

Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
07-SH	Manganese	0.648	0.02	Not Significant
	TDS	794	500	Increasing

Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
03-SH	Manganese	0.026	0.02	Not Significant
	TDS	560	500	Increasing

Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
13-SH_Pz	Manganese	0.236	0.02	Not Significant
	TDS	626	500	Not Significant

Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
15-SH	Manganese	0.029	0.02	Not Significant

Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
12-SH	Manganese	0.079	0.02	Not Significant

Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
01A-SH	pH	6.24	6.5-8.5	Decreasing
	Iron	1.58	0.3	Not Significant
	Manganese	0.084	0.02	Decreasing

Well	Parameter Exceeded	Concentration (mg/L)	Guideline (AB Tier 2 Potable) (mg/L)	Mann Kendall Trend
11-SH	Manganese	0.52	0.02	Not Significant
	TDS	709	500	Increasing

Figure 3-3: 2023 Alberta Tier 2 Potable Groundwater Exceedances Shallow Interval Wells (AECOM Figure 11.1)

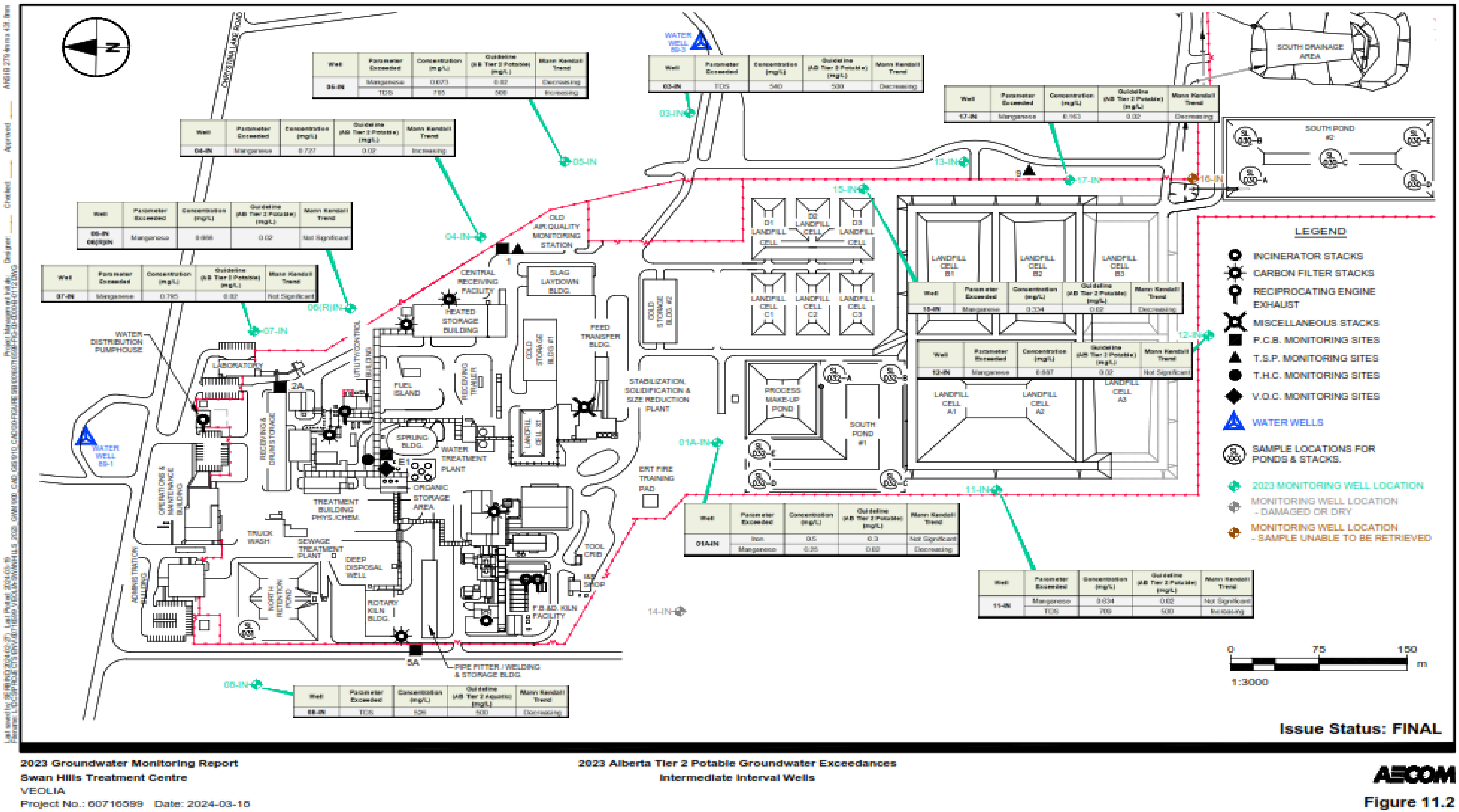


Figure 3-4: 2023 Alberta Tier 2 Potable Groundwater Exceedances Intermediate Interval Wells (AECOM Figure 11.2)

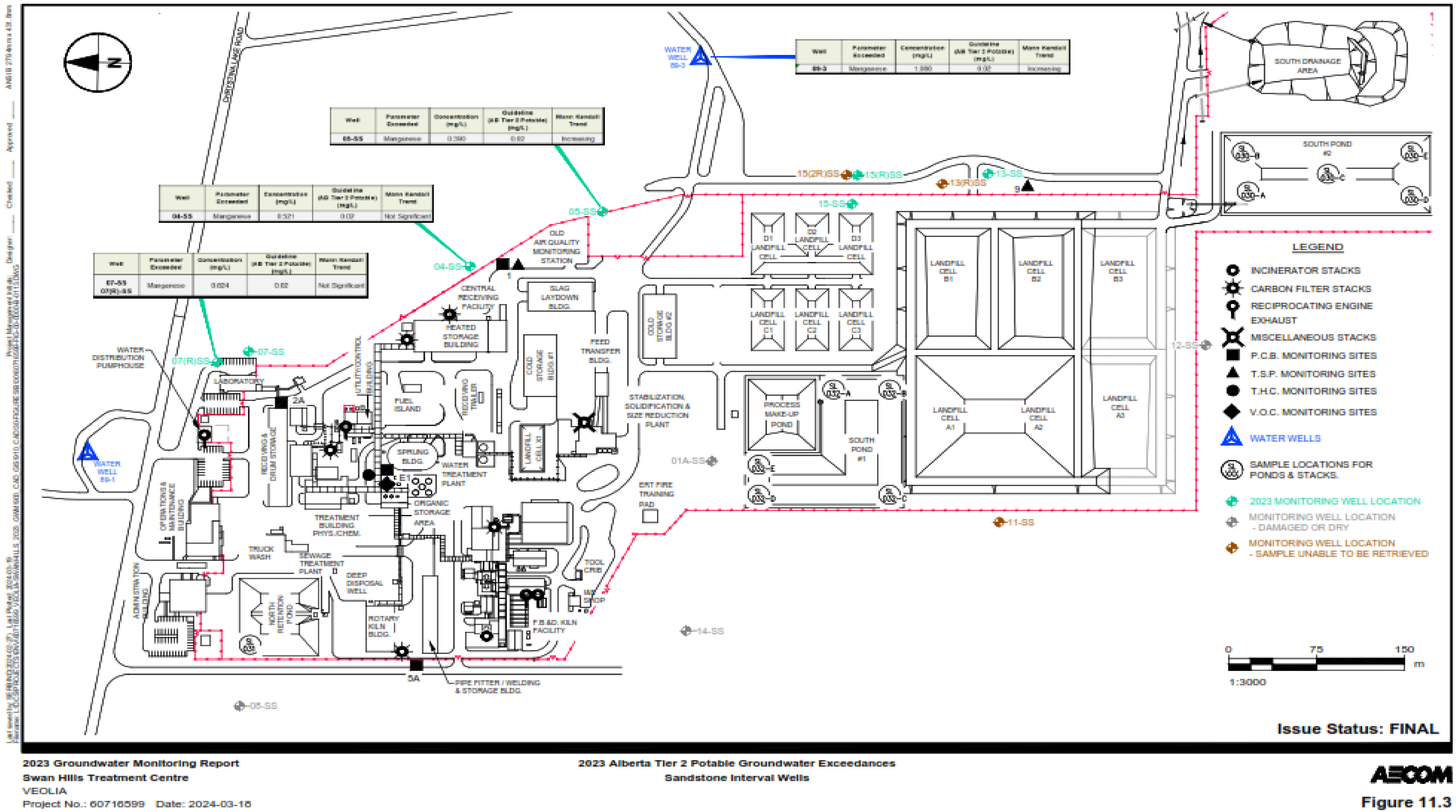


Figure 3-5: 2023 Alberta Tier 2 Potable Groundwater Exceedances Sandstone Interval Wells (AECOM Figure 11.3)

4 TERRESTRIAL ENVIRONMENT

The objective of the terrestrial environmental monitoring program is to assess changes in concentrations of chemicals of concern in the forested area surrounding the SHTC with emphasis on vegetation, soils and wildlife

Based on previous monitoring results, elevated PCB, dioxin (PCDD), and furan (PCDF) concentrations in the live moss, Labrador tea leaves and vole tissue near the SHTC are primarily related to fugitive emissions from the SHTC. Compounds measured in the live moss layer are representative of the cumulative accumulation of these compounds via atmospheric deposition over a period of several years. Labrador tea renews its leaves annually and therefore, results are representative of compounds deposited from the atmosphere over a one-year exposure period (June 2022 – June 2023). Compounds detected in vole tissue are a result of exposure to all potential pathways including inhalation, food consumption and dermal contact throughout their life span. Samples are collected in early June and focus on collection of mature, over-wintering adults.

4.1 Soil and Vegetation

The 2023 program included:

- Assessing changes in chemical concentrations within ten annual monitoring plots by collecting vegetation samples and comparing the analytical results to those of previous sampling events.
    - Samples of Labrador tea leaves were collected from each plot and analyzed for inorganic and organic parameters.
    - Live moss samples were collected from all monitoring plots and held in the event that contaminant levels in the Labrador tea triggered analysis of the live moss layer. Based on the total TEQ levels in the Labrador tea in 2023, the live moss was analyzed for congener PCBs and dioxin (PCDD) & furans (PCDF).
- Collecting moss bags from 14 moss bag plots and deploying unexposed moss bags at these plots for collection in the following year.
    - Plot MB22 could not be accessed as the water levels in several streams leading to the plot where elevated.
- Collecting moss bags from three additional sites situated around the SHTC's fenceline.
- Completing plot maintenance on those plots with identified maintenance issues.

Overall, the monitoring program indicates that historical emissions from the facility have caused certain metals and polychlorinated compounds to accumulate in the surrounding terrestrial environment. However, current levels of these compounds in the SHTC's emissions do not appear be leading to a continued accumulation in the surrounding environment, except for zinc in the live moss. In 2023 the TEQ in the Labrador tea leaves at all plots increased; however, this increase is attributed to the forest fire activity. The forest fires also appear to have caused an increase in PCBs in the Labrador tea leaves at the background and more peripheral monitoring plots.

Figure 4-1: Location of Soil and Vegetation Monitoring Sites

The following summarizes the results for 2023

Labrador Tea

- The concentration of antimony, arsenic, cadmium, copper, lead, mercury, molybdenum, and zinc were elevated at the plots near the SHTC, which is consistent with historical results. Overall, the rate or magnitude of metal deposition near the SHTC may be somewhat elevated relative to background locations. Zinc is the only parameter where concentrations appear to be increasing in the Labrador tea in recent years, although zinc concentrations did not exceed the historical maximum recorded in 2013 or 2014.
- TEQ values in the Labrador tea leaves increased substantially relative to 2022. The increase in PCDD/DF TEQ relative to PCB TEQ was also notable in the Labrador tea.
- Labrador tea leaves represent a shorter exposure period, typically assumed to be 1 year in duration, consequently this increase in TEQ can be attributed to the forest fire activity in the area.
- The forest fires also appear to have caused an increase in PCBs and PCB TEQ at the background and more peripheral plots. Concentrations of PCBs also increased at those plots near the SHTC; however, this increase was within historical ranges and further monitoring is required to confirm if it is an anomaly.

Live Moss

- PCB and TEQ values in the live moss were comparable to 2022; indicating that increased forest fire emissions were not substantial enough to cause a detectable increase in the moss layer and may just have a transient effect on contaminant concentrations in the vegetation.

Table 4-1: 2023 Live Moss Results - PCBB/PCDF, PCB, and TEQ

TABLE 4-1

Live Moss Quality Results - PCDD/PCDF, PCB, and TEQ[1]
Veolia
W ½ 06-067-08 W5M

Sample Point	Sample Date	PCBs mg/kg	PCDD/PCDF TEQ ng TEQ/kg	PCB TEQ ng TEQ/kg	Total TEQ ng TEQ/kg
Live Moss					
Plot 4	19-Jun-23	0.159	2.06	20.8	22.86
Plot 11	29-Jun-23	0.024	0.77	3.65	4.42
Plot 70	19-Jun-23	0.000065	0.117	0.127	0.244
Plot 71	19-Jun-23	0.000075	0.121	0.00956	0.131
Plot 109	20-Jun-23	0.068	1.49	8.52	10.01
Plot 110	20-Jun-23	0.0024	0.192	0.333	0.525
Plot 114	20-Jun-23	0.036	0.805	3.7	4.505
Plot 117	20-Jun-23	0.0055	0.293	0.579	0.872
Plot 123	19-Jun-23	0.0014	0.118	0.222	0.34
Plot 402	20-Jun-23	0.00027	0.109	0.131	0.24

Notes:
[1] - a value equal to 1/2 the detection limit was used for all non-detected congeners to calculate sample TEQ.

Table 4-2: 2023 Labrador Tea Results - PCBB/PCDF, PCB, and TEQ

TABLE 4-2

Labrador Tea Quality Results - PCDD/PCDF, PCD, and TEQ[1]
Veolia
W ½ 06-067-08 W5M

Sample Point	Sample Date	PCBs mg/kg	PCDD/PCDF TEQ ng TEQ/kg	PCB TEQ ng TEQ/kg	Total TEQ ng TEQ/kg
Labrador Tea Leaves					
Plot 4	19-Jun-23	0.0683	8.82	10.1	18.92
Plot 11	29-Jun-23	0.0113	4.51	2.2	6.71
Plot 70	19-Jun-23	0.00159	6.26	0.419	6.68
Plot 71	19-Jun-23	0.00131	8.81	0.259	9.07
Plot 109	20-Jun-23	0.0378	3.88	4.44	8.32
Plot 110	20-Jun-23	0.0034	2.34	0.296	2.64
Plot 114	20-Jun-23	0.0202	4.65	1.11	5.76
Plot 117	20-Jun-23	0.00777	9.45	0.867	10.32
Plot 123	19-Jun-23	0.00176	6.57	0.214	6.78
Plot 402	20-Jun-23	0.000725	4.29	0.332	4.62

Notes:
ND - results reported as zero in lab report
[1] - a value equal to 1/2 the detection limit was used for all non-detected congeners to calculate sample TEQ.

Table 4-3 and Table 4-4 : Historical Live Moss Results - PCB, and Total TEQ

TABLE 4-3

Historical Moss Quality Results - PCB Concentrations (Congeners) - mg/kg
Veolia
W ½ 06-067-08 W5M

Date	Plot 4	Plot 11	Plot 70	Plot 71	Plot 109	Plot 110	Plot 114	Plot 117	Plot 123	Plot 402
May-06	1.90	0.11	0.0021	0.0012	0.36	0.042	0.21	0.058	0.014	0.0053
Jun-07	0.77	0.17	0.0017	0.0012	0.27	0.027	0.69	0.045	0.011	0.0023
May-08	0.96	0.14	0.0013	0.0040	0.50	0.037	0.097	0.033	0.015	0.0064
Jun-08	0.96	0.14	0.0013	0.0040	0.50	0.037	0.097	0.033	0.015	0.0064
Jun-09	1.05	0.065	0.0013	0.00085	0.27	0.020	0.19	0.037	0.011	0.0020
Jul-09	0.86	0.093	0.024	0.0025	0.47	0.032	0.22	0.051	0.015	0.0057
May-10	1.95	0.19	0.0020	0.0023	0.60	0.066	0.35	0.070	0.010	0.0027
May-11	1.73	0.19	0.0036	0.0017	0.76	0.052	0.50	0.14	0.024	0.0039
Jun-12	1.62	0.17	0.00077	ND	0.61	0.034	0.24	0.035	0.0035	0.0011
Jun-13	1.98	0.14	0.0031	0.0022	0.72	0.038	0.38	0.10	0.020	0.0068
May-14	0.34	0.017	0.00096	0.00023	0.24	0.0063	0.087	0.013	0.00055	0.00068
Jun-15	0.98	0.12	0.00051	0.00095	0.54	0.015	0.17	0.066	0.011	0.0019
May-16	0.44	0.026	0.00013	0.00014	0.16	0.0046	0.13	0.016	0.0040	0.00068
Jun-17	0.88	0.074	0.00014	0.00029	0.51	0.017	0.064	0.036	0.0048	0.0013
May-18	1.09	0.056	0.00052	0.00012	0.75	0.013	0.20	0.026	0.011	0.0014
May-19	0.86	0.051	0.00046	0.00028	0.35	0.010	0.14	0.028	0.003	0.0014
Jun-20	0.43	0.029	0.00020	0.00014	0.21	0.004	0.04	0.006	0.013	0.0019
Jun-22	0.22	0.017	0.00014	0.00019	0.09	0.003	0.04	0.004	0.002	0.0017
Jun-23	0.16	0.024	0.00007	0.00007	0.07	0.002	0.04	0.005	0.001	0.0003

TABLE 4-4

Historical Moss Quality Results - Total TEQ - ng TEQ/kg[1]
Veolia
W ½ 06-067-08 W5M

Date	Plot 4	Plot 11	Plot 70	Plot 71	Plot 109	Plot 110	Plot 114	Plot 117	Plot 123	Plot 402
May-06	272.99	38.36	0.52	0.48	75.11	13.64	37.92	12.06	3.89	0.55
Jun-07	157.73	33.34	0.50	0.36	55.5	4.04	58.42	9.73	3.87	0.48
May-08	206.89	38.64	2.01	2.21	117.52	9.87	16.12	7.69	4.77	2.06
Jun-08	222.57	41.33	1.83	1.81	126.09	10.80	17.45	7.70	4.59	1.88
Jun-09	230.88	21.21	0.78	0.42	76.41	7.30	36.43	8.36	3.42	0.38
Jul-09	118.13	18.22	1.84	0.32	84.33	6.00	25.31	7.40	3.35	0.94
May-10	174.27	36.85	1.46	0.86	79.01	9.77	39.83	8	1.39	0.80
May-11	157.10	28.68	1.21	0.23	72.19	8.73	48.17	14.58	3.74	0.61
Jun-12	231.17	36.19	0.79	0.76	78.94	9.85	33.59	1.46	0.67	2.73
Jun-13	277.78	26.38	0.95	0.22	109.50	6.85	41.72	13.33	5.96	0.56
May-14	115.40	13.63	5.37	0.72	75.90	7.00	31.20	4.02	1.78	1.19
Jun-15	138.40	29.00	0.61	0.69	75.20	3.38	27.02	12.12	2.44	1.27
May-16	53.80	4.43	0.21	0.29	19.86	1.14	12.77	2.14	0.76	0.21
Jun-17	131.70	16.88	0.30	0.26	81.50	4.98	9.47	6.16	1.06	0.35
May-18	170.40	10.27	0.40	0.16	151.30	2.87	28.29	4.33	1.70	0.45
May-19	130.00	10.82	0.68	0.23	58.80	2.95	23.93	5.23	0.74	0.53
Jun-20	58.75	4.41	0.14	0.25	28.93	0.81	5.50	0.96	2.45	0.59
Jun-22	29.49	1.93	0.24	0.14	10.46	0.56	3.93	0.50	0.44	0.44
Jun-23	22.86	4.42	0.24	0.13	10.01	0.53	4.51	0.87	0.34	0.24

Notes:
ND - results reported as zero in lab report
[1] - a value equal to 1/2 the detection limit was used fo all non-detected congeners to calculate sample TEQ. Prior to 2014 a value of zero was used for all non-detected congeners.

Table 4-5 and Table 4-6: Historical Labrador Tea Results - PCB, and Total TEQ

TABLE 4-5

Historical Labrador Tea Quality Results - PCB Concentrations (Congeners) - mg/kg

Veolia

W ½ 06-067-08 W5M

Date	Plot 4	Plot 11	Plot 70	Plot 71	Plot 109	Plot 110	Plot 114	Plot 117	Plot 123	Plot 402
May-06	0.15	0.025	0.0034	0.0028	0.076	0.0080	0.060	0.013	0.0050	0.0029
Jun-07	0.23	0.093	0.014	0.026	0.13	0.036	0.10	0.039	0.021	0.020
May-08	0.30	0.025	0.0035	0.010	0.15	0.013	0.075	0.021	0.0089	0.010
Jun-08	0.30	0.025	0.0035	0.010	0.15	0.013	0.075	0.021	0.0089	0.010
Jun-09	0.24	0.020	0.0038	0.00093	0.052	0.0077	0.069	0.014	0.0050	0.0029
Jul-09	0.22	0.049	0.0028	0.027	0.42	0.015	0.075	0.012	0.0081	0.012
May-10	0.52	0.067	0.0057	0.0028	0.41	0.015	0.21	0.035	0.0084	0.0040
May-11	0.25	0.046	0.0026	0.00089	0.24	0.024	0.12	0.021	0.0039	0.0015
Jun-12	0.44	0.021	0.0057	0.00022	0.17	0.0023	0.052	0.0055	0.0012	ND
Jun-13	0.30	0.023	0.0020	0.0022	0.21	0.013	0.052	0.011	0.0026	0.0027
May-14	0.19	0.024	0.00024	0.00018	0.10	0.0072	0.037	0.0059	0.0020	0.00076
Jun-15	0.19	0.020	0.00028	0.00010	0.11	0.0062	0.041	0.0053	0.0013	0.00064
May-16	0.13	0.011	0.00015	0.000092	0.049	0.0027	0.021	0.0073	0.0017	0.00049
Jun-17	0.10	0.0076	0.00014	0.00016	0.073	0.0035	0.017	0.0052	0.0012	0.00041
May-18	0.065	0.0074	0.00031	0.00030	0.028	0.0032	0.013	0.0032	0.00080	0.00036
May-19	0.071	0.0051	0.00015	0.00019	0.026	0.0016	0.010	0.0022	0.00060	0.00030
Jun-20	0.062	0.0048	0.00018	0.00007	0.024	0.0016	0.010	0.0026	0.00079	0.00032
Jun-21	0.063	0.0048	0.00033	0.00144	0.018	0.0016	0.012	0.0025	0.00059	0.00064
Jun-22	0.035	0.0050	0.00045	0.00044	0.025	0.0017	0.008	0.0028	0.00089	0.00057
Jun-23	0.068	0.0113	0.00159	0.00131	0.038	0.0034	0.020	0.0078	0.00176	0.00073

TABLE 4-6

Historical Labrador Tea Quality Results - Total TEQ - ng TEQ/kg[1]

Veolia

W ½ 06-067-08 W5M

Date	Plot 4	Plot 11	Plot 70	Plot 71	Plot 109	Plot 110	Plot 114	Plot 117	Plot 123	Plot 402
May-06	40.50	0.76	0.62	0.50	10.75	0.26	8.92	0.67	0.74	0.29
Jun-07	36.60	5.24	0.57	0.33	10.72	0.71	12.24	0.64	0.37	0.35
May-08	31.20	4.14	0.29	1.16	13.59	1.33	8.34	1.82	1.33	0.20
Jun-08	34.90	4.12	0.31	1.63	15.45	1.45	9.41	2.03	1.89	0.20
Jun-09	33.17	3.35	0.49	0.16	5.39	0.57	6.84	1.40	0.38	0.18
Jul-09	8.51	1.19	0.86	0.67	13.29	0.65	4.90	0.81	0.88	0.67
May-10	46.13	8.44	0.72	0.64	31.99	0.51	23.06	3.42	0.98	0.20
May-11	28.70	4.35	0.14	0.16	20.05	4.04	10.59	2.52	0.13	0.13
Jun-12	66.53	1.14	2.86	0.94	1.50	0.32	0.87	0.88	0.93	1.11
Jun-13	43.16	3.64	0.22	0.20	27.63	0.46	7.18	0.47	0.29	0.50
May-14	29.90	4.10	0.46	0.64	12.59	1.59	5.80	0.58	0.71	0.55
Jun-15	23.00	2.79	0.21	0.19	14.93	1.01	5.62	0.85	0.31	0.31
May-16	18.26	2.20	0.14	0.55	6.76	1.19	2.74	0.89	0.90	0.80
Jun-17	15.11	1.53	0.38	0.40	8.39	1.28	3.98	1.45	0.73	1.58
May-18	10.88	1.28	0.28	0.40	4.46	1.26	1.97	2.09	2.46	0.55
May-19	12.56	1.48	0.17	1.22	3.93	1.00	2.34	1.33	1.36	1.24
Jun-20	8.76	1.05	0.54	0.12	2.86	0.31	1.34	0.52	0.29	0.41
Jun-21	8.35	0.88	0.58	0.96	3.21	1.93	3.45	1.08	1.41	2.16
Jun-22	4.24	1.19	0.68	0.89	2.26	0.77	1.01	0.78	0.60	0.75
Jun-23	18.92	6.71	6.68	9.07	8.32	2.64	5.76	10.32	6.78	4.62

Notes:

ND - results reported as zero in lab report

[1] - a value equal to 1/2 the detection limit was used fo all non-detected congeners to calculate sample TEQ. Prior to 2014 a value of zero was used for all non-detected congeners.

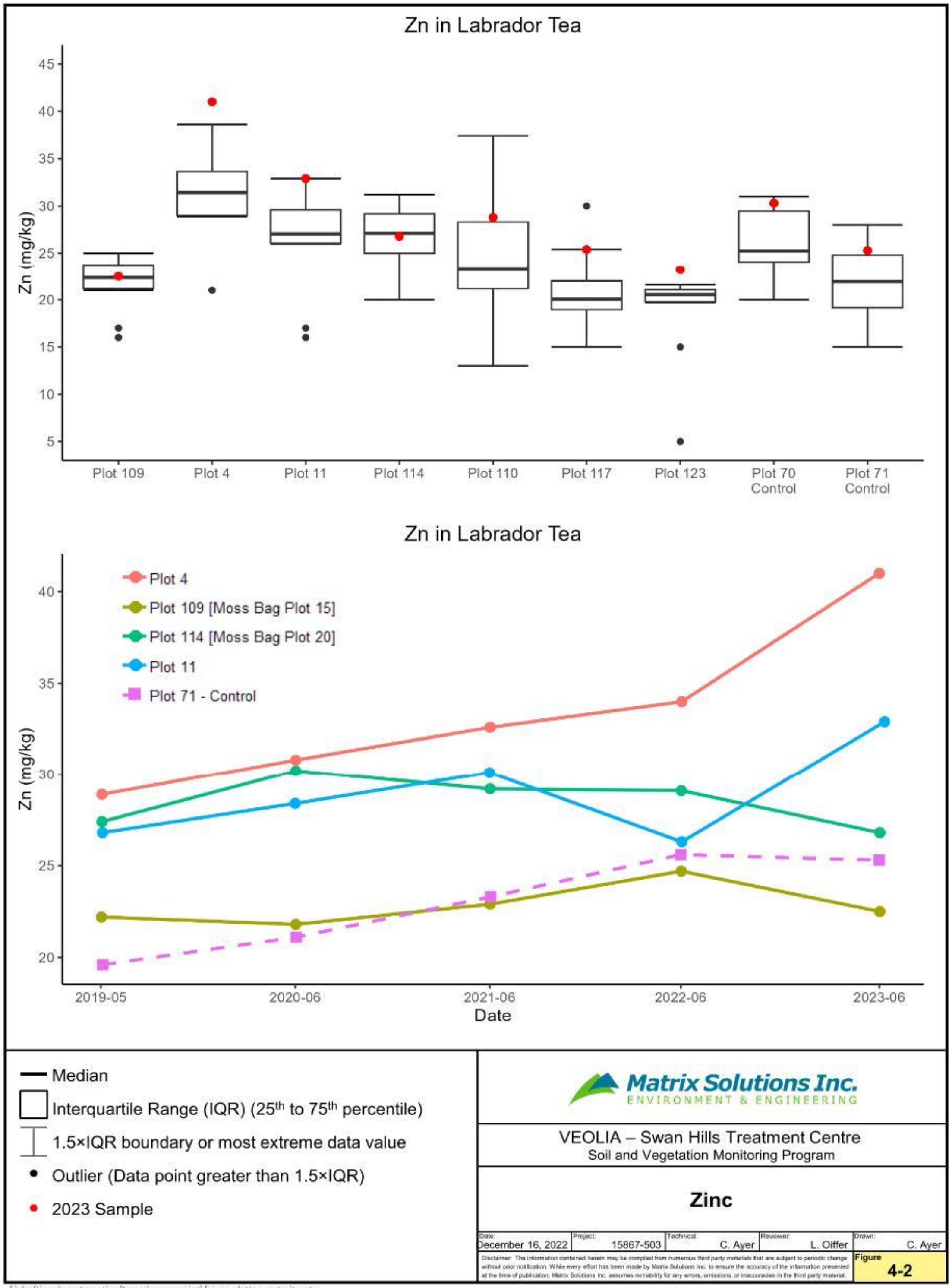


Figure 4-2: Zinc in Labrador Tea Box Plots

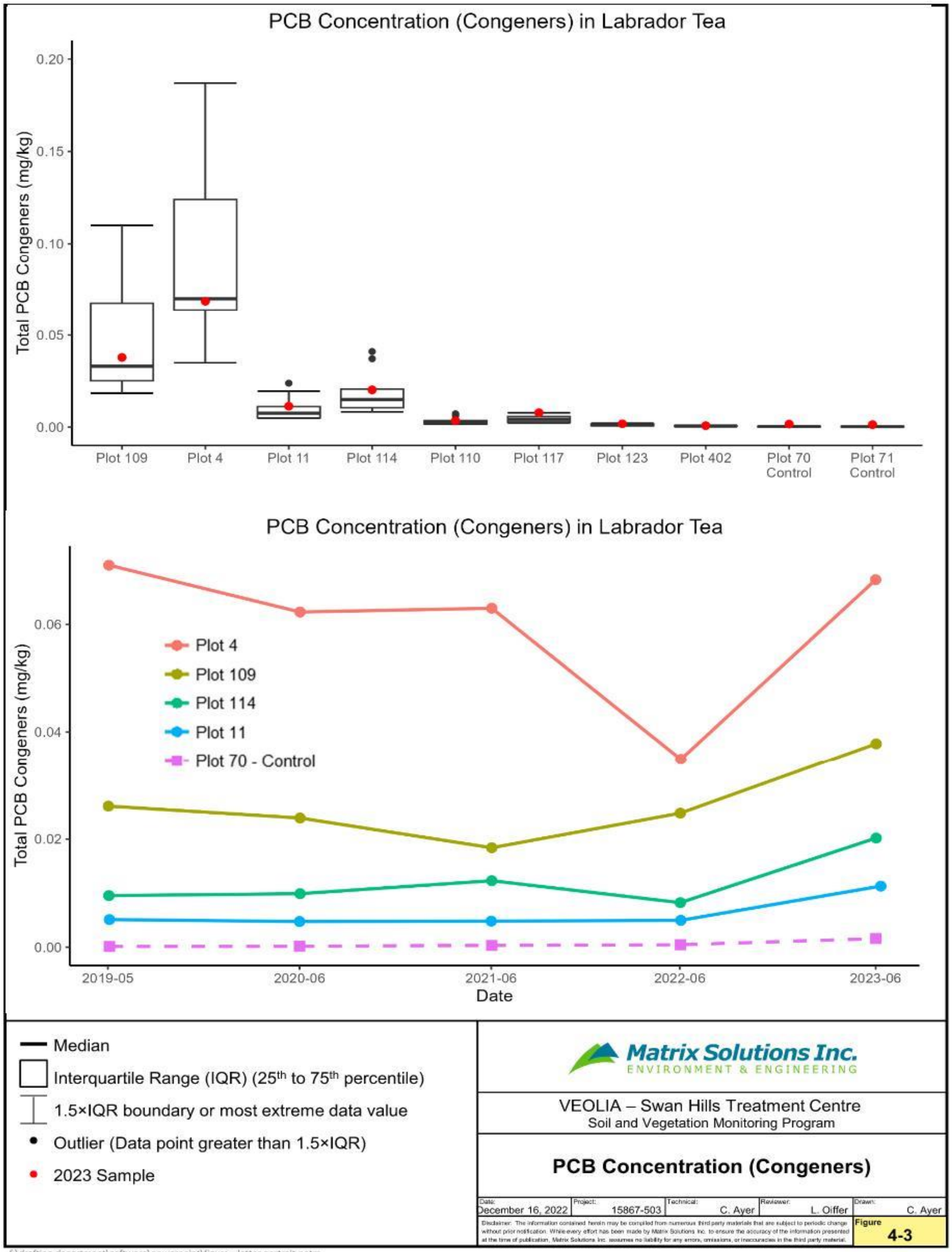


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Figure 4-3: PCB Concentration in Labrador Tea Box Plots

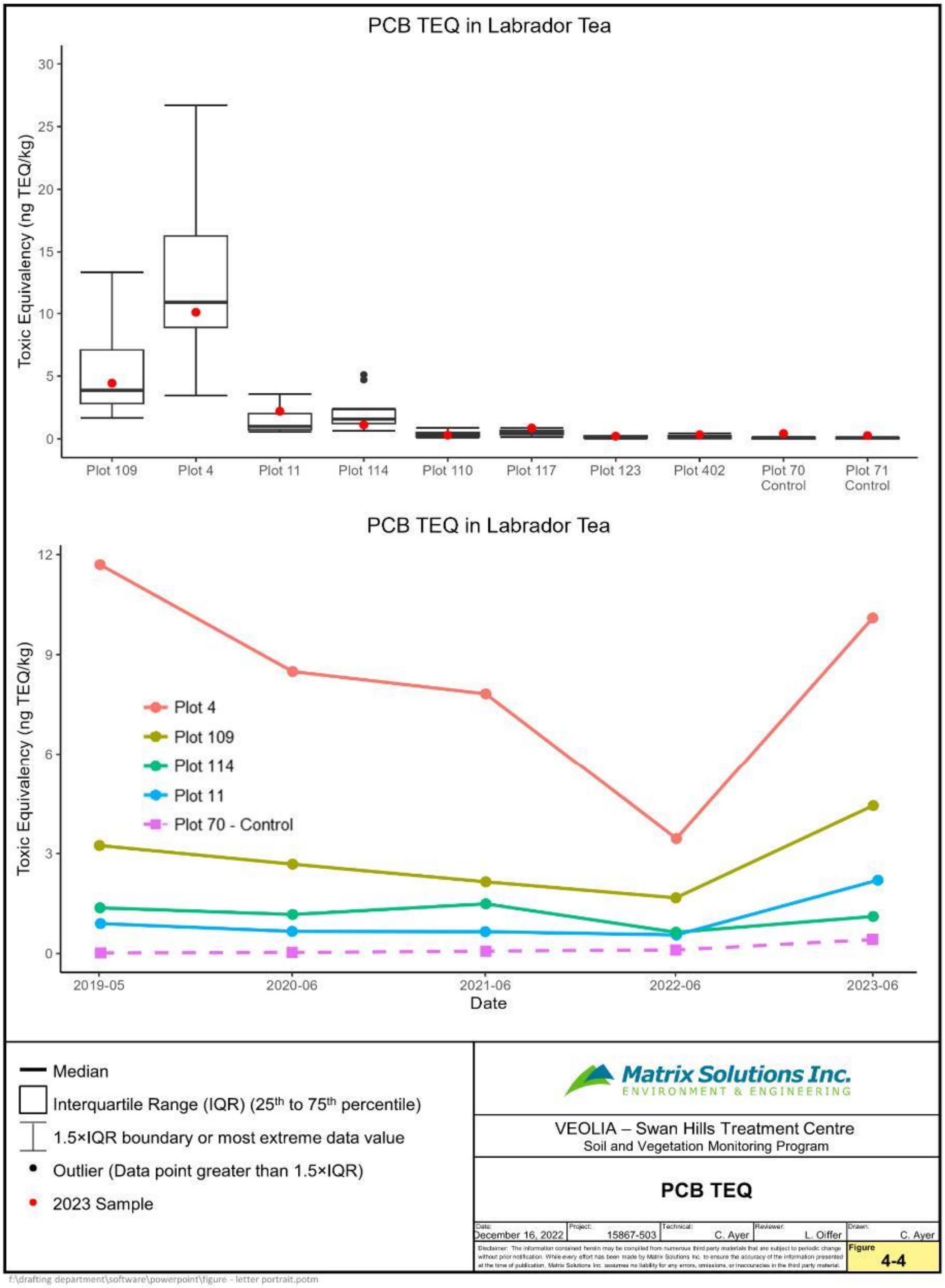

Figure 4-4: PCB TEQ in Labrador Tea Box Plots

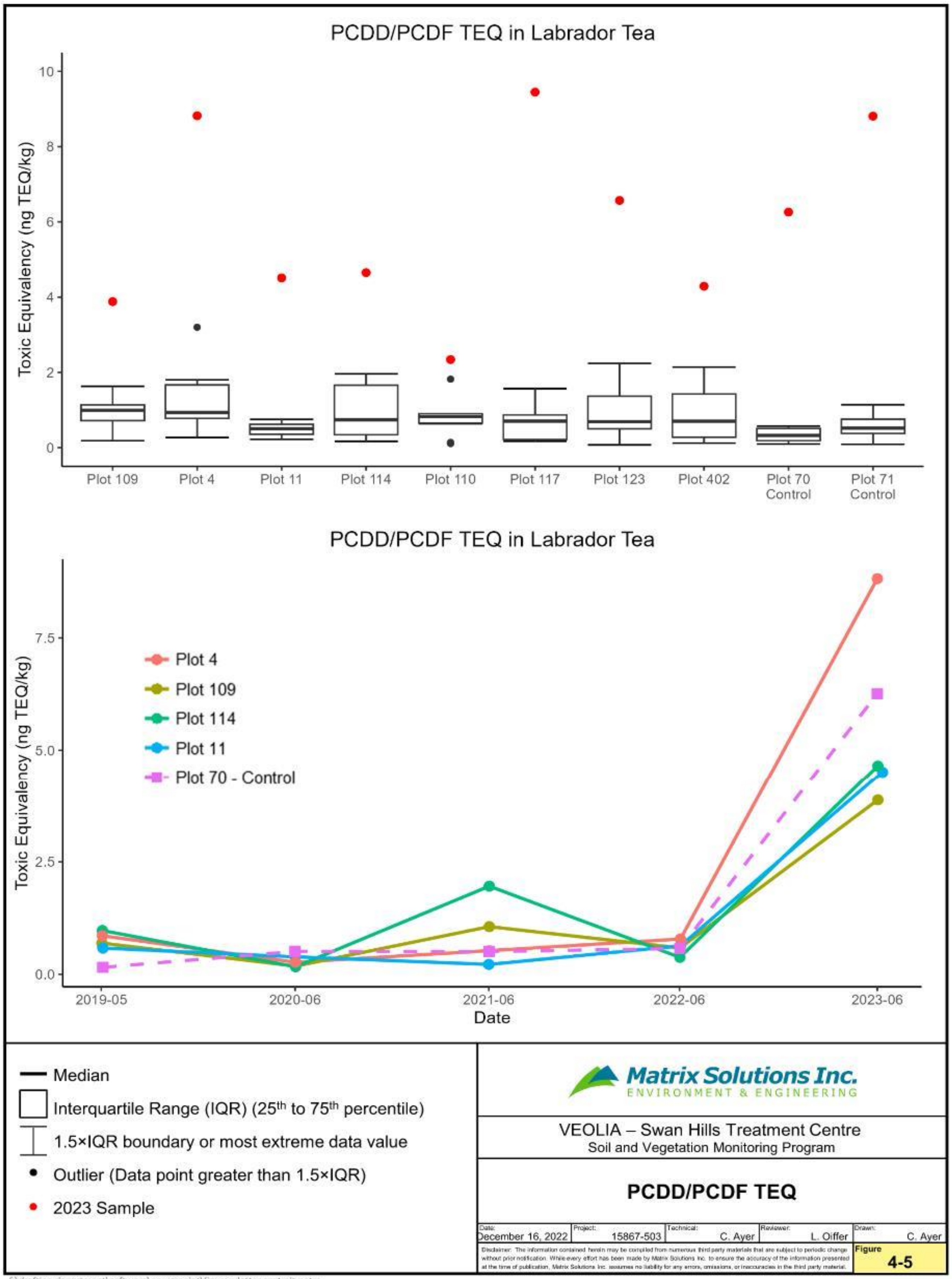

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Figure 4-5: PCDD/PCDF TEQ in Labrador Tea Box Plots

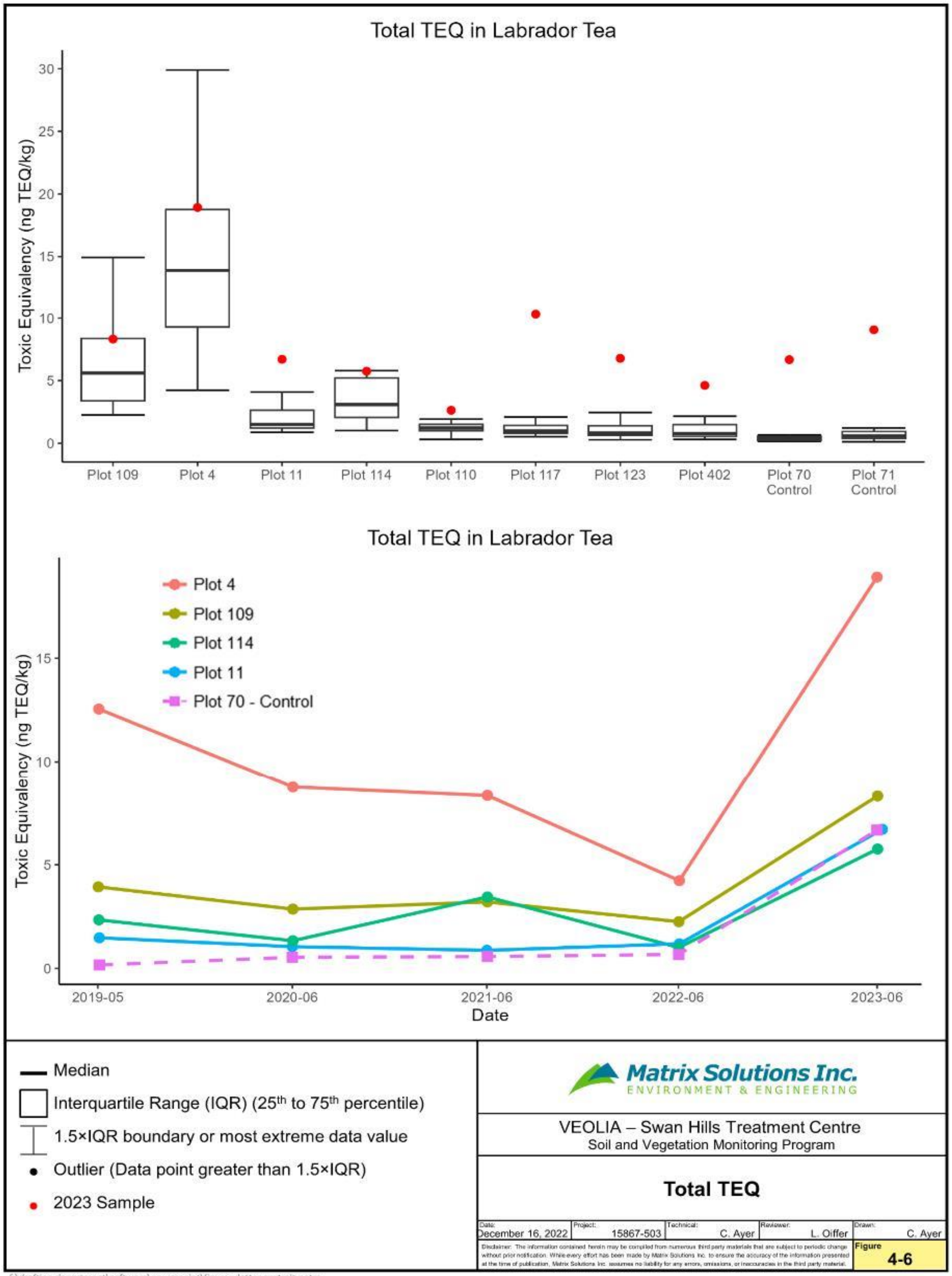

Figure 4-6: Total TEQ in Labrador Tea Box Plots

Moss Bags and Lichen Monitoring Sites

- There was no statistically significant differences in metal concentrations, in the moss bags, between Zones 1 and 2 and there were no obvious differences in metal concentrations between offsite moss bag plots.
- In 2021 moss bags were also deployed at air monitoring Sites 1 (downwind of solidification building), 5 (upwind of SHTC), and 9 (downwind of the landfill). Most metallic parameters were elevated at Site 9 relative to Sites 1 and 5. Metals were elevated at all fenceline monitoring locations relative to the off site moss bag plots.
- There were no decreasing trends in health at any of the lichen monitoring sites and overall the vitality of lichen appeared to be unchanged relative to the previous monitoring period in 2021. Overall, there is no evidence that emissions from the SHTC are affecting lichen health.

4.2 Vole Tissue Chemistry and Population Monitoring

During 2023, demographic studies of voles were conducted on three live-trapping plots in June and September as part of the annual wildlife monitoring program. In addition, concentrations of PCB congeners and TEQs, dioxin/furan congeners and TEQs, and total TEQs were determined for animals collected from 10 plots in May 2023.

Red-backed voles are monitored annually at three locations for population studies and at ten locations for tissue chemistry. The monitoring plots are shown in Figure 4-7. Tissue chemistry plots are located adjacent to plots sampled in the soil and vegetation program (Figure 4-1), providing consistent information on different receptors at the same sites.

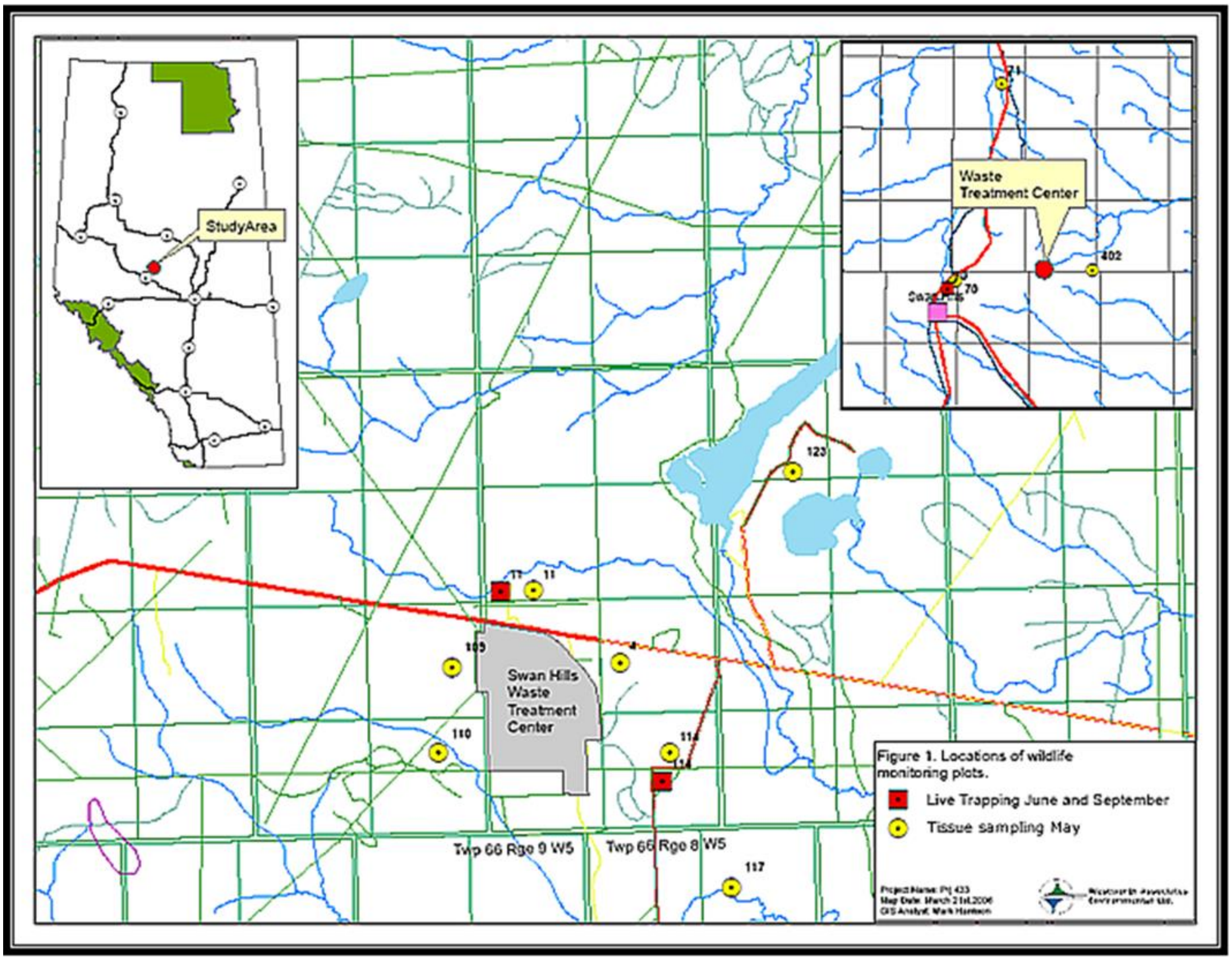

Figure 4-7: Location of the 2023 Wildlife Monitoring Plots in the Vicinity of the SHTC

Vole Population Monitoring

Between 1991 and 2015, average red-backed vole densities in the SHTC area have varied between 1.9 (2000) and 18.8 (2013) voles/ha in June, and between 4.9 (2011) and 37.5 (2013) voles/ha in September. However, vole populations in the SHTC area reached their highest average densities ever recorded for June (19.2 voles/ha) and September (39.8 voles/ha) during the 2016 vole monitoring program. These densities were 2.4 and 2.3 times higher than the respective 25-year average (1991 – 2015) vole densities for June (8.2 voles/ha) and September (17.5 voles/ha). Then in 2017, vole densities declined to some of the lowest levels recorded since monitoring began in the SHTC area (e.g., plots 11 and 70 fell to the lowest recorded September densities since 1991). Vole densities between 2018 and 2021 returned to similar densities recorded prior to the respective population peak and population low reported in 2016 and 2017. Vole densities at the 3 monitoring plots in both June (Figure 4-8) and September (Figure 4-9) 2023 were within historical ranges previously recorded in the SHTC study area.

Historically, population increases, and decreases have almost been synchronous at the 3 annually monitored plots in the SHTC study area, although periodically there have been differences in population dynamics among the plots, particularly in the June populations. This happened June in 2009, 2010, and at least partially, again in 2011 and 2022. For example, vole densities at plots 11 and 70 decreased from 2010 to 2011, while the density at plot 114 increased. During 2022, June (Figure 4-8) vole densities at plots 11 and 70 increased but decreased at plot 114 while in September (Figure 4-9), densities at all 3 plots decreased. In 2023, vole densities increased at all 3 plots in June and only at 2 plots in September. Vole density at plot 70, however, decreased and may have been a result of the wildfires that occurred in the vicinity of the SHTC study area.

The reason(s) for these inconsistencies in vole densities among plots is unclear but likely reflect differences in habitat structure at the plots (or site conditions) and therefore, their ability to support voles under variable weather conditions (e.g., overwinter survival), levels of predation, and food supply. However, vole population synchronicity in June and September within the SHTC area appears to have returned since 2012 and is similar to the population cycles observed prior to 2009. Aside from some variability in vole weight classes and breeding voles in the heavy weight class (i.e., breeding proportions) among the 3 plots, most other demographic parameters were consistent with those recorded during previous monitoring years, suggesting that plot proximity in relation to the SHTC did not affect vole demography in 2023. With densities increasing in June and September (with the exception of plot 70) 2023, it appears likely that vole populations in the vicinity of the SHTC will continue the increase phase of their cycle in 2024.

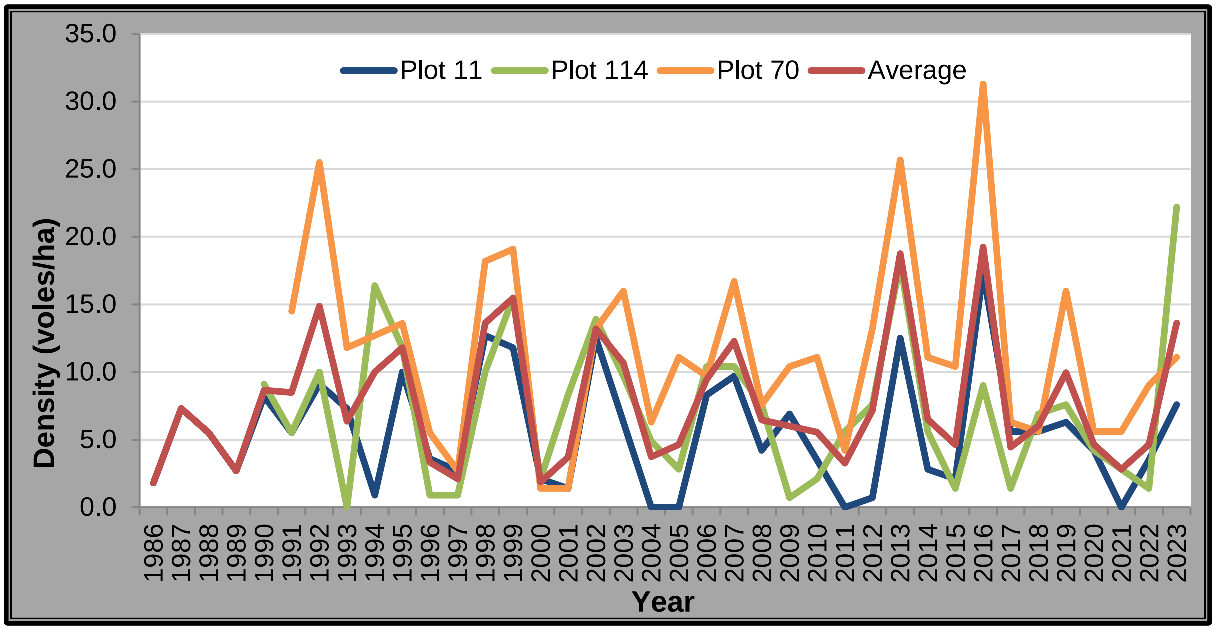

Figure 4-8: Densities of Red-Backed Voles in the SHTC Study Area, June 1986-2023

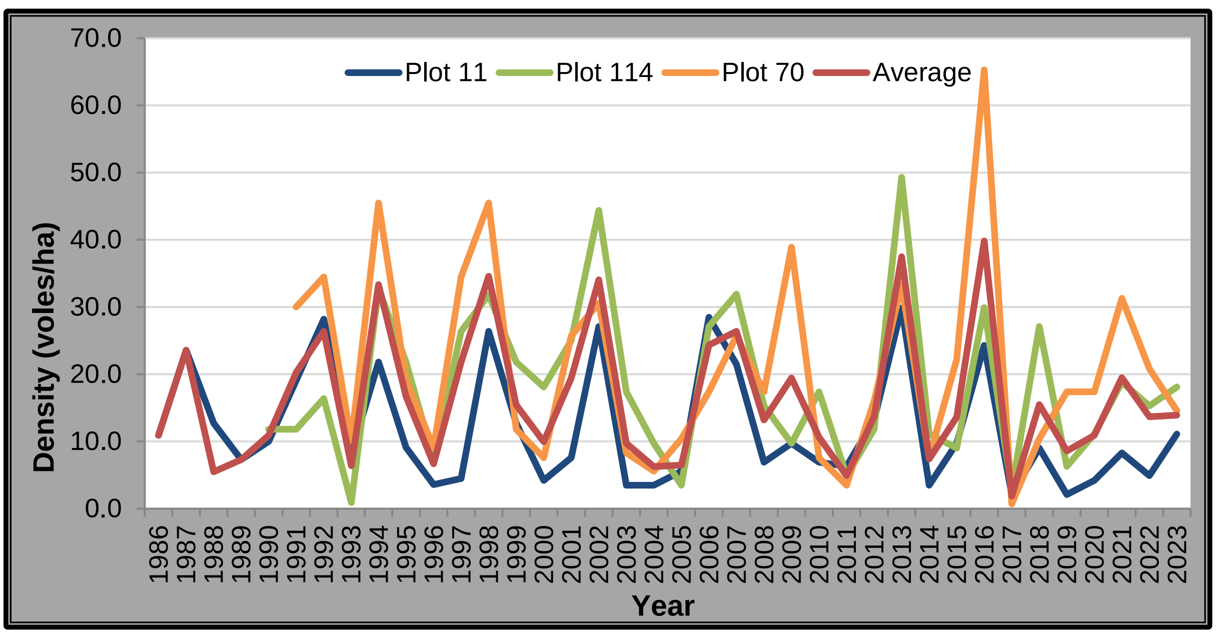

Figure 4-9: Densities of Red-Backed Voles in the SHTC Study Area, September 1986-2023

Vole Tissue Chemistry Monitoring

PCB Congeners and TEQs

The average concentration of congener PCBs in vole tissues across the 10 vole tissue collection plots decreased (-37% or -18,802 pg/g) from 50,888 pg/g in May 2022 to 32,086 pg/g in May 2023 (Table 4-7). While congener PCBs decreased at 8 plots, year-over-year increases were recorded at plots 402 (158% or 1,047 pg/g) and 70 (6,885% or 32,429 pg/g). Despite the increase in PCB congeners at plots 402 and 70, the average 2023 concentration across the 10 plots is 72% lower than the 23-year average (2000 – 2022) for the SHTC study area; the second lowest concentration recorded since 2000 (Table 4-7). The increases in congener PCBs at plots 402 and 70 appear to be related to the extensive smoke associated because of fires that occurred in the region during 2023.

Between May 2022 and May 2023, PCB TEQ concentrations increased at 3 plots and decreased at the remaining 7 plots (Table 4-8), representing a decrease in average PCB TEQ of 32%. The largest percentage increases occurred at plot 70 which increased by 11.69 pg/g (or 10,627%), followed by plots 402 (0.17 pg/g or 109%), and 71 (0.04 pg/g or 78%) (Table 4-8). The higher concentrations of PCB TEQs at the 3 plots located furthest from the SHTC likely were affected by the fires that were burning close to the Town of Swan Hills in 2023. In contrast, PCB TEQs at the remaining plots, all of which were closer to the SHTC, were among the lowest recorded since 2000 (Table 4-8). The highest PCB TEQ in 2023 among the 10 plots was recorded at plot 4 (96.5 pg/g), which has been the case for all but one year (plot 109 in 2012) since 2000 (Table 4-8). Although the PCB TEQ at plot 4 was the highest recorded in 2022, it represents the second lowest concentration recorded at this plot since 2000. While PCB TEQ values at plots 402 and 71 were ≤1 pg/g in 2023, continuing to represent the lowest levels recorded among the 10 plots on a historical basis, plot 70 (11.80 pg/g) was the highest PCB TEQ on record for this plot (Table 1-3).PCB TEQs increased at 6 and decreased at 4 of the 10 plots between May 2021 and May 2022 (Table 4-8), representing an average increase in PCB TEQ concentration of 84%. The highest PCB TEQ in 2022 was recorded at plot 4, which has been the case for all but one year (plot 109 in 2012), although it represents the lowest concentration recorded at this plot since 2000. PCB TEQ values at plots 402, 70 and 71 were all ≤0.16 pg/g in 2022 (Table 4-8). Historically, the highest PCB TEQ concentrations have been found in vole tissues collected near (≤0.7 km) and lowest at plots further away (>0.7 km) the SHTC. The exceptions to this in 2022 were plot 110 (7.62 pg/g) which is located only 0.3 km from the SHTC and plot 117 (28.1 pg/g) which is located 2.7 km from the SHTC unlike most previous monitoring years.

Table 4-7: PCB congener concentrations[1] (pg/g) in red-backed voles in SHTC study area, 2000 – 2023.

Year	Plot[2]										Averages
	11	109	4	110	114	123	117	402	70	71	
2000	480,000	-	300,000	-	170,000	-	24,000	5,500	8,800	3,600	**141,700**
2001	169,000	563,000	163	28,800	466,000	32,100	34,600	1,960	1,440	479	**129,754**
2002	627,382	819,944	642,093	16,715	495,810	53,724	108,457	5,557	1,799	393	**277,187**
2003	249,000	583,000	250,000	11,500	129,000	25,100	35,300	1,330	667	199	**128,510**
2004	70,359	1,034,201	687,233	133,077	136,802	14,997	17,438	734	1,084	406	**209,633**
2005	17,865	114,298	140,940	-	34,465	7,601	8,917	953	837	455	**36,259**
2006	203,545	254,766	867,215	17,820	143,851	9,468	34,099	2,944	2,363	1,273	**153,734**
2007	91,000	340,000	360,000	19,000	200,000	23,000	45,000	4,300	1,900	2,900	**108,710**
2008	100,000	99,000	410,000	17,000	85,000	23,000	69,000	47,000	7,200	3,800	**86,100**
2009	120,000	69,400	245,000	11,000	63,200	10,200	4,500	2,070	1,980	785	**52,814**
2010	192,000	98,800	351,000	43,500	294,000	19,300	74,900	3,530	1,680	795	**107,951**
2011	281,000	960,000	547,000	225,000	121,000	16,800	42,500	2,610	3,100	939	**219,995**
2012	181,000	815,000	357,000	136,000	250,000	27,400	45,900	6,150	1,860	1,280	**182,159**
2013	296,000	267,000	1,110,000	72,400	209,000	16,400	10,400	4,050	1,480	1,440	**198,817**
2014	114,000	115,000	399,000	105,000	263,000	19,900	42,500	4,570	935	716	**106,462**
2015	111,000	97,300	386,000	39,500	82,100	13,100	18,800	2,360	1,200	377	**75,174**
2016	90,400	87,700	429,000	21,600	86,900	11,300	33,300	2,330	770	356	**76,366**
2017	110,000	96,700	317,000	21,500	91,900	12,900	16,700	2,220	934	401	**67,026**
2018	84,200	187,000	368,000	26,400	102,000	14,300	34,500	2,470	779	888	**82,054**
2019	98,150	83,250	304,500	11,385	68,200	7,620	21,150	1,380	663	255	**59,832**
2020	63,700	60,400	161,000	7,380	45,900	12,900	17,000	1,410	533	190	**37,041**
2021	39,500	31,600	92,500	13,200	54,600	18,800	6,540	1,200	544	217	**25,870**
2022	65,200	66,100	171,000	28,000	121,000	4,650	51,600	663	471	191	**50,888**
2023	43,500	38,700	140,000	11,200	36,100	3,510	13,100	1,710	32,900[3]	143	**32,086**

[1] PCB congener concentrations are the sum of the homologues.
[2] Order of plots indicate increasing distance from SHTC (Plot 11 [100 m] to Plot 71 [23 km]).

Table 4-8: .TEQ of PCB congeners in red-backed voles (pg/g) collected from the SHTC study area, 2000 - 2023.

Year	Plot[1]										Averages
	11	109	4	110	114	123	117	402	70	71	
2000	500	-	670	-	144	-	33	1.3	6.7	0.06	**193.58**
2001	108	253	352	18.7	252	15	23.4	0.03	0.01	0.01	**102.22**
2002	241	346	461	5.1	215	22	53	0.1	0.05	0.00	**134.33**
2003	400	385	568	6.1	164	20.4	21.2	0.5	0.0	0.00	**156.52**
2004	94.8	120	836	29.5	3.35	11.5	11.8	0.01	0.02	0.01	**110.70**
2005	40.6	106	267	-	42.2	4.1	6.4	0.03	0.02	0.01	**51.82**
2006	369.9	133.2	1039.8	12.3	96.2	9.5	16.7	1.36	0.04	0.02	**167.90**
2007	119.6	411.2	614.2	7	152.1	18.8	26.4	0.13	0.05	0.03	**134.95**
2008a[2]	85.49	43.97	318.3	5.65	47.07	10.71	41.43	2.4	0.49	0.24	**55.58**
2008b[3]	84.59	42.8	319.02	5.42	45.52	10.42	40.32	2.26	0.47	0.23	**55.11**
2009	139.16	51.54	279.87	5.11	36.24	6.96	1.71	0.55	0.52	0.26	**52.19**
2010	146.72	74.46	207.07	22.1	114.18	6.05	18.93	0.02	0.01	0.00	**58.95**
2011	88.3	259	438	115	34.9	3.9	7.48	0.01	0.99	0.35	**94.79**
2012	74.2	313	294	49.3	52.2	5.31	12.7	0.99	0.49	0.00	**80.22**
2013	203	224	603	22.5	84.4	5.95	3.12	0.84	0.01	0.01	**114.68**
2014	86.4	59.4	305	115	57.6	7.57	10.6	1.0	0.28	0.25	**64.31**
2015	57.2	38.3	335	15.2	38.1	5.85	9.32	0.83	0.56	0.15	**50.05**
2016	43.5	28.4	289	6	26.1	3.9	8.62	0.54	0.30	0.13	**40.65**
2017	52.2	41.8	170	10.6	30.6	4.73	5.24	0.87	0.39	0.20	**40.57**
2018	39.4	98.4	232	8	33.8	4.42	11.4	0.73	0.27	0.36	**42.88**
2019	45.1	45.5	198	3.84	25.5	3.06	7.19	0.20	0.26	0.15	**32.88**
2020	40.4	25.9	113	2.12	18.7	3.7	5.6	0.51	0.24	0.07	**21.03**
2021	21.5	15.8	61.1	6.15	23	7.1	2.66	0.43	0.22	0.09	**13.81**
2022	25.2	23.7	111	7.62	54.4/2.4[4]	1.67	28.1	0.16	0.11	0.05	**25.20**
2023	22.5	17.7	96.5	3.7	14.4	1.25	3.7	0.33	11.8[4]	0.09	**17.20**

[1] Order of plots indicate increasing distance from SHTC (Plot 11 [100 m] to Plot 71 [21 km]).
[2] WHO-TEF: World Health Organization Toxic Equivalency Factor (1998).
[3] WHO-TEF: World Health Organization Toxic Equivalency Factor (2005).

Dioxin/Furan Congeners and TEQs

Dioxin/furan concentrations in red-backed voles decreased at 5 plots and increased at 5 plots between May 2022 and May 2023 (Table 4-9). The highest concentrations occurred at plots 4 (98.15 pg/g) and 11 (60.70 pg/g) while concentrations at the remaining plots were ≤26.41 pg/g (plot 109). For the most part, the highest levels of dioxins/furans occurred at plots 11 through 114 (range = 11.82 – 98.15 pg/g) which are located ≤0.7 km of the SHTC while the lowest values were recorded at plots 123 through to plot 71 (range = 1.55 - 13.29 pg/g), which are located the furthest away (>0.7 km) (Table 4-9). Unlike the PCB congener concentration at plot 70 in 2023, the concentration of dioxins/furans at plot 70 was within the range recorded during previous monitoring years. Of the 10 annually monitored plots, dioxin/furan concentrations at the 10 plots in 2023 were within previously observed ranges. Overall, dioxin/furan congener concentrations in the SHTC study area were highest between 2000 and 2006 but for the most part, have been declining since 2006 although slight increases were recorded in 2022. In 2023, dioxin/furan congers were slightly lower compared to 2022.

The average dioxin/furan TEQ concentration in 2023 increased slightly (12% or by 0.40 pg/g) between May 2022 and May 2023 and still represents the third lowest concentration (3.80 pg/g) recorded in the SHTC study area since 2000 (range = 2.1 to 1,371.4 pg/g) (Table 4-10). Since 2006, dioxin/furan TEQs have consistently declined to the low levels that have been recorded between 2017 and 2023. The congener 23478 PeCDF was the most important contributor to total dioxin/furan TEQ at 7 of the 10 plots in 2023. As with PCB TEQs, dioxin/furan TEQ concentrations in voles generally declined with increasing distance from the SHTC in May 2023 although larger increases were documented at plots 114 and 117 in 2022 and at plot 70 (likely related to the wildfires in the vicinity of the Town of Swan Hills) in 2023 compared to recent monitoring years (Table 4-10).

Table 4-9: Concentrations of dioxin/furan congeners (pg/g) in red-backed voles collected from the SHTC study area, 2000 - 2023.

Year	Plot[1]										Averages
	11	109	4	110	114	123	117	402	70	71	
2000	5,757	11,026	11,827	2,229	1,585	1,840	591	22	110	59	**3,504.6**
2001	655	2,902	9,203	460	960	931	1,225	8	7	7	**1,635.8**
2002	3,862	4,684	6,349	86	1,550	1,533	1,017	143	23	6	**1,925.3**
2003	2,994	3,938	9,432	112	1,874	865	273	5	25	4	**1,952.2**
2004	1,177	530	6,095	323	677	370	99	n.d.[3]	1.6	0.2	**927.3**
2005	581	1,280	2,005	-[2]	344	155	66	2.8	11	1.3	**444.4**
2006	8,043	648	7,633	158	488	345	78	15	22	8	**1,743.8**
2007	1,142	2,167	2,546	54	912	716	85	29	26	8	**768.5**
2008	862	373	2,316	76	223	266	506	20	36	18	**469.6**
2009	1,013	421	1,145	44	145	194	26	7	31	3	**302.9**
2010	1,720	503	434	168	314	43	48	7	3.4	<0.2	**324.1**
2011	131	312	1,010	438	55.8	22.9	10.2	1	1.9	<0.09	**198.3**
2012	171	973	1,156	168	139	23	43.1	4.4	15.5	1	**269.4**
2013	651	732	1,493	126	183	30.6	37	7.7	44.4	7.3	**331.2**
2014	329	162	781	386	91.8	82.3	27.8	13.7	32.8	7.5	**191.4**
2015	70	12	472	159	45.4	36.9	32.3	6.6	23.2	3.5	**86.1**
2016	123	53	488	31	53.8	20.5	15.6	3.7	17.0	9.2	**81.5**
2017	49.7	66.2	309.1	24.2	26.5	15.9	8.4	4.6	13.1	4.7	**52.5**
2018	77.6	173.7	257.6	21.8	31.1	19.6	11.2	3.4	7.1	1.2	**60.4**
2019	62.2	70.4	193.3	15.6	25.3	13.1	10.5	3.2	20.3	4.3	**41.8**
2020	66.6	26.3	111.9	8.5	14.0	8.2	4.3	3.8	6.7	1.9	**25.2**
2021	27.39	17.11	37.45	11.02	15.25	6.17	9.61	5.72	11.91	3.02	**14.5**
2022	19.66	18.27	135.15	14.17	41.74	5.81	27.17	1.34	11.85	8.44	**28.36**
2023	60.70	26.41	98.15	10.00	11.82	6.07	10.23	3.17	13.29[4]	1.55	**24.14**

[1] Order of plots indicate increasing distance from SHTC (Plot 11 [100 m] to Plot 71 [21 km]).
[2] No animals were collected for tissue samples.
[3] n.d. - Not Detected. Average values calculated based on ½ the reported detection limit.

Table 4-10: .TEQ of dioxin/furan congeners (pg/g) in red-backed voles collected from the SHTC study area, 2000 - 2023

Year	Plot[1]										Averages
	11	109	4	110	114	123	117	402	70	71	
2000	2,200	4,200	4,900	820	600	700	230	7.2	37	20	**1,371.4**
2001	230	1,100	3,800	160	340	350	440	0.76	2.9	1.2	**642.5**
2002	1,460	1,750	2,450	26.4	553	593	391	19.8	2.6	1.6	**724.7**
2003	1,200	1,490	3920	28.6	682	321	89.2	0.7	3.1	0.3	**773.5**
2004	416	187	2,190	99.5	262	126	31.7	0.79	1.5	0.27	**331.5**
2005	187	465	754	-[2]	104	48.8	17.5	0.81	2	0.43	**157.8**
2006	3,071	219	2,851	32.5	154	109	19.2	2.2	0.5	1.1	**646.0**
2007	421	765	885	14	283	274	21	4	3	2	**267.2**
2008a[3]	310	110	830	14	58	87	44	3.6	3.4	0.92	**146.1**
2008b[4]	200	71	530	11	40	56	30	2.8	4.5	0.94	**94.6**
2009	217	81	241	7	24	36	3	1	2	0	**61.2**
2010	366	100	88	32	58	8	7	1	3	0	**66.3**
2011	19.3	53.4	234	104	8.6	4.5	2.2	1.3	2	0.4	**43.0**
2012	21.2	185.0	223.6	27.56	19.69	4.48	6.84	0.76	2.94	0.18	**49.2**
2013	121.2	129.5	197.7	17	20.3	4	3.8	0.5	4.8	1.4	**50.0**
2014	53.9	22.2	133	81.3	13.0	12.1	2.92	1.4	2.81	0.803	**32.3**
2015	7.26	1.62	75.9	19.2	4.66	5.01	4.04	0.565	2.59	0.378	**12.1**
2016	14.8	6.54	80.8	3.4	5.59	2.79	1.73	0.488	1.97	0.745	**11.9**
2017	5.38	8.71	46.8	4.27	3.03	1.99	0.70	0.53	1.94	0.55	**7.4**
2018	10.8	25.9	35.9	3.15	3.16	3.42	1.4	0.79	1.55	0.31	**8.6**
2019	9.86	10.9	33.7	2.54	3.7	2.19	1.39	0.435	3.05	0.65	**6.8**
2020	10.2	4.32	19.0	1.43	2.1	1.39	0.70	0.516	1.65	0.364	**4.2**
2021	4.44	2.43	5.79	1.5	1.65	0.77	1.33	0.461	1.69	0.45	**2.1**
2022	3.03	2.86	12.8	2.19	5.81/0.27[5]	1.04	3.97	0.201	2.04	0.284	**3.4**
2023	8.72	4.28	15.4	1.91	2.02	1.16	1.34	0.557	2.39[6]	0.274	**3.8**

[1] Order of plots indicate increasing distance from SHTC (plot 11 [100 m] to plot 71 [21 km]).
[2] No animals were collected for tissue samples.
[3] Between 2000 and 2008a, dioxin and furan TEQs calculated based on NATO I-TEFs (1990).
[4] From 2008b and onwards, dioxin and furan TEQs calculated based on WHO (2005).

Total TEQ

Analyses of chemical concentrations in relation to distance and prevailing wind direction did not result in a statistically significant relationship between TEQ concentrations and distance in 2023. While PCB TEQ, dioxin/furan TEQ, and total TEQ concentrations generally decreased as distance from the SHTC increased in 2023, no significant trends with respect to TEQ values and prevailing wind direction even though the dominant wind direction was from the west.

Between May 2022 and 2023, total TEQ levels in red-backed voles decreased at 6 plots and increased at 4 of the 10 monitoring plots resulting in an average 26% decrease (-7.54 pg/g). Average total TEQ at plots >2 km from the SHTC remained well-below total TEQ concentrations at plots ≤2 km from the SHTC in 2020 (Figure 4-10). The overall trend for total TEQs in voles collected from plots ≤2 km and >2 km from the SHTC has been to decrease between 2000 and 2021 although concentrations had been somewhat variable up to about 2013 within both distance categories (Figure 4-10). However, total TEQs generally increased with relatively large increases recorded at plots 4, 114, and 117 in 2022 and at plot 70 in 2023.

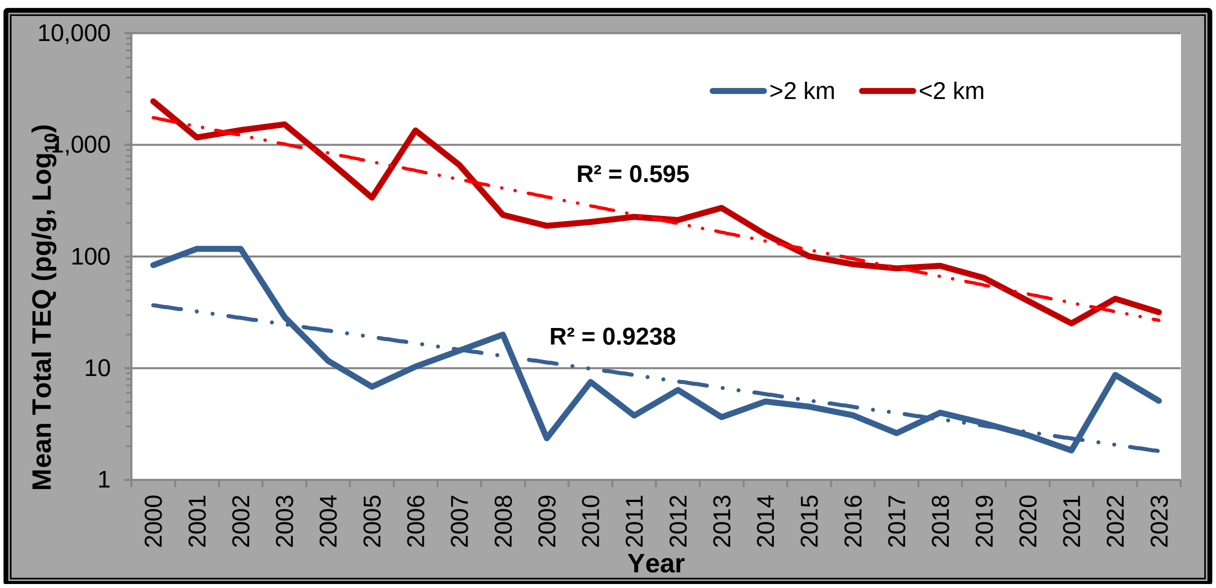

Figure 4-10: Mean total TEQ concentrations at plots ≤2 km and >2 km from SHTC, 2000 - 2023.

5 AQUATIC ENVIRONMENT

Aquatic ecosystem health monitoring includes indicators of water and sediment quality as well as indicators of fish health and contaminant load. Surface water quality (i.e., that of lakes and streams) near the SHTC is important for both human health and the integrity of aquatic ecosystems. Sediment quality in waterbodies near the SHTC is an important indicator of both current environmental conditions affecting aquatic biota and of cumulative pollutant deposition. Fish tissue provides a good indicator of aquatic system contaminant levels and is important to monitor given its direct potential linkage to human health risk through consumption of natural local foods.

The objective of the aquatic monitoring program is to assess changes in the concentration of chemicals of concern in lakes and streams near the SHTC (Figure 5-1) and their potential implications for human health risk.

5.1 Surface Water Monitoring

Surface water quality (i.e., that of lakes and streams) near the SHTC is important for both human health and the integrity of aquatic ecosystems. The surface water monitoring program evaluates spatial and temporal patterns in water quality relative to the SHTC. In 2023, monitoring occurred at one river (Coutts River) and two lakes (Edith Lake and Chrystina Lake) as part of the regulatory environmental monitoring program. The Coutts River and Chrystina Lake monitoring stations are located downgradient and downwind of the SHTC. Specifically, the Coutts River station (S5A) is approximately 5.0 km southeast of the SHTC, while the Chrystina Lake station (S12) is approximately 1.5 km northeast of the SHTC. Edith Lake is the background reference lake for the surface water monitoring program and is situated upwind and up-gradient from the SHTC, approximately 15 km from the facility.

Over 60 water quality parameters were measured in water samples collected from the Coutts River and the two lakes, including routine, nutrient, biological, and metal parameters. Due to low flow, hydrometric measurements were not collected at the time of sampling for any site. For each of the surface water quality parameters measured at each monitoring site, summary statistics were calculated to place the 2023 measurements in historical context (where adequate data were available). Values that were high relative to historic measurements were flagged. Measurements from 2023 were also compared to the Alberta Surface Water Quality Guidelines for the Protection of Aquatic Life (PAL; where applicable) and exceedances were noted and described. Finally, non-parametric monotonic trend analysis was conducted on parameters with at least 8 years of data and with fewer than 50% of those measurements being censored. The Mann-Kendall test was used to assess whether water quality parameters significantly increased, decreased, or lacked a distinct pattern over time. In 2023, a "moving window" trend analysis approach was implemented, where only the 10 most recent observations were included in the analysis to ensure that any trends detected are representative of current conditions.

A summary of historical range and regulatory guideline exceedances, as well as significant water quality trends, is outlined in Table 5-1. Based on the 2023 monitoring results, surface water quality near the SHTC is largely comparable to historical conditions observed in the Coutts River, Chrystina Lake, and Edith Lake. The Coutts River had 1 parameter above historical conditions (silicon), Chrystina Lake had 2 parameters above historical conditions (hardness and total manganese), and Edith Lake had 7 parameters above historical conditions (hardness, dissolved calcium, chlorophyll-a, total barium, total calcium, total iron, and total manganese). PAL guidelines were met for all parameters, except total alkalinity and pH in Edith Lake and Chrystina Lake; and dissolved iron and total lead in the Coutts River (which was above guidelines). The low alkalinity value reflects the naturally low buffering capacity in the lakes, and the guidelines only apply if natural conditions are not normally low. Dissolved iron values are consistent with historical results for the Coutts River. There is a decreasing trend for pH at Chrystina Lake; decreasing phosphorus and total organic carbon for Coutts River; decreasing total organic carbon in Edith Lake; increasing trends for total potassium, manganese, and chlorophyll-a in Edith Lake; and increasing total barium, sodium, strontium, and chlorophyll- a in Chrystina Lake. There are no guidelines for any of these parameters, except for pH. Since pH is decreasing at a test site (Chrystina Lake), and since pH can affect the toxicity of certain metals, it is worth exploring these trends more closely.

5.2 Sediment Monitoring

Sediment quality in waterbodies near the SHTC is an important indicator of both current environmental conditions affecting aquatic biota and of cumulative pollutant deposition. The sediment monitoring program evaluates spatial and temporal patterns in water quality relative to the SHTC, with stream stations being monitored annually and lake stations monitored biannually. In 2023, sediment samples were collected from two streambed sites (Coutts River (S5A) and S6) and two lake sites (Edith Lake and Chrystina Lake (S12)) as part of the regulatory environmental monitoring program. Over 300 sediment quality parameters were measured, including nutrient, metal, and organic parameters. S6 is located approximately 700 m southwest of the SHTC and is along an unnamed tributary of the Coutts River. This tributary discharges into the main stem of the Coutts River downstream of S5A (Coutts River); thus, the two stations do not influence each other. The Edith Lake, Chrystina Lake (S12) and Coutts River (S5A) monitoring stations are as described above.

Similar to the surface water quality monitoring program, summary statistics were calculated for each sediment parameter at each site to place the 2023 measurements in historical context (where adequate data were available). Values that were high relative to historic measurements were flagged. Measurements from 2023 were also compared to CCME Sediment Quality Guidelines for the Protection of Aquatic Life (PAL; where available) and exceedances were noted and described. Finally, non-parametric monotonic trend analysis was conducted on parameters with at least 8 years of data and with fewer than 50% of those measurements being censored. The Mann-Kendall test was used to assess whether sediment quality parameters significantly increased, decreased, or lacked a distinct pattern over time. As with the surface water quality analysis, in 2021 a 10 year "moving window" trend analysis approach was implemented, highlighting contemporary trends in sediment quality instead of being driven by historically high values.

A summary of historical range and regulatory guideline exceedances, as well as significant sediment quality trends, is outlined in Table 5-2. Generally, sediment quality near the SHTC has not significantly changed, and is comparable to historical conditions observed in Chrystina Lake, Edith Lake, and the Coutts River (metals were only historically high at the reference site S6). The PCB TEQ was historically high at the Coutts River, but it is based on relatively few samples (9) taken in more recent years. Interim Sediment Quality Guideline (ISQG) exceedances were documented for arsenic at Chrystina Lake and S6; nickel at Chrystina Lake and Edith Lake, and manganese at Edith Lake and S6. Total PCBs remained unchanged at all four sites – likely because the historically high PCB values occurred several decades ago and the moving window trend analysis is now capturing baseline values. No significant trends in PCB or PCDD/F Toxic Equivalents (TEQs) occurred at any sites; however, PCDD/F TEQs exceeded the respective ISQG at Chrystina Lake and Edith Lakes, as has been the case for much of the data record. Exceedances occurred in both test and reference sites.

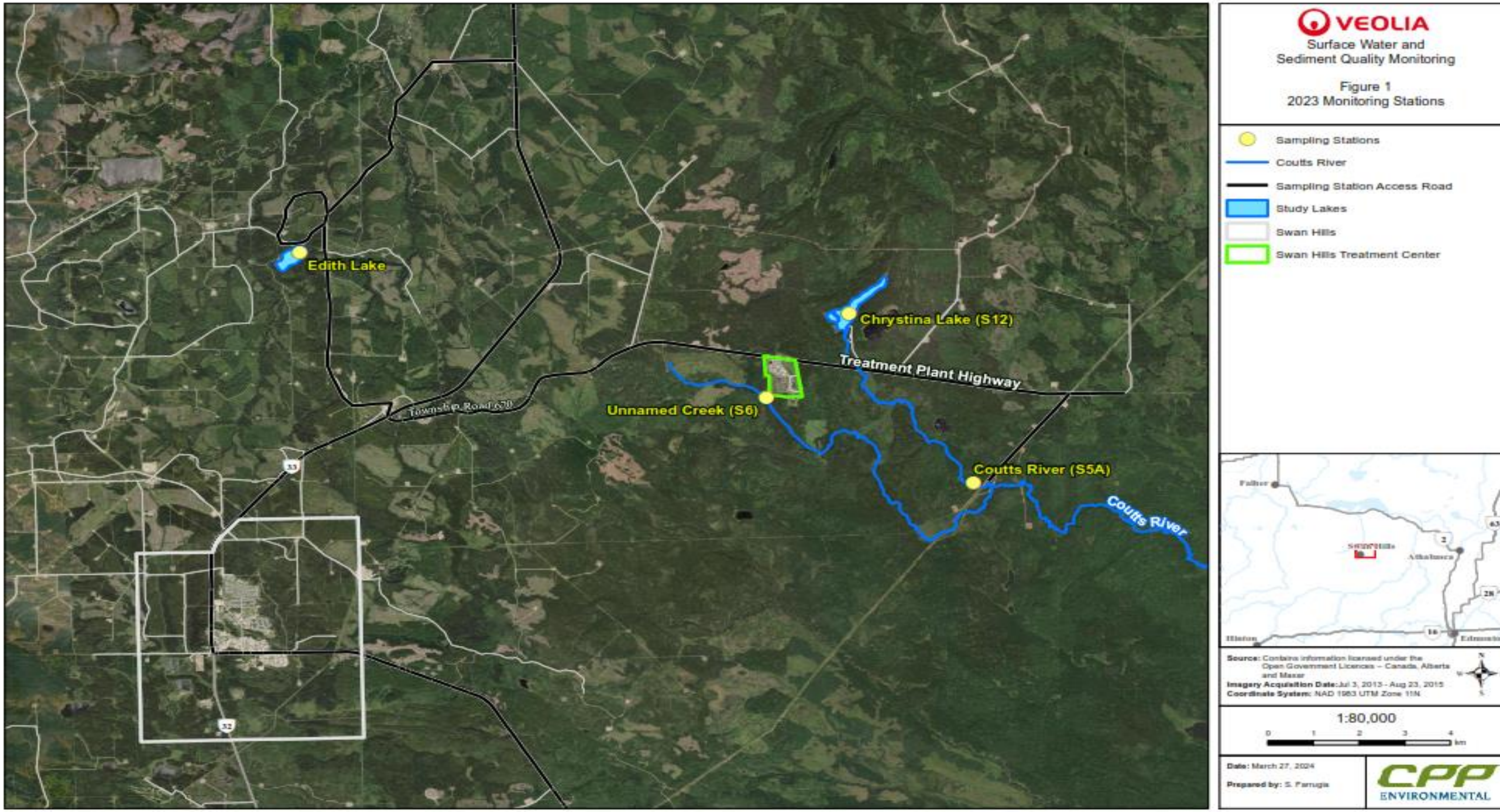

Figure 5-1: Surface Water, Sediment and Fish Tissue Monitoring Locations

Table 5-1: Summary of 2023 Surface Water Quality Monitoring Program

2023 surface water quality data summary, including variables that were high in 2023 relative to historical levels, exceedances of regulatory guidelines (AB = Alberta chronic surface water quality guidelines; Government of Alberta 2018), and significant (α = 0.1) water quality trends over 10 years for each of three monitoring sites.

Parameter	Above Historical Range			Exceeding Regulatory Guidelines			Mann-Kendall Trends		
	Chrystina L (S12)	Edith L	Coutts R (S5A)	Chrystina L (S12)	Edith L	Coutts R (S5A)	Chrystina L (S12)	Edith L	Coutts R (S5A)
Alkalinity, as CaCO3	-	-	-	Below	Below	-	NS	NS	NS
Aluminum, total	-	-	-	-	-	-	NS	NS	NS
Arsenic, total	-	-	-	-	-	-	NS	NS	NS
Barium, total	-	Yes	-	-	-	-	Up	NS	NS
Bicarbonate, diss	-	-	-	-	-	-	NS	NS	NS
Calcium, diss	-	Yes	-	-	-	-	NS	NS	NS
Calcium, total	-	Yes	-	-	-	-	NS	NS	NS
Chloride, diss	-	-	-	-	-	-	ID	ID	NS
Chlorophyll-a	-	Yes	-	-	-	-	Up	Up	NS
Copper, total	-	-	-	-	-	-	NS	NS	NS
Electrical conductivity	-	-	-	-	-	-	NS	NS	NS
Hardness	Yes	Yes	-	-	-	-	NS	NS	NS
Iron, dissolved	-	-	-	-	-	Above	NS	NS	NS
Iron, total	-	Yes	-	-	-	-	NS	NS	NS
Kjeldahl nitrogen, total	-	-	-	-	-	-	NS	NS	NS
Lead, total	-	-	-	-	-	Above	NS	NS	NS
Magnesium, diss	-	-	-	-	-	-	NS	NS	NS
Manganese, total	Yes	Yes	-	-	-	-	NS	Up	NS
Mercury, total	-	-	-	-	-	-	ID	ID	NS
Nickel, total	-	-	-	-	-	-	ID	NS	NS
Organic carbon, total	-	-	-	-	-	-	NS	Down	Down
pH	-	-	-	Below	Below	-	Down	Down	NS
Phosphorous, total	-	-	-	-	-	-	ID	ID	Down
Potassium, diss	-	-	-	-	-	-	NS	ID	NS
Silicon, total	-	-	Yes	-	-	-	NS	NS	Up
Sodium, diss	-	-	-	-	-	-	NS	ID	NS
Strontium, total	-	-	-	-	-	-	Up	ID	NS
Sulphur, total	-	-	-	-	-	-	ID	NS	NS
Suspended solids, total	-	-	-	-	-	-	NS	NS	NS
Titanium, total	-	-	-	-	-	-	ID	ID	NS

Note: ID = insufficient data available for trend calculation, NT= Non-significant trend

Table 5-2: Summary of 2023 Sediment Quality Monitoring Program

2023 sediment quality data summary, including variables that were high in 2023 relative to historical levels, exceedances of regulatory guidelines (ISQG = interim sediment quality guidelines; CCME 2001c), and significant (α = 0.1) water quality trends over 10 years.

Parameter	Above Historical Range				Exceeding Regulatory Guidelines				Mann-Kendall Trends			
	Chrystina L. (S12)	Edith L.	Coutts R. (S5A)	S6	Chrystina L. (S12)	Edith L.	Coutts R. (S5A)	S6	Chrystina L. (S12)	Edith L.	Coutts R. (S5A)	S6
Aluminum	-	-	-	-	-	-	-	-	NT	NT	NT	Up
Arsenic	-	-	-	-	Above	-	-	Above	Up	NT	NT	ID
Barium	-	-	-	-	-	-	-	-	NT	NT	NT	NT
Cadmium	-	-	-	-	-	-	-	-	NT	Up	NT	NT
Calcium	-	-	-	Yes	-	-	-	-	NT	NT	NT	ID
Chromium	-	-	-	-	-	-	-	-	NT	NT	NT	ID
Cobalt	-	-	-	-	-	-	-	-	Up	Up	NT	NT
Copper	-	-	-	-	-	-	-	-	NT	NT	NT	NT
Iron	-	-	-	Yes	-	-	-	-	NT	NT	NT	NT
Lead	-	-	-	-	-	-	-	-	NT	NT	NT	NT
Magnesium	-	-	-	-	-	-	-	-	NT	NT	NT	NT
Manganese	-	-	-	Yes	-	Above	-	Above	NT	NT	NT	NT
Mercury	-	-	-	-	-	-	-	-	NT	NT	NT	NT
Molybdenum	-	-	-	-	-	-	-	-	NT	NT	ID	ID
Nickel	-	-	-	-	Above	Above	-	-	NT	NT	NT	NT
Organic carbon, total	-	-	-	Yes	-	-	-	-	NT	NT	NT	NT
PCB TEQ	-	-	Yes	-	-	-	-	-	ID	ID	NT	ID
PCBs, Total	-	-	-	-	-	-	-	-	NT	NT	NT	NT
PCDD/F TEQ	-	-	-	-	Above	Above	-	-	NT	NT	NT	NT
Phosphorus	-	-	-	Yes	-	-	-	-	NT	NT	NT	NT
Potassium	-	-	-	-	-	-	-	-	NT	NT	NT	NT
Sodium	-	-	-	-	-	-	-	-	Down	NT	NT	ID
Strontium	-	-	-	Yes	-	-	-	-	NT	NT	NT	ID
Sulphur	-	-	-	Yes	-	-	-	-	NT	NT	NT	ID
Uranium	-	-	-	-	-	-	-	-	NT	NT	NT	Down
Vanadium	-	-	-	-	-	-	-	-	Up	NT	NT	NT
Zinc	-	-	-	-	-	-	-	-	Up	Up	NT	NT

Note: ID = insufficient data available for trend calculation, NT= Non-significant trend

5.3 Fish Tissue Monitoring

The annual monitoring program includes collection and chemical analysis of brook trout tissue from Chrystina Lake and Edith Lake to assess potential fish tissue contamination and fish health. Chrystina Lake is the main study lake since it is closer (1.5 km) and down-wind to the facility, whereas Edith Lake is farther away and upwind (Figure 5-1 shows sample locations). It is used as a local reference for the FTMP. Both lakes are open year-round to recreational fishing and are stocked each spring with brook trout from the Raven Brood Trout Station near Caroline, Alberta. In previous years stocked trout have been provided by the Cold Lake Fish Hatchery (CLFH) but this location has been closed for renovations and was unable to provide fish since 2022. Stocked brook trout have been implanted with coded wire tags (CWTs) each year since 2012 to provide definitive ages. These tags are 1.1 mm long, biologically inert, stainless-steel tags that are imprinted with codes specific to each stocking year and are implanted into the fish snouts before stocking. Tissue samples from both lakes were separated by age and analyzed for contaminants of concern (COC) listed in Table 5-3. Historically, PCBs drive toxicity levels in Chrystina Lake brook trout and are the main COC associated with the facility. There currently is an Alberta Health advisory recommending that consumption of brook trout captured from within 20 km of Swan Hills be kept to only two servings (75 grams/serving) per week.

Table 5-3: Contaminants of Concern Measured During the 2023 FTMP

Metals	Organics
Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Phosphorus, Potassium, Selenium, Silver, Sodium, Thallium, Uranium, Vanadium, Zinc	Polychlorinated Biphenyls (PCB) Dioxins Furans

Brook trout were captured from Chrystina and Edith lakes in mid-September. Chemical concentrations in brook trout from Chrystina Lake were compared with applicable guidelines, historical ranges, and concentrations in Edith Lake brook trout (reference condition), to investigate potential effects of the facility on fish in nearby waterbodies. In previous years fish from the hatchery were acquired to act as a control group but these fish were unable to be procured for the 2023 season. Objectives of the 2023 monitoring programs include: evaluating brook trout size and condition to detect possible effects of chemical stressors near the facility; comparing PCB concentrations among brook trout age classes in Chrystina and Edith lakes to investigate possible COC accumulation and health impacts; and identifying key recommendations to improve the effectiveness and reliability of the FTMP.

Tissue Residue Quality Criteria

The toxicity of dioxins, furans, and dioxin-like PCBs occurs through similar physiological processes therefore the toxicity of these compounds can be quantified by combining their respective toxic effects into a single toxic equivalency (TEQ). The TEQ approach uses the toxic equivalence factor (TEF) method, which is based on the concept of dose addition where the toxicity of individual dioxin and dioxin-like compounds in a mixture is combined into the single TEQ metric that can be used to facilitate risk assessment and regulatory control. The TEQs calculated during the FTMP are based on the 2005 World Health Organization (WHO) TEFs for mammals that express the toxicity of each dioxin, furan, and dioxin-like PCB relative to the most toxic form of dioxin.

Guidelines and toxicological thresholds applicable to the FTMP are summarized in Table 5-4. The Canadian Council of Ministers of the Environment (CCME) guidelines and tissue residue benchmarks (TRB) for dioxins, furans, and dioxin-like PCBs set tissue residue criteria based on TEQ and provide context for concentrations of organic contaminants in Chrystina Lake brook trout. The CCME guidelines provide stringent criteria to protect wildlife consumers of aquatic biota and are protective of the most sensitive wildlife consumers of fish (i.e. mink). The TRBs assist in evaluating the potential of PCBs to cause adverse effects on Chrystina Lake brook trout.

The Great Lakes region has one of the longest running PCB monitoring programs in the world and the region continues to be impacted by elevated PCB concentrations because of historical PCB use. Fish consumption advisory limits in the region, based on total PCB concentrations in edible tissue, are outlined in the Binational Strategy for Polychlorinated Biphenyl (PCB) Risk Management. Canada's federal quality criterion for total PCBs is under review and orders of magnitude above tissue concentrations in brook trout near the facility, and there is no provincial guideline for total PCBs. Therefore, total PCB concentrations in the edible tissue of brook trout collected during the FTMP are compared with the consumption advisory levels established for the Great Lakes region. The advisory level for unrestricted consumers (0.05 µg/g) is the most stringent consumption limit and is protective of individuals that consume over 225 meals of wild caught fish per year.

Toxicological thresholds have been developed for eleven metals from the Society of Environmental Toxicology and Chemistry (SETAC) toxicity database based on previously reported no observable effect concentrations (NOEC). The NOEC represents the highest concentration of a contaminant that will not cause an adverse effect. In addition, maximum levels for contaminant concentrations established by Health Canada under the Food and Drug Regulations are used to evaluate concentrations of arsenic, lead, and mercury in Chrystina Lake brook trout relative to limits imposed on retail foods.

Table 5-4: Tissue Residue Quality Criteria for the Fish Tissue Monitoring Program

Guideline/ Benchmark	Source	Applicable COC	Protection
Great Lakes Consumption Advisory Levels (2018)	Binational Strategy for Polychlorinated Biphenyl (PCB) Risk Management	Total PCBs	Protection of human fish consumers
CCME (2001)	Canadian Council of Ministers of the Environment (CCME) - Tissue Residue Guidelines	PCBs Dioxins/Furans	Protection of wildlife consumers of aquatic biota
Tissue Residue Benchmarks (TRB)	TRB for Aquatic Biota derived for TCDD and Equivalents (Steevens et al. 2005)	PCBs Dioxins/Furans	Benchmarks derived for protection of: 99% of fish species present 95% of fish species present 90% of fish species present
SETAC (1999)	Society of Toxicology and Chemistry - Linkage of effects to Tissue Residues Database	Aluminum, Antimony, Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Zinc	No Observable Effect Concentrations (NOEC) for salmonid fish species
Health Canada (2020)	*List of Maximum Levels for Various Chemical Contaminants in Foods* and *List of Contaminants and Other Adulterating Substances in Foods*	Arsenic, Lead, Mercury TCDD	Maximum Levels (ML) for chemical contaminants in retail foods
GOA 2018	Alberta Surface Water Quality Guidelines – Tissue Residue Guideline	Selenium	Fish protection from adverse effects

Fish Characteristics

Brook trout condition and average fork length in 2023 in both lakes remains consistent with previous years and does not suggest detrimental effects on growth at the whole-body level. The average brook trout condition in Chrystina and Edith Lake continues to be approximately 1.2 and 1.16 respectively which most recreational fishers would deem sufficient. The Catch Per Unit Effort (CPUE) was lower in 2023 compared with previous years, with Edith Lake having the lowest CPUE since 2018. Although the catch rates were lower, and no individuals were captured with a FL of over 400mm, the size of brook trout captured was overall higher than it was during the 2022 FTMP. The brook trout collected in 2023 from Edith Lake were the largest on average captured since 2003. No known brook trout over 3+ years old were collected from Chrystina Lake, although a wider range of age classes were captured from Edith Lake with 4+ and 6+ year-olds being captured. Two fish who did not have CWT were captured within Chrystina Lake who had body sizes large enough to possibly fit them into older age classes. Older age classes are particularly beneficial for the FTMP given that these age classes improve analyses designed to estimate the rate of PCB accumulation in Chrystina Lake by extending reconstructed life-histories. The composition of samples analysed each year depend on the age distribution of brook trout captured. Samples analysed as part of the 2023 FTMP are summarized in Table 5-5.

Table 5-5: Brook Trout Age Classes Analyzed during the 2023 FTMP

Age Class	Chrystina Lake (CHBKTR)	Edith Lake (EDBKTR)
0+	---	---
1+	*Composite (5 fish)*	*Composite (2 fish)*
2+	*Composite (2 fish)*	*Composite (3 fish)*
3+	*Composite (5 fish)*	*Composite (5 fish)*
4+	---	*Composite (5 fish)*
5+	---	---
6+	---	*Composite (3 fish)*
UNK A	Individual	---
UNK B	Individual	---

Polychlorinated Biphenyl (PCB) Levels and Trends

Total PCB concentrations in 2023 for Chrystina Lake and Edith Lake are provided along with historical data in Figure 5-2. Each measurement since 2006 is provided as a single point (concentrations for duplicate samples averaged) with green points representing more recent data and blue representing old PCB concentrations. Total PCB concentrations for 2023 (red) are provided as single points, while mean concentrations for each age class are represented by a horizontal (mean) and vertical (standard error) black line (Figure 5-2)

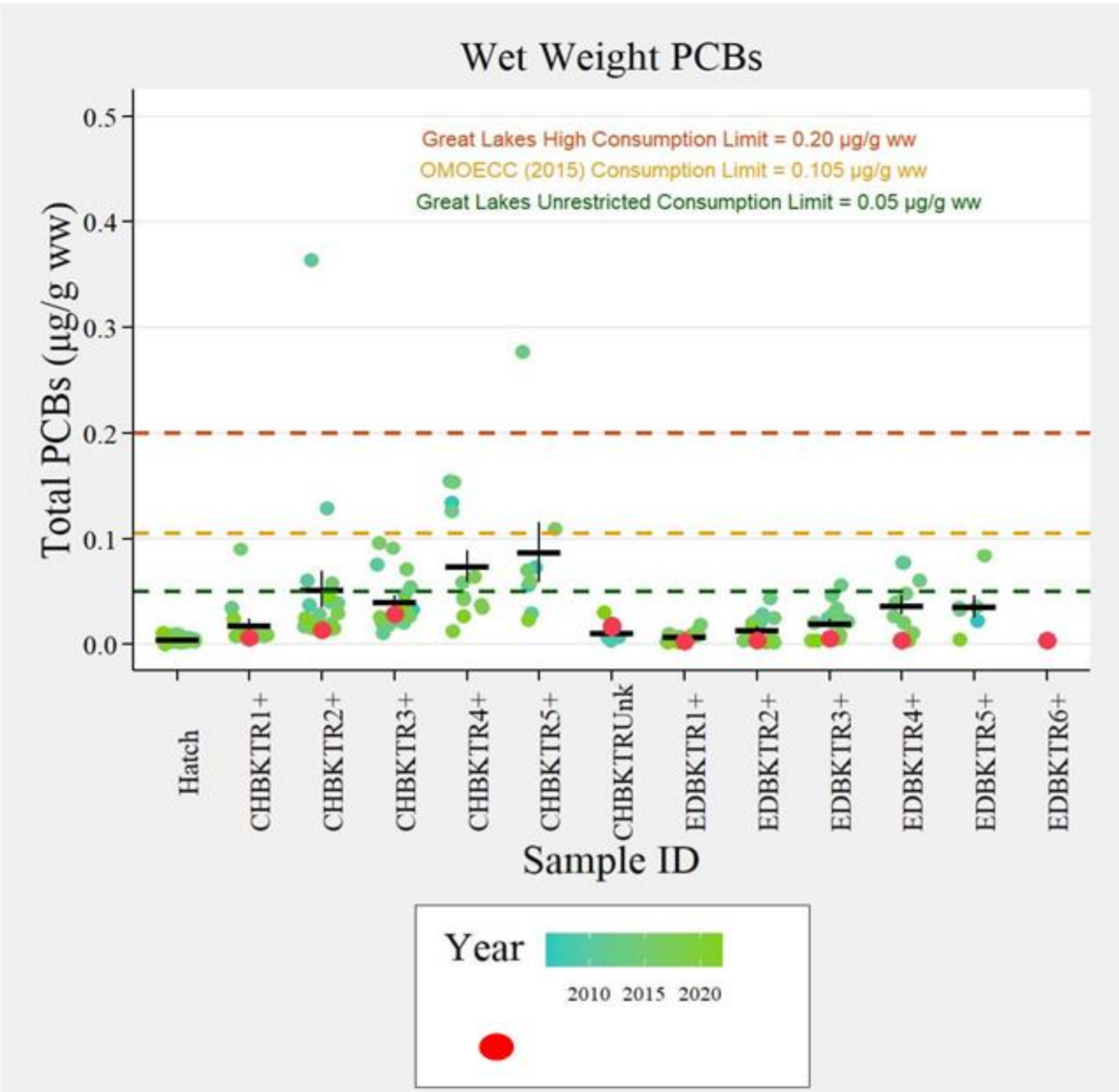

Figure 5-2: Ave Total PCB Concentrations in Chrystina & Edith Lake Brook Trout (2006 to 2023)

Total PCB concentrations in Chrystina Lake brook trout dropped from the 2022 results in 2023. In contrast, Edith Lake saw increased PCB concentrations in all age classes except for the 2+ year- olds which had also decreased. All wet weight total PCB concentrations measured in 2023 remain below the consumption limit for unrestricted consumers established for the Great Lakes area for both lakes (Figure 5-2). Three of the congeners tested from the 1+ year old age class from Chrystina Lake presented values that were under the historical minimums from previous year's samples.

PCBs are lipophilic meaning that they preferentially accumulate in fatty tissue. Fish with a higher lipid content are therefore expected to accumulate PCBs more readily than leaner fish. The total PCB content was therefore normalized to the lipid content of each brook trout sample to minimize variability introduced by differences in lipid content between individual fish. Average lipid normalized PCB content continues to significantly decrease in Edith Lake brook trout since 2012 based on trend analysis. Although a decreasing trend in total PCBs is observed in Chrystina Lake, this trend was not statistically significant and has a shallower slope that is indicative of PCBs decreasing at a slower rate. Continued monitoring of PCB concentrations is warranted to see if concentrations in Chrystina Lake continue to decrease further as the total PCB processed by the Facility has decreased over time. Reconstruction of the life-history of a single fish (stocked each year) since 2007 has provided an estimate of PCB accumulation rates in Chrystina Lake and Edith Lake brook trout. This analysis has been refined over the years to minimize variability and sources of error and now uses PCBs 105, 118, 126, and 153 as key indicator congeners. Reconstructed life-history results based on PCB 118 are summarized for cohorts stocked into Chrystina Lake and Edith Lake from 2007 to 2020 in Figure 5-3. Plots A and B in Figure 5-3 provide the exponential relationships plotted on a log transformed axis therefore they appear linear for each successive cohort in Chrystina Lake (Plot A) and Edith Lake (Plot B). Plots C and D provide the slope parameter for each cohort from 2007 to 2020. Statistically significant relationships are shown in green whereas relationships that are not statistically significant are blue. Since the slope controls how steep the relationship is for each cohort, it is treated as a proxy for the rate of PCB accumulation as brook trout age.

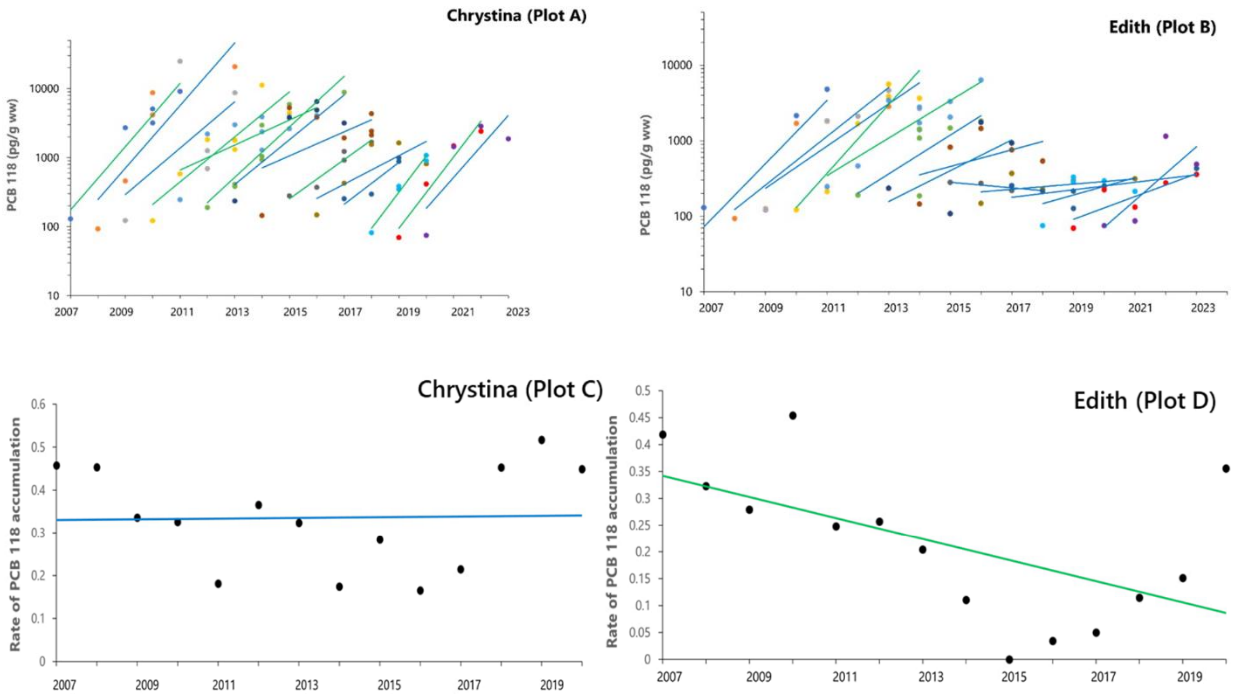

Figure 5-3: PCB 118-Based Reconstructed Life-Histories of Brook Trout Stocked into Chrystina Lake and Edith Lake for Cohorts stocked from 2007 to 2020

Overall Toxicity Levels and Trends

Dioxins and furans contribute little to overall toxicity historically and concentrations are mostly below detection in 2023 which confirms that toxicity in Chrystina Lake brook trout is primarily driven by PCBs. Consequently, no trends are analyzed for dioxins or furans, and interpretation of these results is limited to incorporation into TEQ calculations.

The PCB-based TEQ remained within the historical range for each age class of Chrystina Lake and Edith Lake brook trout. The PCB-based TEQ decreased in 2023 compared with 2022 in all age classes analyzed from Chrystina Lake and the 3+_year-old age class from Chrystina Lake was the only one to exceed the CCME guideline for PCB-based TEQ in 2023.

The total TEQs of brook trout sampled in 2023 are compared with the CCME guideline, historical ranges, and Edith Lake brook trout in Figure 5-4. Additionally, the total TEQ was normalized according to lipid content and the average TEQ of Chrystina Lake, Edith Lake, and hatchery brook trout since 2012 were fit to a logarithmic regression to assess for trends over time (Figure 5-5). Lipid normalization of TEQs also enables comparison of tissue concentrations near Swan Hills with TRBs established for the protection of fish from adverse effects. From these results the younger age classes (1+ and 2+ year-olds) in Chrystina

Lake had TEQs below the CCME guideline, while older brook trout (>3+ years old) had TEQs over the CCME guideline. Meanwhile, all TEQ concentrations in Edith Lake brook trout were below the CCME guideline in 2023. The average lipid normalized TEQ is decreasing in both lakes between 2012 and 2023 with a decrease observed in Edith Lake compared with Chrystina Lake (Figure 5-5). It is important to note that the observed decrease in Edith Lake is considered statistically significant whereas the decrease in Chrystina Lake is not. Lastly, the lipid normalized TEQs in both lakes are below the most conservative TRB which is protective of 99% of fish species including brook trout.

Average TEQ in both lakes has been decreasing since 2012 and this decrease is statistically significant for both lakes despite the increases observed in 2023. When TEQ is lipid normalized the decreasing trend remains statistically significant in Edith Lake but not for Chrystina Lake. The results for TEQ since 2012 therefore reinforce the results from the PCB analysis, which suggest that toxicity and PCB content is decreasing in both lakes and that this decrease is more pronounced in Edith Lake compared with Chrystina Lake.

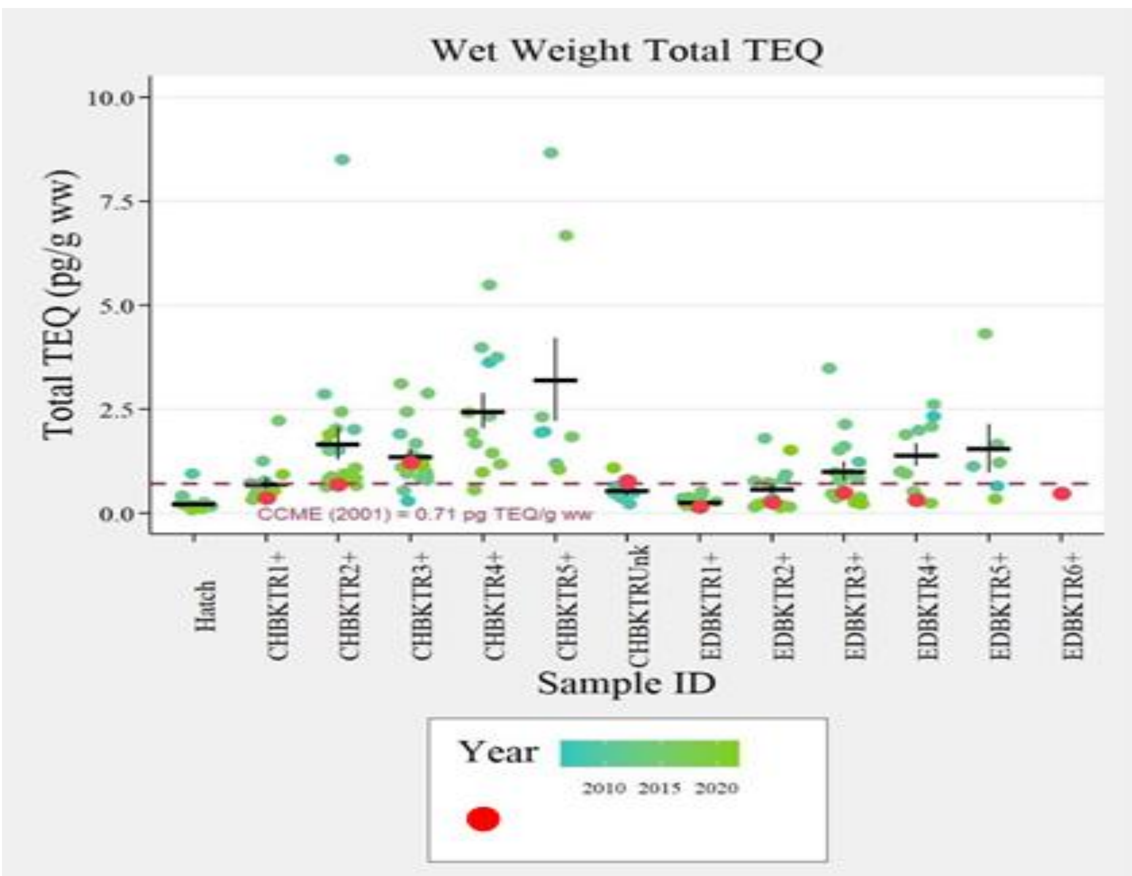

Figure 5-4: Historical and 2023 Wet Weight Total TEQs in Brook Trout (2006 to 2023)

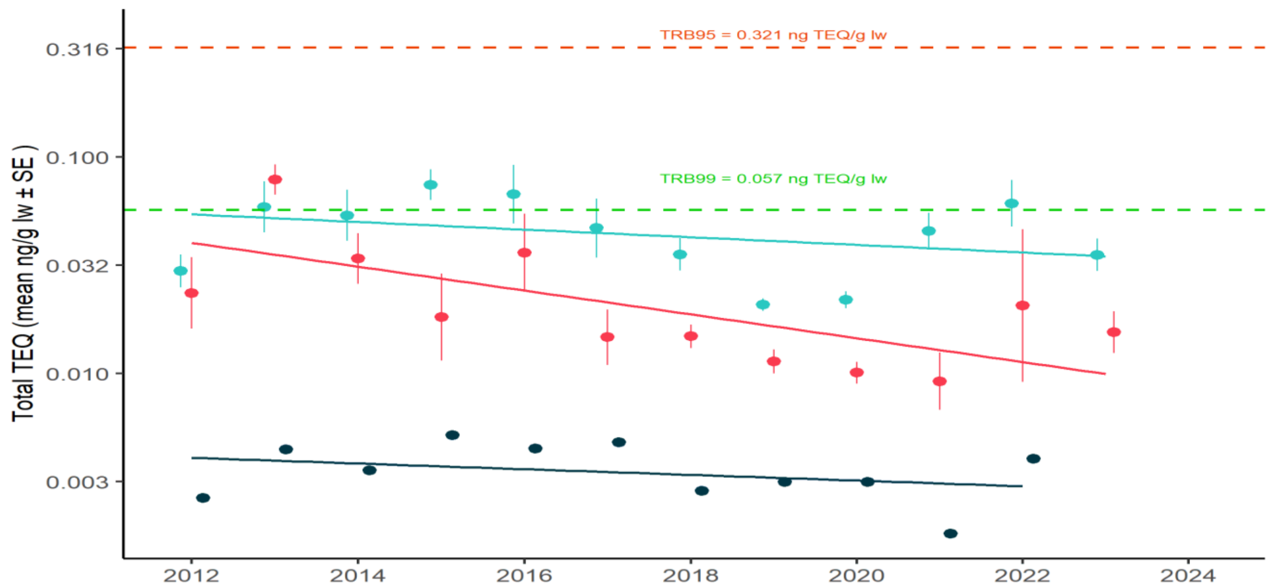

Figure 5-5: Average Lipid Normalized Total TEQs in Brook Trout (2010 to 2023)

Other Contaminants and Guidelines

Inorganic and organic concentrations that exceed tissue residue criteria in 2023 are summarized alongside historical range comparisons in Table 5-6. Metal concentrations in Chrystina Lake brook trout were primarily within the historical range, no increasing trends were documented for any metals. Zinc was the only metal that exceeded the SETAC threshold concentration in Chrystina Lake or Edith Lake brook trout which is consistent with historical measurements obtained previously during the FTMP. The Health Canada maximum levels for arsenic, lead, and mercury were not exceeded in 2023. Notably, the last metal concentration exceeding a maximum level occurred in 2016 when the mercury concentration of a 5+ year-old from Edith Lake had a concentration above the maximum level.

Table 5-6: Guideline Exceedances & Historical Comparisons of 2023 Tissue Concentrations

Location/Age Class	Guideline Exceedances	Contaminants Outside Historical Range[1]
Chrystina Lake 1+	Zinc	*Coplanar PCB 81, 167, 189, Chromium, Mercury*
Chrystina Lake 2+	Zinc	*Chromium*
Chrystina Lake 3+	PCB-based TEQ, Total TEQ	*Arsenic, Chromium*
Chrystina Lake (Unk A)	Total TEQ	N/A
Chrystina Lake (Unk B)	Total TEQ	N/A
Edith Lake 1+	Zinc	*Chromium, Coplanar PCB 105*
Edith Lake 2+	Zinc	*Chromium, Sodium*
Edith Lake 3+	Zinc	*Arsenic, Chromium, Iron, Selenium*
Edith Lake 4+	Zinc	*Chromium, Molybdenum*
Edith Lake 6+	Zinc	N/A

Notes:
Guideline exceedances indicate tissue concentrations above SETAC thresholds for metal contaminants and CCME tissue residue guidelines for organic contaminants.
Superscript 1 - Contaminants listed in *italics* indicate that the tissue concentration is below the historical minimum for the corresponding age class.
Superscript 2 – Associated TEQ measurement refers specifically to lipid normalized TEQ values

5.4 Toxicological Assessment of Fish Tissue Monitoring Results

The 2023 human-health assessment involved the identification of potential human health risks associated with consumption of fish from Chrystina Lake and Edith Lake based on measured tissue concentrations of PCB, dioxins and furans. Risks were estimated to fish consumers based on measured PCB and total TEQ concentrations.

For risk characterization, Exposure Ratios (ERs) of potential health risks were calculated by dividing the estimated exposure by the respective exposure limit, as shown below.

$$Exposure\ Ratio\ (ER) = \frac{Estimated\ exposure\ (\mu g/kg\ /day)}{Exposure\ Limit\ (TDI)}$$

Interpretation of ER values was as follows:

- ER ≤ 1.0 – estimated exposures from fish consumption are below the respective exposure limit and no risk of adverse health effects are expected.
- < ER ≤ 10 – estimated exposure from fish consumption presents a low risk of potential adverse human health effects given the conservatism built into the HHRA.

- 10 < ER – higher likelihood of potential adverse health effects, indicating that risk management measures should be considered.

Tolerable daily intakes (TDI) are established by Health Canada and were recently updated in Version 3 of the Toxicological Reference Values (TRV) that was released in 2021 (Health Canada 2021). The TDI for total TEQ (dioxin-like PCB, dioxin, and furan toxicity) did not change from the 2009 TRVs (Health Canada 2009); however, the TDI for total PCBs was reduced from 0.13 µg/kg/day. The updated TDIs for organic COCs, including total PCBs and dioxins/dioxin-like compounds, near the facility are:

- Total (non-dioxin-like) PCBs = 0.01 µg/kg/day; and
- Total TEQ (dioxin-like PCBs, dioxins and furans) = 2.3 pg/kg/day.

Predicted total PCB ERs were elevated compared with those historically reported due to a more conservative exposure limit introduced by Health Canada in 2021. Risk outcomes of the HHRA based on ERs for total PCBs and TEQ are briefly summarized below

Summary and Conclusions

The 2023 HHRA included risk characterization of brook trout samples collected from two lakes near Swan Hills (Chrystina Lake and Edith Lake). Total PCBs decreased in edible brook trout tissue from both Chrystina Lake and Edith Lake in 2023 and this translated into a decrease in total TEQ in both lakes. Predicted total PCB ERs were similar to those reported before the elevated concentrations observed in 2021 and 2022. Risk outcomes of the HHRA based on ERs for total PCBs and TEQ are briefly summarized below.

Total PCBs in Chrystina Lake

- Low potential risk of adverse effects for adults consuming brook trout at a high and medium rate (ERs from 1.18 to 6.14).
- No risk (ER ≤ 1) of adverse effects for adults that are low consumers, very low consumers, and adults following the Alberta Health consumption rate.
- Low potential risk of adverse effects for all adolescent/juvenile age categories consuming brook trout (ERs from 1.14 to 4.07).

Total PCBs in Edith Lake

- Low potential of adverse effects for adult high brook trout consumers (ERs from 1.16 to 1.44).
- No risk (ER ≤ 1) of adverse effects for adults other than those with a high consumption rate.
- No risk (ER ≤ 1) of adverse effects for adolescent or child consumers, but low potential risk to toddler consumers (ERs from 1.23 to 1.39).

Total TEQ in Chrystina Lake

- Low potential risk of adverse effects for adults consuming brook trout at a high rate, based on risk estimates using maximum reported and 'Keeper' tissue concentrations measured in 2023 (ERs from 1.12 to 1.39).
- No risk (ER ≤ 1) of adverse effects for adults other than those with a high consumption rate.
- No risk (ER ≤ 1) of adverse effects for adolescent and child consumers but low potential risk to toddlers (ERs from 1.25 to 1.49).

Total TEQ in Edith Lake

- No risk (ER ≤ 1) of adverse effects for adults in any consumer group.
- No risk (ER ≤ 1) of adverse effects for adolescent and child consumers but low potential risk to toddlers (ERs from 1.01 to 1.10).

Predicted total TEQ ERs are similar to those historically observed and remain near 1, suggesting that there is no risk from exposure to dioxin-like PCBs, dioxins, and furans to consumers of Chrystina Lake or Edith Lake brook trout. Alternatively, the risk estimates from non-dioxin-like PCBs suggest that there is a low potential risk to high and medium consumers of Chrystina Lake and Edith Lake brook trout from exposure. It is notable that only the high consumer group has a low potential risk based on tissue concentrations measured in 2023.

Figures 5-6 to 5-8 show predicted exposure risk for high-fish consumers.

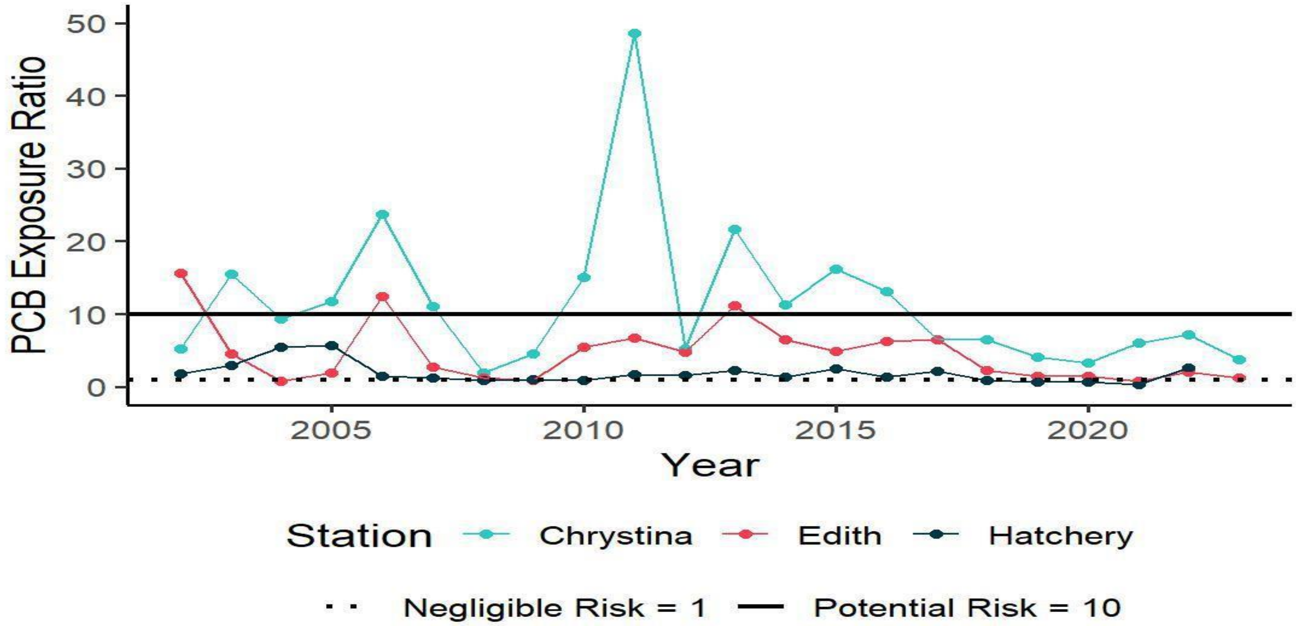

Figure 5-6: Predicted ERs for Total PCBs from 2002 to 2023 for Adults with High Fish Consumption near Swan Hills based on the 2021 Exposure Limit of 0.01 ug/kg/day (Health Canada 2021)

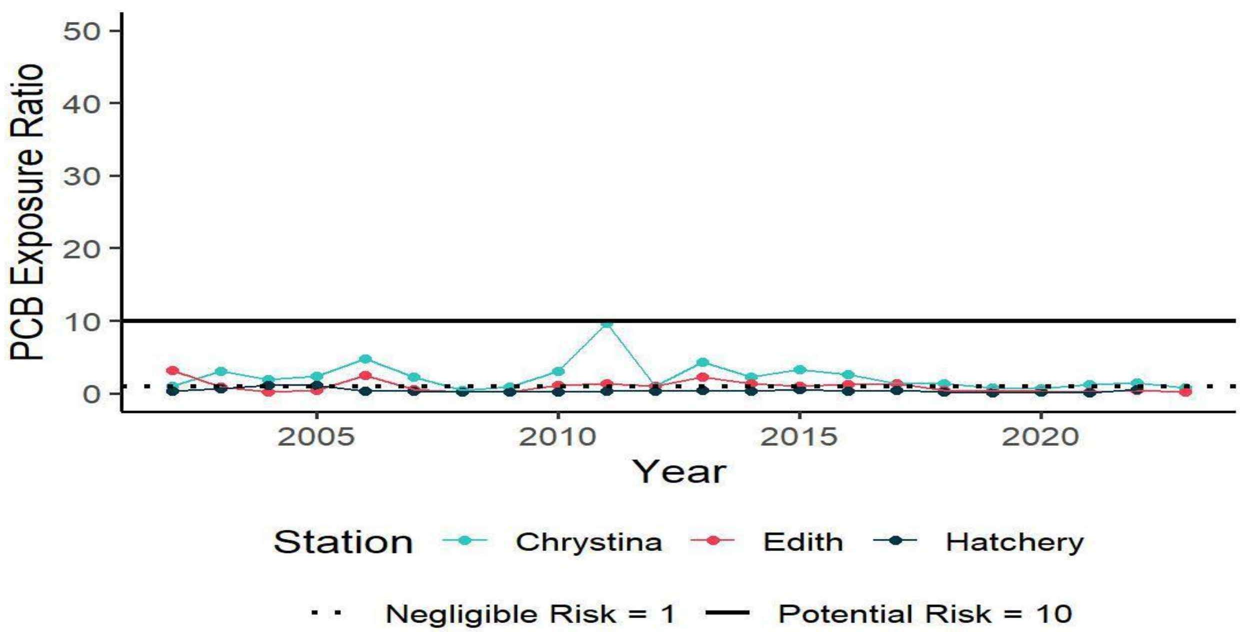

Figure 5-7 Predicted ERs from 2002 to 2023 for Adults with High fish consumption near Swan Hills based on the Great Lakes exposure limit of 0.05 µg/kg/day (GLSFATF 1993)

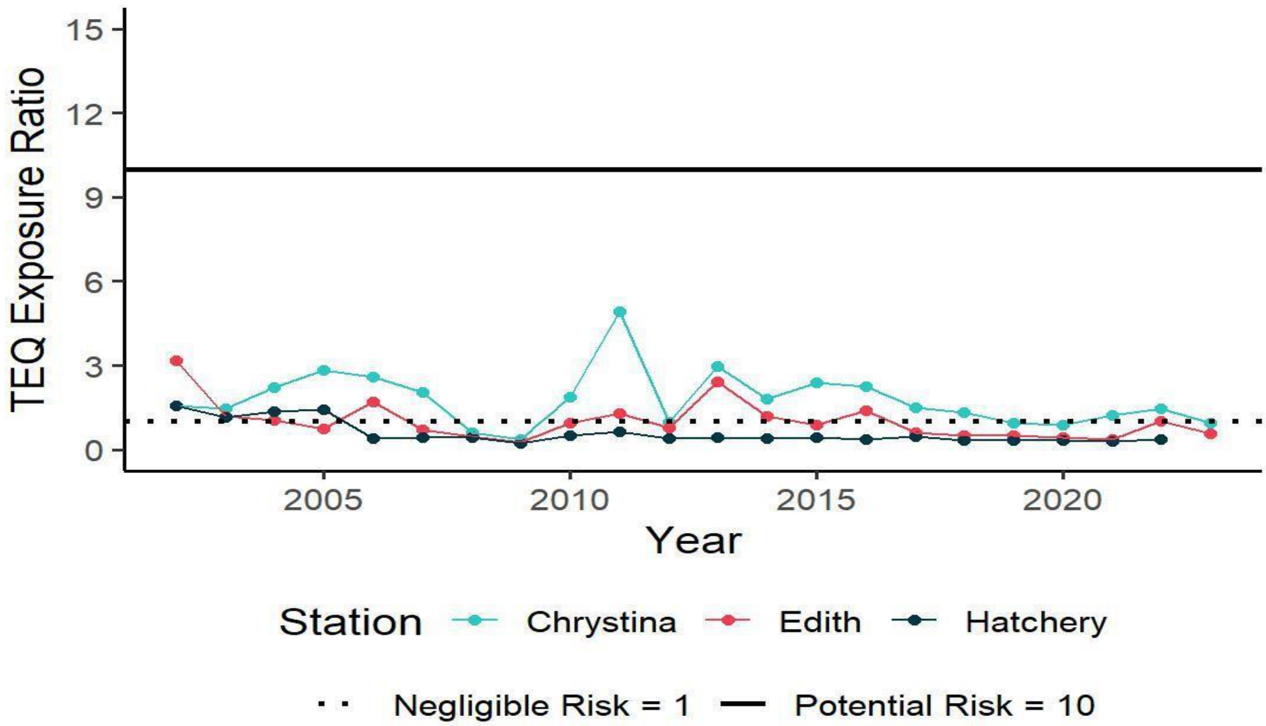

Figure 5-8: Predicted ERs for Adult High Consumers near Swan Hills based on Total TEQ (2002 to 2023)

6 STATE OF THE ENVIRONMENT SURROUNDING THE SWAN HILLS TREATMENT CENTRE

6.1 On-Site Monitoring

The SHTC operated within its Approval requirements, except for the continuous monitoring of mercury emissions, in 2023 and no excursions resulting in significant emissions occurred. Incinerator performance during the compliance tests did not meet emission requirements for total PCDD/DF TEQ or mercury and follow up testing is scheduled for April 2024. Fugitive emissions remained well controlled and the activated carbon in the air management units was replaced as required. No leaks were identified in the annual tank farm survey. The success in fugitive emission control measures was demonstrated in the ambient air monitoring results. The annual average PCB levels in ambient air recorded at all fence line sites and the off-site monitoring location remain among the lowest reported to date. VOC and TOC levels measured at the OTF remained low and consistent with recent monitoring results. All Total Suspended Particulate (TSP) samples were well below the ambient air quality objective of 100 $\mu g/m^3$, except for the samples collected in May 2023 while the site was evacuated due to forest fires in the area, and the fine particulate ($PM_{2.5}$) samples were low at all monitoring locations and met the Alberta ambient air quality objective of 29 $\mu g/m^3$.

On-site soil monitoring and management programs continued in accordance with the Soil Monitoring Directive. Soil management activities were completed in May, June and September 2023 and recommendations for ongoing monitoring and contaminant evaluations were submitted to AEPA on March 20, 2024.

Groundwater monitoring was completed in September and results in 2023 confirmed that water quality in the till (shallow and intermediate depths) and the sandstone aquifer remains good and consistent with previous results.

6.2 Terrestrial Environment

The 2023 soil, vegetation and wildlife monitoring results were consistent with previous monitoring program results. The primary contaminants of concern (PCBs, dioxins and furans) were detected in all three receptors and show a similar distribution. Although levels are declining, they remain elevated above background at sites nearest to the SHTC and decrease significantly with distance. The area of influence is relatively small as concentrations return to near background levels beyond approximately 2 km from the facility. In 2023, the forest fires appear to have caused an increase in PCBs and PCB TEQ at the background and more peripheral plots for Labrador tea and live moss. Concentrations of PCBs also increased at those plots near the SHTC; however, this increase was within historical ranges and further monitoring is required to confirm if it is an anomaly. Significant variation is often seen in the organic results year to year. This likely reflects the variability inherent in environmental monitoring programs and the highly sensitive analytical methods being employed. To summarize potential contaminant risk and show trends over the past 20 years, the mean total TEQ results for Labrador tea, live moss and red-backed vole tissue are presented in Figures 6-1 to 6-3. The results from 10 monitoring plots were segregated according to their proximity to the SHTC. Six of the 10 sites are situated near the SHTC and are all within 2 kilometers. The remaining four plots are located at distances of 2.4 to 21 kilometers and include the two reference sites. The magnitude of concentrations varies by receptor with the lowest levels observed in Labrador tea and the highest in red-backed vole tissue. This reflects the nature of the receptor and its exposure to the contaminants of concern. Despite these differences, consistency is seen in the results. Levels are highest at plots located closest to the facility (plots <2 km) and show a decreasing trend over time. Although the trends are not significant in all cases, a consistent decrease in average total TEQ is evident in Labrador tea, live moss and voles at plots near the facility. The Labrador tea mean total TEQ levels for plots >2 km has remained at a low level (typically <1 pg/g and near the analytical detection limit) since 2000.

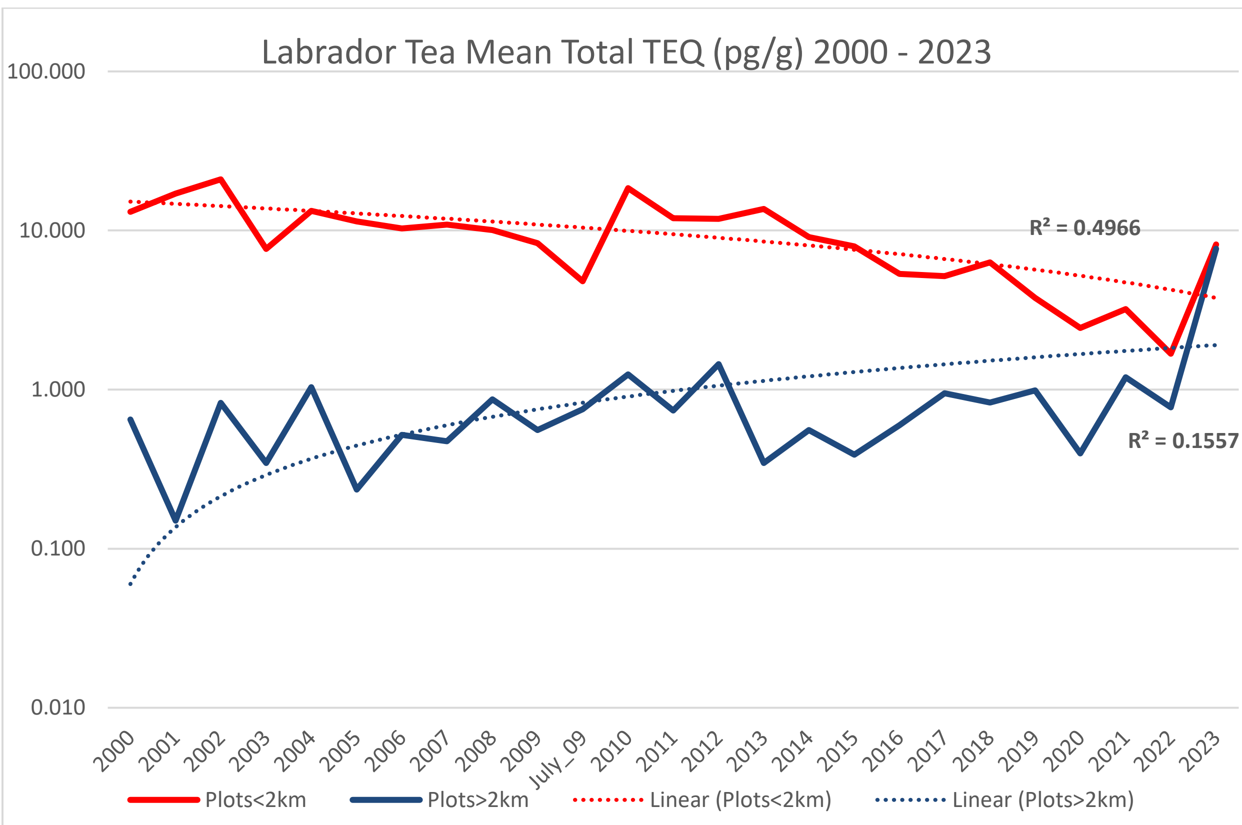

Figure 6-1: Labrador tea Mean Total TEQ at plots ≤2 km and >2 km from the SHTC (2002-2023)

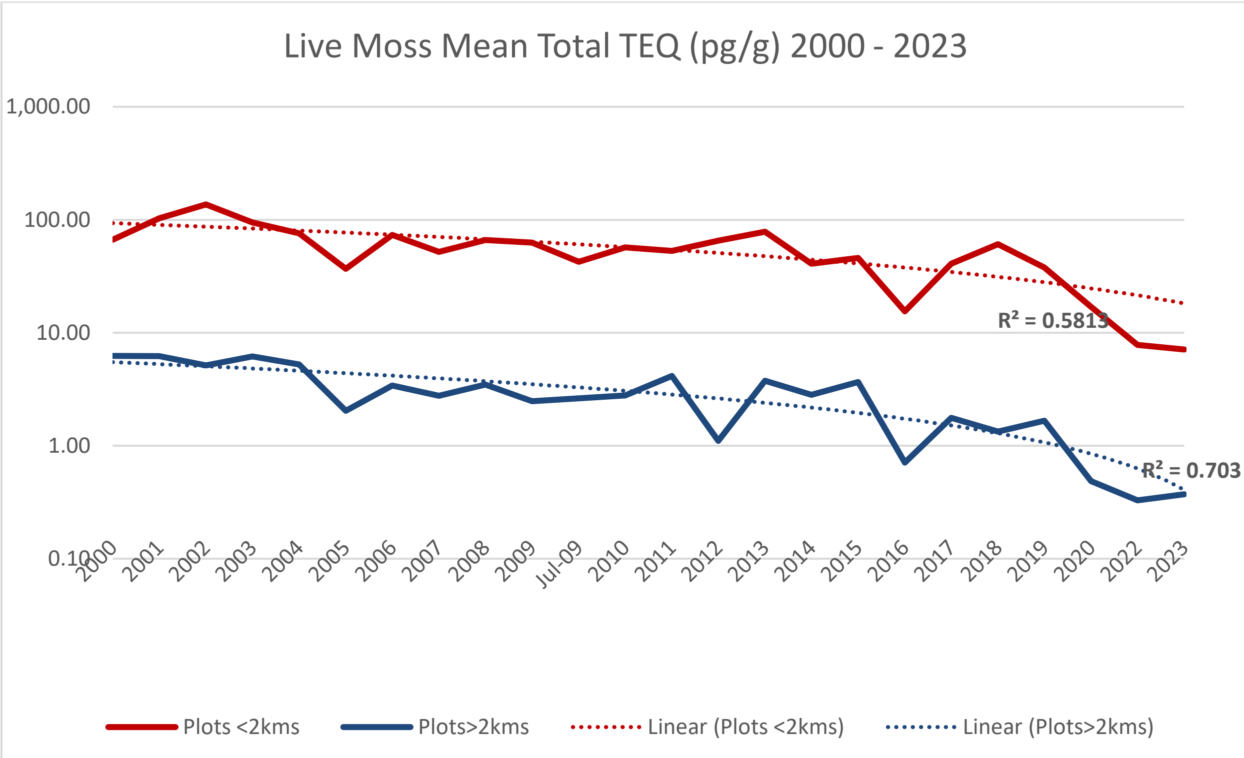

Figure 6-2: Live moss Mean Total TEQ at plots ≤2 km and >2 km from the SHTC (2000-2023)

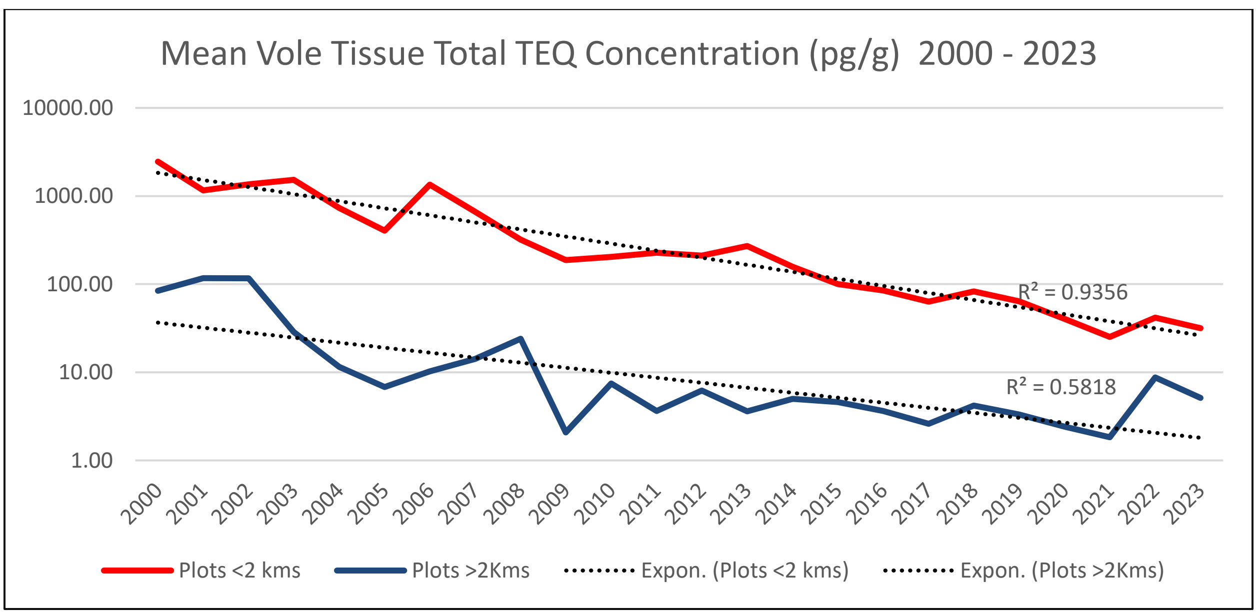

Figure 6-3: Wildlife Mean Total TEQ at plots ≤2 km and >2 km from the SHTC (2000-2022)

Collectively, these results suggest that the area influenced by trace organic contaminant emissions (total TEQ) from the SHTC is localized and that contaminant levels are either decreasing or stable. Furthermore, the Labrador tea results suggest that annual emissions of organic contaminants, reported as total TEQ, are very low and have not shown any significant change at sites beyond 2 km since 2000.

Organic contaminant results are lower than what has been observed historically in all media and appear to be stable and/or decreasing. Currently, results are below relevant guidelines and have not resulted in any observable impacts on the indicator receptors used in the monitoring program (lichen, live moss or Labrador tea). In addition, contaminant levels in small mammals (red-backed voles) are well below the lowest observed adverse effect level (LOAEL) and decreased from levels observed in 2022. The results for Total TEQ are among the lowest results at most sites. Demographic studies continue to show that vole populations are healthy, and no impacts have been observed.

Metals are also monitored in Labrador tea, live moss, moss bags and vole tissue (expanded years only). Metal results are generally low and consistent with background and historic levels at most sites. However, several metals including antimony, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, silver, tin and zinc have been observed at higher concentrations at monitoring plots closest to the SHTC from 2019-2023. This may be partially due to improved sample extraction methods, analytical procedures and lower detection limits implemented in recent years. All results are below levels of concern and only zinc in live moss at plots 4 and 114 showed a statistically significant increasing trend in 2023. However, recent results suggest that the SHTC may be a minor source of metals and additional monitoring effort is currently being implemented to better define and understand potential issues related to these findings.

6.3 Aquatic Environment

Based on the 2023 monitoring results, surface water quality near the SHTC is largely comparable to historical conditions observed in the Coutts River, Chrystina Lake, and Edith Lake. The Coutts River had 1 parameter above historical conditions (silicon), Chrystina Lake had 2 parameters above historical conditions (hardness and total manganese), and Edith Lake had 7 parameters above historical conditions (hardness, dissolved calcium, chlorophyll-a, total barium, total calcium, total iron, and total manganese). PAL guidelines were met for all parameters, except total alkalinity and pH in Edith Lake and Chrystina Lake; and dissolved iron and total lead in the Coutts River (which was above guidelines). The low alkalinity value reflects the naturally low buffering capacity in the lakes, and the guidelines only apply if natural conditions are not normally low. Dissolved iron values are consistent with historical results for the Coutts River. There is a decreasing trend for pH at Chrystina Lake; decreasing phosphorus and total organic carbon for Coutts River; decreasing total organic carbon in Edith Lake; increasing trends for total potassium, manganese, and chlorophyll-a in Edith Lake; and increasing total barium, sodium, strontium, and chlorophyll- a in Chrystina Lake.

Generally, sediment quality near the SHTC has not significantly changed, and is comparable to historical conditions observed in Chrystina Lake, Edith Lake, and the Coutts River (metals were only historically high at the reference site S6). The PCB TEQ was historically high at the Coutts River, but it is based on relatively few samples (9) taken in more recent years. Interim Sediment Quality Guideline (ISQG) exceedances were documented for arsenic at Chrystina Lake and S6; nickel at Chrystina Lake and Edith Lake, and manganese at Edith Lake and S6. Total PCBs remained unchanged at all four sites – likely because the historically high PCB values occurred several decades ago and the moving window trend analysis is now capturing baseline values. No significant trends in PCB or PCDD/F Toxic Equivalents (TEQs) occurred at any sites; however, PCDD/F TEQs exceeded the respective ISQG at Chrystina Lake and Edith Lakes, as has been the case for much of the data record. Exceedances occurred in both test and reference sites.

Fish remain in a healthy condition and contaminant levels in brook trout in both Chrystina and Edith lakes were low in 2023. No exceedances of Health Canada Maximum Levels for metals (Hg, Pb, As) were observed in Chrystina, or Edith Lake fish. Organic contaminants (PCBs, dioxins/furans) were higher in fish from Chrystina Lake in comparison to fish in the reference lake (Edith Lake). However, results were very low and at or near minimum levels observed in previous studies.

The human health risk assessment conducted using the 2023 fish tissue levels concluded that the predicted total PCB ERs were elevated compared with those historically reported due to a more conservative exposure limit introduced by Health Canada in 2021. The risk assessment results suggest that there is little to no risk to consumers of Edith Lake brook trout, whereas non-dioxin-like PCBs pose a potential risk to people consuming brook trout from Chrystina Lake at a high and medium consumption rate. It is recommended that consumers remain aware of the current Alberta fish consumption advisory of 150 g/week (22 g/day) of fish from lakes within 20 km of Swan Hills (including Chrystina Lake and Edith Lake) and consumers should remove fish skin from edible tissue and cook tissue before eating.

Overall, environmental quality surrounding the SHTC is good and contaminant levels associated primarily with historic operations (PCBs, dioxins and furans) continue to decrease and/or have stabilized at low concentrations near background levels.

7 2024 MONITORING PROGRAM

7.1 Existing Program and Changes for 2024

The results of the 2023 monitoring program were reviewed at the technical meeting which was held virtually on February 21, 2024. Participants included members of the Veolia staff, external consultants, representatives from Alberta Infrastructure, Alberta Health, and Alberta Environment and Protected Areas. There was limited scope change recommended for the 2024 monitoring program based on the results of the 2023 data, these recommendations were discussed during the technical review meeting.

Overall objectives for the 2024 monitoring program include:

1. Continue with the overall monitoring programs, reducing or expanding where necessary based on objectives and effectiveness.
2. Continue to review and monitor triggers to optimize the effectiveness of the current scope for sampling and analysis.

Table 7-1: Overview of 2024 expanded monitoring year and proposed changes.

Monitoring Program	Existing	Expanded Program	Changes for 2024
Air	• Program as specified in EPEA Approval No. 1744-03-00	N/A	• No changes proposed for 2024
Groundwater	• Routine water, PCB's, metals and Organic Carbon on all wells • BTEX, F1, AOX, Dioxin and Furan also analyzed on shallow wells	• Final year for dioxin/furans monitoring on select shallow wells	• Well maintenance • Replacement of dry upgradient sandstone wells
Soils and Vegetation	• Labrador Tea & Live Moss at 10 sites • Moss Bags & Lichen at 15 sites • Moss Bags at 3 additional fence line site	• Expanded to include historical sampling plots • Expanded analytical scope • Live moss sampling program • Final monitoring year for Mo at discharge site locations	• Complete a fly ash emission study
Wildlife	• 3 live trapping plots • 10 snap trapping plots	• Expanded to include historical sampling plots • Expanded analytical scope	• Reduce sample locations of vole tissue collection during "standard" monitoring years
Surface Water, Sediments and Fish	• Annual surface water sampling at 3 locations • Biennial sediment sampling at 4 locations	• Sediment sampling	• Increase WQM frequency • Increase range of carbon specie analysis • Biennial analysis of Edith Lake • Remove White Sucker program • Community outreach for additional fish head collection
Toxicology	• Annual fish tissue collection at 2 locations • Based on fish tissue and vole results	N/A	• Follow up with Regulators regarding the new TDI for PCB in fish tissue.

7.2 Triggers

Triggers provide specific levels and actions that expand the Environmental Monitoring Program to address potential issues that may be identified through the initial review of monitoring results and/or to respond quickly to a potential off-site release. Recommended 2024 program triggers for all monitoring components have been reviewed and are presented in Table 7-1.

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Table 7-2: Environmental Monitoring Triggers for 2024

Component	Trigger	Response - Additional Monitoring Work
Operations	A facility upset resulting in off-site emissions of significant magnitude to warrant immediate assessment	Implement Emergency Response Plan and compile relevant data regarding the incident to facilitate development of an effective Environmental Monitoring Program response
Ambient Air	PCB concentration exceeds 150 ng/m^3 at fenceline monitoring locations	Verify result and investigate potential sources of fugitive emissions. Increase frequency of PCB air monitoring to NAPS cycle – once every 6 days if warranted.
	VOC exceeds a level of 3 ppm or THC exceeds 5 ppm	Report individual VOC compounds and compare with appropriate air quality and occupational health and safety guidelines and review trends over the period of record. If deemed significant, the OTF fugitive emission survey would be triggered if not already conducted
	A facility upset resulting in an off-site release of significant magnitude to warrant immediate assessment	Review meteorological data and conduct dispersion modelling (if appropriate) to support initial assessment and guidance for environmental monitoring response. Conduct additional air monitoring as recommended
Groundwater	Statistically significant increase in key parameter (e.g. PCBs).	Implement Response Plan and conduct follow up sampling to verify and assess results
	A significant facility upset resulting in on-site spill of significant magnitude to warrant immediate assessment	Incorporate additional monitoring as recommended by the Response Plan
Soil & Vegetation	Total TEQ increases above 75th percentile (last 10 years data) in the Labrador tea at plots (4, 11, 109, 114)	Analyze archived live moss samples If levels are elevated in both Labrador tea and live moss, expand monitoring scope in following year to include both Labrador tea and live moss from 10 Plots
	A facility upset resulting in off-site emissions of significant magnitude to warrant immediate assessment	Soil and vegetation monitoring to proceed at selected sites immediately following incident. The number/location of sites and analytical scope would be based on meteorological conditions and the nature of the release.

Component	Trigger	Response - Additional Monitoring Work
Wildlife	Statistically significant change in June vole population levels correlated with the April/May tissue contaminant levels	Collect and analyze September vole tissue from population monitoring plots (11, 114 and 70) for PCBs, dioxins and furans
	Elevated Total TEQ in live moss and Labrador tea is observed	Expand vole tissue collection to 10 plots consistent with the Soil and Vegetation program
	A facility upset resulting in off-site emissions of significant magnitude to warrant immediate assessment	Additional sampling of vole tissue. Timing, sample locations and analytical scope would be determined based on meteorological conditions and the nature of the release.
Aquatic	Contaminant levels exceed the 95th percentile value in Chrystina Lake sediments	Verify result and include sediment sampling in both Chrystina and Edith lakes during the next annual program if warranted
	Contaminant levels exceed 95th percentile value and/or the Interim Sediment Quality Guidelines (ISQG) in stream sediment samples	Verify results and initiate additional downstream sampling in following sampling period if warranted
	Organic contaminant levels in Chrystina Lake brook trout exceed the recommended toxicity trigger	Analyze any archived samples to verify results Sample Edith Lake brook trout in the following year
	A facility upset resulting in off-site emissions of significant magnitude to warrant immediate assessment	Initiate immediate water quality, sediment and fish tissue sampling as recommended.
Toxicology	New toxicity information becomes available (i.e. significant change in end-point toxicity of the compounds of interest – PCBs, PCDD/F)	Conduct full HHRA on fish tissue results Re-evaluate vole toxicity assessment
	Chrystina Lake fish tissue level exceeds Toxicity Trigger	Conduct full HHRA and assess fish tissue levels in Edith Lake
	Any new compounds are identified at elevated levels (e.g. heavy metals) in animal or fish tissue.	Assess vole toxicity Expand HHRA to incorporate new compounds of interest