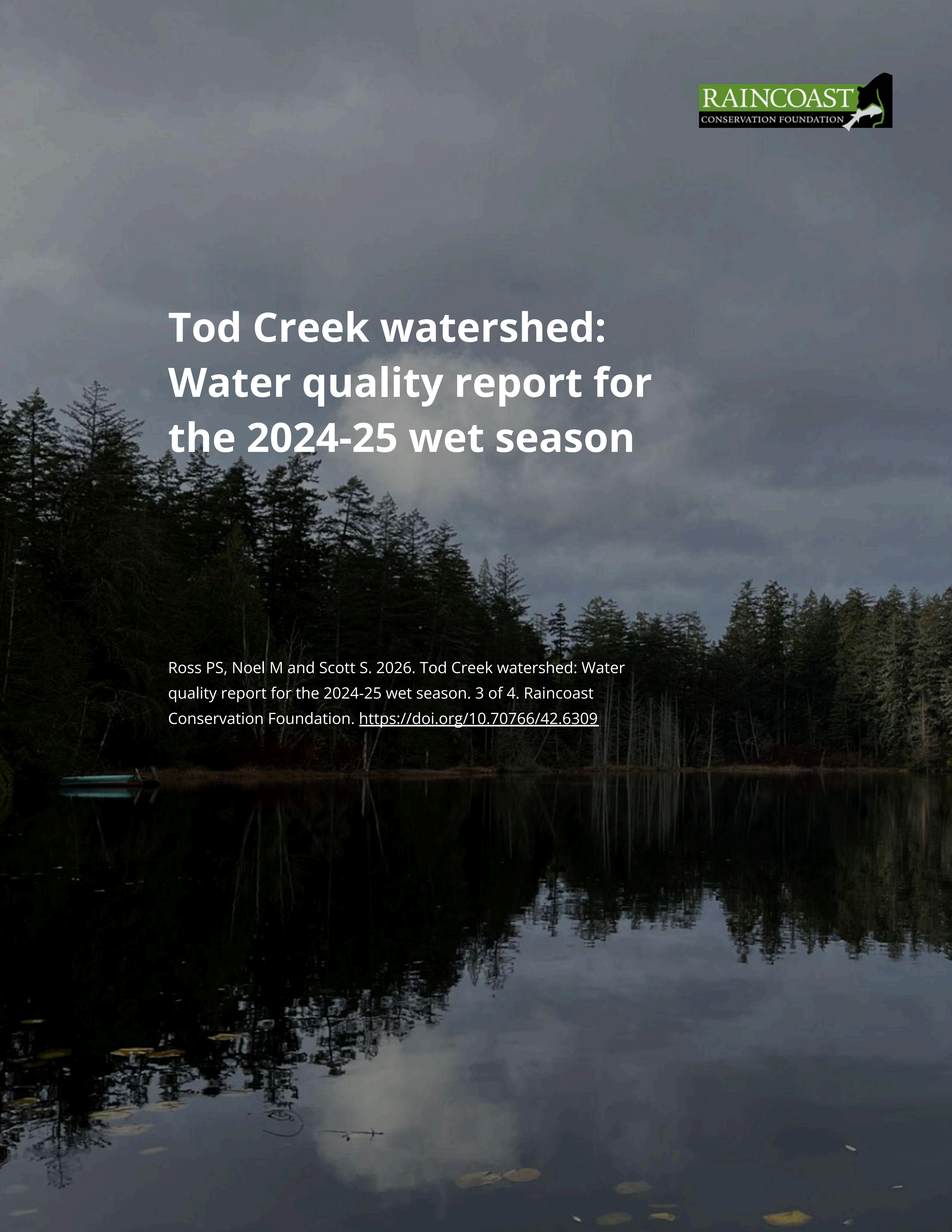

Tod Creek watershed: Water quality report for the 2024-25 wet season

Ross PS, Noel M and Scott S. 2026. Tod Creek watershed: Water quality report for the 2024-25 wet season. 3 of 4. Raincoast Conservation Foundation. https://doi.org/10.70766/42.6309

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Contributions by CRD Staff; Tsartlip First Nation: Franklyn Sampson and Will Morris; W̱SÁNEĆ Leadership Council: Joni Olsen; SGS Axys: Pam Mackenzie and Richard Grace; Fisheries and Oceans Canada: Xiangjun Liao, Andrew Ross, Neil Dangerfield; and Bonnie Lo.

Editing by Peter Ross, Marie Noel and Sam Scott.

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Executive summary

Water is essential for life, and steps are needed to understand, protect and restore its health in fish habitat throughout British Columbia. The Raincoast Healthy Waters program was launched in 2023 to establish community-oriented water pollution monitoring in select BC watersheds. Two Healthy Waters sampling events take place every year in each watershed: the dry season (summer), and the wet season (winter). This wet season report from winter 2024-25 highlights results from one sampling event: the third seasonal sampling, which followed the first dry season in 2024 and wet season 2023. This was carried out with the support and participation of the Capital Regional District (CRD) and Tsartlip First Nation.

Briefly, the Healthy Waters team sampled the Tod Creek watershed on November 20, 2024. The team worked with CRD, Tsartlip First Nation and community volunteers to first determine basic water properties (temperature, conductivity, pH, dissolved oxygen and turbidity) in situ. Water samples were collected from six water categories, including source water (3 samples), stream and river water (3 samples), road runoff (3 samples), tap water (10 samples - 9 from the Sooke supply and 1 from groundwater were pooled into a single composite sample) and marine water (3 samples), alongside surface water samples collected in the areas surrounding the Hartland landfill (1 sample). The samples were pooled into composites by category and then analysed for coliform (3), nutrients (6), physical parameters, metals (37), pesticides (62), polycyclic aromatic hydrocarbons (PAHs; 76), pharmaceuticals and personal care products (PPCPs; 141), polychlorinated biphenyls (PCBs; 209), alkylphenol ethoxylates (APEs; 4), bisphenols (BPs; 6), per- and poly-fluoroalkyl substances (PFAS; 40), sucralose and 6PPD-Quinone.

We detected 105 contaminants out of 577 measured in the stream and river category - i.e. fish habitat - for the Tod Creek watershed, excluding nutrients, fecal coliform and physical parameters. This suggests that, overall, Tod Creek water quality during the wet season was **moderate.** Additional sampling and an integrated exploration of all data will provide additional insight into the activities that are impacting the health of this valued watershed.

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Key findings

- This assessment of water quality in Tod Creek reflects the third of four site visits, and the second wet season sampling during the winter. Our understanding of water quality in the Tod Creek watershed is growing as we complete additional sampling, and explore the entire dataset.
- Our study design was not designed to explicitly address the performance of Hartland Landfill, but rather to provide an integrated 'snapshot' of water quality in six categories of water in the Tod Creek watershed, including source, stream & river, road runoff, tap, marine and Hartland drainage samples.
- The Hartland drainage water sample had the highest wet season 2024 concentrations of *E. coli*, nitrate, PCBs and PFAS. Some of these may be attributed to quarry activities and aggregate storage, with CRD working to address concerns that had been previously noted. Additional influences from vehicular and machine operations in the landfill may contribute to some of the water quality issues noted here.
- The road runoff sample had the highest concentration of bisphenols, PPCPs, and sucralose.
- Stream and river water had the highest concentration of pesticides.
- Source water had the highest concentration of APEs.
- The pooled tap water sample had the highest concentrations of PAHs; there is currently DWQG for only one PAH and it was not exceeded.
- Tap water, source, stream and river, and marine water were less contaminated than the other water categories in the wet season.
- Overall, the Tod Creek watershed had **moderate** water quality in the wet season:
    - There were 13 exceedances of Canadian Environmental Quality Guidelines for the protection of aquatic life.
    - Exceedances included:
        - PCBs, nitrate, aluminum, copper and iron for Hartland drainage;
        - low dissolved oxygen and high iron for source;
        - low dissolved oxygen for stream and River;
        - low dissolved oxygen and high aluminum, copper and iron for road runoff;
        - PCBs in marine water.
    - There was 1 exceedance of Health Canada Drinking Water Quality Guidelines.

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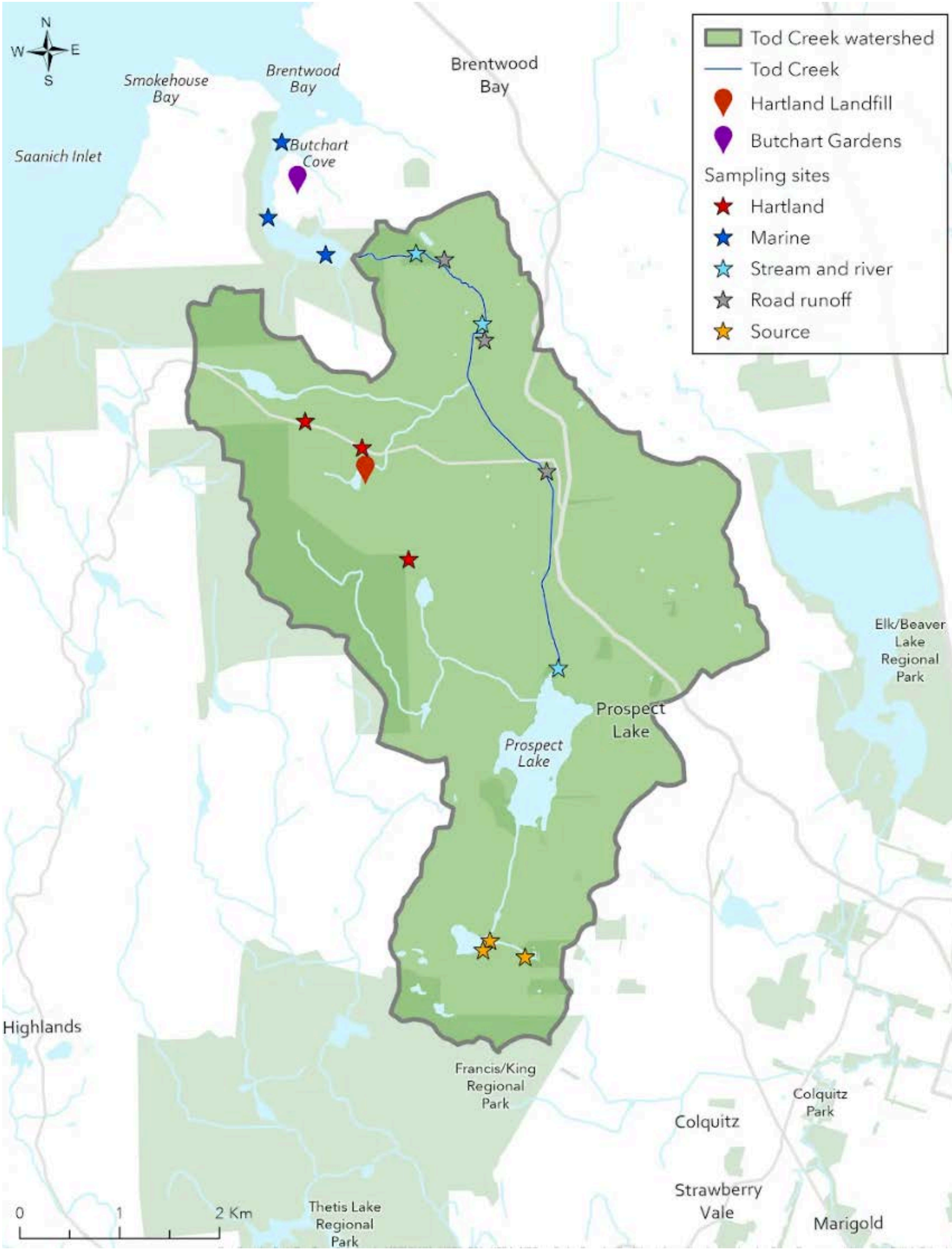
Figure 1: The Tod Creek Watershed



The Tod Creek watershed runs north from Prospect Lake, along West Saanich Road down to Tod Inlet, and covers an area of 24 km^2. Sampling sites (detailed in Table 1 below) were distributed throughout the watershed in order to capture a wide spatial range for our assessment of the health of fish habitat (Map by Brooke Gerle / Raincoast Conservation Foundation).

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Acknowledgements

We acknowledge the financial support of the Capital Regional District (Victoria). We thank CRD staff for feedback before and during sampling, and for helpful comments on earlier drafts of this report. We thank Joni Olsen at the W̱SÁNEĆ Leadership Council (WLC) and William Morris at Tsartlip First Nation for their support and guidance. We acknowledge the expert analytical support of Pam MacKenzie and Richard Grace at SGS-AXYS. We thank Xiangjun Liao, Andrew Ross and Neil Dangerfield at Fisheries and Oceans Canada for the provision of 6PPD-Q analysis. We thank Bonnie Lo for expert reviews. We thank Nicole Van Zutphen and Sherwin Arnott for report design. Photo credits: Sam Scott and Peter Ross.

Sampling team

- Raincoast Healthy Waters: Sam Scott and Peter Ross
- Friends of Tod Creek: Winona Pugh, Francis Pugh and Carmel Thomson
- Tsartlip First Nation: Franklyn Sampson, Will Morris
- CRD Hartland Landfill Staff

Photo of Winona Pugh (left) and Sam Scott (right) at Trevlac Pond.

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General introduction

Background

Raincoast's Healthy Waters Program (https://www.raincoast.org/waters/) delivers high-resolution, community-oriented water quality analysis to watersheds across southern British Columbia. The goal of Healthy Waters is to empower communities with the understanding of the status of water quality in their watersheds, to allow for local advocacy regarding both point and nonpoint source pollution.

The Capital Regional District (CRD) serves approximately 440,000 people from 13 municipalities and three electoral areas on southern Vancouver Island and the Gulf Islands. The traditional territories of many First Nations span portions of the region and 11 of those Nations hold reserve lands throughout the capital region.

Community and Indigenous concerns expressed about possible threats to water quality in Tod Creek sparked interest in this project, but Tod Creek is at the receiving end of numerous activities and potential contaminant sources. Of note is that local agriculture, the Heals Rifle Range as a federal contaminated site, domestic septic fields, the Hartland Landfill operation, and other sectors also are likely to influence water quality in Tod Creek. Findings from this and future sampling events will provide insight into the potential for each of these sectors to explain any degradation of water quality - an important element of protection and restoration.

Tsartlip First Nation is one of two current members of the W̱SÁNEĆ Leadership Council (WLC); the second is Tseycum First Nation. The Tsartlip reserve is situated in Brentwood Bay, BC. The WLC was formed to create a unified entity responsible for representing the common interests of the W̱SÁNEĆ Nations. The W̱SÁNEĆ Peoples have been responsible for stewardship of the land since time immemorial.

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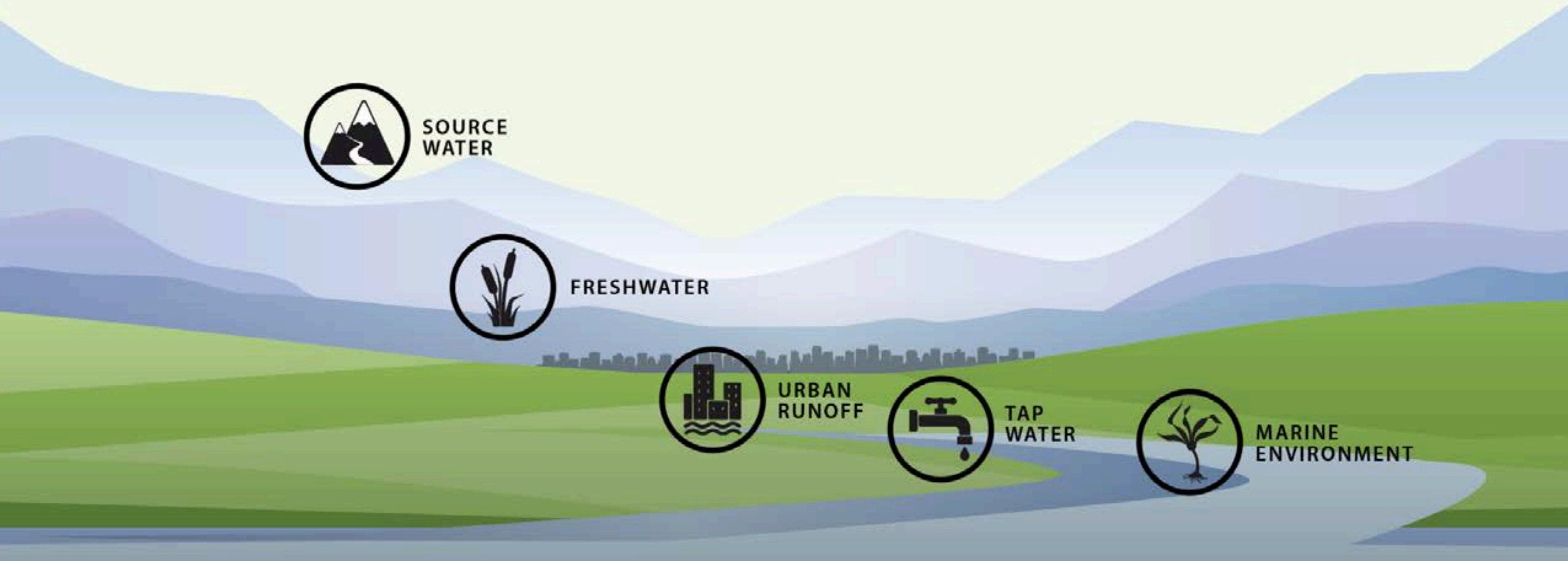

A watershed based approach to sampling

Healthy Waters

We collect samples from five different categories of water in each of our partner watersheds for our Healthy Waters program: source water, upstream of human impacts, down to the marine environment. Our Tod Creek partnership entails additional sampling from Hartland landfill drainage.

Source water serves as an upstream reference sample, allowing us to determine which contaminants are being introduced as water traces its path down through the watershed.

Stream and river samples allow us to investigate the quality of fish habitat directly, by collecting samples from streams, creeks, and rivers used by salmon and other fish species (either currently or historically).

Road runoff serves as an impacted sample category of current concern, as many contaminants, including PAHs, metals, surfactants and chemicals such as 6-PPD quinone can be washed off roadways and into fish habitat during rain events.

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We include **tap water** samples in our analysis as a way to bring our homes into the conversation - we borrow water from the environment in the form of municipal or well water, and generally return it to aquatic habitats in a more-degraded state in the form of storm and sewage effluent (treated or untreated).

Marine water samples provide insight into those contaminants that may degrade fish and whale habitat in the ocean, and enable an understanding of the contribution of land-based pollutants from the adjacent watershed to the marine environment.

A sixth composite sample from the **Hartland** Landfill drainage was also included in this project.

Collectively, the lessons learned from our partnering watersheds will contribute to a greater understanding of threats to water quality across British Columbia, and ultimately what policy changes can be implemented to preserve the quality of water for the future of salmon, whales, and people.

Methods

Field sampling

A total of 15 surface water samples were collected from locations in the Tod Creek watershed on November 20, 2024 by the Raincoast Healthy Waters team along with representatives of CRD Hartland Landfill staff, Tsartlip First Nation, and Friends of Tod Creek following the *Raincoast Healthy Waters – Standard Operating Procedure (SOP) for water sample collection* (Appendix 1). An additional 10 samples of tap water were obtained from homes and offices within the Tsartlip First Nation Reserve (which represent a combination of CRD and well water sources) on October 9, 2024.

A portable water properties meter (YSI-ProDSS) was deployed to measure temperature, pH, conductivity, dissolved oxygen and turbidity in situ following the *Raincoast Healthy Waters – Standard Operating Procedure (SOP) for in situ determination of basic water properties* (Appendix 2).

Samples were submitted to three service labs for additional analyses: ALS Environmental, SGS-AXYS, and the Raincoast Conservation Genetics Lab. Contaminant analytes were determined in water samples according to established protocols (see Table 2).

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Table 1: Sampling sites in the Tod Creek watershed

Site Number	Water Type	Site Name	Lat/Long
1	Source	Maltby Lake - Carmel's Dock	N 48.496813, W 123.449331
2	Source	Trevlac Pond	N 48.495230, W 123.444669
3	Source	Maltby Lake - A Frame Dock	N 48.495974, W 123.450316
4	Stream and River	Tod Creek @ Prospect Lake	N 48.521186, W 123.438774
5	Stream and River	Tod Creek @ Gowland Tod	N 48.559102, W 123.455963
6	Stream and River	Tod Creek @ Durrance Bridge	N 48.552520. W 123.447359
7	Runoff	Wallace Drive Ditch	N 48.551040, W 123.447130
8	Runoff	Ditch @ Wallace and Garden	N 48.558439, W 123.452182
9	Runoff	Tod Creek @ Farmington	N 48.538990, W 123.439361
10	Marine	Tod Inlet 1	N 48.559291, W 123.468188
11	Marine	Tod Inlet 2	N 48.562825, W 123.475803
12	Marine	Tod Inlet 3	N 48.569584, W 123.473602
13	Hartland	South Hartland Drainage Ck	N 48.531494, W 123.458465
14	Hartland	Willis Point Roadside ditch	N 48.544298, W 123.471783
15	Hartland	Creek in Hartland Proper	N 48.541726, W 123.464216
-	Tap	Tap 10 (composite)	Various - 9 CRD water and 1 well

Water samples were collected from 15 field sites in the Tod Creek watershed, as well as 10 homes and offices within the Tsartlip First Nation Reserve. These were then pooled into composite samples and submitted for analysis, or retained for specialised analyses.

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Water quality analyses

Table 2: List of analytes, service lab, analytical methods, instruments, and number of samples submitted

Analyte	Laboratory	Analytical Method	Instruments	No. samples analysed
Tier 1				
Temperature (℃)	in situ		YSI ProDSS	12
Dissolved Oxygen (%, mg/L)	in situ	optical sensor	YSI ProDSS	12
Turbidity (FNU)	in situ		YSI ProDSS	12
Conductivity (uS/cm)	in situ		YSI ProDSS	12
pH	in situ		YSI ProDSS	12
Tier 2				
Total Suspended Solids (TSS)	ALS Environmental	APHA 2540 D (mod)	gravimetry	6
Total Dissolved Solids (TDS)	ALS Environmental	APHA 2540 C (mod)	gravimetry	6
Hardness	ALS Environmental	APHA 2340B	calculated	6
Total Organic Carbon (TOC)	ALS Environmental	APHA 5310 B (mod)	combustion	6
Chemical Oxygen Demand (COD)	ALS Environmental	APHA 5220 D (mod)	colorimetry	6
Biological Oxygen Demand (BOD)	ALS Environmental	APHA 5210 B (mod)	dissolved oxygen meter	6
Nitrate	ALS Environmental	EPA 300.1 (mod)	ion chromatography	6
Ammonia	ALS Environmental	Method Fialab 100, 2018	fluorometry	6
Phosphate	ALS Environmental	APHA 4500-P F (mod)	colorimetry	6

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Total Metals	ALS Environmental	EPA 200.2/6020B (mod)	Collision/Reaction Cell ICPMS	6
Total coliform	ALS Environmental	APHA 9223 (mod)	MPN	6
Fecal coliform	ALS Environmental	APHA 9223 (mod)	MPN	6
E. coli	ALS Environmental	APHA 9223 (mod)	MPN	6
MST (in Development)	RCF Conservation Genetics Lab (PSEC)	In development		6
6PPD-quinone	Pending		LCMS	6
Tier 3				
Polycyclic Aromatic Hydrocarbons (PAHs)	SGS Axys Analytical	EPA 8270/ EPA 1625	GC-MS	6
Multiresidue Pesticides	SGS Axys Analytical	EPA 1699 (mod)	HRMS	6
Pharmaceuticals and Personal Care Products (PPCPs)	SGS Axys Analytical	EPA 1694	HPLC/MS/MS	6
Per and Poly-fluoroalkyl substances (PFAS)	SGS Axys Analytical	EPA 1633 Draft	LC-MS/MS	6
Polychlorinated biphenyls (PCBs)	SGS Axys Analytical	SGS AXYS METHOD MLA-210 Rev 01	GC-MS/MS	6
Alkylphenol Ethoxylates (APEs)	SGS Axys Analytical	SGS AXYS METHOD MLA-004 Rev 07	GC-MS	6
Bisphenols	SGS Axys Analytical	SGS AXYS METHOD MLA-113 Rev 01	LC-MS/MS	6
Sucralose	SGS Axys Analytical	MLA-116	LC-MS/MS	6

Data handling

In some cases, contaminants were not detected in our water samples and concentrations were therefore considered to be 0 for the calculations of totals. Detection limit values for all analyses are collated in a separate file (CRD_24W_DL.XLS).

With each batch of samples, analytical laboratories ran blank samples (e.g. samples that go through the same laboratory processes as our environmental samples) that should, in theory, not contain any contaminants. However, in some cases, blank samples contained low concentrations of contaminants. These levels in blanks were subtracted from the concentrations measured in each of our environmental samples ('blank correction').

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Environmental Quality Guidelines

We interpreted contaminant concentrations using three sets of Canadian environmental quality guidelines (EQGs): provincial (British Columbia (BC)), federal, and those developed by the Canadian Council of the Ministers of the Environment (CCME). The latter CCME guidelines are derived in consultation with the environment ministers from the federal, provincial and territorial governments. Relevant EQGs and Drinking Water Quality Guidelines (DWQGs) from Health Canada are summarized in Appendix 3.

The British Columbia Ministry of Environment and Climate Change Strategy (BC MoECCS) has developed Water Quality Guidelines (WQGs) that are considered protective for different water uses. We refer to WQGs and EQGs interchangeably to simplify the use of terminology from different sources across Canada. We apply EQGs for the protection of aquatic life (source, stream and rivers and Road runoff samples) and marine aquatic life (marine water samples). All approved BC WQGs can be found on the BC MoECCS website.

Federal Environmental Quality Guidelines (FEQGs) are developed to support emerging federal environmental quality monitoring, risk assessment and risk management activities, and are derived to complement those developed by the CCME. They are only available for a limited number of chemicals captured in this list of EQGs (Government of Canada, 2024).

In addition, BC Working Water Quality Guidelines (WWQGs) are available for some contaminants for which a completed EQG is not yet available.

It is important to note that exceeding a WQG/EQG or WWQG does not imply that unacceptable risk exists but rather that the potential for adverse health effects is increased (BC MoECCCS, 2023). Conversely, EQGs may not fully capture the sensitivity of all species to different contaminants, such that adverse effects may occur in some species even at levels below an EQG. EQGs, therefore, serve as a benchmark based on best available evidence at the time of development, and are subject to change as new evidence emerges.

Application of metals guidelines

It is important to note that there are three different types of guidelines for metals (Appendix 4):

- ***Fixed guidelines***: a single guideline concentration that can be applied regardless of water chemistry. This type of guideline can be compared directly to our total measured metal concentrations.

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- ***Formula-based guidelines***: a 'moving' guideline for a metal that is dependent on site-specific water chemistry parameters (including pH and/or hardness and/or dissolved organic carbon (DOC). Where possible, we calculated the chemistry-adjusted guideline values to be compared to our total metal concentrations. While pH and hardness were measured as part of the study, DOC was not and we calculated adjusted-guidelines using 50%, 75%, and 100% of the measured organic carbon (TOC) (Appendix 5,6) to bracket a reasonable range of DOC concentrations, consistent with literature indicating that DOC typically represents the dominant fraction of organic carbon (BC MoECCS, 1998).
- ***Where dissolved metal concentrations are needed***: Some guidelines require dissolved metal concentrations for the interpretation of guideline exceedances. As we measured total metal concentrations, there are two metals in this category for which we were unable to interpret metal guideline exceedances (Zn, Mn).

Drinking Water Quality Guidelines

Guidelines are available to protect human health from different contaminants in drinking water. These have been developed at the federal level by Health Canada in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water (CDW) and other federal government departments (Health Canada, 2022). Guidelines for Canadian Drinking Water Quality are developed specifically for contaminants that meet all of the following criteria (Health Canada, 2022):

- Exposure to the contaminant could lead to adverse health effects in humans;
- The contaminant is frequently detected or could be expected to be found in a large number of drinking water supplies throughout Canada; and,
- The contaminant is detected, or could be expected to be detected, in drinking water at a level that is of possible human health significance.

In BC, the [First Nations Health Authority (FNHA)] oversees drinking water safety on reserves, where the Chief and Council are responsible for drinking water infrastructure and monitoring. Monitoring of drinking water relies on meeting the Health Canada DWQGs. Drinking water quality guidelines can be found on the [Health Canada website]. In addition to the guidelines listed in Table 3, Health Canada maintains a Beach Action Value (BAV) for safe recreational use of water based *E.coli* being detected at less than 235 CFU/100 mL.

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Table 3: Analyte classes and number of available Environmental (or Water) Quality Guidelines (EQGs or WQGs) and Drinking Water Quality Guidelines (DWGs) or Objectives

Analyte Class	Number of Analytes Measured	Drinking WQGs	Federal EQGs	BC WQGs	CCME EQGs
Basic Water Properties	5	1	0	4	5
Coliform	3	2	0	0	0
Nutrients	6	2	0	4	4
Metals	37	18	5	18	17
PAHs	76	1	0	10	10
Pesticides	62	6	0	10	9
PPCPs	141	0	2	1	1
PFAS	40	3	1	1	0
PCBs	209	0	0	5	0
Alkylphenols	4	0	0	1	1
Bisphenols	6	0	1	1	0
Sucralose	1	0	0	0	0
6PPD-Quinone	1	0	0	1	0
Total	*589*	*33*	*9*	*56*	*47*

We applied three sets of EQGs and one set of DWQGs to our water quality data: The Federal government's Federal Environmental Quality Guidelines (FEQGs), the BC Government's Approved Water Quality Guidelines (BC WQGs), and the Canadian Council of Ministers of the Environment's (CCME) Canadian Environmental Quality Guidelines (CCME CEQGs); and Health Canada's Drinking Water Quality Guidelines. These guidelines were all designed to protect aquatic life and human health.

International Guidelines and emerging PFAS concerns

There exist several thousand PFAS compounds, but only two are regulated in Canada: PFOA and PFOS, which were banned in 2011. Given the increasing concern over the presence, persistence and toxicity of per- and poly-fluoroalkyl substances (PFAS), Health Canada has developed screening values for a number of PFAS compounds (Appendix 4). These are considered as approved guidelines for drinking water quality, and are based on risk assessment approaches that are similar to formal guidelines (Health Canada, 2023). They therefore serve as guidance when evaluating the risk of PFAS exposure from tap water consumption and are considered in the present report.

Given the limited guidance afforded by Canadian guidelines for the rapidly emerging PFAS concerns, we have included guidelines derived internationally (USA, European Union and WHO).

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Table 4: Environmental Quality Guidelines for PFAS (USA and Canada)

Compound	Guideline (mg/L)	Issuing Agency	Notes
PFOS	0.0068	Canadian FEQG	EQG - PFOA under development
PFOS	3	US EPA	DRAFT EQG - Acute
PFOS	0.0084	US EPA	DRAFT EQG - Chronic
PFOA	49	US EPA	DRAFT EQG - Acute
PFOA	0.094	US EPA	DRAFT EQG - Chronic

Very few Environmental Quality Guidelines are available for PFAS. A Canadian Federal EQG was set for PFOS, while a guideline value for PFOA is currently in development.

Table 5: Drinking Water Quality Guidelines for PFAS

Compound	Guideline (ng/L)	Issuing Agency	Notes
Sum of 25 PFAS	30	Health Canada - Drinking Water Quality Objective	Objective expected to become Guideline
PFOS	600	Health Canada	
PFOS	4	US EPA	New in 2024
PFOA	200	Health Canada	
PFOA	4	US EPA	New in 2024
PFHxS	10	US EPA	
PFNA	10	US EPA	
HFPO-DA	10	US EPA	
Total PFAS	500	EU - Drinking Water Directive	

Most available guidelines address the two PFAS compounds thought to be of greatest concern to human health: PFOA and PFOS.

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Water properties

Capsule

Basic water properties provided elementary information on the quality of fish habitat in the Tod Creek watershed. Stream and river sites were found to have the lowest temperature. The highest dissolved oxygen (% and mg/L) was measured at the marine and Hartland sites. Source sites were found to have the lowest dissolved oxygen (% and mg/L). The highest conductivity among non-marine samples was measured at the Hartland sites.

Introduction

Water properties including temperature (℃), dissolved oxygen, conductivity, pH, and turbidity are commonly measured as a preliminary method of assessing the quality of fish habitat. Temperature and dissolved oxygen are of particular significance to fish - as increased temperatures and low dissolved oxygen are often associated with summertime fish kills. Conductivity and turbidity measurements can act as proxies for total dissolved solids (TDS) and total suspended solids (TSS) respectively. These parameters can be relevant as increased TDS and TSS in a body of water can indicate contamination from road salt or flushing of disturbed sediments into the waterway. Unusual conductivity measurements suggest the need for more in-depth analysis for contaminants.

Methods

A YSI ProDSS was used to take three measurements at each site of the following parameters: temperature (°C), dissolved oxygen (mg/L and %), specific conductivity (uS/cm), pH, and turbidity (FNU).

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Results

Table 6: Average water property results for five categories of water sampled in the Tod Creek watershed (WET Season 2024)

Analyte	Source (n=3)	Stream and river (n=3)	Road runoff (n=3)	Tap* (n=10)	Marine (n=1)	Hartland (n=3)
Temperature (℃)	7.7 ± 0.33 6.3 - 8.4	7.3 ± 0.41 6.4 - 9.0	7.8 ± 0.52 6.2 - 9.9	-	8.2 ± 0.06 8.1 - 8.3	9.9 ± 0.21 9.3 - 10.9
DO %	45.0 ± 7.0 9.9 - 59.3	58.6 ± 3.8 43.5 - 72.1	64.4 ± 8.2 32.0 - 86.9	-	91.3 ± 0.57 90.2 - 91.9	71.3 ± 7.7 25.3 - 87.7
DO (mg/L)	**5.3 ± 0.80** 1.2 - 6.9	**7.0 ± 0.39** 5.4 - 8.3	**7.6 ± 0.90** 3.9 - 9.9	-	10.3 ± 0.09 10.2 - 10.5	8.1 ± 0.88 2.8 - 10.1
pH	6.9 ± 0.14 6.2 - 7.5	7.4 ± 0.15 7.1 - 8.1	7.4 ± 0.07 7.2 - 7.8	-	7.3 ± 0.33 6.6 - 7.7	7.2 ± 0.20 6.2 - 7.7
Conductivity (uS/cm)	105.5 ± 3.3 98.9 - 122.6	158.3 ± 9.9 118.6 - 183.7	213.1 ± 17.7 164.9 - 292.5	-	12179 ± 2509 9495 - 17194	548.9 ± 94.2 329.0 - 983.0
Turbidity (FNU)	0.93 ± 0.20 0.56 - 2.4	4.3 ± 0.89 2.0 - 8.5	4.5 ± 1.2 1.9 - 13.0	-	11.1 ± 2.2 8.8 - 15.4	22.6 ± 5.5 0.22 - 35.6

Bold indicates an exceedance of an EQG. Data represent the mean +/- Standard Error of the Mean (SEM), with the Range in parentheses (min-max). DO = Dissolved Oxygen. uS/cm = MicroSiemens per cm. FNU = Formazin Nephelometric Units. *We were unable to measure water properties accurately in the tap sample due to logistical constraints associated with individual sample collections.

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Conclusions

- Mean dissolved oxygen values at the source sites (5.3 ± 0.80 mg/L) fell below the CCME guideline (minimum dissolved oxygen for other life stages = 6.5 mg/L).
- Mean dissolved oxygen values at the source, stream and river (7.0 ± 0.39 mg/L) and road runoff (7.6 ± 0.90 mg/L) were below the BC MoE long-term minimum dissolved oxygen guideline (8 mg/L).
- Turbidity could not be assessed in relation to Environmental Quality Guidelines as it requires knowledge of background turbidity, but it was higher in those water categories that were downstream of source water.
- Conductivity was highest - as expected with naturally occurring ions and metals - in the marine sample, but was also elevated at the Hartland sites when compared to the other freshwater categories.

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Coliform bacteria

Capsule

Coliform bacteria in water indicate a potential threat to human health. The highest concentration of total coliform was detected in the road runoff sample. The Hartland sample has the highest concentrations of total and fecal coliform, as well as *E. coli.* Relative low counts in the surface water samples may reflect human, pet or wild animal sources. Future Microbial Source Tracking results will be useful in identifying the host species for this observation. There were total coliform detected in the composite tap water sample, perhaps reflecting localised contamination of a private well. This merits further investigation. There were no exceedances of Water Quality Guidelines designed for recreational use of water for *E. coli*.

Introduction

Coliform bacteria have historically been used to gauge water quality with respect to implications for human recreational use and drinking water consumption. Most recently, the spotlight has been on counts (MPN of CFU) of the gram-negative coliform bacteria species *Escherichia coli* as an indicator of recent contamination with wastewater, and to determine the risk to human health posed by consumption and recreational use of waterways. There are no Environmental Quality Guidelines for coliform bacteria, reflecting the general idea that these potentially pathogenic bacteria are not likely to present a risk to aquatic life. Further work to measure Enterococci bacteria in future marine water samples will strengthen the evaluation of microbial contamination in water.

Results

Table 7: Concentration (MPN/100mL) of coliform bacteria in water samples from the Tod Creek watershed (WET Season 2024)

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Tap (n=1)	Marine (n=1)	Hartland (n=1)
Coliform, Total	649	1410	0	**20**	<10	2500
Coliform, Fecal	5	23	47	<1	<1	169
E. coli	3	16	19	<1	<1	110

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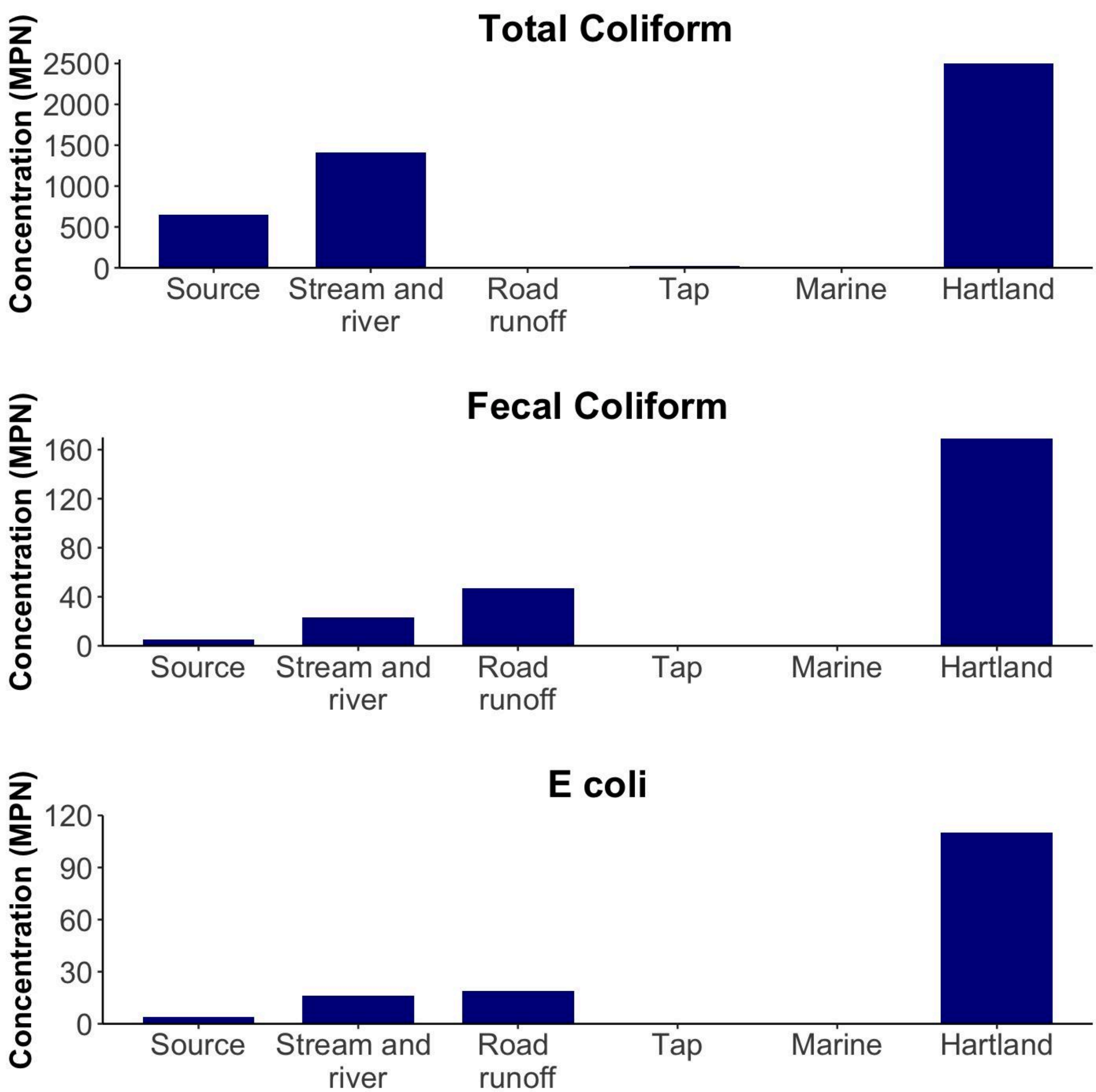
The highest concentrations of total and fecal coliform were detected in the Hartland sample. *E. coli* also had the highest concentration in the Hartland sample.

Figure 2: Coliform concentration (MPN/100mL) in water samples from the Tod Creek watershed (WET Season 2024)



The highest concentrations of total and fecal coliform bacteria as well as E. coli were detected in the Hartland sample. No fecal coliform bacteria were detected in the tap water sample.

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Conclusions

- Total *E. coli* concentrations for the five water categories were ranked from highest to lowest as follows: Hartland > road runoff > stream and river > source > tap > marine.
- The detection of a small number of total coliform in the composite tap water sample warrants further investigation, and may reflect a localised contamination of a private well that served as one of 10 samples for the combined analysis.
- *E. coli* values in all water samples were well below Recreational Use Guidelines set by Health Canada (>235 CFU/100ml).
- The composite tap water sample exceeded the Health Canada Maximum Allowable Concentration (MAC) for Total Coliforms of none detectable in 100ml of water as it leaves a drinking water treatment plant, or from groundwater sources. While this MAC does not strictly apply to water collected from distribution systems, the finding at least can be used to monitor water quality (Health Canada 2020). We therefore consider this as a preliminary finding of an exceedance meriting further investigation, preferably on an individual based approach using single sample analyses for the 10 homes and offices that we considered as a composite in this analysis.
- The inherent variability of coliform measurements in environmental samples (over time, place and among analyses) underscore the value in generating larger sample sizes or a modified approach to study design.

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Nutrients and physical parameters

Capsule

Excess nutrients from fertilizers, wastewater and other human activities can readily degrade fish habitat by increasing plant and algal growth and causing a subsequent reduction in dissolved oxygen. Nitrate concentrations in the Hartland drainage sample exceeded the long-term Environmental Quality Guideline for the protection of aquatic life, but not the short-term acute Guideline. Nitrite concentrations in the Hartland sample exceeded both the short- and long- term BC guidelines for the protection of aquatic life.

Introduction

Nutrients such as nitrogen and phosphorus compounds can be naturally occurring, and are critical for the health and growth of plants and animals. However, nutrients from fertilizers and wastewater that are released into a body of water can put it at risk of eutrophication - a process which is characterized by an overgrowth of plants and algae and resulting in oxygen depletion. Eutrophication poses a significant risk to aquatic life, as low oxygen levels create an inhospitable environment for the survival of fish - in particular salmonids who require relatively high levels of dissolved oxygen for survival and reproduction.

In addition, some nutrients such as total ammonia are considered to be acutely toxic to freshwater fish species at concentrations that vary with the temperature and pH of the water.

Results

Table 8: Concentrations (mg/L) of physical and chemical properties in water samples from the Tod Creek watershed (WET Season 2024)

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Tap (n=1)	Marine (n=1)	Hartland (n=1)
Hardness, Total (as $CaCO_3$)	36.1	61.4	76.3	18.6	1080	282
Carbon, Total Organic	7.24	7.08	10.9	1.67	7.56	8.75
Solids, Total Dissolved	77	120	160	36	5570	465

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Solids, Total Suspended	<3	<3	7.1	<3	3.9	72.5
Biological Oxygen Demand (BOD)	<2	<2	<2	<2	<2	<2

Table 9: Nutrient concentrations (mg/L) in water samples from the Tod Creek watershed (WET Season 2024)

Analyte	**Source** (n=1)	**Stream and river** (n=1)	**Road runoff** (n=1)	**Tap** (n=1)	**Marine** (n=1)	**Hartland** (n=1)
Ammonia, total (as N)*	0.050	0.0338	0.0521	0.2420	0.0160	0.0514
Nitrate (as N)	0.0088	0.1820	0.8880	0.0539	0.6240	**5.28**
Nitrate + Nitrite (as N)	0.088	0.1860	0.8920	0.0651	0.6350	5.32
Nitrite (as N)	<0.001	0.0043	0.0035	0.0112	0.0110	0.0406
Nitrogen, total	0.400	0.661	1.44	0.449	1.05	6.34
Phosphate, ortho-, dissolved (as P)**	<0.001	0.0440	0.0812	<0.0010	0.0475	0.0023

Bold indicates an exceedance of an EQG. Water samples were analyzed for the following nutrients: total nitrogen, nitrate (NO^{-3}), ammonia (NH_3), phosphate (PO_4^{3}) and nitrite (NO^{-2}). n=1 is a composite of 3 sample locations of the same water type. *There are no DWQGs for ammonia but Health Canada recommends keeping ammonia levels <0.1 mg/L to prevent lead/copper corrosion and increase in nitrite/nitrate levels in drinking water systems. **There is no EQG for dissolved phosphate (measured here), but a water quality objective (WQO) of 0.015 mg/L for phosphorus (the most common form of phosphate found in water) has been developed for BC lakes, and the CCME classifies water bodies with total phosphorus < 0.020 mg/L as healthy.

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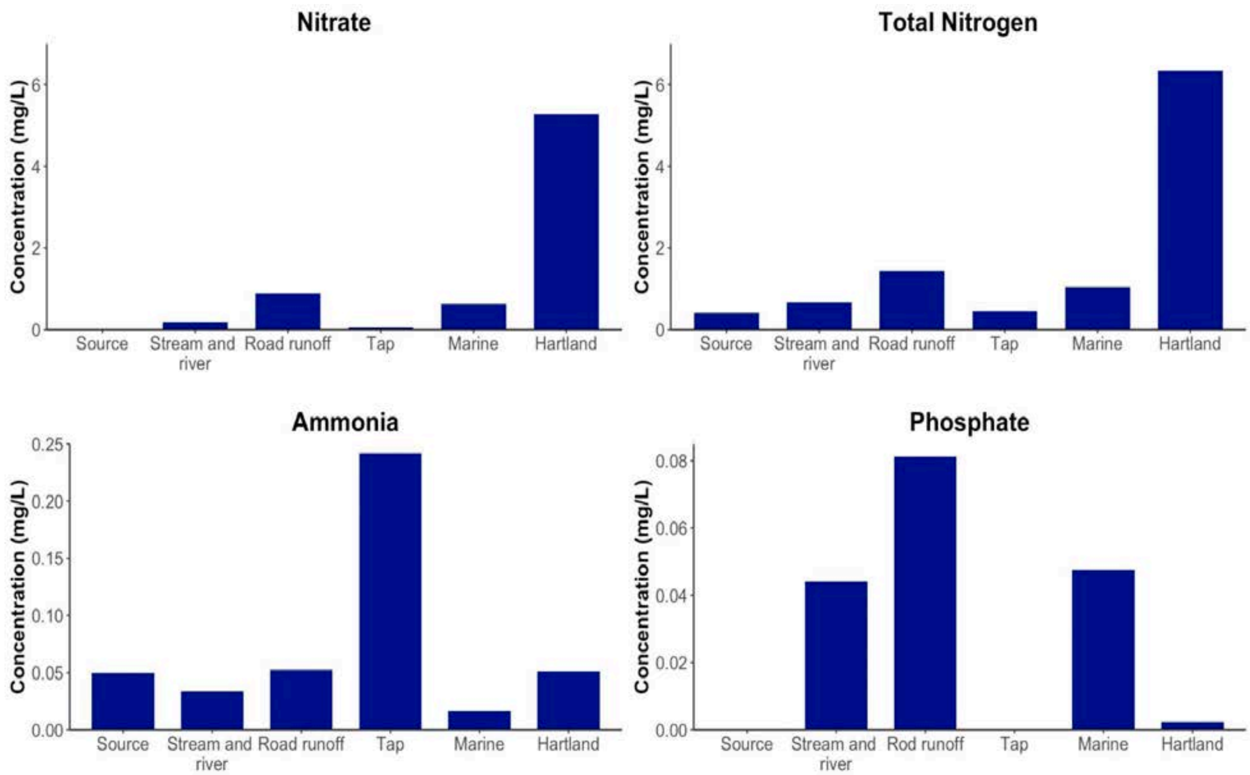
Figure 3: Nutrient concentrations (mg/L) in water samples from the Tod Creek watershed (WET Season 2024)



Ammonia (NH_3) was the most commonly detected nutrient in water samples from the Tod Creek watershed, and was present in all water samples. The highest concentration (5.28 mg/L) of nitrate (NO^{-3}) was detected in the Hartland sample. Ammonia (NH_3) was detected at the highest concentration in the tap water sample. Phosphate (PO_4^{3}) was detected in four out of the six samples, with the highest concentrations being in the road runoff sample.

Conclusions

- Nitrate concentrations detected in the five water categories were ranked from highest to lowest as follows: Hartland > road runoff > marine > stream and river > tap > source.
- Ammonia was the most frequently detected nutrient in water samples from the Tod Creek watershed.
- The Hartland sample was found to have the highest concentration of nitrate (5.28 mg/L), which was below the BC acute guideline value for the protection of freshwater aquatic life (32.8 mg/L), but above the BC long-term guideline value for the protection of freshwater aquatic life (3.0 mg/L).

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- The Hartland sample was found to have the highest concentration of nitrite (0.0406 mg/L).
- The tap sample was found to have the highest concentration of ammonia (0.24 mg/L); there is no Canadian Drinking Water Guideline for ammonia.
- The ammonia concentration detected in the tap water sample (0.24 mg/L) was slightly above the average ammonia concentration found in a study of 1,119 raw water samples collected in the Province of Alberta between 1998 and 2008 (Health Canada 2013).

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Metals and minerals

Capsule

Metals and minerals can be present in water due to both natural and anthropogenic inputs. Sixteen metals were detected in all of the water samples collected in the Tod Creek watershed. Aside from the marine sample, total metal concentrations were highest in the Hartland water sample, consistent with our observation of higher levels of conductivity. Iron concentrations exceeded Environmental Quality Guidelines in the source sample. There were exceedances for aluminum, copper, and iron in the road runoff and Hartland drainage samples.

Introduction

Metals and minerals are present in aquatic environments as a result of both natural and anthropogenic sources, with baseline levels reflecting the unique geology of the area surrounding a body of water. Anthropogenic sources of metal contamination in waterways may originate from industrial effluent, municipal wastewater, agricultural practices, and urban runoff.

Many metals are capable of impacting the health of aquatic life, with some representing a priority concern in fish habitat, including zinc and copper.

Where guidelines were available or could be applied using additional measured parameters, such as hardness, pH, and TOC, we calculated the adjusted guideline values and compared these with the detected metal concentrations (Table 10). For some metals, DOC was required for adjusted-guideline calculations. As we did not measure DOC, we calculated parameter adjusted-guidelines values using DOC set at 50%, 75%, and 100% of measured TOC (Appendix 5,6) to bracket a reasonable range of DOC concentrations. This is based on the understanding that DOC typically represents the dominant fraction of organic carbon (BC MoECCS, 1998). The resulting range of parameter-adjusted guideline values were then compared with detected metal concentrations.

DOI: 10.70766/42.6309

Results

Table 10: Total concentrations (mg/L) of metals and minerals that were detected in all six water categories in the Tod Creek watershed (WET Season 2024).

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Tap (n=1)	Marine (n=1)	Hartland (n=1)
Aluminum*	0.0607	0.0947	**0.418**	0.008	0.623	**1.69**
Antimony	<0.0001	<0.0001	<0.0001	<0.0001	<0.003	0.00017
Arsenic	0.00017	0.00046	0.00049	<0.0001	<0.003	0.00143
Barium	0.00552	0.00656	0.0121	0.00354	0.0118	0.0207
Beryllium	<0.00002	<0.00002	<0.00002	<0.00002	<0.0005	3.6e-05
Boron	0.024	0.03	0.03	<0.010	0.85	0.088
Cadmium	<0.000005	9.1e-06	1.72e-05	<0.000005	<0.0002	5.65e-05
Calcium	10.6	17.6	22	5.5	86.4	90.5
Chromium	<0.0005	<0.0005	9e-04	<0.0005	<0.005	0.00328
Cobalt	<0.0001	0.00016	0.00036	2e-04	<0.001	0.00189
Copper	0.00064	0.00194	**0.00545**	0.156	<0.005	**0.00643**
Iron*	**0.309**	0.244	**0.419**	0.036	0.62	**3.12**
Lead	<0.0005	0.000234	0.000455	0.000608	<0.002	0.00103
Lithium	<0.001	<0.001	<0.001	<0.001	0.029	<0.001
Magnesium	2.35	4.25	5.18	1.18	209	13.5
Manganese	0.0498	0.015	0.0256	0.00296	0.0374	0.96
Mercury	<0.000005	<0.000005	7e-06	<0.000005	6.8e-06	8.7e-06
Molybdenum	0.000161	0.000325	0.000295	7.6e-05	<0.0025	0.00132
Nickel	<0.0005	0.00088	0.00163	0.00156	<0.005	0.00324
Phosphorus	<0.05	0.09	0.144	<0.05	<1	0.096
Potassium	0.414	1.11	1.42	0.133	63.1	1.29
Rubidium	NA	NA	NA	NA	0.018	NA
Selenium	<0.00005	5.3e-05	0.000115	<0.00005	<0.002	0.000435
Silicon	3.04	3.76	6.28	2.2	5.54	9.27

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Silver	<0.00001	<0.00001	1e-05	<0.00001	<0.00025	1.6e-05
Sodium	7.23	7.61	11.8	3.71	1650	11.1
Strontium	0.036	0.0578	0.0684	0.0178	1.23	0.209
Sulfur	1.23	4.19	3.95	<0.5	154	61.6
Titanium	0.00178	0.00391	0.0167	<0.0003	0.0285	0.0793
Uranium	<0.00001	2e-05	3.8e-05	<0.00001	0.00071	0.000243
Vanadium	<0.0005	0.00083	0.00192	<0.0005	<0.005	0.00777
Zinc	<0.003	<0.003	0.0103	0.0146	<0.025	0.0239
Zirconium	<0.0002	<0.0002	0.00043	<0.0002	<0.010	<0.0002
Total metals	*25.4*	*39.1*	*51.8*	*13.0*	*2171.5*	*193.6*

Bold indicates a concentration that exceeded an Environmental or Water Quality Guideline. Additional scrutiny of these findings can be found in Appendix 5 and 6, where certain water quality parameters are applied or can be applied for a site-specific evaluation. *BC Water Quality Guidelines there were calculated using three different %TOC concentrations that allowed us to compare with metal concentrations in a parallel post hoc exercise (Appendix 5,6).

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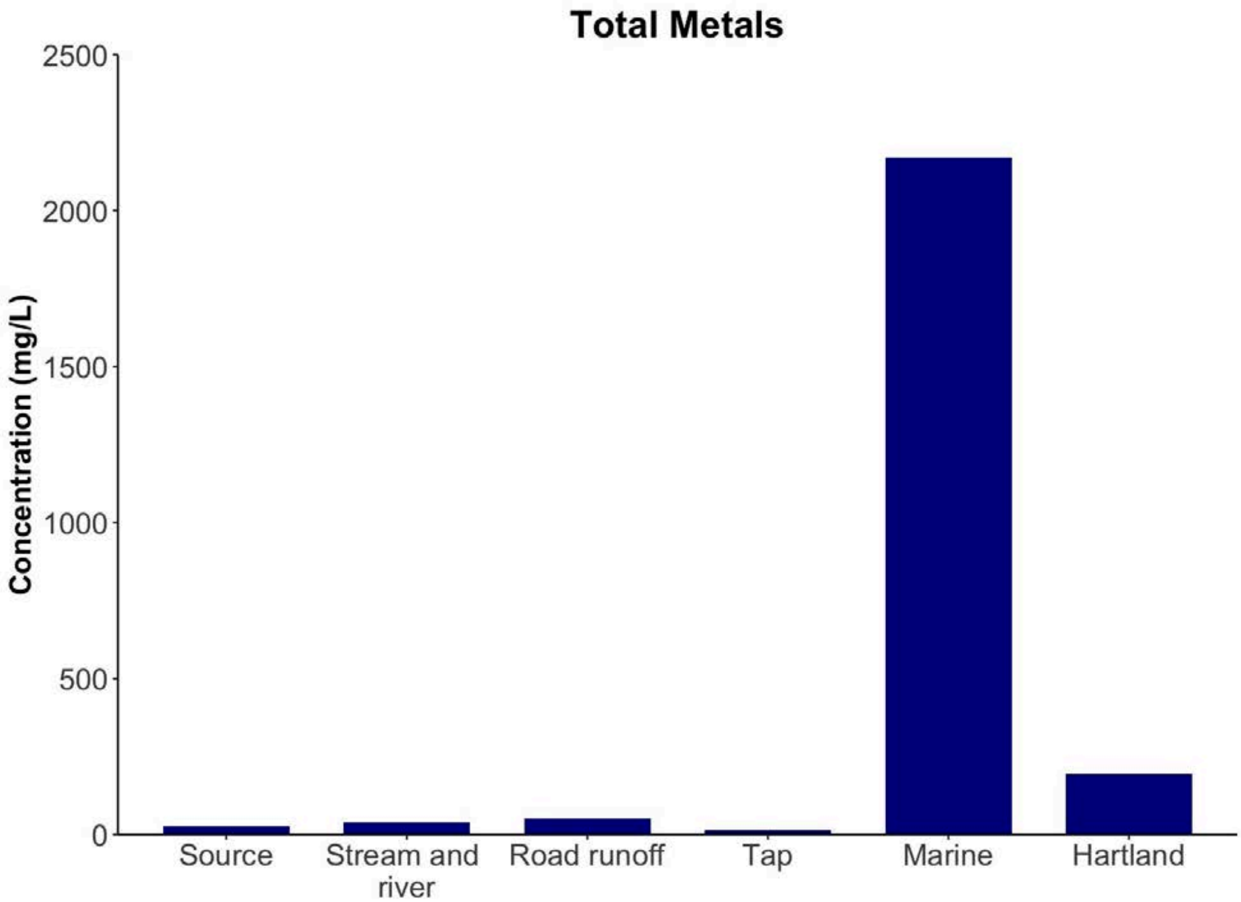
Figure 4: Total metal concentrations (mg/L) in six water categories in the Tod Creek watersheds (WET Season 2024)



The marine sample - as expected - had the highest concentration of total metals among all samples, while the Hartland sample had the highest concentrations of total metals among the non-marine categories.

Table 11: Concentrations (mg/L) of lead detected in all six water categories in the Tod Creek watersheds (WET Season 2024)

Analyte	Source (n=1)	Stream and river (n=1)	Road runoff (n=1)	Tap (n=1)	Marine (n=1)	Hartland (n=1)
Lead (mg/L)	<0.00005	<0.00005	0.000234	0.000455	0.000608	0.00103

Lead can be a concern when found in drinking water. No water samples exceeded DWGs or EQGs available for lead.

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Conclusions

- Total metal concentration for the five water categories was ranked from highest to lowest as follows: marine > Hartland > road runoff > stream and river > source > tap.
- Lead was detected in the pooled tap water sample, and was present at concentrations of 0.00045 mg/L - which was below the limit set by Health Canada for safe drinking water (0.005 mg/L).
- The aluminum concentration in the road runoff and Hartland samples were above the BC Long Term Guidelines for the protection of aquatic life (calculated at each site based on DOC). See Appendix 5 for BC aluminum guideline calculations.
- The copper concentration in the road runoff and Hartland samples were above the CCME guideline for the protection of aquatic life based on the hardness measured at the sites.
- The iron concentrations exceeded several guidelines:
    - The CCME long term guideline of 0.3 mg/L was exceeded in the source, road runoff and Hartland samples;
    - the FEQG (calculated at each site based on DOC and pH - see appendix 6 for calculations) was exceeded in the Hartland sample.

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Polycyclic Aromatic Hydrocarbons (PAHs)

Capsule

PAHs were detected in all six water samples with the highest concentrations observed in the tap water sample, and the lowest in the road runoff sample. The Fl/(Fl+Pyr) ratio in all samples, except road runoff, suggested a contribution of combustion of solid fuel such as wood, plant material or coal as the source of PAHs in these water categories, perhaps consistent with the recent heavy forest fire season. PAHs in the road runoff sample likely originated from fossil fuel sources. EQGs were only available for 10 PAHs, but no exceedances were observed for any samples. DWG was only available for benzo-a-pyrene and was not exceeded.

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a complex group of compounds found in coal, petroleum and plant materials. They can enter waterways in the form of liquid petroleum products (gasoline, diesel, oil) or via the incomplete combustion of coal, oil, gas, wood garbage or other organic substances. They can occur naturally or as a result of human activities (anthropogenic). In Canada, forest fires are the single most important natural source of PAHs, while anthropogenic sources include residential wood heating, aluminum smelters, creosote-treated products, spills of petroleum products and metallurgical and coking plants, and household activities (Government of Canada, ECCC and Health Canada, 1994; Marvin et al., 2021).

Hydrocarbons can enter aquatic ecosystems either directly through oil spills or discharges from vessels (Morales-Caselles et al., 2017) or indirectly through atmospheric deposition, runoff and discharge from wastewater treatment plants. Depending on their molecular size, PAHs vary in toxicity and have been classified as toxic under the Canadian Environmental Protection Act (CEPA).

Results

We measured 76 different parent and alkylated PAHs in the six water samples collected in the Tod Creek watersheds during the wet season.

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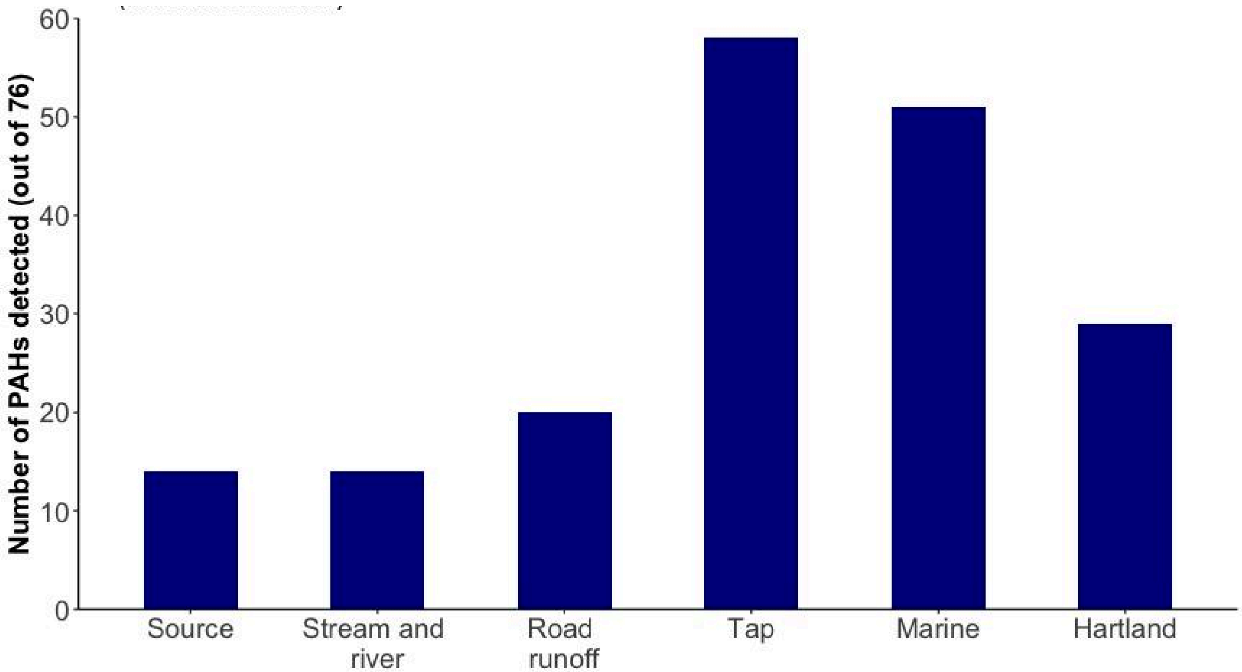
Figure 5: Number of PAHs detected in water samples from the Tod Creek watershed (WET Season 2024)



PAHs were detected in all five water categories. The number of PAHs detected ranged from 14 (source and stream and river) to 58 (tap) with an average of 31.0 ± 7.8.

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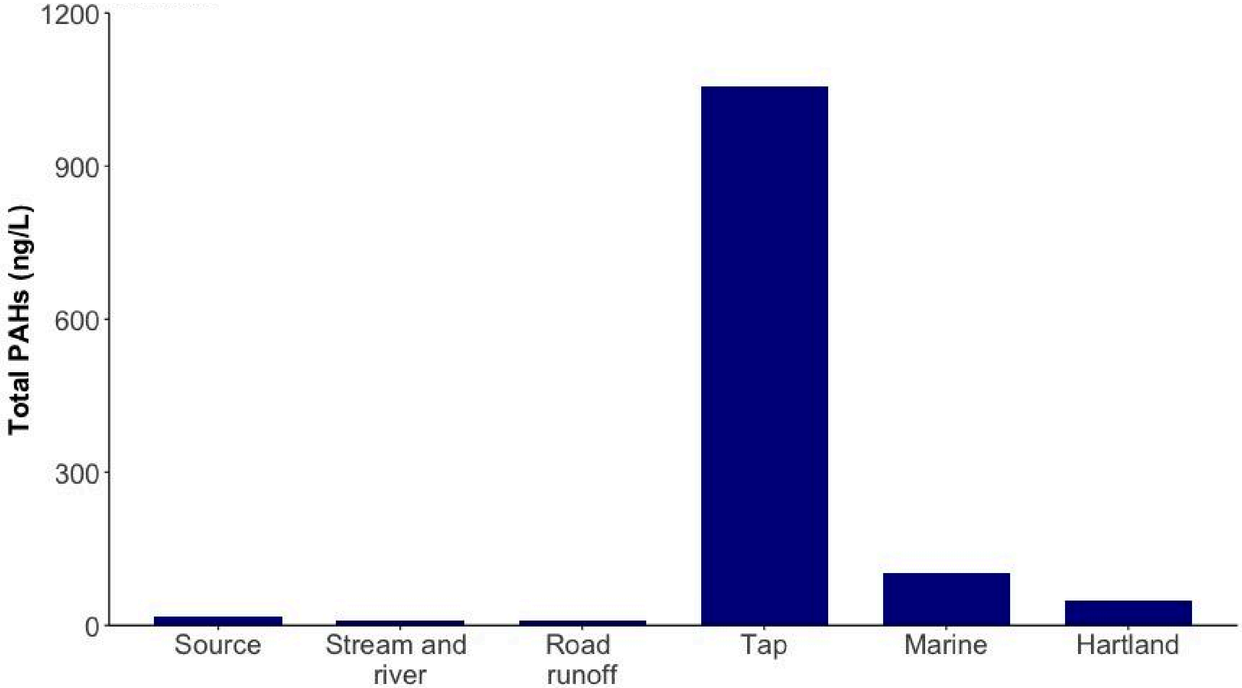
Figure 6: Total PAH concentrations in water samples from the Tod Creek watershed (WET Season 2024)



Total PAH levels ranged between 8.7 (road runoff) and 1055 ng/L (tap) with an average across all water categories of 207 ± 170 ng/L.

Ratios of certain PAHs can be used to evaluate sources. Given that only a limited number of PAHs were detected in the water samples, the Fluoranthene - Pyrene ratio was the only one that could be calculated reliably for all samples.

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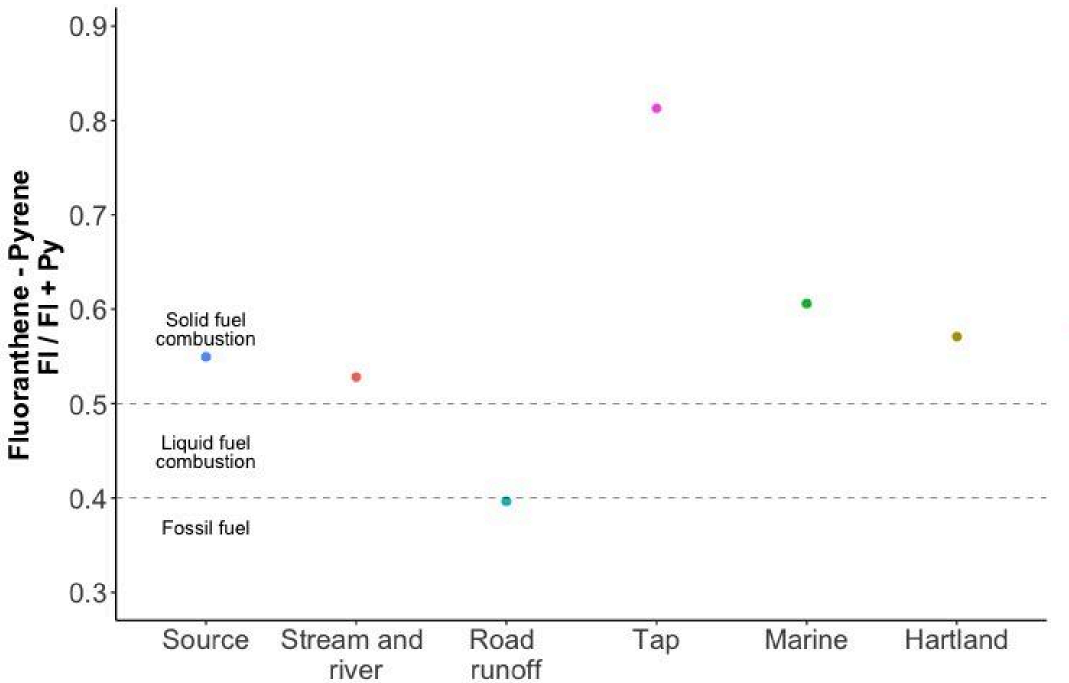
Figure 7: PAH profiles from wood combustion and fuels in water samples from the Tod Creek watershed (WET Season 2024)



All samples (except road runoff) had Fl/Py ratios higher than 0.5, suggesting the contribution of combustion of solid fuel such as wood, plant material or coal as the source of PAHs. The road runoff sample had a ratio <0.4 suggesting the contribution of fossil fuel for the PAHs found in this sample.

Conclusions

- PAH concentrations were ranked as follows from highest to lowest: tap > marine > Hartland > source > stream and river > road runoff.
- Total PAH concentrations in Tod Creek watershed water samples ranged from 8.7 to 1055 ng/L.
- Fluoranthene - Pyrene ratios revealed that PAHs in all samples, except road runoff, originated from the combustion of solid fuel such as wood or plant material. This is consistent with wood burning for heating homes, and wildfires, as being major sources of PAHs in Canada (Berthiaume et al., 2021). In addition, biomass burning in Asia has been shown to deliver PAHs to Canada through air masses traveling across the Pacific Ocean (Berthiaume et al., 2021).
- The fluoranthene - Pyrene ratio suggested liquid fossil fuel sources of PAHs in the road runoff sample.

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- All the water samples were well below the BC EQGs available for individual PAHs (naphthalene, acenaphthene, fluorene, anthracene, phenanthrene, fluoranthene, pyrene, chrysene, benzo-a-pyrene and benzo-a-anthracene).
- DWG is only available for benzo-a-pyrene and was not exceeded.

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Pesticides

Capsule

A limited number of pesticides were detected in all six water samples, with the highest concentrations in the stream and river sample, and the lowest in the tap water sample. The majority of the pesticides detected were banned in Canada at the time of sampling, except simazine and metribuzin. Alpha-endosulphan and 4,4' DDE were detected in the majority of samples. Out of the pesticides detected in environmental samples, EQGs were only available for endosulphan, simazine and metribuzin, and no exceedances were observed.

Introduction

Pesticides have been developed to control, destroy or inhibit the activities of pests. They have a wide range of applications in agriculture such as insecticide to prevent crop damage and fungicides to prevent plant disease but also in forestry, industry as well as in our own backyards for lawn care or weed and insect control. In Canada, all pesticides used, sold or imported are regulated by Health Canada's Pest Management Agency (PMRA) (Health Canada, 2007).

While pesticides are mostly applied on terrestrial habitats, they can reach aquatic environments through overspray or drift during application, surface runoff, and through long range atmospheric transport and deposition. It is estimated that 10% of pesticides applied to soil reach non-target areas, leading to their widespread presence in surface waters worldwide (Schulz, 2004; Anderson et al., 2022).

Organochlorine pesticides (OCP) were heavily used from the 1940s to the 1980s, but have been restricted due to their persistence, toxicity and potential for bioaccumulation. Current-use pesticides (CUPs) were subsequently favoured as an alternative to OCPs, and have been widely applied in recent decades (Ding et al., 2023). These tend to be more water-soluble and may be more mobile in fish habitat (Harris et al., 2008).

Results

We measured 62 different pesticides, including both legacy and CUPs in the five water samples collected within the Tod Creek watershed during the wet season.

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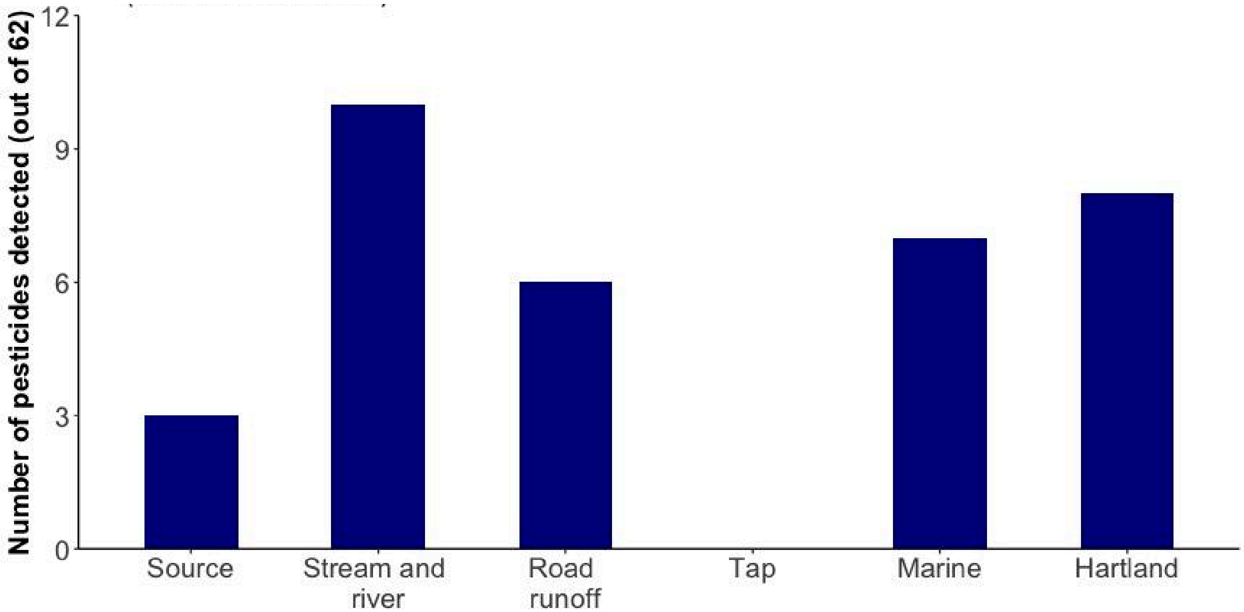
Figure 8: Number of pesticides detected in water sampled in the Tod Creek watershed (WET Season 2024)



The number of pesticides detected ranged from 0 (tap) to 10 (stream and river) with an average of 5.7 ± 1.5, similar to the wet season.

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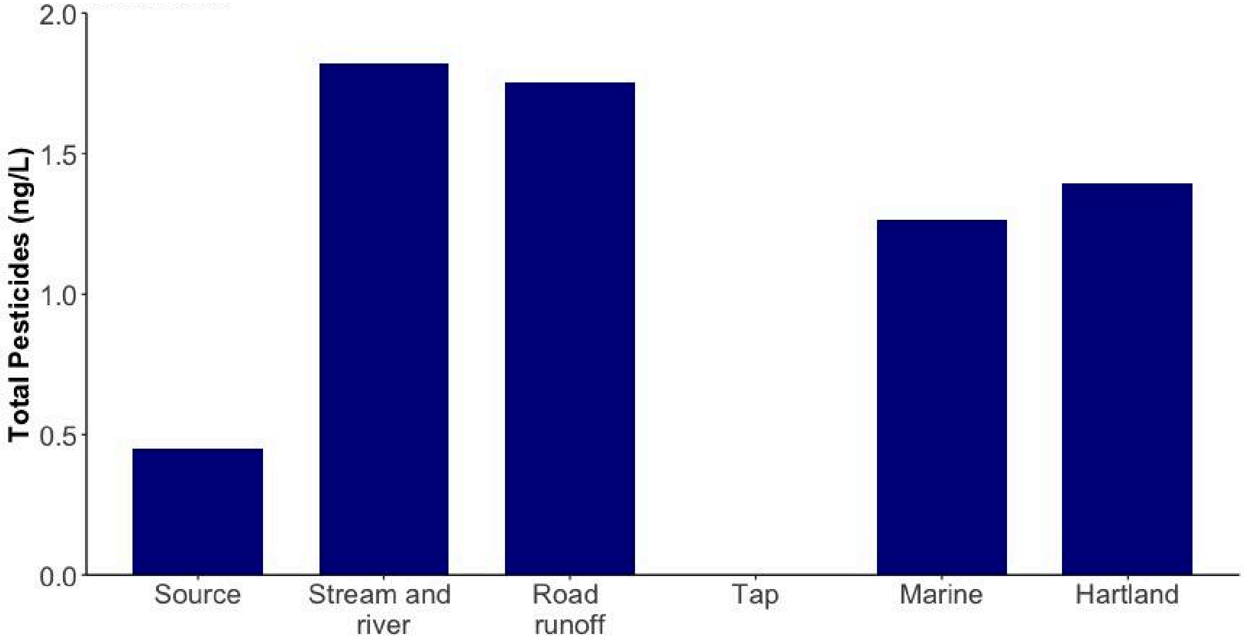
Figure 9: Total pesticide concentrations in water sampled in the Tod Creek watersheds (WET Season 2024).



Total pesticide levels ranged from 0 (tap) to 1.8 ng/L (stream and river), with an average across all water categories of 1.1 ± 0.30 ng/L.

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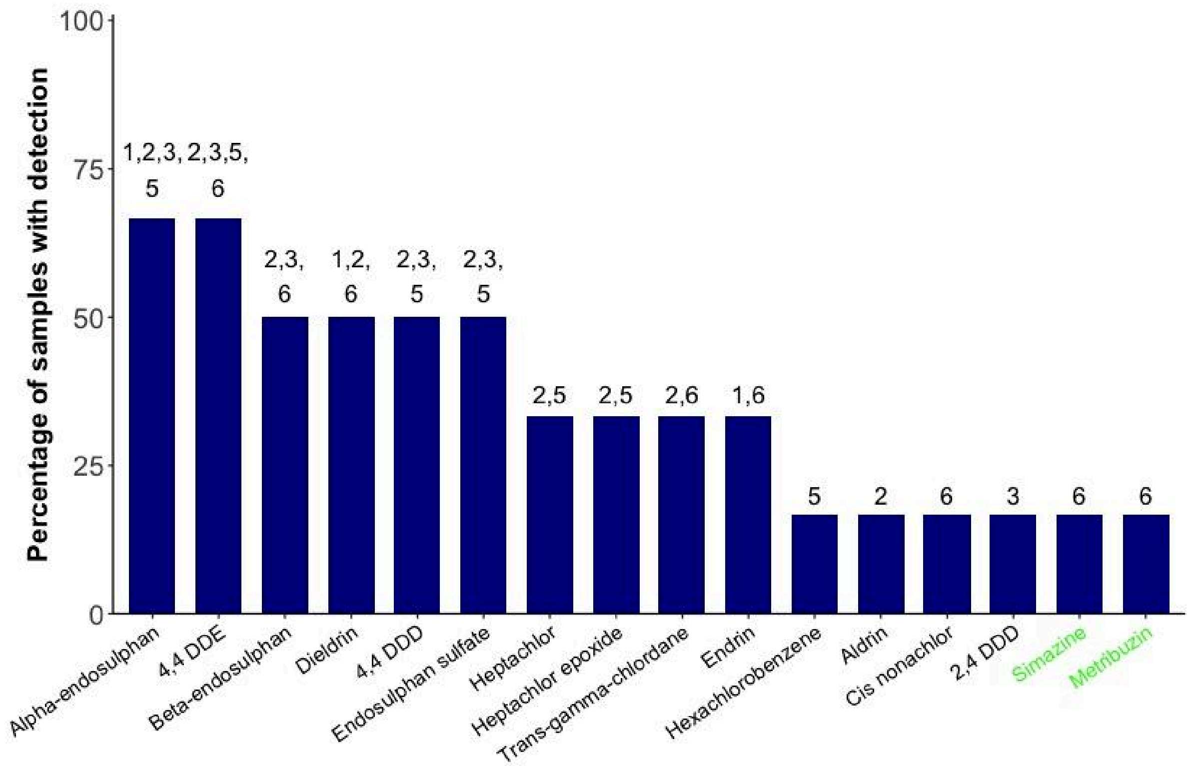
Figure 10: Most frequently detected pesticides in water categories sampled in the Tod Creek watershed (WET Season 2024)



Numbers refer to water categories (1: Source; 2: Stream and river, 3: Road runoff, 4: Tap; 5: Marine; 6: Hartland). For example, the Hartland landfill water sample had detectable concentrations of alpha-endosulphan, 4,4' DDE, beta-endosulphan, dieldrin, trans-gamma-chlordane, endrin, cis-nonachlor, simazine and metribuzin. Source water had detectable levels of alpha-endosulphan, dieldrin and endrin. Simazine and metribuzin (highlighted in green) were the only pesticides detected still in use in Canada.

Alpha-endosulphan and 4,4' DDE were detected in the majority of samples (67% of samples).

- Endosulfan is a restricted-use insecticide and acaricide used to control a broad range of insect and arthropod pests on a wide variety of food, feed and ornamental crops (Health Canada, 2011). The commercial mixture contains both alpha- and beta- endosulfan. endosulfan has been banned in Canada since 2016 and is banned or restricted in most other countries (ECCC, 2023).

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- DDE is a breakdown product of the pesticide DDT that was used as a broad spectrum insecticide. DDT was banned in the 1970s due to its bioaccumulative properties and adverse effects in wildlife (CCME, 1999).

Simazine and metribuzin were two pesticides detected that were still in use in Canada at the time of sampling:

- Simazine is an herbicide used to control weeds in various crops, at airports, and along shelterbelts and rights-of-way, as well as being used in aquatic weed control in ditches, farm ponds, fish hatcheries, aquaria, and fountains (Health Canada, 2016).
- Metribuzin is used for pre- and post-emergence control of broadleaf and grass weeds in spring wheat and barley (CCME, 1999).

Conclusions

- Pesticide concentrations in the Tod Creek watershed during the wet season 2024 were ranked as follows from highest to lowest: stream and river > road runoff > Hartland > marine > source > tap.
- Total pesticide concentrations ranged from 0 to 1.8 ng/L.
- The majority of pesticides detected were no longer in use in Canada at the time of sampling. Their detection likely reflects historical use nearby as well as deposition following long-range atmospheric transport. Interestingly, endosulfan was the most abundant pesticides detected in air samples collected from four mountains across British Columbia, including Grouse Mountain in North Vancouver (Ding et al., 2023).
- Endosulphan, simazine and metribuzin were the only pesticides detected that had EQGs, and no samples exceeded existing guidelines.

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Pharmaceuticals and Personal Care Products

Capsule

Pharmaceuticals and Personal Care Products (PPCPs) are a category of contaminants that can enter the environment via wastewater, and are typically not removed during treatment. DEET, theophylline and caffeine were detected in all six water samples. Amphetamine, cotinine and metformin were detected in five out of six water samples. It is unclear why the highest total PPCP concentrations were detected in the Hartland water sample but this measure reflected the sum of 11 different pharmaceuticals. The lowest PPCP levels were found in the tap water sample.

Introduction

Pharmaceuticals and Personal Care Products (PPCPs) comprise a wide range of products and chemical formulations. The common link among these compounds is their use in human health, veterinary health and personal care. Many PPCPs are introduced into the environment via wastewater streams, and are not reliably removed during treatment at wastewater treatment plants (WWTPs).

DEET (N,N-diethyl-meta-toluamide) is a widely used insect repellent. Theophylline is an asthma/pulmonary medication. Caffeine is a plant-derived stimulant found in widely-consumed beverages. Caffeine has been used as an indicator of human wastewater in the environment - as it is relatively stable and persistent in surface waters, but sucralose is increasingly used in its place.

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Results

Table 13: PPCP concentrations (ng/L) for all analytes detected in each water category for the Tod Creek watershed (WET Season 2024)

Analyte	Source	Stream and river	Road runoff	Tap	Marine	Hartland
2 Hydroxy ibuprofen	5.1	5.5	6.9	<4.0	<4.0	6.0
Ibuprofen	<3.8	<4.1	<4.0	<4.0	<4.0	6.4
Cefotaxime	<9.4	<6.5	12.3	<6.0	<6.0	<6.1
Caffeine	5.9	32.6	20.4	6.9	18.3	84.5
Carbamazepine	<0.28	0.68	<0.29	<0.30	1.8	1.8
Trimethoprim	<0.29	<0.31	<0.30	<0.30	0.87	<0.31
Benzoylecgonine	<0.14	0.443	0.321	<0.15	0.37	1.32
Cocaine	<0.14	<0.15	<0.15	<0.15	0.21	0.93
DEET	0.67	3.1	1.6	0.66	2.9	97.8
Theophylline	<5.7	13.1	9.41	<6.0	9.14	18.4
Amphetamine	0.13	0.13	0.25	0.48	<0.3	0.18
Cotinine	0.53	1.6	0.86	<0.29	0.87	2.03
Metformin	0.72	7.5	4.5	<0.29	8	19.7
Total PPCP concentrations	*13.1*	*64.6*	*56.5*	*8.1*	*42.4*	*239.2*
Number of PPCPs	*6*	*9*	*9*	*3*	*9*	*11*

The highest concentration was detected in the Hartland water sample and the lowest concentrations in the tap water sample. The greatest number of different PPCPs was detected in the Hartland water sample.

Conclusions

- PPCP concentrations in water samples ranged from highest to lowest as follows: Hartland > stream and river > road runoff > marine > source > tap.
- The only EQG available for the PPCP detected was for carbamazepine and it was not exceeded for any of the samples from the Tod Creek watershed.
- The other PPCP for which there is an Environmental Quality Guideline is Ethinylestradiol (EE), which is used widely as one of the hormonal components of

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birth control - as it has been shown to negatively impact both reproductive and immune function in some fish species. We did not detect EE in any of the samples collected from the Tod Creek watershed.

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Per- and poly-fluoroalkyl substances (PFAS)

Capsule

Per- and poly-fluoroalkyl substances (PFAS) were detected in all Tod Creek watershed samples, with the highest concentrations observed in the Hartland sample and the lowest in tap water. Perfluorobutanoic acid (PFBA), Perfluorobutane sulfonate (PFBS), Perfluoroheptanoic acid (PFHpA), Perfluorohexanoic acid (PFHxA), Perfluorohexanesulfonic acid (PFHxS), Perfluorooctanoic Acid (PFOA), Perfluorooctanesulfonic acid (PFOS) and Perfluoropentanoic acid (PFPeA) were detected in all samples except tap water. Perfluoro-octanesulfonamide (PFOSA) was the only PFAS detected in the tap water sample. None of the samples exceeded the few environmental quality guidelines available (PFOS, PFOA). New guidelines for PFAS are in development, such that this interpretation may change for this class of contaminant.

Introduction

Per- and poly-fluoroalkyl substances (PFAS) are large group (~15,000 compounds) of human-made substances that are widely used in a variety of products such as food packaging, non-stick cookware, clothing, cosmetics but also firefighting foams, lubricants and oil/water repellents. They are extremely stable and therefore persistent in the environment, which has led to the use of the term “forever chemicals”.

PFAS can be released in the environment at point sources such as manufacturing plants, or where firefighting foams have been used such as airports and military installations. PFAS can also be released through consumer use and disposal of PFAS-containing products. PFAS has been found in all environmental compartments (ECCC and Health Canada, 2023).

Evidence of adverse effects on the environment and human health has led Canada to prohibit the manufacture, use, sale, offer for sale and import of a limited number of PFAS including perfluorooctanesulfonic acid (PFOS), perfluorooctanoic Acid (PFOA), long-chain perfluorocarboxylic acids and their salts and precursors under the *Prohibition of Certain Toxic Substances Regulations* and the *Canadian Environmental Protection Act* (CEPA) (ECCC and Health Canada, 2023b).

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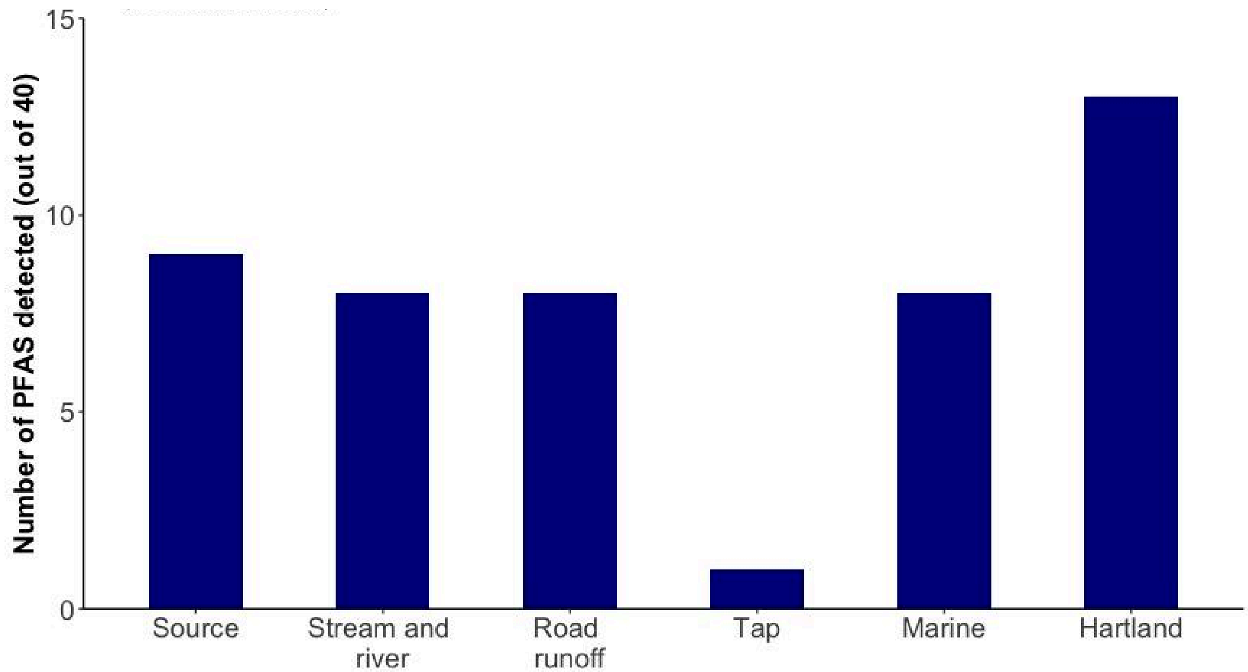
Results

We analysed up to 40 different PFAS in the six water samples collected within the Tod Creek watershed during the wet season.

Figure 11: Number of PFAS substances detected in water samples from the Tod Creek watershed (WET Season 2024)



PFAS were detected in all six water categories. The number of PFAS detected ranged from 1 (tap) to 13 (Hartland) with an average of 7.8 ± 1.6.

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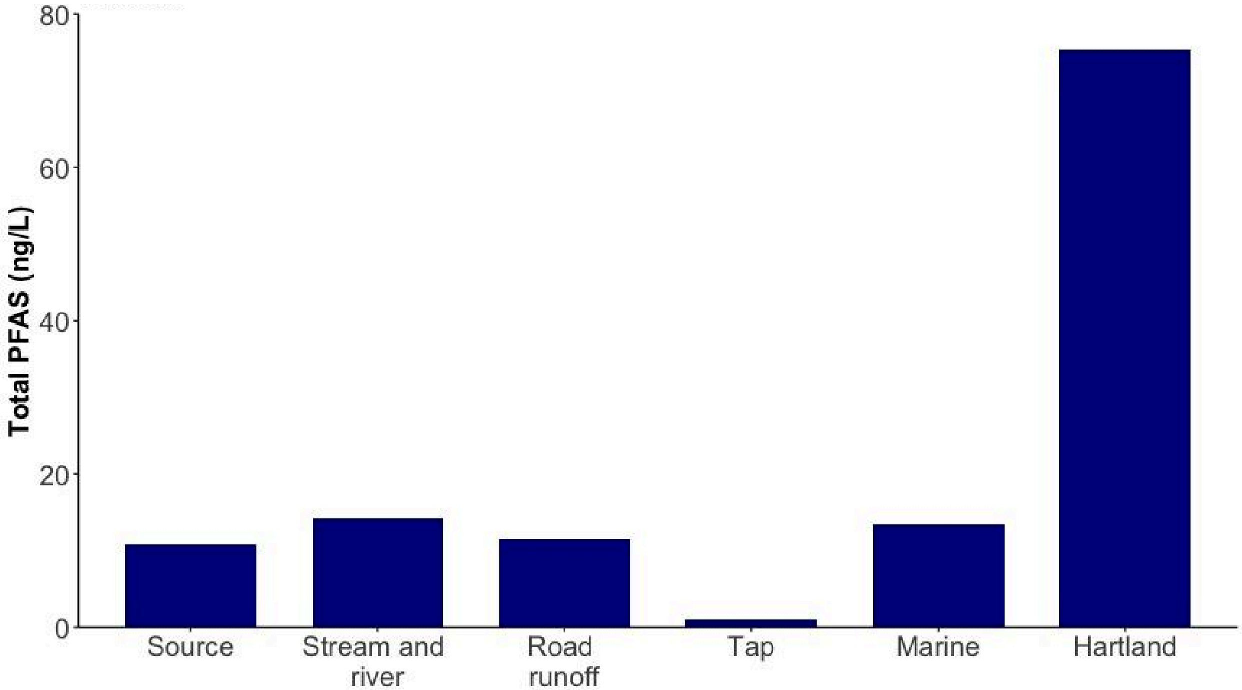
Figure 12: Total PFAS concentrations in water sampled in the Tod Creek watershed (WET Season 2024)



Total PFAS levels ranged between 0.99 (tap) and 75.4 ng/L (Hartland), with an average across all sample categories of 21.1 ± 11.0 ng/L.

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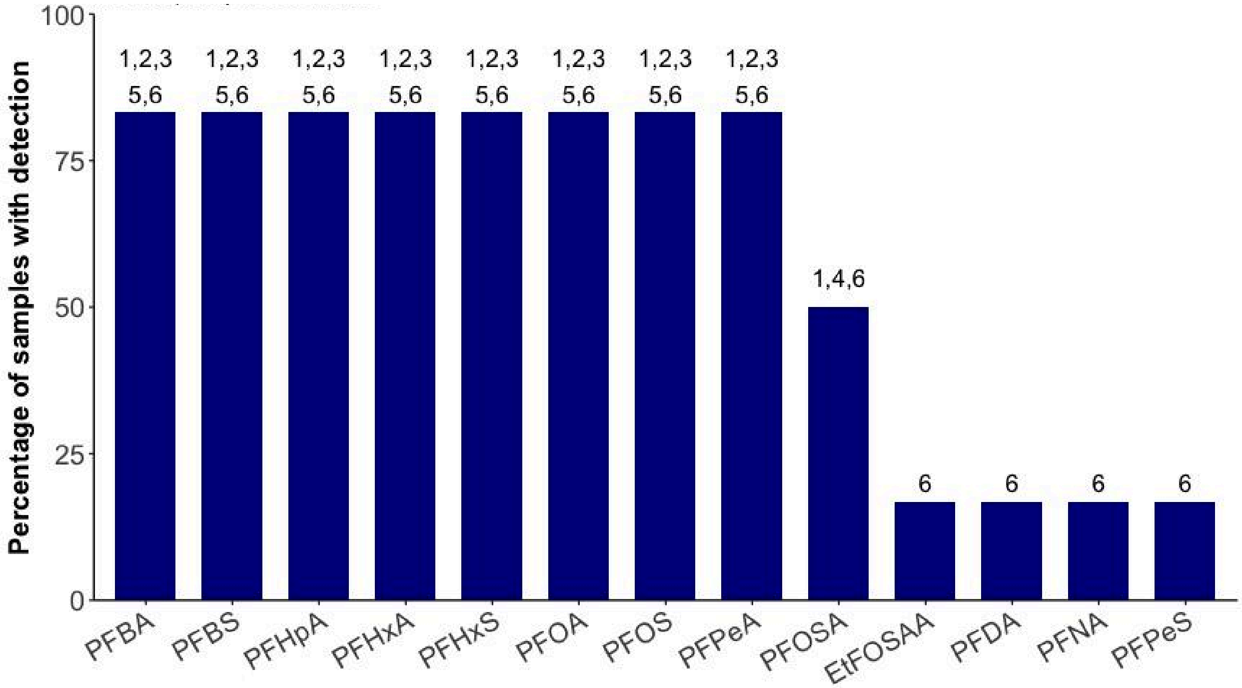
Figure 13: Most frequently detected PFAS in water sampled in the Tod Creek watershed (WET Season 2024)



Numbers refer to the water category (1: Source, 2: Stream and river, 3: Road runoff, 4: Tap, 5: Marine, 6: Hartland). While Perfluorobutanoic acid (PFBA), Perfluorobutane sulfonate (PFBS), Perfluoroheptanoic acid (PFHpA), Perfluorohexanoic acid (PFHxA), Perfluorohexanesulfonic acid (PFHxS), Perfluorooctanoic Acid (PFOA), Perfluorooctanesulfonic acid (PFOS) and Perfluoropentanoic acid (PFPeA) were detected in all samples except tap water, Perfluorooctanesulfonamide (PFOSA) was the only PFAS detected in tap water.

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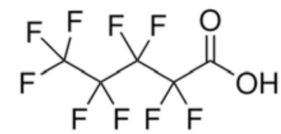
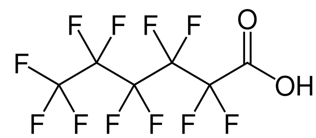
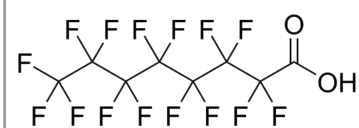
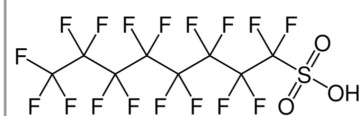
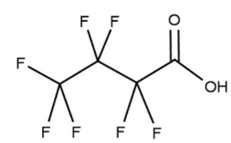
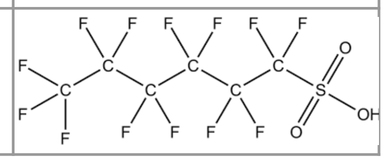
Table 14: Top 6 individual PFAS compounds detected in the Hartland water sample and their concentrations (from highest to lowest) during the WET Season 2024

Individual PFAS	Concentrations (ng/L)	Notes	Structure
PFPeA	17.0	Used as stain- and grease-proof coatings on food packaging and household products. Also a breakdown product of larger PFAS.	
PFHxA	11.9	Used as stain- and grease-proof coatings on food packaging and household products. Also a breakdown product of larger PFAS.	
PFOA	13.5	Used in industrial and household applications. Was banned in Canada in 2012 and added to the *List of Toxic Substances* in 2013. (Health Canada, 2012) Also a breakdown product of larger PFAS.	
PFOS	9.5	Used primarily as a dirt-, oil-, water-repellant in papers and fabrics, as well as in fire fighting foams. Voluntarily phased-out globally in 2000. Added to the *List of Toxic Substances* in 2006.	
PFBA	9.4	Commonly used in non-stick and stain-resistant consumer products, food packaging, fire-fighting foam, and industrial processes.	
PFHxS	3.9	Used as surfactant and protective coating in applications such as aqueous firefighting foams, textile coating, metal plating and in polishing agents.	

Perfluoropentanoic acid (PFPeA), perfluorohexanoic acid (PFHxA) and perfluorooctanoic acid were the three pFAS with the highest concentrations in the Hartland water samples.

Conclusions

- PFAS concentrations were ranked as follows from highest to lowest: Hatland > stream and river > marine > road runoff > source > tap.
- Total PFAS levels in all water samples collected from the Tod Creek watershed ranged from 0.99 to 75.4 ng/L.

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- PFAS concentrations were in the lower range of PFAS levels (0 - 138 ng/L) reported for 29 ambient surface freshwater sites across Canada between 2013 and 2020 (ECCC and Health Canada, 2023).
- Although the Hartland water sample had the highest PFAS concentration (75.4 ng/L) when compared to other Tod Creek samples, it was lower than total PFAS (320 - 9,400 ng/L) measured in leachate at 12 large landfills across Canada between 2009 and 2011 (Gewurtz et al., 2013, Government of Canada, 2013).
- All water samples were below the available EQGs (PFOS: Federal Environmental Quality Guideline (FEQG) = 6.8 ug/L; BC Working Water Quality Guideline (WWGG) = 3.4 ug/L; PFOA: US EPA guideline for chronic exposure: 94 ug/L).
- The total PFAS concentration detected in the tap water sample was below the new Health Canada Drinking Water Quality Objective of 30 ng/L for the sum of 25 different PFAS compounds.
- PFOSA was the only PFAS detected in tap water and there were no DWGs available.

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Polychlorinated Biphenyls (PCBs)

Capsule

Despite having been targeted for phase out in Canada in 1977, with some closed uses allowed until December 31, 2029, industrial PCBs continue to be found in the environment, reflecting their stability and persistence. PCBs were detected in all six water samples, with the highest concentration observed in the Hartland sample and the lowest in the source sample. The tap water sample had the 'lightest' PCB signature with the 'heaviest' reported for the road runoff, marine and Hartland samples. The marine and landfill water samples exceeded the Water Quality Guideline (WQG) for the protection of aquatic life for total PCBs.

Introduction

Polychlorinated biphenyls (PCBs) comprise 209 congeners that are structurally related but have differing degrees of chlorination. The commercial production of PCBs began in 1929, after which they were heavily used in electrical and hydraulic equipment, as well as in paint additives, sealing and caulking compounds and inks. Due to their adverse health effects, the production of PCBs was banned in the late 1970s around the world (Othman et al., 2022). PCBs are among the first 12 Persistent Organic Pollutants (POPs) - often referred to as the "dirty dozen" - defined by the Stockholm Convention, an international treaty aimed at eliminating or restricting the production and use of POPs (UNEP, 2025).

PCBs were never produced in Canada, but were widely used, and are currently specified on the List of Toxic Substances under the Canadian Environmental Protection Act (ECCC 2010). Despite restrictions beginning in 1977, PCBs continue to pose a threat due to their persistence in the environment and their release from products that were manufactured before the ban, and/or were improperly disposed of (Othman et al., 2022). Closed use applications in the electricity generation sector may continue in Canada until final phase out in December 2029 (ECCC 2023) . Military uses of PCBs may continue thereafter.

In British Columbia (BC), PCBs remain the number one contaminant of concern in marine food webs with the iconic killer whales being among some of the most-PCB contaminated marine mammals in the world (Ross et al., 2000). Regulatory steps in the 1970s and since have led to declining PCB concentrations in aquatic animals in BC (Ross et al., 2013).

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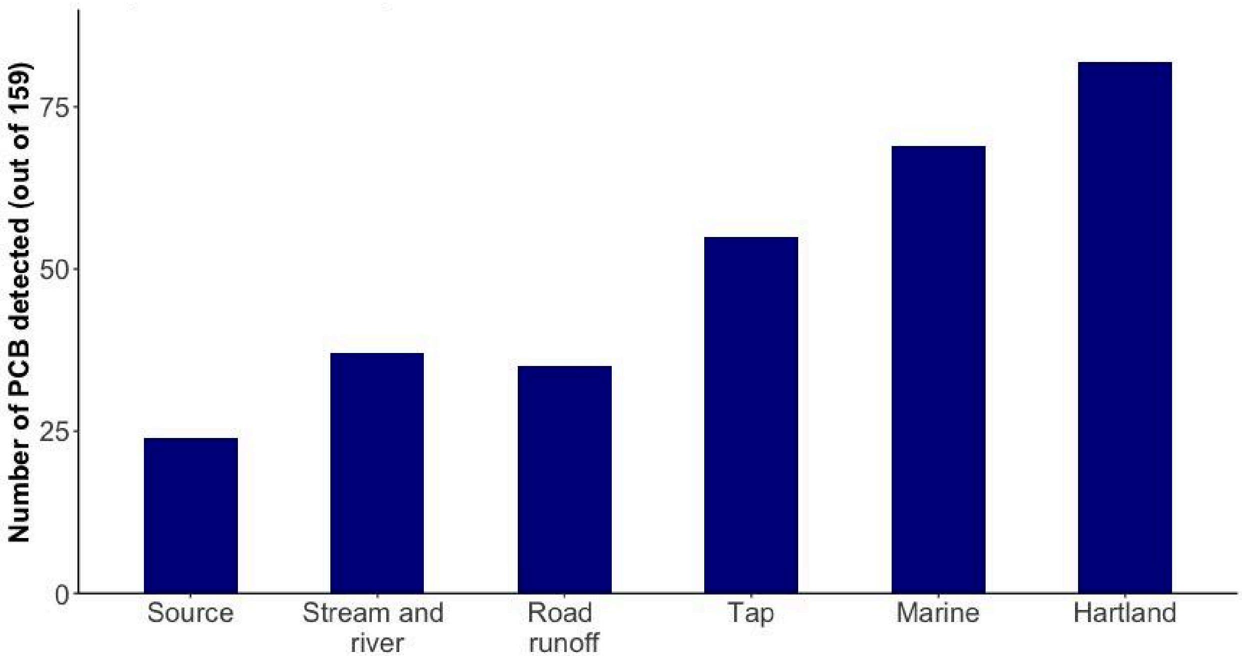
Results

We measured 159 out of a total 209 PCB congeners in the six water samples collected within the Tod Creek watershed during the wet season. Concentrations of the top six PCBs detected in the six water samples collected from the Tod Creek watershed can be found in Appendix 5.

Figure 14: Number of PCB detections in water sampled from the Tod Creek watershed (WET Season 2024)



PCBs were detected in all six water categories. The number of PCBs detected ranged from 24 (source) to 82 (Hartland) with an average of 50.3 ± 9.1.

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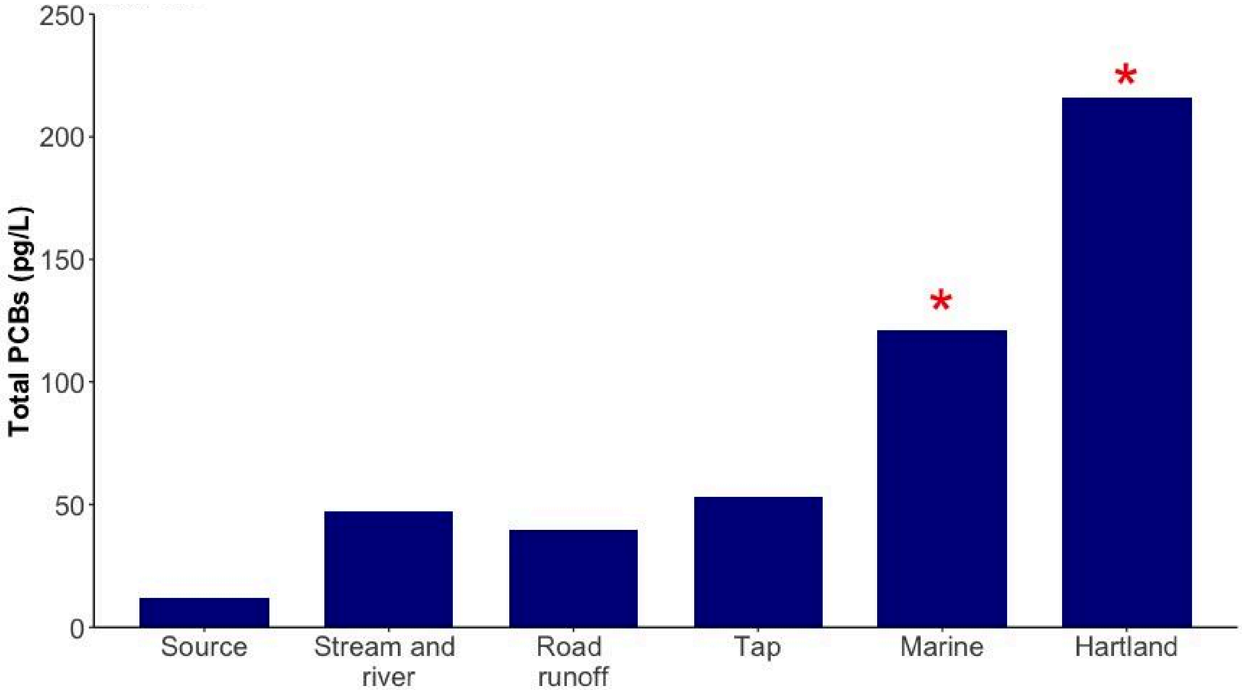
Figure 15: Total PCB concentrations in water sampled from the Tod Creek watershed (WET Season 2024)



Total PCB levels ranged from 12.0 (source) to 216 pg/L (Hartland), with an average across all water categories of 81.6 ± 30.6 pg/L. (* indicates that the marine and landfill samples exceeded the BC WQG of 100 pg/L).

The 209 individual PCBs have different degrees of chlorination, with each individual PCB containing between 1 and 10 chlorine atoms in their structure. PCBs can be categorized by their degree of chlorination into homologue groups. For example, all PCBs with one chlorine will fall into the mono-chlorinated homologue group and all PCBs with five chlorines will fall into the penta-chlorinated PCBs. In general, the more chlorines bound to a biphenyl ring, the ‘heavier’ the PCB molecule is. Heavier PCBs tend to not travel far from their sources, whereas lighter PCBs are more volatile and can undergo long-range transport. PCBs are strongly lipophilic - fat-soluble - such that they have a tendency to bind to organic particles and fatty tissues, rather than dissolve in water.

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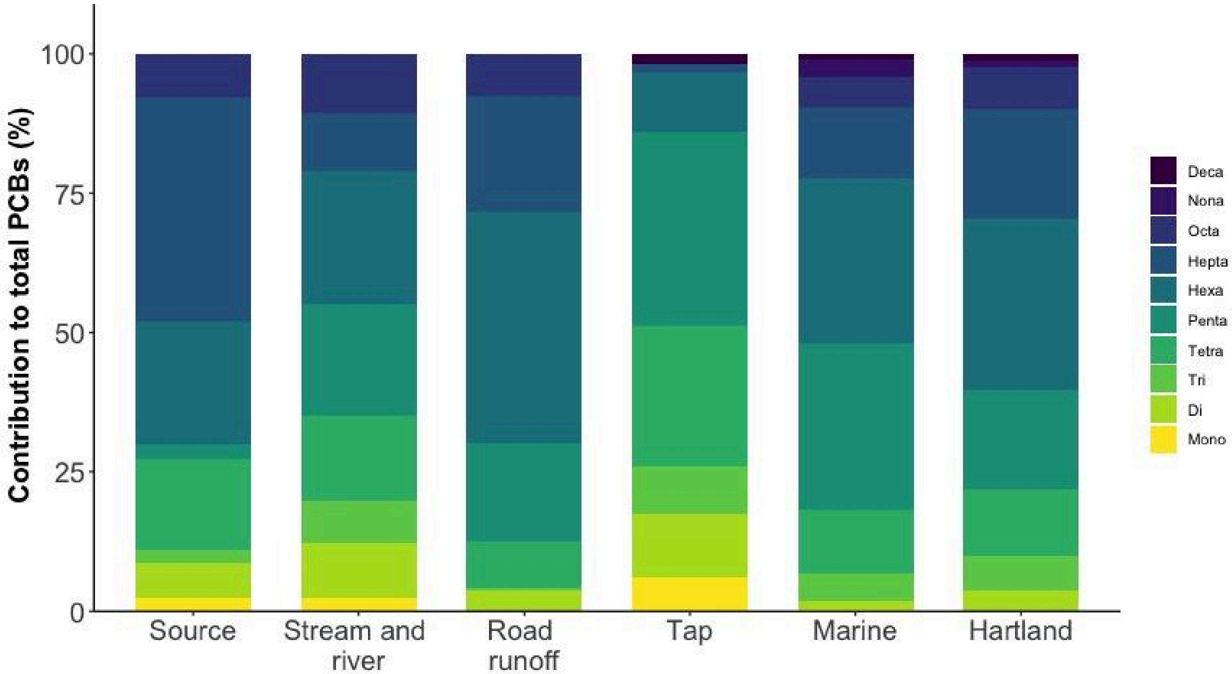
Figure 16: Homologue group contribution to total PCBs in water sampled from the Tod Creek watershed (WET Season 2024)



The lighter colours represent 'lighter' PCB homologue groups, such that the tap water sample had the 'lightest' PCB signature while the road runoff, marine and Hartland samples had the 'heaviest' PCB signatures. The source and stream and river samples had similar homologue group signatures.

Conclusions

- PCB concentrations were ranked as follows from highest to lowest: Hartland > marine > tap > stream and river > road runoff > source.
- PCB concentrations ranged from 12.0 to 216 pg/L. In a recent study of urban-influenced and background stream and rivers samples collected in the northwestern part of Lake Ontario, Zhang et al. (2020) identified PCBs as the dominant compound class measured with levels ranging from 10 pg/L in remote areas to 4,100 pg/L in urban areas.
- The PCB levels reported here were in the range reported northwest of Lake Ontario. In their study of air samples in coastal British Columbia, Noël et al. (2004) also observed uniform background levels for this legacy compound.
- Water Quality Guidelines were available for four individual PCBs (PCB-77, -105, -126 and -169), as well as total PCBs.

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- There were no exceedances for any of the individual PCBs.
- The Hartland water sample and marine sample exceeded the WQG for the protection of aquatic life for total PCBs (100 pg/L).
- There are no guidelines for PCBs in drinking water in Canada. The US Environmental Protection Agency's enforceable Maximum Contaminant Level (MCL) for PCBs in public water systems is 500,000 pg/L (EPA, 2001), well above the 53.2 pg/L reported in the current tap water sample.

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Alkylphenol Ethoxylates

Capsule

Alkylphenol ethoxylates (APEs) are industrial grade surfactants that have been found in wastewater and industrial discharges. APEs were detected in all samples except the road runoff and Hartland samples. Only 4-n-Octylphenol was detected.

Introduction

Alkylphenol ethoxylates are non-ionic surfactants used in industrial and consumer applications. APEs and their breakdown products are considered estrogenic and can disrupt reproductive development in fish. These surfactants can be released into the environment via municipal and industrial discharges (Lalonde et al., 2021). Once released, APEs may reside in aquatic sediments and/or undergo some breakdown into shorter chain APEs; their half-life is estimated at over 60 years (Shang et al., 1999).

The endocrine-disrupting potential of APEs and their breakdown products in fish and wildlife has represented a concern in receiving waters around municipal wastewater treatment plants (La Guardia et al., 2001).

Results

Table 15: Alkylphenol concentration (ng/L) for six water samples from the Tod Creek watershed (WET Season 2024)

Analyte	**Source** (n=1)	**Stream and river** (n=1)	**Road runoff** (n=1)	**Tap** (n=1)	**Marine** (n=1)	**Hartland** (n=1)
4-Nonylphenols	<1.2	<0.39	<0.59	<0.45	<1.8	<2.5
4-Nonylphenol monoethoxylates	<0.97	<0.85	<1.4	<2.1	<0.93	<3.6
4-Nonylphenol diethoxylates	<2.9	<0.62	<1.3	<1.1	<0.64	<12.4
4-n-Octylphenol	2.2	1.3	<0.58	0.37	0.95	<0.59
Total Alkylphenols	*2.2*	*1.3*	*0*	*0.37*	*0.95*	*0*

4-n-Octylphenol was detected in all samples except the road runoff and Hartland samples..

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Conclusions

- Total APE concentration for the six water samples in the Tod Creek watershed was ranked from highest to lowest as follows: source > stream and river > marine > tap > road runoff = Hartland.
- The concentrations are well below the long-term CCME guideline for the protection of freshwater aquatic life for nonylphenol and its ethoxylates of 1,000 ng/L (calculated as Toxic Equivalency).
- There are no Health Canada Drinking Water Guidelines for APEs.
- APE levels were all low relative to the Detection Limit at the lab.

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Bisphenols

Capsule

Bisphenols are plastic additives with widely reported estrogenic (endocrine disrupting) properties. We detected Bisphenol A (BPA) and S (BPS) in one of the six samples collected from the Tod Creek watershed (source and tap, respectively) and bisphenol F in two samples (stream and river, road runoff). The highest BP concentration was detected in the road runoff sample.

Introduction

Bisphenols are used widely in the manufacturing sector, and are primarily used in the production of plastics and resins. Both single and multi-use plastic containers are frequently produced using bisphenol compounds, the most popular of which is Bisphenol A (BPA). Bisphenols are endocrine-disrupting chemicals that have been found to negatively impact reproductive development in fish, amphibians, and mammals (Faheem and Bhandari, 2021; Marlatt, *et al.* (2022)).

BPA has come under intense regulatory scrutiny in recent years. The widespread use of these chemicals in food packaging, beverage containers, and in water delivery systems has led to exposure in the general population, and associations with adverse outcomes in humans (Rochester 2013).

Results

Table 16: Concentration (ng/L) of bisphenols in six water samples from the Tod Creek watershed (WET Season 2024)

Analyte	**Source** (n=1)	**Stream and river** (n=1)	**Road runoff** (n=1)	**Tap** (n=1)	**Marine** (n=1)	**Hartland** (n=1)
Bisphenol E (BPE)	<4.9	<4.9	<4.6	<4.9	<4.9	<4.9
Bisphenol F (BPF)	<4.9	5.9	14.3	<4.9	<4.9	<4.9
Bisphenol A (BPA)	12.2	<2.0	<1.8	<2.0	<2.0	<2.0
Bisphenol AF (BPAF)	<1.9	<2.0	<1.8	<2.0	<2.0	<2.0

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Bisphenol B (BPB)	<1.9	<2.0	<1.8	<2.0	<2.0	<2.0
Bisphenol S (BPS)	<1.2	<1.2	<1.2	1.3	<1.2	<1.2
Total bisphenols	*12.2*	*5.9*	*14.3*	*1.3*	*0*	*0*

Conclusions

- Bisphenol concentrations in water samples from highest to lowest are as follows: road runoff > source > stream and river > tap > marine = Hartland.
- Bisphenol F was detected in two samples (stream and river and road runoff) while bisphenol A (source) and bisphenol S (tap) were only detected in one sample.
- There is currently no Guideline for Bisphenol S in drinking water from Health Canada.
- A FEQG for BPA is set at 3.5 ug/L (3500 ng/L), which is much higher than the concentration we measured in the source water sample (12.2 ng/L).

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Sucralose

Capsule

Sucralose is a popular artificial sweetener (trade name '*Splenda*') used in foods and beverages. Because it survives the wastewater treatment process, sucralose has become a useful tracer of domestic wastewater. Sucralose was detected in five out of six water samples collected within the Tod Creek watershed, indicating a possible influx of human wastewater from septic or sewage networks. It was detected at the highest concentration in the road runoff sample, followed by the stream and river sample.

Introduction

Sucralose (*Splenda*) is an artificial sweetener used in the production of sugar-free food and beverage products. Its consumer popularity, and its resistance to breakdown during the wastewater treatment process, have led to its adoption as a useful tracer of human wastewater infiltration.

Sucralose is not fully metabolized by the human body following consumption, and is not removed during the wastewater treatment process. Therefore, its detection in environmental samples indicates the presence of treated or untreated sewage.

Results

Table 17: Sucralose concentration (ng/L) in six categories of water from the Tod Creek watershed (WET Season 2024)

Analyte	Source	Stream and river	Road runoff	Tap	Marine	Hartland
Sucralose (ng/L)	31.4	236	353	<17.5	114	87.7

Sucralose was detected in the highest concentration in the road runoff sample. The second highest concentration was detected in the stream and river sample.

Conclusions

- Sucralose concentrations in water samples from highest to lowest are as follows: road runoff > stream and river > marine > Hartland > source > tap.
- The highest concentration of the artificial sweetener sucralose was detected in the road runoff sample, possibly indicative of residential septic seepage or failures in the area.

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- There are no current Canadian Environmental Quality Guidelines available for sucralose.
- There are no current Health Canada Drinking Water Guidelines available for sucralose.

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6PPD-Quinone

Capsule

The breakdown product of a UV-stabilizing chemical in vehicle tires (6PPD-Quinone) has been associated with significant and repeated instances of coho salmon mortality events in Washington State and in British Columbia. The Hartland sample had the highest 6-PPD-Quinone concentrations and the marine sample had the lowest. None of the samples exceeded the newly developed BC guideline of 10 ng/L.

Introduction

6PPD is an anti-ozonant chemical that is added to automotive tire rubber during the manufacturing process in order to extend the life of tires. When 6PPD comes into contact with air, it oxidizes and becomes 6PPD-quinone - a transformation product that in recent years was discovered to be lethal to Coho salmon (*Onchorhynchus kitsutch*) at low concentrations (Tian et al., 2021). It is the causative agent of what has been deemed Urban Runoff Mortality Syndrome (URMS) - which has seen mortality rates of up to 90 percent. Research is being conducted to assess the risk to other fish species.

Results

Table 18: 6PPD-quinone concentration (ng/L) in six categories of water from the Tod Creek watershed

Analyte	**Source** (n=1)	**Stream and river** (n=1)	**Road runoff** (n=1)	**Tap** (n=1)	**Marine** (n=1)	**Hartland** (n=1)
6PPD-q (ng/L)	0.12	<0.15	0.24	na	0.09	1.31

Low levels of 6PPD-Quinone were detected in water samples from the Tod Creek watershed.

Conclusions

- 6PPD-quinone concentrations in water samples from highest to lowest are as follows: Hartland > road runoff > source > marine >stream and river.
- The BC Ministry of Water, Land and Resource Stewardship released an official short-term acute Water Quality Guideline (WQG) of 0.010 μg/L (10 ng/L) in February 2025. All samples were below this guideline.

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- There are no current Health Canada Drinking Water Guidelines available for 6PPD quinone.

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Wet season water quality summary

This report encapsulates the third in a series of seasonal water quality reports in the Tod Creek watershed, with samples collected in the wet season (2024-25). Sampling comprised pooled samples from six water categories: source water, stream & river water, road runoff, tap water, marine water and Hartland drainage water. Each report represents a stand alone data report for the season in question, with supporting interpretations providing insight into the activities contributing to degraded water quality in Tod Creek.

Results suggest that Tod Creek waters were in moderate condition during the wet season of 2024, with indications of degraded fish habitat in Tod Creek proper. This included detected inputs of pharmaceuticals, nutrients, PCBs, PFAS and other contaminants of concern into the watershed. Hartland drainage samples had high levels of PCBs, PFAS and other contaminants of concern, but the flows were minimal at the time of sample collection.

Collectively, these findings will provide an integrated evaluation of the contaminants, activities and sectors that are influencing water quality in the Tod Creek watershed. This may, in turn, provide guidance on mitigation, stewardship and restoration initiatives that protect and restore fish habitat throughout the Tod Creek watershed.

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List of acronyms

Abbreviation	Meaning
APE	Alkylphenol ethoxylates
BC EMA	British Columbia Environmental Management Act
CCME	Canadian Council of Ministers of the Environment
CEC	Contaminants of Emerging Concern
CEPA	Canadian Environmental Protection Act
CUP	Current-use pesticide
DO	Dissolved oxygen
DRIPA	Declaration on the Rights of Indigenous Peoples Act
ECCC	Environment and Climate Change Canada
MOE	Ministry of Environment
MST	Microbial Source Tracking
NP	Nonylphenol
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PFAS	Polyfluoroalkyl substances
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
POP	Persistent organic pollutant
PPCP	Pharmaceutical and personal care products
PVC	Polyvinyl chloride

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TDS	Total dissolved solids
TOC	Total organic carbon
TSS	Total suspended solids
TWP	Tire wear particle
WQGs	Water Quality Guidelines
WQI	Water Quality Index
WWTP	Wastewater treatment plant

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Appendix

Appendix 1: Healthy Waters - Standard Operating Procedure (SOP) for water sample collection

Healthy Waters – Standard Operating Procedure (SOP) for water sample collection

Purpose: The collection of water samples for lab analysis is an important step in assessing the potential impacts to water quality in our partner watersheds. This Standard Operating Procedure (SOP) outlines the steps to collect water samples for lab submission and analyses in support of the Raincoast Healthy Waters program. This SOP should follow in situ measurements of water quality properties using a YSI ProDSS (detailed in *Healthy Waters – SOP for in situ determination of water properties*).

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Required Equipment

- Clean sampling wand
- Sampling bottles (suitably cleaned in advance and typically provided by service lab for a specific analysis)
- Labels with sample ID, date, sample custodian
- Large containers for pooling of samples (cleaning methodology detailed in *Healthy Waters – Bottle cleaning procedure*)
- Coolers
- Ice packs (frozen)
- Nitrile gloves
- Data sheets
- Pencils

Step 1: Record site details

Upon arrival at a sampling site, record the following on your Data Sheet:

Data Sheet Healthy Waters			
Date:			
Watershed:			
Weather:			
Air Temperature:			
Name (recorder):			
Name (YSI):			
Name (others):			
Site Name:		**Dominant vegetation (circle):**	**Riparian Zone (circle):**
Time Sampled:		conifers	natural
GPS Location:		hardwood trees	disturbed - agriculture
Water Source Type:	source streams/rivers road runoff marine tap	shrubs/grasses	disturbed- forestry
Width (Stream/River):		agricultural	disturbed - roadway
Depth:		other:	other:

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Step 2: Describe riparian zone

Circle the site characteristics for the surrounding vegetation and riparian zone under "Dominant Vegetation" and "Riparian Zone". If none of the labels apply, circle "other" and describe the conditions.

Step 3: Record sample IDs

Record the sample ID for each on the datasheet in the space provided, using the following format:

XXX-MMDD-##(a)

XXX - a three-letter code specific to the watershed.

MMDD- record the four digit month and year.

- Sample number (1-5 (5 buckets)) 01 = source water; 02 = freshwater; 03 = road runoff; 04 = tap; 05 = marine) - Where discrete samples are being submitted for each individual site, use a letter (e.g. a,b,c,d) to differentiate samples. Where necessary, additional water categories can be included by adding additional numbers.

Step 4: Collect the water samples

Using a sampling wand with attached 600ml cup, reach out towards the middle of the body of water to be sampled and fill the cup with a shallow scoop of water. Rinse twice in this way, without disturbing sediments. Continue by collecting water in approximately the same location until all sampling containers are full. The person responsible for opening and closing bottles should wear a pair of nitrile gloves. If sampling from inside a boat, sample as far away from the boat's engine as possible - turning it off when possible to reduce the risk of sample contamination.

For tap/well water

1. Turn the tap on and allow water to run for 3 seconds.
2. Fill a clean sample bottle with tap water till approximately ¼ full and stop filling.
3. Allow tap to run for an additional 3 seconds.

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4. Repeat until the sampling container is full.

For pooled samples

Use a 4L amber glass bottle to collect samples from each of the sites to be pooled (volume per site to depend on the number of sites being sampled) in most cases, fill each of four large pooling containers 1/3 at each of three sampling sites to ensure that there is enough total volume (minimum of 10L for all analytes) to subdivide into lab bottles.

Once sample collection is complete, pooled samples should be aliquoted into lab bottles for submission, carefully using nitrile gloves to avoid contamination of samples.

Samples should be placed into a cooler containing ice packs as quickly as possible - as many parameters require the sample to be kept at a temperature of 4°C prior to analysis.

Sample bottles must be returned to the correct partner lab within required holding times (see Lab holding times). Tier 2 analytes to be analyzed at ALS Environmental, Tier 3 analytes to be analyzed at SGS Axys Analytical Labs.

Completed datasheets

Confirm that field datasheets have been completed and make a backup copy using a phone camera or scanner. Upload completed datasheets to the Watershed partnership folder on the Raincoast Google Drive.

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Lab-specific holding times (in water)

Tier 2 - ALS Environmental

Coliform: 24-30 hours

BOD/COD: 3 days

TSS/TDS: 7 days

Nutrients: 28 days

TOC: 28 days

Metals: 180 days

Tier 3 - SGS Axys Analytical

PAHs: 7 days (unpreserved - 14 days if preserved with sodium azide)

PPCPs (including sucralose and BPAs): 7 days

A/Ps: 14 days (unpreserved)

MRES Pesticides: not defined

PFAS: 90 days

PCBs: 1 year

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References

Canadian Council of Ministers of the Environment (2011) procedures Manual for Water Quality Sampling in Canada
https://beta-static.fishersci.com/content/dam/fishersci/en_CA/documents/brochures-and-catalogs/catalogs/ccme-procedures-manual-water-quality-sampling.pdf

Government of the Northwest Territories. NWT-Wide Community-Based Water Quality Monitoring Program- procedures for Collecting Water Quality Samples.
https://nwtdiscoveryportal.enr.gov.nt.ca/geoportaldocuments/FINAL%20CBM%20procedures%20for%20Collecting%20Water%20Quality%20Samples.pdf

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Appendix 2: Healthy Waters - Standard Operating Procedure for for in situ determination of basic water properties

Healthy Waters – Standard Operating Procedure (SOP) for in situ determination of basic water properties

Purpose: The use of handheld instruments to determine basic water properties is the first step to understanding fish habitat and the threats to its quality. This Standard Operating Procedure (SOP) outlines the steps to deploying a YSI ProDSS meter during water sampling events in support of the Raincoast Healthy Waters program. This SOP represents a necessary first step when one is collecting samples for later analysis in dedicated laboratories (detailed in ***Healthy Waters – Water sample collection SOP***).

*Calibrate the YSI ProDSS 24 hours prior to the sampling date

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Required Equipment

- YSI ProDSS (or other water quality meter capable of measuring parameters)
- Nitrile gloves
- Clean bucket
- Data sheets
- Pencils

Step 1: Record site details

Upon arrival at a sampling site, record the following on your Data Sheet:

Data Sheet Healthy Waters			
Date:			
Watershed:			
Weather:			
Air Temperature:			
Name (recorder):			
Name (YSI):			
Name (others):			
Site Name:		**Dominant vegetation (circle):**	**Riparian Zone (circle):**
Time Sampled:		conifers	natural
GPS Location:		hardwood trees	disturbed - agriculture
Water Source Type:	source streams/rivers road runoff marine tap	shrubs/grasses	disturbed- forestry
Width (Stream/River):		agricultural	disturbed - roadway
Depth:		other:	other:

Step 2: Describe riparian zone

Circle the site characteristics for the surrounding vegetation and riparian zone under "Dominant Vegetation" and "Riparian Zone". If none of the labels apply, circle "other" and describe the conditions.

Step 3a: Measure Tier 1 water properties at the site

To take a measurement with the YSI ProDSS directly in a body of water (ie. stream, pond, ditch, river etc.) perform the following procedure:

1. Review instrument manual (YSI (Revision H) *ProDIGITAL User Manual*. Xylem, Inc.).

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10. Confirm that all data have been recorded on the data sheet and then make a copy for safekeeping (take a picture with phone camera or scan).

11. Upload field data sheets to Watershed partner folder on Raincoast Google Drive.

Step 3b: Measure Tier 1 water properties ex situ

To take a measurement with the YSI ProDSS where the probe cannot be submerged in the water (ie. municipal manhole access, well-water, tap water, small stream etc.) perform the following procedure:

1. Take a water sample from the desired water source using a clean bucket (if bucket has been used for previous water samples rinse three times with water from a new site before taking YSI measurements)

   For Tap/Well Water:

   - Turn the tap on and allow water to run for 3 seconds.
   - Fill clean bucket with tap water till approximately ¼ full and stop filling.
   - Allow tap to run for an additional 3 seconds.
   - Repeat until the bucket is full.

2. Turn the YSI ProDSS on.

3. Remove the light blue – protective calibration cup from the device by unscrewing it. Make sure to leave the black probe guard covering the sensors ON while sampling.

4. Rinse the YSI ProDSS probes with a small amount of sample water.

5. Submerge the YSI probe guard in the collected sample water – ensuring that all probes are fully submerged.

6. Allow the parameters to stabilize for approximately 1 minute – parameters are considered "stable" when there is no change in each value for 30 seconds. Gently stir the probe continuously while the values stabilize to ensure an accurate DO reading.

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7. Once the parameters stabilize, record the following parameters in the Healthy Waters datasheet provided:

   - Temperature (°C)
   - pH
   - DO (both mg/L and %DO)
   - Turbidity (FNU)
   - Specific conductance (uS/cm)

8. Remove the probe from the water. Rinse probes and probe guard thoroughly with clean water, and replace the calibration cup. Always ensure that there is a small amount of clean water in the calibration cup to prevent the sensors from drying out.

9. Confirm that all data have been recorded on the data sheet and then make a copy for safekeeping (take a picture with phone camera or scan).

10. Upload field data sheets to Watershed partner folder on Raincoast Google Drive.

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References

YSI (Revision H) ProDIGITAL User Manual. Xylem, Inc. Accessed 25/07/23.
<https://www.ysi.com/file%20library/documents/manuals/prodigital-user-manual-english.pdf>

Canadian Council of Ministers of the Environment (2011) procedures Manual for Water Quality Sampling in Canada
https://beta-static.fishersci.com/content/dam/fishersci/en_CA/documents/brochures-and-catalogs/catalogs/ccme-procedures-manual-water-quality-sampling.pdf

Government of the Northwest Territories. NWT-Wide Community-Based Water Quality Monitoring Program- procedures for Collecting Water Quality Samples.
https://nwtdiscoveryportal.enr.gov.nt.ca/geoportaldocuments/FINAL%20CBM%20procedures%20for%20Collecting%20Water%20Quality%20Samples.pdf

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Appendix 3: Environmental and Drinking water quality guidelines relevant for the present study. These guidelines were retrieved in January 2025

Analyte Class	Federal EQGs[1]	BC WQGs		CCME EQGs[2]		Drinking WQGs[6]
		Freshwater	Marine	Freshwater	Marine	
Basic Water Properties						
Temperature	-	19 (short-term)	+1°C per hour change from background	narrative	max change of +0.5°C per hour	-
pH	-	6.5-9.0	7.0-8.7	6.5-9.0	7.0-8.7	7.0-10.5
Dissolved oxygen	-	>8.0 (long-term) >5.0 (short-term)	-	6.5-9.5 mg/L	80 mg/L	-
Conductivity	-	-	-	-	-	-
Turbidity	-	-	-	narrative	narrative	≤ 1.0 NTU
Nutrients (mg/L)						
Nitrate (as N)	-	3.0 (long-term) 32.8 (short-term)	3.7 (long-term)	550	200 (long-term) 1500 (short-term)	10
Nitrite (as N)	-	table	0.02 when Cl- ≤ 2 (long-term) 0.06 when Cl- ≤ 2 - (short-term)	0.06	-	1.0
Ammonia (Total as N)	-	table	table	table	-	-
Phosphate	-	0.015 (long-term)	-	-	-	-
Coliform						
Total coliform	-	-	-	-	-	0
Fecal coliform	-	-	-	-	-	0
E. coli	-	-	-	-	-	0
PAHs (ug/L)						
Naphthalene	-	1	-	1.1	1.4	-
Acenaphthene	-	6	6	5.8	-	-
Fluorene	-	12	12	3	-	-
Anthracene	-	4	-	0.012	-	-
Phenanthrene	-	0.3	-	4.4	-	-

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Fluoranthene	-	4	-	0.04	-	-
Pyrene	-	0.02	-	0.025	-	-
Chrysene	-	-	0.1	-	-	-
Benzo-a-anthracene	-	0.1	-	0.018	-	-
Benzo-a-pyrene	-	0.01	-	0.015	-	0.04
PCBs (ng/L)						
Total PCBs	-	0.1	-	-	-	-
PCB-105	-	0.09	-	-	-	-
PCB-169	-	0.06	-	-	-	-
PCB-77	-	0.04	-	-	-	-
PCB-126	-	0.00025	-	-	-	-
Bisphenols (ug/L)						
BPA	3.5	3.5	-	-	-	-
Alkylphenols (ug/L)						
TEQ[5]	-	1 (long-term)	-	1	0.7	-
PFAS (ug/L)						
Perfluorooctane Sulfonate (PFOS)	6.8 (fresh)	3.4	-	-	-	0.6
Perfluorooctanic acid (PFOA)	-	-	-	-	-	0.2
Pesticides (ug/L)						
Atrazine	-	1.8[5]	-	1.8	-	5
Chlorothalonil	-	-	-	0.18	-	-
Cyanazine	-	2	-	-	-	-
Chlorpyrifos	-	0.02	0.002	-	-	90
Diazinon	-	0.0043	-	-	-	-
Dimethoate	-	-	-	6.2	-	20
Endosulfan	-	0.03 (short-term) 0.0015 (long-term)	0.015 (short-term) 0.001 (long-term)	0.06 (short-term) 0.003 (long-term)	0.09 (short-term) 0.002 (long-term)	-
Hexachlorocyclohexane	-	-	-	0.01	-	-
Malathion	-	0.1	-	-	-	290
Metolachlor	-	-	-	7.8	-	-
Metribuzin	-	1[5]	-	1.0	-	80
Permethrin	-	0.004[5]	-	0.004	0.001	-
Picloram	-	29	-	-	-	-
Simazine	-	10[5]	-	10	-	10

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Pharmaceuticals (ug/L)						
Carbamazepine	-	-	-	10	-	-
Triclocarban	0.150	0.05	-	-	-	-
Triclosan	0.470 (benchmark)	-	-	-	-	-
6PPD quinone (ug/L)						
6PPDq	-	0.010	-	-	-	-

[1]Federal EQGs apply to both fresh and marine waters unless otherwise stated. [2]CCME EQGs are reported for long-term effects unless otherwise stated.[3] Some metal guidelines are based on complex formulas that take into account chemical parameters which can be found on the CCME or Government of BC website). [4] Represents CCME guidelines that the BC government has adopted as working water guidelines. [5] The TEQ approach is used to characterize the toxicity of nonylphenol mixtures by expressing the toxicities of each individual compound in common terms and summing them. [6] Drinking Water Quality Guidelines from Health Canada.

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Appendix 4: Federal, CCME, Health Canada, and BC environmental and water quality guidelines for metals (mg/L) analyzed in this study. These guidelines were retrieved in January 2025

Analyte Class	Federal EQGs[1]	BC WQGs		CCME EQGs		Health Canada
		Freshwater	Marine	Freshwater	Marine	
Aluminum[1]	Formula requires unavailable DOC value to calculate	Formula requires unavailable DOC value to calculate	-	**0.005 if pH < 6.5**	-	**2.9**
Arsenic	-	**0.005[2]**	**0.0125[2]**	**0.005**	**0.0125**	**0.01**
Barium	-	-	-	-	-	**2**
Boron	-	**1.2 (long-term)**	**1.2 (long-term)**	**1.5 (long-term)**	-	**5**
Cadmium	-	Dissolved metal guideline. Formula requires hardness to calculate	**0.00012**	**Hardness applied to formula to calculate exceedance**	**0.00012**	**0.007**
Chromium*		0.005 (Cr VI)	0.001 (Cr VI) 0.0089(Cr III)	0.0015 (Cr VI)	0.001 (Cr Vi) 0.0089(Cr III)	**0.05**
Copper	Dissolved metal guideline. Formula requires unavailable DOC, pH and hardness to calculate	Dissolved metal guideline. Formula requires unavailable DOC, pH and hardness to calculate	**0.002 (chronic) 0.003 (acute)**	**Hardness applied to formula to calculate exceedance**	-	**2**
Iron[1]	Formula requires unavailable DOC and pH to calculate	**1 (short-term, total iron)**	**-**	**0.3 (long-term)**	-	**<0.1 (aesthetic)**
Lead	Dissolved metal guideline. Formula requires unavailable DOC and hardness to calculate	Dissolved metal guideline. Formula requires unavailable DOC and hardness to calculate	**0.002 (over 30 days) <0.140 at all times**	**Hardness applied to formula to calculate exceedance**	-	**0.005**
Manganese*	-	Dissolved metal guideline. Formula requires	-	Dissolved metal guideline. Formula requires	-	**0.12**

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		pH and hardness to calculate		and hardness to calculate		
Methylmercury*	-	0.00002	0.00002	0.000026 (total Hg)	0.000016 (inorganic Hg)	**0.001**
Molybdenum	-	**7.6 (long-term) 46 (short term)**	-	**0.073**	0	**-**
Nickel	-	Dissolved metal guideline. Formula requires unavailable DOC, pH and hardness to calculate	-	**0.025 if Hardness <60 mg/L** **Formula using hardness for hardness 60 -80 mg/L** **0.150 for hardness >180** **Unknown hardness 0.025**	-	-
Selenium	**-**	**0.002**	**0.002 0.001 - water column alert - need to increase fish monitoring**	**0.001**	**0.001**	**0.05 0.01 (BC - water source)**
Silver	**-**	**0.00012**	**0.0005**	**0.00025**	**-**	**-**
Thallium	-	**0.0003**[3]	**-**	**0.0008**	-	-
Zinc*	-	Dissolved metal guideline. Formula requires unavailable DOC, pH and hardness to calculate	0.010[2]	Dissolved metal guideline. Formula requires unavailable DOC, pH and hardness to calculate	-	-

Bold indicates guidelines that were applied.*indicates that we were unable to compare with available EQGs because we did not measure the required analytes. [1] Indicates a formula that requires dissolved organic carbon (DOC) which we did not measure. Guideline values were therefore calculated using DOC set at 50%, 75% and 100% of measured total organic carbon (TOC)(See Appendix 5 and 6).[2] Represents CCME guidelines that the BC government has adopted as working water guidelines. [3] Represents a Working Water Quality Guideline, rather than an approved WQG. Federal EQGs apply to both fresh and marine waters unless otherwise stated. CCME EQGs are reported for long-term effects unless otherwise stated. Formulae for calculating guidelines can be found on the BC MoE website (https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-guidelines/approved-water-quality-guidelines, BC MWLRS 2026) and the CCME website (https://ccme.ca/en/resources/water-aquatic-life).

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Appendix 5: BC Aluminum (Al) Guideline calculations using different dissolved organic carbon estimates based on our measured total organic carbon (TOC)

Site	Measured Al (µg/L)	DOC-adjusted Guideline (50% of TOC) (µg/L)	DOC-adjusted Guideline (75% of TOC) (µg/L)	DOC-adjusted Guideline (100% of TOC) (µg/L)
Source	60.7	101.4	131.7	158.6
Stream & river	94.7	180.7	234.7	282.6
Road runoff*	418	**258.7**	**336.0**	**404.5**
Tap	8	-	-	-
Marine	623	-	-	-
Hartland*	1690	**244.1**	**317.0**	**381.6**

Bold indicates an exceeded calculated BC Water Quality Guideline (BC MWLRS 2026). We evaluated guideline exceedances under three scenarios: 50%, 75%, 100% of the TOC that was measured in each water sample to approximate a realistic range of possible DOC values, as we did not measure DOC (BC Ministry of Environment and Climate Change Strategy 1998). *We flag any CCME guideline when exceeded, or a BC Guideline with the above deliberations when at least two of the three TOC scenarios produce exceedances. There exists no marine guideline for aluminum in Canada, so this was not included in the calculation of total exceedances.

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Appendix 6: Federal Environmental Quality Guideline calculations for Iron (Fe) using different dissolved organic carbon estimates based on our measured total organic carbon (TOC)

Site	Measured Fe (µg/L)	DOC-adjusted Guideline (50% of TOC) (µg/L)	DOC-adjusted Guideline (75% of TOC) (µg/L)	DOC-adjusted Guideline (100% of TOC) (ug/L)
Source	309	380	480	600
Stream & river	244	400	500	620
Road runoff	419	500	670	800
Tap	36	-	-	-
Marine	620	-	-	-
Hartland*	3120	**430**	**590**	**680**

Bold indicates an exceeded calculated FEQG. It is important to note that the FEQG for iron is meant for use in fresh water, rather than in marine water (ECCC 2024). We evaluated guideline exceedances under three scenarios: 50%, 75%, 100% of the TOC that was measured in each water sample to approximate a realistic range of possible DOC values, as we did not measure DOC (BC Ministry of Environment and Climate Change Strategy 1998). *We flag any CCME guideline when exceeded, or a BC Guideline with the above deliberations when at least two of the three TOC scenarios produce exceedances. There exists no marine guideline for iron in Canada, so this was not included in the calculation of total exceedances.

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Appendix 7: Health Canada Screening values for nine different PFAS compounds

Compound Name	Acronym	Screening value (mg/L)	Screening value (ug/L)
perfluorobutanoate	PFBA	0.03	30
perfluorobutane sulfonate	PFBS	0.015	15
perfluorohexanesulfonate	PFHxS	0.0006	0.6
perfluoropentanoate	PFPeA	0.0002	0.2
perfluorohexanoate	PFHxA	0.0002	0.2
perfluoroheptanoate	PFHpA	0.0002	0.2
perfluorononanoate	PFNA	0.00002	0.02
6:2 fluorotelomer sulfonate	6:2 FTS	0.0002	0.2
8:2 fluorotelomer sulfonate	8:2 FTS	0.0002	0.2

Adapted from
https://www.canada.ca/en/services/health/publications/healthy-living/water-talk-drinking-water-screening-values-perfluoroalkylated-substances.html

Appendix 8: Top 6 PAHs with the highest concentrations in each water sample from the Tod Creek watersheds (WET Season)

Source	Stream and river	Road runoff	Tap	Marine	Hartland
Retene (6.0)	Naphthalene (2.2)	Naphthalene (1.6)	Phenanthrene (245)	C4-Phenanthrenes/Anthracenes (7.8)	Fluoranthene (6.5)
C4-Phenanthrenes/Anthracenes (5.1)	C1-Naphthalenes (1.1)	C1-Naphthalenes (1.1)	Naphthalene (231)	C2-Naphthalenes (5.7)	Naphthalene (5.2)
Naphthalene (1.2)	Phenanthrene (0.83)	1-Methylnaphthalene (0.66)	C1-Naphthalenes (84.7)	Phenanthrene (5.3)	Pyrene (4.9)
C1-Naphthalenes (1.0)	Acenaphthene (0.79)	C4-Phenanthrenes/Anthracenes (0.56)	Acenaphthene (80.0)	C3-Phenanthrenes/Anthracenes (5.2)	C4-Phenanthrenes/Anthracenes (4.1)

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	Phenanthrene (0.85)	1-Methylnaphthalene (0.72)	Phenanthrene (0.53)	Fluoranthene (50.6)	Fluoranthene (4.6)	C1-Fluoranthenes/Pyrenes (2.8)
	1-Methylnaphthalene (0.76)	Retene (0.65)	Retene (0.51)	2-Methylnaphthalene (49.8)	C1-Naphthalenes (4.5)	Retene (2.6)
Total concentrations of top 6 (% of total PAHs)	48.7 (68%)	6.3 (68%)	4.9 (56%)	1353 (74%)	33.2 (33%)	26.2 (54%)

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Appendix 9: The top six PCBs in each water category sampled in the Tod Creek watershed and their concentrations (WET Season)

	Source	Stream and river	Road runoff	Tap	Marine	Hartland
	PCB-180+193 (1.8)	PCB-152 (3.8)	PCB-153+168 (8.5)	PCB-52 (4.4)	PCB-153+168 (11.9)	PCB-153+168 (18.1)
	PCB-181 (1.8)	PCB-93+95+98+100+102 (3.4)	PCB-129+138+160+163 (4.3)	PCB-93+95+98+100+102 (3.8)	PCB-129+138+160+163 (9.8)	PCB-129+138+160+163 (17.3)
	PCB-153+168 (1.0)	PCB-197+200 (2.6)	PCB-180+193 (3.8)	PCB-11 (2.7)	PCB-118 (6.9)	PCB-180+193 (13.1)
	PCB-61+70+74+76 (0.97)	PCB-178 (2.6)	PCB-118 (2.6)	PCB-90+101+119 (2.4)	PCB-90+101+119 (5.5)	PCB-147+149 (8.7)
	PCB-187 (0.96)	PCB-194 (2.5)	PCB-187 (1.9)	PCB-118 (2.4)	PCB-180+193 (5.2)	PCB-187 (7.2)
	PCB-194 (0.93)	PCB-180+193 (2.4)	PCB-90+101+119 (1.7)	PCB-61+70+74+76 (2.3)	PCB-93+95+98+100+102 (4.5)	PCB-118 (6.9)
Total concentrations of top 6 (% contribution to total PCBs)	7.5 (63%)	17.1 (36%)	22.8 (57%)	17.9 (34%)	43.9 (36%)	71.3 (33%)

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Appendix 10: Total analyte concentrations in water sampled in the Tod Creek watersheds (WET Season)

	Source	Stream and river	Road runoff	Tap	Marine	Hartland
E. coli (MPN)	3	16	19	0	0	**110**
Nitrate (mg/L)	0.0088	0.1820	0.888	0.054	0.624	**5.28**
Metals (mg/L)	25.4	39.1	51.8	13.0	**2171.5**	193.6
Pesticides (ng/L)	0.45	**1.8**	1.7	0	1.3	1.4
PCBs (pg/L)	11.9	47.5	39.6	53.2	121.3	**215.8**
PAHs (ng/L)	17.1	9.2	8.7	**1055.6**	101.6	48.6
PPCPs (ng/L)	44.5	300.6	409.5	8.1	156.4	**340.5**
PFAS (ng/L)	10.9	14.2	11.5	0.99	13.5	**75.4**
APEs (ng/L)	**2.2**	1.3	0	0.37	0.95	0
bisphenols (ng/L)	12.2	5.9	**14.3**	1.3	0	0
Sucralose	31.4	236	**353**	0	114	87.7
6-PPDq (ng/L)	0.12	<0.15	0.24	na	0.09	1.31

Bold indicates the highest concentrations across water categories for each contaminant.

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