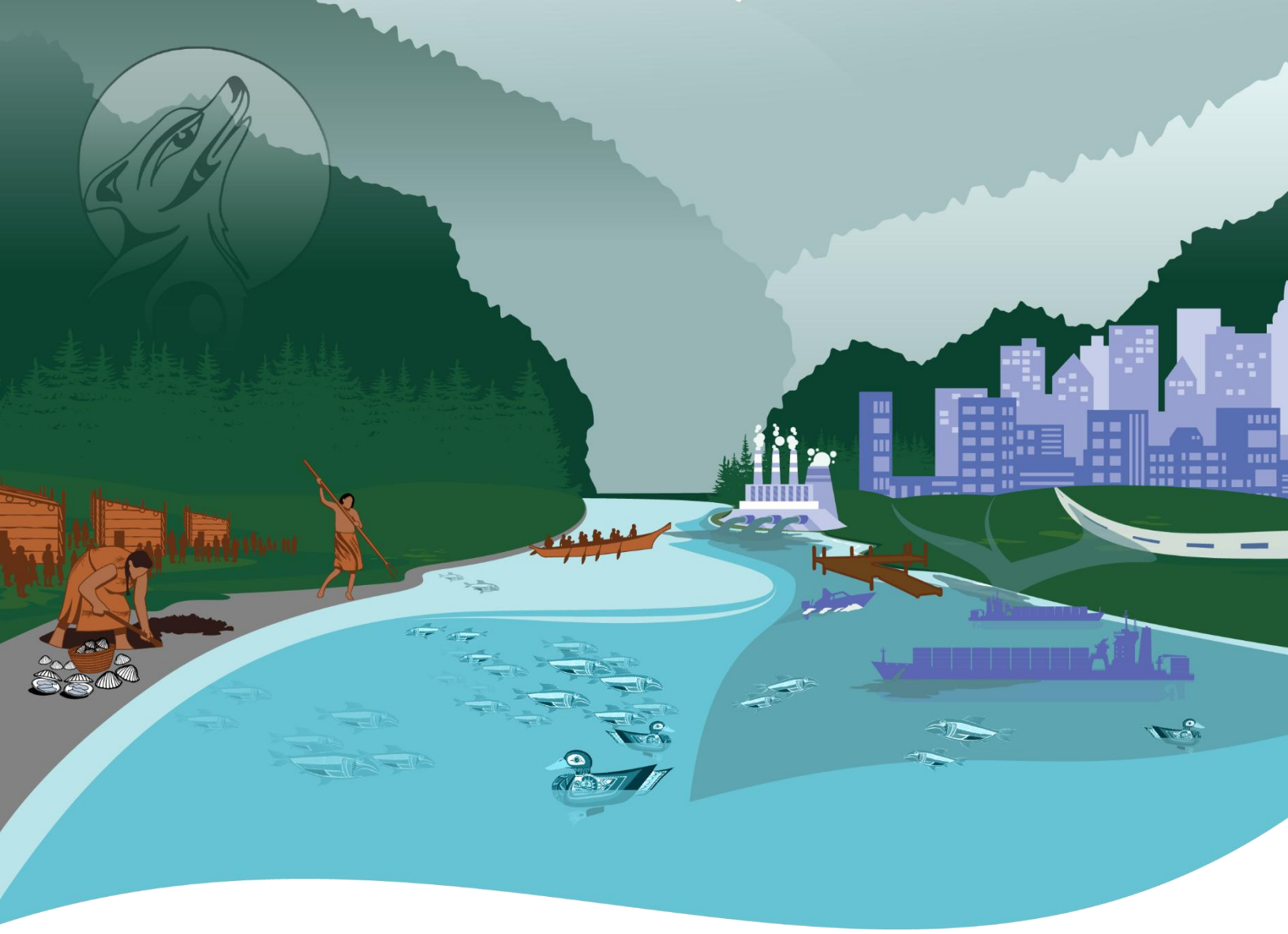

Technical Report

səlilwət Water Quality Report Series

Knowledge Gaps and Research Needs

Tsleil-Waututh Nation

səlilwətaɬ

This Report supplements the səlilwət / Burrard Inlet Water Quality Objectives, Burrard Inlet Action Plan and Cumulative Effects Management Initiative.

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SUMMARY

This report identifies critical knowledge gaps and research needs essential for achieving səlilwət / Burrard Inlet Water Quality Objectives (WQOs). These are derived from the səlilwət / Burrard Inlet Water Quality Assessment Technical Reports for priority contaminants, published by Tsleil-Waututh Nation (TWN) and the Province of British Columbia.

The report is organized into three key areas: contaminant source, transport, and fate; effects on human and aquatic receptors; and knowledge and data sharing. These are further divided into categories which are meant to streamline the process of identifying and addressing gaps relevant to practitioners and researchers (local research and broader research needs).

Specific research priorities include determining contaminant sources and transport pathways, monitoring toxins in fish and shellfish species preferred for human consumption, and understanding the effects of contaminants on human and aquatic life. The ultimate purpose of water quality monitoring and research should be to direct action towards improving water quality.

A significant challenge identified is the lack of consistent, comparable, and accessible data, which is crucial for understanding and addressing the inlet's environmental concerns. The report, therefore, also recommends improving data management and accessibility to support effective research and solutions for maintaining water quality within the proposed WQOs.

The report highlights the importance of səlilwət as a food source for Tsleil-Waututh people and the increasing pressures and associated impacts from population growth and industrialization.

CONTENTS

ACRONYMS

ATSDR	Agency for Toxic Substances and Disease Registry
BC	British Columbia
CECs	Contaminants of Emerging Concern
ENV	Ministry of Environment and Climate Change Strategy
GESAMP	Group of Experts on the Scientific Aspects of Marine Environmental Protection.
MPs	Microplastics
PAH	Polycyclic aromatic hydrocarbon
PCBs	Polychlorinated biphenyls
PCDDs	Polychlorinated dibenzodioxins
PCDFs	Polychlorinated dibenzofurans
PBDEs	Polybrominated diphenyl ethers
PFAS	Per- and polyfluoroalkyl substances
PPCPs	Pharmaceuticals and personal care products
TWN	Tsleil-Waututh Nation
USEPA	United States Environmental Protection Agency
WQOs	Water Quality Objectives

1. INTRODUCTION

> *Our creation story tells how our very first* ***səlilwətaɬ*** *grandmother was born out of these waters. Our Elders had a saying about Burrard Inlet: "when the tide went out, the table was set". But today, the general public sees the inlet as an urbanized industrial port and a wastewater dumping ground, not a place to harvest healthy, wild foods. We must fight to counter this viewpoint, protect our rights and culture, and persistently remind everyone that the inlet is our refrigerator, pantry and dinner table before it is an industrial port and urban waterway. – Tsleil-Waututh Nation*

Updating the səlilwət / Burrard Inlet Water Quality Objectives was identified as a priority action in Tsleil-Waututh Nation's Burrard Inlet Action Plan (TWN, 2017), as part of the ongoing work of Tsleil-Waututh Nation (TWN) to restore the health of səlilwət (Burrard Inlet), which has been severely impacted by colonial development (e.g. Efford *et al.*, 2025). As the People of the Inlet, TWN has a sacred obligation to steward səlilwət marine waters and the surrounding watershed. TWN is actively working to restore traditional food sources and ways of life. The rising human population and increased urbanization and industrialization around səlilwət continue to degrade water quality, for example due to the mobilization and transport of contaminants.

This report outlines knowledge gaps and research needs which, if addressed, could assist with the attainment of xaɬəmət ct tə səlilwət / Water Quality Objectives (WQOs) for səlilwət (Burrard Inlet). These knowledge gaps and research needs are adapted from those that have been proposed in the səlilwət (Burrard Inlet) Water Quality Assessment Technical Reports for priority contaminants (ENV and TWN, 2024). Predominant data gaps identified include a lack of information on contaminant sources and behaviour as well as a lack of adequate baseline data. Without this information, monitoring contaminants in səlilwət and determining appropriate future monitoring programs may use resources less efficiently and effectively.

The knowledge gaps and research recommendations discussed in the following sections could help direct the allocation of resources to where they are needed most. These were adapted from the priority contaminant technical reports[1], which include: physical parameters; contaminants of emerging concern (CECs); pesticides; metals (arsenic, mercury, cadmium, copper, lead, nickel and zinc); polychlorinated biphenyls (PCBs), dioxins (PCDDs) and furans (PCDFs); microbiological; pharmaceuticals and personal care products (PPCPs) and microplastics (MPs); and polybrominated diphenyl ethers (PBDEs) and polycyclic aromatic hydrocarbons (PAHs), among others.

These knowledge gaps and research recommendations are organized into three sections**:**

- Source, transport and fate of contaminants.
- Effects of contaminants on human and aquatic receptors.

[1] https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-objectives/south-coast-region-water-quality-objectives/burrard-inlet-water-quality-objectives#wqa-tech-reports

- Knowledge and data sharing.

Within the first two sections, discussion of knowledge gaps and research needs are divided into categories which are meant to streamline the process of identifying and addressing gaps relevant to practitioners and researchers (local research and broader research needs). For more detailed specific recommendations for monitoring and applying the səlilwət / Burrard Inlet WQOs, please refer to the səlilwət / Burrard Inlet Monitoring Guidance document (TWN and the Province of BC, in prep.). TWN asks to be informed of water quality research proposed within Burrard Inlet; such information can be sent to referrals@twnation.ca.

It is important to note that this report is not intended to summarize the entirety of monitoring and research needed in səlilwət. It is a summary of gaps that became apparent during the data assessments and preparation of səlilwət water quality technical reports.

2. SOURCES, TRANSPORT AND FATE OF CONTAMINANTS

Understanding the source, transport, and fate of marine contaminants is integral to assessing how these pollutants might be affecting both human and aquatic receptors, and directing priority actions to improve water quality. This understanding is particularly critical for areas like səlilwət, which is an essential source of food for people living around the Inlet, especially the Tsleil-Waututh people. Understanding the source, transport and fate of pollutants in səlilwət is important to determine appropriate future monitoring efforts, and to direct action to reduce contamination. Research needs for source, transport and fate for different contaminants are outlined below, and have been adapted from the səlilwət / Burrard Inlet WQOs technical reports (ENV and TWN, 2024).

Information on a contaminant's physical and chemical properties can provide overall insight into its behaviour; however, this alone does not allow for a complete prediction of how a certain contaminant will behave in the environment (ATSDR, 2022). Chemical and physical properties of contaminants have been established through laboratory-based studies done in highly controlled conditions, which often does not provide information on how contaminants will behave under varying environmental processes and geochemical conditions (ATSDR, 2022).

Evaluating the influence of climate change on contaminant behaviour is also important. Factors such as the rapid increase in water temperatures could lead to cascading impacts on the environmental fate, transport and cycling of pollutants (GESAMP, 2023). Such impacts include changes in bioavailability, bioaccumulation, and toxicity of pollutants (e.g., nutrients, metals, organic compounds and plastics) that may be exacerbated under global climate changes; thus it remains crucial to further study these contaminants under environmentally relevant conditions.

Further research to determine specific contaminant sources as well as transport pathways into səlilwət will be instrumental in efforts to maintain concentrations within the proposed WQOs. Further research and knowledge are suggested in the bullets below. Exceedances observed in

research and monitoring programs should prompt timely management actions to reduce the entry of contaminants into səlilwət and its tributaries.

2.1 Practitioners - Monitoring

- Monitor emerging contaminants, metals, and other pollutants in relevant environmental matrices to help delineate the distribution patterns, temporal dynamics, sources, and fate in the environment. Compare measurements to the WQOs.
- Develop a detailed monitoring plan that includes measurements of physical parameters and toxicity modifying factors (e.g., temperature, hardness, pH, dissolved organic carbon) to support analyses of toxicity and biological availability. A better understanding of toxicity modifying factors can also help to refine the WQOs.
- Monitor at a frequency of five samples over thirty days, which is necessary for evaluation of chronic water quality conditions.
- Monitor at multiple locations in a tributary or stormwater system (e.g. upstream and downstream) at the same time of year to enable a better understanding of potential contaminant sources and entry points throughout a watershed.
- Consistently monitor microbial indicators at various water column levels.
- Collect data in freshwater and stormwater for dissolved concentrations of metals (not just total concentrations).
- Monitor sediments for compounds that predominantly attach to particulate matter, and may not be detected in the water phase, e.g. PAHs, PCBs.
- Increase monitoring of legacy and emerging contaminants of concern in marine water, freshwater and stormwater, to understand occurrence, and spatial and temporal shifts.
- Prior to submitting samples for analysis, verify that the laboratory's detection limits are lower than the WQOs. This ensures that the laboratory's testing capabilities are sufficient for the required sensitivity levels.

2.2 Local Research Needs

- Determine the relative importance of current sources versus existing concentrations in marine sediment that may be at risk of re-suspension to understand whether elevated fish tissue concentrations are driven by current discharges or historical contamination in the sediment.
- Conduct an evaluation of the more toxic forms of contaminants (e.g. trivalent arsenic, methylmercury, and hexavalent chromium) in samples to understand their potential impact on aquatic life and humans.
- Conduct short-term studies to determine the ratio of methylmercury to total mercury in the marine water column, using the findings to refine marine water objectives and evaluate mercury bioavailability in səlilwət.
- Investigate the historical and current trends of PCBs, PCDDs, and PCDFs in səlilwət by analyzing age-dated sediment cores.
- Investigate the occurrence, persistence and impacts of CECs, MPs and PPCPs in wastewater treatment by-products, such as biosolids. Assess their degradation rates

and potential for transport to freshwater and marine systems when these by-products are applied to soil, to better understand their impact on the marine environment.
- Include high production volume chemicals such as glyphosate, s-metolachlor, and 2,4-D in future monitoring programs for water, sediment and biota, due to their established toxicity to humans and aquatic life. These herbicides are widely used in agriculture and urban areas, potentially reaching marine environments through runoff and atmospheric deposition (CAREX, 2023).

2.3 Broader Research Needs

- Assess the presence and effects of CECs in the marine food web, particularly in shellfish and finfish, to understand their potential for biomagnification and subsequent impact on apex marine predators and humans.
- Study the behavior and fate of PBDEs and PAHs, including their remobilization during sediment disturbance, and their phototoxicity.
- Undertaking a geospatial analysis of relative loading of different pollutants into səlilwət and its tributaries, similar to The Nature Conservancy's Stormwater Heatmap (The Nature Conservancy, 2023), could help identify priority areas to address nonpoint source pollution and support stormwater planning.

3. EFFECTS OF CONTAMINANTS ON HUMAN AND AQUATIC RECEPTORS

Tsleil-Waututh people once obtained more than 90% of their diet from səlilwət and the Fraser River. The rising human population and increased urbanization and industrialization in the area continue to increase pressure on səlilwət and therefore pose health risks to humans and aquatic life, for example from the mobilization, transport and uptake of contaminants. The interactions between human and aquatic receptors and the ocean are thus significant and warrant further comprehensive studies to fully understand the effects contaminants have on receptors.

One of the overarching research gaps to fill is to monitor toxins in fish and shellfish species that are preferred for human consumption. Results could be compared to those from species that have typically been sampled to determine whether any species are representative and could be studied as indicators for monitoring purposes. This work will require collaboration with Indigenous cultural experts, and their health and community development departments. Considerations could include shifts in available and preferred species and consumption patterns over time, barriers to harvesting, and current monitoring programs. An understanding is also required of how the species are typically consumed; for example, whole organisms, or certain tissues which do or do not tend to concentrate contaminants.

The recommendations below are listed to better understand the effects of contaminants on human and aquatic receptors.

3.1 Practitioners - Monitoring

- Increase sampling of water quality parameters relevant to human health in water, sediment and tissue of preferred species for human consumption, and at current and aspirational harvesting sites, and compare them to the səlilwət WQOs. Use results to determine potential health risks, as well as potential for remediation and restoration.
- Enhance monitoring of arsenic[2], PCB, PCDD and PCDF levels in seafood species, as well as copper levels that may impact the development of forage fish embryos, particularly in interstitial waters. Also monitor lead if detected in fish tissue.
- Implement regular monitoring of microbiological indicators in high-risk consumption areas, to prompt more extensive sampling when necessary. Carry out more detailed sampling when elevated counts are detected to establish the applicability of indicator organisms.
- Consider adopting both *E. coli* and enterococci as preferred indicators for ambient and recreational water quality monitoring and sample for both indicators wherever possible.
- Include glyphosate, s-metolachlor, and 2,4-D in future monitoring programs due to their high production volume and established toxic effects on humans and aquatic life (USEPA, 1995; USEPA, 2022; USEPA, 2023).

3.2 Local Research Needs

- Conduct long-term toxicity assessments using environmentally relevant concentrations of pollutants to better understand their potential adverse effects on marine biota occurring in səlilwət.
- Evaluate CECs, PPCPs and MPs in the local marine food web to better understand their potential for biomagnification and impacts on humans and marine top predators.
- Further investigate uptake of contaminants in intertidal species which are currently harvested by people (e.g., crabs).
- Use contaminant levels in seafood species harvested from səlilwət to inform human health risk assessments and establish safe daily consumption limits. Also conduct tests on the potential effects of cooking or processing seafood at high temperatures.

3.3 Broader Research Needs

- Establish laboratory detection limits that are adequately low to enable comparison of contaminant levels to the səlilwət WQOs. PCBs are an example of a contaminant for which this is required.
- To address the uncertainties in nickel toxicity mechanisms in marine environments (Brix et al, 2016), compare biotic ligand model calculations with expanded toxicity studies to support or contextualize water quality objectives and guidelines.

[2] Determine adequate methodology to obtain sufficient arsenic speciation data to determine an appropriate percent for speciated inorganic arsenic in water and tissue samples. Once defined, conduct a study to confirm or refine the assumption that approximately 10% of the total arsenic content is inorganic arsenic.

- Establish a surveillance system for MPs to evaluate their physical effects on marine organisms, such as stress, malnutrition, entrapment, suffocation, and smothering.
- Study the impact of PAHs on benthic organisms.
- There is limited understanding of the interactions between certain co-contaminants and their effects on aquatic health. Investigate the combined toxic effects of metal mixtures and other pollutants, known as "cocktail effects," which can alter the expected toxicity of individual chemicals, challenging the current single-compound safety regulations (Singh et al, 2017). These complex interactions highlight the need for more comprehensive approaches to evaluate and mitigate environmental and health risks.

4. KNOWLEDGE AND DATA SHARING

One of the most significant challenges in understanding səlilwət water quality is the lack of availability of consistent and comparable data. In addition, any data that does exist is usually difficult to access. Access to well managed data is crucial for researchers to develop insight into səlilwət's most pressing issues and to inform effective solutions (Persaud et al., 2020). Recommendations for coordinated water quality monitoring in səlilwət are presented in a separate Tsleil-Waututh Nation technical report (Tsleil-Waututh Nation, 2025).

Data sharing is an important aspect of coordinated efforts that can address differences in sampling strategies and methods, and improve comparability of monitoring results (Andrade-Rivas et al., 2022). Data sharing and coordination can also reduce redundancy, increase efficiency, and increase opportunities for facilitating informed decision making. Public accessibility and ease of data access could increase public engagement in protection of water quality. The Province of BC's Environmental Monitoring Data System could be used as a data repository, as it is already required to be used by multiple data holders.[3]

Data sharing should include both the final data, and associated metadata, to demonstrate that it is interoperable and reusable. Shared data can help determine where problem areas exist, identify where resources are most needed for pollution control, and track progress of pollution reduction efforts. A public data interface should include monitoring locations and easy interpretation of monitoring results with near real-time and web-based reporting tools.

For further details on the recommendations and water quality parameters discussed in this report, please refer to the səlilwət water quality technical assessment reports (ENV and TWN, 2024).

[3] https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/environmental-monitoring-data-system (Accessed August 2025)

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