

Water Quality Assessment for the Lower Kitimat River

Technical Report



April 2026

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EXECUTIVE SUMMARY

This report presents a summary of the ambient water quality of the lower Kitimat River which runs through the District of Kitimat, British Columbia (B.C.) and two of its tributaries. The water quality assessment conducted here forms the basis for making recommendations for updates to the 1987 provisional WQOs for the lower Kitimat River to protect existing and future water uses.

This medium-sized coastal watershed's geography, flora, and fauna have attracted industry and recreationists for decades. Heavy industrial developments have been occurring in the lower Kitimat River and estuary since the 1950s. The watershed has also experienced extensive forest harvesting. The unique geographic features that initially attracted industry to Kitimat continue to do so and multiple major energy projects are currently in the proposal and development phases. Despite the extensive industrial activity, the Kitimat River remains one of the most popular recreational angling destinations on the British Columbia coast, primarily due to ease of access, proximity to population centers and the large numbers of returning hatchery-raised Pacific salmon and steelhead trout (DFO, 2009).

The lower Kitimat River is an approximate 10-kilometer section of the Kitimat River mainstem running from the Haisla Bridge, downstream to the end of the freshwater before its connection to the Kitimat Arm marine waters. The water values and uses to be protected are drinking water sources, aquatic life, wildlife, cultural practices, and recreation. Existing industry in this region has the potential to degrade habitat and impact water quality and water uses.

Recommended updates to the provisional WQOs and for new WQOs.

Variable	Objective
pH ¹	6.5 -9.0 pH units
Temperature ³	Instantaneous measurement < 16°C
Dissolved Oxygen ¹	> 7.8 mg/L (min)
True Color ³	≤ 5 mg/L increase when upstream values are less than or equal to 20 mg/L
	≤ 20 percent increase when upstream values are greater than 20mg/L
Turbidity ¹	≤ 5 NTU (max) increase when the upstream value is less than or equal to 50 NTU
	10 percent maximum increase when the upstream value exceeds 50 NTU
Total Suspended Solids (TSS) ¹	10 mg/L maximum increase when the upstream value is less than or equal to 100 mg/L
	10 percent maximum increase when the upstream value exceeds 100 mg/L
Ammonia-nitrogen ²	≤ 1 mg/L average
Fluoride ³	≤ 0.12 mg/L average
Nitrate ³	≤ 3 mg/L average
Nitrite ²	≤ 0.013 mg/L average
Sulphate ³	≤ 30 mg/L average
Dissolved Aluminum ²	≤ 50 ug/L average
<p>Note: ¹Retained provisional WQOs. ²Recommended changes to provisional WQOs ³Recommended new WQOs</p>	

Water quality monitoring in the Kitimat River (one upstream reference site, and two sites in the lower 10 kilometers of the river) and in the two tributaries, Hirsch Creek and Little Wedeene River, were conducted in 2015, 2019 and 2020. The results of this monitoring indicated that the overall state of the water quality is good. All chemical and physical parameters met provincial water quality guidelines (WQGs) and the 1987 provisional WQOs with a few exceptions. Turbidity exceeded the objective, and true colour, aluminum and copper exceeded WQGs for the protection of aquatic life, predominantly in the fall high flow period. Based on background levels, potential anthropogenic sources, and future developments, it is recommended that four of the 1987 WQOs be retained, three should be updated to new values, five new parameters be considered for future WQOs. Monitoring suggestions are provided for existing and updated provisional WQOs and for the recommended new WQOs. No data was collected to evaluate the provisional WQO for periphyton growth during the monitoring period for this report so there are no recommendations on this WQO. Based on current water quality and values, and changes to industrial activity, the 1987 provisional WQO for pulp mill effluent toxicity and hydrogen sulphide should be removed as the pulp mill closed in 2010.

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ACRONYMS

AAC	Allowable Annual Cut
ANC	Acid Neutralizing Capacity
B.C.	British Columbia
BCCDC	B.C. Conservation Data Centre
BCGS	British Columbia Geographical System
DEM	Digital Elevation Model
DFO	Fisheries and Oceans Canada
DOK	District of Kitimat
D/S	downstream
DTSID	distributed temperature sensing to Identify groundwater discharge
EcoCat	Ecological Reports Catalogue (B.C. ENV)
EFN	environmental flow needs
ENV	Ministry of Environment and Parks
FISS	B.C. Fisheries Information Summary System
FLNRO	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
GW	groundwater
ID	identifier or identification number
KLNG	Kitimat LNG
MAF	mean annual flow
MDL	method detection limit
MOE	Ministry of Environment
PET	potential evapotranspiration

STP	sewage treatment plant
SW	surface water
TFL	Tree Farm Licence
TRU	True colour units
U/S	upstream
URL	uniform resource locator (website address) WQG water quality guideline(s)
WQO	water quality objective(s) WSA Water Sustainability Act
WSC	Water Survey of Canada
WSS	Water Science Series
WTN	well tag number

1. INTRODUCTION

Water quality monitoring and assessment is the standard way the B.C. Ministry of Environment and Parks (ENV) gathers science-based information to support the development of Water Quality Objectives (WQOs) in high priority waterbodies.

British Columbia's (B.C.) WQOs are approved provincial policy documents that apply to specific waterbodies and set benchmarks to inform decision makers (under the *Environmental Management Act*), formalize water quality goals for the protection or enhancement of important waterbodies in B.C., and promote water sustainability and stewardship. They inform the management of water quality and can guide other processes, such as land use decisions and the establishment of water objectives under the *Water Sustainability Act*.

The provisional WQOs that exist for the lower 10 kilometers of the Kitimat River were proposed in 1987 (Warrington, 1987). Limited monitoring since 1995 and considerable changes to effluent and air discharges in the Kitimat area raised concerns that these old WQOs (Table 1) required review. In 2020, a forty-year data review and technical assessment (BWP & ENV, 2020) was completed on data up to 2014 to determine if the 1987 WQOs were still applicable. The sporadic sampling and changes in industrial activity posed challenges to the assessment. Additionally, the closure of the Methanex methanol and ammonia plants (2005) and the Eurocan pulp mill (2010), meant that contaminants that were once a concern were no longer being discharged.

The Kitimat River is a key waterbody in the west-central portion of British Columbia and flows through the District of Kitimat. As with previous assessments, this report focuses on the lower 10 kilometers of the mainstem Kitimat River. This river reach is a small portion of the Kitimat drainage but is heavily used by fish and wildlife and is where most industry and anthropogenic activities occur. The lower Kitimat River is a priority area because of the differing water uses such as fish and industry, both of which are important to the area.

The primary water quality concerns pertain to elevated turbidity and total suspended solids concentrations and the potential for increases in nitrates, sulphates, fluoride, and aluminum.

This report addresses monitoring and assessment recommendations made in the 2020 technical assessment report, considers water quality results in the Kitimat River from 2015 to 2020, evaluates potential water quality issues presented by current and proposed industries in the area and recommends updates to the provisional WQOs. The methods in the Guidance for the Derivation of Water Quality Objectives document (ENV, 2021c) were used to evaluate water quality and make recommendations for additional parameter concentrations. The recommendations include retiring the provisional hydrogen sulphide, periphyton, and toxicity WQOs and WQO for seven new parameters: aluminum, ammonia, fluoride, nitrate, sulphate, temperature and true color.

Table 1: Summary of Provisional WQOs for the lower Kitimat River (Warrington, 1987)

Parameter	WQO
pH	6.5 to 9.0
Dissolved oxygen	7.8 mg/L minimum
Turbidity	5 NTU maximum increase when the upstream value is less than or equal to 50 NTU 10 percent maximum increase when the upstream value exceeds 50 NTU
Suspended solids	10 mg/L maximum increase when the upstream value is less than or equal to 100 mg/L 10 percent maximum increase when the upstream value exceeds 100 mg/L
Ammonia-nitrogen	Ammonia water quality guidelines
Nitrite-nitrogen	less than or equal to 0.020 mg/L mean 0.060 mg/L maximum
Hydrogen sulphide	0.002 mg/L maximum (2 µg/L)
Periphyton growth	up to 50 mg/m ² as a mean
Toxicity	the percent concentration of pulp mill effluent in the river should not exceed 0.05 of the 96-h LC50 of the pulp mill effluent at any time

Note: The objectives apply to discrete samples from all parts of the water bodies, except initial dilution zones of effluents. The initial dilution zone in the Kitimat River is defined as extending up to 100 m downstream from a discharge and up to fifty percent of the width of the river, from the surface to the bottom.

- 1. For turbidity and suspended solids the increase is over levels measured at a site upstream from a discharge or series of discharges, and as close to them as possible. The increase applies to downstream or affected levels.*
- 2. The ammonia and nitrite averages are calculated from at least five weekly samples taken in a 30- day period.*
- 3. The periphyton chlorophyll-a average is calculated from at least five rock scraping samples collected at random from natural substrates, at any station, in one day.*
- 4. For toxicity the percent concentration of pulp mill effluent in the river is calculated by dividing 100 by the effluent dilution ratio. The dilution ratio is calculated by dividing the concentration of sodium in the effluent by the increase in sodium between sites upstream and downstream from the outfall. After complete mixing, the dilution ratio may also be calculated by dividing the river flow by the effluent flow.*

2. KITIMAT RIVER WATERSHED PROFILE

The Kitimat River is in the west-central portion of British Columbia and enters the Pacific Ocean in the Kitimat Arm, at the north end of Douglas Channel. The river originates in the Kitimat Ranges, which are part of the Coast Mountains. The biogeoclimatic zones vary with elevation, starting from the Coastal Western Hemlock in the valley bottom to the Coastal Mountain-heather Alpine in the highest elevation zones. The watershed is 1,990 square kilometers (Water Survey of Canada, 2016), and the river is 97.7 km long (B.C. Watershed Dictionary, 2016). There are 81 mapped tributaries to the Kitimat River, most of

which are fast-moving streams cut through steep mountain canyons (MacDonald & Shepherd, 1983). The major limiting factors along the river include bank variability, periodic flooding, and undesirable soil structure, while the mountainous sections of the river show low productivity due to steepness and large areas of exposed bedrock (MacDonald & Shepherd, 1983)

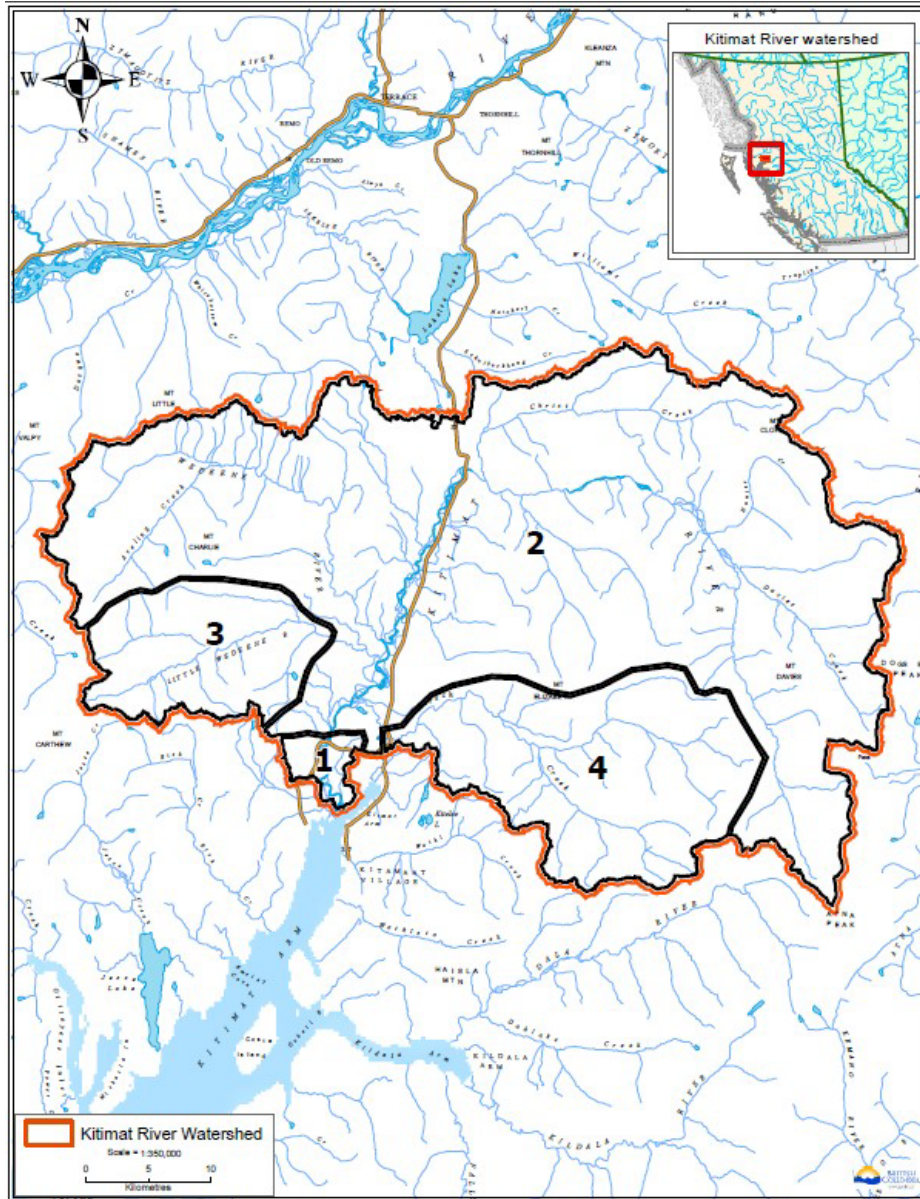


Figure 1: Kitimat River watershed and sub-drainage areas identified in this report. (B.C. FLNRO, 2022). Numbers correspond with the following watersheds: 1: Lower Kitimat River; 2: Upper Kitimat River Watershed; 3: Little Wedeene River; 4: Hirsch Creek.

2.1 Climate

The climate of the Kitimat River watershed is characterized as having very heavy annual precipitation as illustrated by climate data compiled by the Government of Canada at the Kitimat Townsite climate station in the Kitimat Municipal District, elevation 98 meters (Figure 2). From 1981 to 2010 the area received an

average total annual precipitation of about 2,210 mm, with October being the wettest month (320 mm of rain, or 14 percent of the total precipitation) Three quarters or about 72 percent of the total annual precipitation occurs from September to February. Seasonally, autumn is the wettest and spring, driest. The temperature averages -1.7°C in January and 16.7°C in July (Government of Canada, 2020).

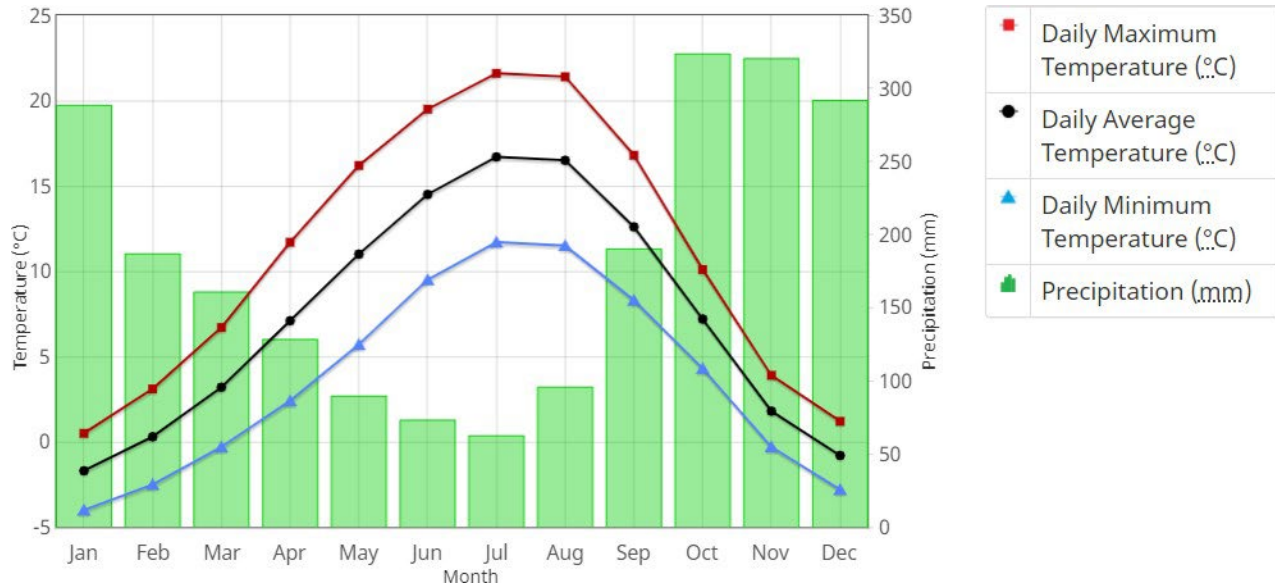


Figure 2: Air temperature and precipitation for 1981-2010 Canadian Climate Normals – Kitimat Townsite (Government of Canada, 2020)

2.2 Hydrology

There are established Water Survey of Canada hydrometric stations on the Kitimat River and two of its tributaries, namely the Little Wedeene River and Hirsch Creek (Figure 3). Flow measurements in the Kitimat River have been collected from the Water Survey of Canada station 08F001 (Kitimat River below Hirsch Creek) for over fifty years, with statistics available for data collected between 1964 to 2019. The hydrology graph in Figure 3 depicts the long-term summary statistics and 2020 flow readings (Northwest Water Tool, 2020). March median low flows in the Kitimat River measure approximately 40 m³/sec with minimum flows as low as 10.9 m³/sec. Flows in the river begin to increase early in April and continue through to early June with peak flows of approximately 435 m³/sec and median peak flows of 248 m³/sec. After freshet, the flows decrease until autumn precipitation increases the river flows with median flows of 181 m³/sec. Freezing at higher elevations causes decreased low-flow periods characteristic of the winter months.

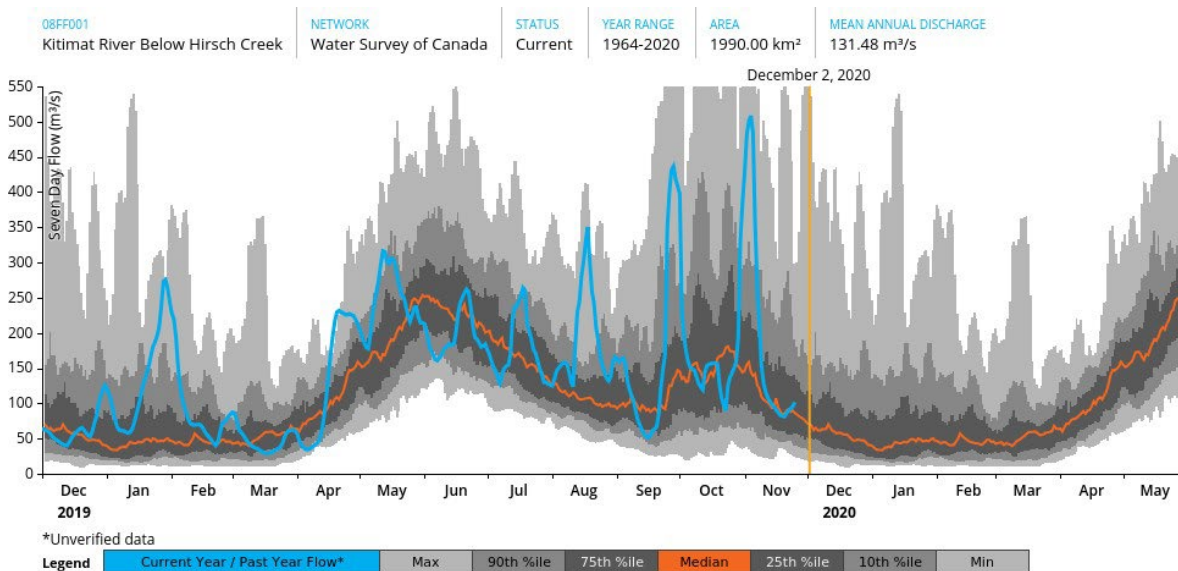


Figure 3: Fifty-six year (1966-2020) monthly discharge hydrograph for the Kitimat River from the Government of Canada hydrometric station (08FF001).

According to MacDonald and Sheppard (1983), flows in the two tributary streams included in this study are described as follows:

“The flow regime of the Little Wedeene River has a wide range in an average year. Low flows are observed from December to March inclusively, with the lowest mean monthly discharge in January. Streamflow then rises quickly to several times the winter low. Maximum instantaneous discharges are usually observed in October. [...]

Hirsch Creek maintains a fairly stable mean monthly discharge profile over an average year with peaks appearing in June and October. However, monthly maximum discharge profiles indicate much higher short-term variability.”

2.3 Biota and species of concern

The Kitimat River watershed contains valuable wildlife and fish habitat. Wildlife includes grizzly and black bear, black-tailed deer, wolf, mountain goat, moose, wolverine, fisher, and porcupine. The B.C. Fish Inventory Projects Query¹ lists 19 species of fish occurring in the Kitimat River, including all five species of Pacific salmon (*Oncorhynchus*; Chinook (*O. tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), pink (*O. gorbuscha*) and sockeye (*O. nerka*)), rainbow trout (*O. mykiss*), steelhead (*O. mykiss irideus*), cutthroat trout (*O. clarkia*), Dolly Varden (*Salvelinus malma*), kokanee (lacustrine Sockeye Salmon), eulachon (*Thaleichthys pacificus*), threespine stickleback (*Gasterosteus*), lamprey and three species of sculpin (*Cottus*).

The B.C. Conservation Data Centre (BCCDC) indicates a few species of concern within the watershed boundaries including coastal tailed frogs (*Ascaphus truei*) in the upper Kitimat River and tributaries, and white adder’s mouth orchids (*Malaxis brachypoda*), bog adder’s mouth orchids (*Malaxis paludosa*), and oldgrowth specklebelly lichen (*Pseudocyphellaria rainierensis*) in the lower watershed (BCCDC, 2016).

¹ Fish Inventory Projects Query – Individual Fish Data <https://a100.gov.bc.ca/pub/figd/viewFdisProjects.do>

3. WATER VALUES AND USES

Identifying water values and uses helps to define specific water quality parameters of concern for a given waterbody and supports management decisions to maintain these uses. The water values in the Kitimat River include drinking water and domestic water supply, aquatic and wildlife use, cultural practices, recreational water uses, and water for industrial processes such as smelting of aluminum. Agriculture and livestock are not identified water uses for the lower Kitimat River.

3.1 Cultural Values - Haisla and Kitselas Nations

The Kitimat River Valley and surrounding areas have been identified as important areas for the Haisla Nation and the Kitselas Nation. The area provides land and water resources fundamental to support and sustain their way of life, culturally, spiritually, and economically.

Today the Haisla (“dwellers downriver”) people are centered on the Kitimaat Village which sits at the head of the Douglas Channel and is home to about half of the [Haisla population of about 1700]. Living and working on the water has always been, and remains today, important to the Haisla. The Haisla people have lived off the land and water resources of the Douglas Channel and [their] traditional territory for hundreds of years, and protection of those resources for future generations is a strong commitment by every Haisla member.

[Haisla] territory’s resources have sustained [them] for generations, providing [...] food, shelter, and livelihood. [They] have worked hard to harvest food, build [their] villages, and develop the resources [they] need to survive. The land is connected to [their] past, culture, and future.

Most Haisla continue to carry on the traditions of hunting, berry picking, gathering, and fishing. Every spring, Haisla family groups still travel to the Kemano River for Eulachon fishing. The Haisla use Eulachon for everything, from food to medicine and they still trade the valuable pure white Eulachon grease commodity with neighbouring villages.

The wording and information were adapted from the official Haisla webpage: <https://haisla.ca>.

Ksi’aamks (clear water) is life for Kitselas people. More than that, it is a way of life for Kitselas as it is a part of all life. *Ksi’aamks* is key for the sustainability and health of future generations. As such, *ksi’aamks* is of great value to Kitselas. Kitselas has a deep cultural connection, and maintain a very strong territorial connection to the Kitimat River Valley since time immemorial. The Kitimat River Valley is an important area for hunting, trapping, fishing, gathering traditional plants, and recreation. In addition, it is important for drinking and hygiene.²

The entire Kitimat River watershed is valued by the Kitselas people, especially areas close to fish migration routes, spawning channels, and traplines. There are many traplines in the Upper Kitimat River Watershed that are currently used by Kitselas families.

Kitselas is conscious that these connections are continuously threatened due to industrial activities and the legacy of colonization. As stewards of the land, air, and water, Kitselas is concerned with the water quality of the Kitimat River, specifically as it related to health, ecosystem function, and sustainability for future generations. In addition, Kitselas is concerned with how continual degradation of water quality, due to industrial activities and climate change, will impact access to resources and food security for current and future generations’ use.

² Kitselas Lands and Resources Department personal communication, June 25, 2020

The wording and information were provided in a letter from the Kitselas Lands and Resources Department in 2020. The official Kitselas First Nation webpage is <https://kitselas.com/>.

3.2 Drinking Water

The Kitimat River is the water source for the District of Kitimat's municipal water system which provides drinking water to Kitimat residents. The B.C. *Drinking Water Protection Act* sets minimum disinfection requirements for all surface supplies and requires drinking water to be potable. The District of Kitimat (DOK) has an infiltration gallery on the Kitimat River, which provides some natural filtration to the raw water prior to it entering the chlorination/fluoridation facility (BWP & ENV, 2020). Chlorination treatment eliminates or reduces microorganisms (bacteria, viruses, and parasites, such as *Cryptosporidium* and *Giardia*) that are naturally found in water. As no one type of treatment system is effective in treating all hazards, a multi-barrier approach should be followed to adequately address all risks, which typically include two or more forms of treatment. To this end, the DOK is working with Northern Health to identify priorities and upgrades to meet the [Drinking Water Treatment Objectives for Surface Water](#). Upgrades to the system would reduce turbidity-related water quality and boil water notices, as well as provide a pH-balanced water supply, and reduce the risk of pathogens in drinking water (District of Kitimat, 2020).

3.3 Fisheries

The Kitimat River is an important waterbody for aquatic life in the region. The river is used as a migration route for fry, smolts and returning spawning adult fish, but very little actual spawning occurs in the lower reaches of the river; most takes place in the headwaters and up the tributary streams (Warrington, 1987). Nineteen species of fish occur in the Kitimat River, including those previously identified in Section 2.3. Sharp decreases (an order of magnitude) in salmon escapement numbers occurred in the 1970s, likely due to severe floods in 1974, 1976 and 1978 (Karanka, 1993). As a result, Fisheries and Oceans Canada (DFO) built the Salmonid Enhancement Program Hatchery on the Kitimat River in 1984. Since that time, escapement numbers of salmonids have recovered considerably, and DFO continues to release Chinook, coho and chum salmon, as well as steelhead and cutthroat trout on an annual basis. Declines in the eulachon populations have brought Haisla community members, industry, and scientists together to work on conservation and recovery planning for the species in the Kitimat area. There are several studies underway to promote eulachon recovery in formerly active harvesting sites (Stantec, 2022).

3.4 Recreation

The Kitimat River is known as one of the preeminent sportfishing destinations in the province. Year-round fishing on the Kitimat River is very common. Radley Park is a popular 57-unit campground located on the banks of the Kitimat River. Camping and several other primary and secondary contact recreational activities (e.g., canoeing, kayaking, paddleboarding, Class 2 white water rafting, etc.) are practiced regularly.

3.5 Water Licences, Allocations and Withdrawals

There are 11 water licences for surface water withdrawal all in the lower reach of the river, for a total of 154,202,395 m³ per year. More than two-thirds of the overall volume of the licences is represented by withdrawals by Rio Tinto Inc., as part of their aluminum manufacturing process. DFO also withdraws a considerable volume of water (about 25 percent of all licenced withdrawals) for the operation of the Kitimat River Hatchery. However, the water is not removed from the hydrological system of the Kitimat

River as it is returned 100 meters downstream to the same water source. Waterworks licences issued to the DOK for the residential water system in the town represent about four percent of the licenced water withdrawals. Eight short-term use approvals (STUA) account for less than one percent of water withdrawal from the river. The current estimate is that, when at full production, LNG Canada may require the withdrawal of approximately 70,000 m³/day (LNG Canada Development Inc., 2014). This would bring the total annual surface water withdrawal volume to 179,752,395 m³ per year and LNGC's portion would represent 14 percent of the total.

Mean monthly discharge in the Kitimat River ranges from 48.71 m³/s in March to 274.58 m³/s in June (Northwest Water Tool, 2020). Assuming maximum withdrawals by each surface water licence holder, and that the volume of withdrawal is constant throughout the year, the current withdrawal volume would represent approximately 10 percent of the low-flow volume. Adding maximum withdrawal estimates by LGNC, the total withdrawal volume would represent 11 percent of the low-flow volume. During the remainder of the year, when water levels are much higher, the relative proportion of the withdrawal would be considerably lower. According to the Northwest Water Tool Watershed report for the Kitimat River, the monthly water supply and demand for the river and associated risk management level calculations, the river's flow sensitivity is classified as low. However, there is a high degree of uncertainty when it comes to assessing water quantity since there are currently no standardized reporting requirements that would provide the data necessary to properly calibrate water allocation and usage estimates.

4. INFLUENCES ON WATER QUALITY

4.1 Natural Physical Processes

The Kitimat River is susceptible to periodic glacial-lake outburst flood events, possibly originating in upper Chist Creek (Schwab, 2011). Glacier meltwater is trapped behind an ice dam at the top of the watershed, and under specific conditions the ponded water escapes, causing a high volume of water to flush down Chist Creek and into the Kitimat River approximately two kilometers upstream of the Highway 37 Bridge. These rare, stochastic events generate large amounts of suspended solids, temporarily skewing water quality in the river.

4.2 Forestry

Much of the Kitimat Valley was logged intensively in the 1960s and 1970s, which, according to DFO spawning files, resulted in badly deteriorated lower portions of the river and low river stability (MacDonald & Shepard, 1983). The removal of trees can decrease water retention times within the watershed and result in a more rapid response to precipitation events and earlier and higher spring freshets. The improper construction of roads can change drainage patterns, destabilize slopes, and introduce high concentrations of sediment to streams. The loss of riparian vegetation can increase the mobilization of sediments and other contaminants due to the reduced barrier between land and water.

All forestry activities within the Kitimat River watershed now occur in either Tree Farm Licence 41 (located upstream from Chist Creek and Highway 37 crossing) and FL A16885 (which is confined to land within the District of Kitimat boundary). The current allowable annual cut (AAC) for TFL 41 is 128,000 m³ (FLNRO, 2012) and the AAC for FL A16885 in 2018 was 26,000 m³ (Forest Practices Board, 2018).

Apart from forestry and possible short-range atmospheric deposition, there are few anthropogenic influences on the upper watershed.

4.3 Current Authorized Discharges and Contaminants of Potential Concern

All authorized effluent discharges described below are located within the lower 10 kilometers of the river.

4.3.1 Wastewater Treatment: Ammonia and phosphorus

The District of Kitimat (DOK) has an authorized discharge from their treatment plant into the Kitimat River under *Environmental Management Act* (EMA) permit 256. The outfall is located about four kilometers upstream from the mouth of the Kitimat River. This discharge is the source of relatively minor amounts of BOD5, fecal contamination, ammonia, phosphorus, and dissolved solids.

4.3.2 Aluminum Smelter: SO₂ emissions

On the lower Kitimat River is an aluminum smelter operated by Rio Tinto since 1954. Rio Tinto also has four authorized effluent discharges to Kitimat Arm, but none to the Kitimat River. There are also eight air discharges authorized for the smelter and sulphur deposition that can contribute to the acidification of soils and water bodies. In 2015, Rio Tinto initiated a major modernization project, which nearly doubled production capacity and increased the authorized sulphur dioxide (SO₂) emissions from the new facility. Both the lower and upper watershed are subject to short-range atmospheric deposition from the smelter.

4.3.3 Liquefied Natural Gas (LNG) Facilities: SO₂ and NO_x emissions

LNG Canada (LNGC) operates a liquefied gas export facility on the former Methanex location, the adjacent property to Rio Tinto. LNGC currently has several permits, none of which allow discharges to the Kitimat River. The EMA permit for a storm sewer discharge to the Kitimat River was cancelled in 2020. LNGC is also authorized to discharge air contaminants, including SO₂ and nitrogen oxides (NO_x), which can contribute to acidification and eutrophication respectively of nearby soils and water bodies.

Cedar LNG received an Environmental Assessment Certificate in 2023 and is planning to start operating in 2027. Cedar is planning to operate an all-electric drive system that could significantly reduce its SO_x and NO_x emissions compared to other similar facilities using fuel.

4.3.4 Landfills: Leachate

The DOK landfill is located adjacent to Hirsch Creek, a tributary to the Kitimat River. An ENV review of groundwater quality near the landfill and Hirsch Creek surface water quality stated the migration of leachate from the landfill through groundwater sources has the potential to negatively impact the sensitive aquatic habitats in Hirsch Creek (ENV, 2009). Since 2013, under the permit, a comprehensive monitoring program of landfill leachate indicator parameters in groundwater and surface waters continues to be conducted to manage for potential localized effects to Hirsch Creek.

The current authorized discharge from the former Eurocan site is held by Kitimat LNG and includes site stormwater and landfill leachate; however, no new material is being added to the landfill. The leachate is collected in a settling basin and aeration lagoon prior to discharge to the main channel of the Kitimat River. Discharge to the river is passive (over a weir) as water levels rise with precipitation events.

5. SAMPLING

5.1 Collection Methods and Data Handling

To assess the applicability of the 1987 provisional WQOs to the lower Kitimat River, water quality monitoring was conducted in 2015, 2019 and 2020. Water quality data were collected by ENV at five locations on the Kitimat River in May 2015 (BWP & ENV, 2020) and at five locations in the watershed from June 2019 to March 2020 (three on the Kitimat River, one on the Little Wedeene River and one on Hirsch Creek) (Figure 4). The latter sites were selected as potential long-term monitoring locations. The EMS number and location information for all sites considered in this assessment are in Table 2.

All sampling was conducted in accordance with the British Columbia Field Sampling Manual (ENV, 2013). Samples were collected as monthly grab samples or in some instances, five times at the site over a 30-day period. At the long-term Kitimat River sites, five in 30-day sampling was conducted during the spring and fall high flows and summer low-flow periods. During sample collection, field measurements for temperature, pH, dissolved oxygen, specific conductivity, and turbidity were recorded at each site using a YSI Pro Plus and WTW 3510 turbidity probe (multi-parameter meters). Hand-held field instruments were pre-calibrated under controlled (regional ENV laboratory) conditions before use.

To characterize ambient water quality, averages of each parameter for each site were calculated using one of four different approaches depending on the number of samples above (detects) and below (non-detects) the method detection limit (MDL). Half the MDL was used to represent the average of samples when all samples were below the MDL. For sites with less than three detects, half MDL was substituted for the non-detect values and then averaged with the other result(s). Regression on order statistical analysis (ROS) was used to calculate an estimate of the mean for sites that had a mixture of non-detectable results with at least three detected values (Huston & Juarez-Colunga, 2009). Although Huston and Juarez-Colunga (2009) state that ROS analysis can be used on sample sizes with no detects, a minimum of three detectable results is required to calculate a valid regression using the NADA package (Lee, 2017) in R (R Core Team, 2020). The arithmetic mean was calculated for sites where all samples were above the MDL.

Statistics to summarize the site data (median, the 10th, 90th and 95th percentile) were then calculated for each station. The 95th percentile of site data was used to assess all parameters and to recommend WQO for new parameters.

Table 2: ENV water quality monitoring sites on the Kitimat River and tributaries between 2015 and 2020.

EMS ID /Site Name and Description	Latitude	Longitude
Reference site		
E301870 Kitimat River Upstream Reference	54.2604	128.523
Kitimat River site located upstream of the northernmost Kitimat River / HWY 37 bridge crossing.		
River reach and tributaries upstream of authorized discharges to the Kitimat River		
E279768 Little Wedeene River	54.1352	128.6838
A tributary to Kitimat River, this site is located 100m upstream of the Little Wedeene FSR bridge crossing. (2019/20 data only). No upstream discharges.		
E216319 Hirsch Creek upstream of Hwy37 Bridge	54.0643	128.6009
A tributary to Kitimat River, this site is located 100m upstream of the Hirsch Creek Hwy 37 bridge crossing, which is 3km upstream of the Kitimat landfill. (2019/20 data only). No upstream discharges.		
0430025 Kitimat River upstream of Haisla Bridge	54.06007	128.67786
Site on the Kitimat River 200m upstream of the Haisla Bridge.		
E207569 Kitimat River upstream of Eurocan discharge	54.0419	128.6779
Kitimat River, upstream of the old Eurocan discharge and the DOK sewage treatment outfall and downstream of the DFO hatchery. (2015 data only)		
River reach downstream of authorized discharges to the Kitimat River		
E207570 Kitimat River downstream of Eurocan discharge	54.0314	128.6840
Kitimat River, downstream of the municipal sewage outfall and old Eurocan discharge.		
E218981 Kitimat River downstream of Eurocan, upstream of Reserve	54.0311	128.6764
Kitimat River, downstream of the old Eurocan discharge and upstream of Reserve land. (2015 data only)		

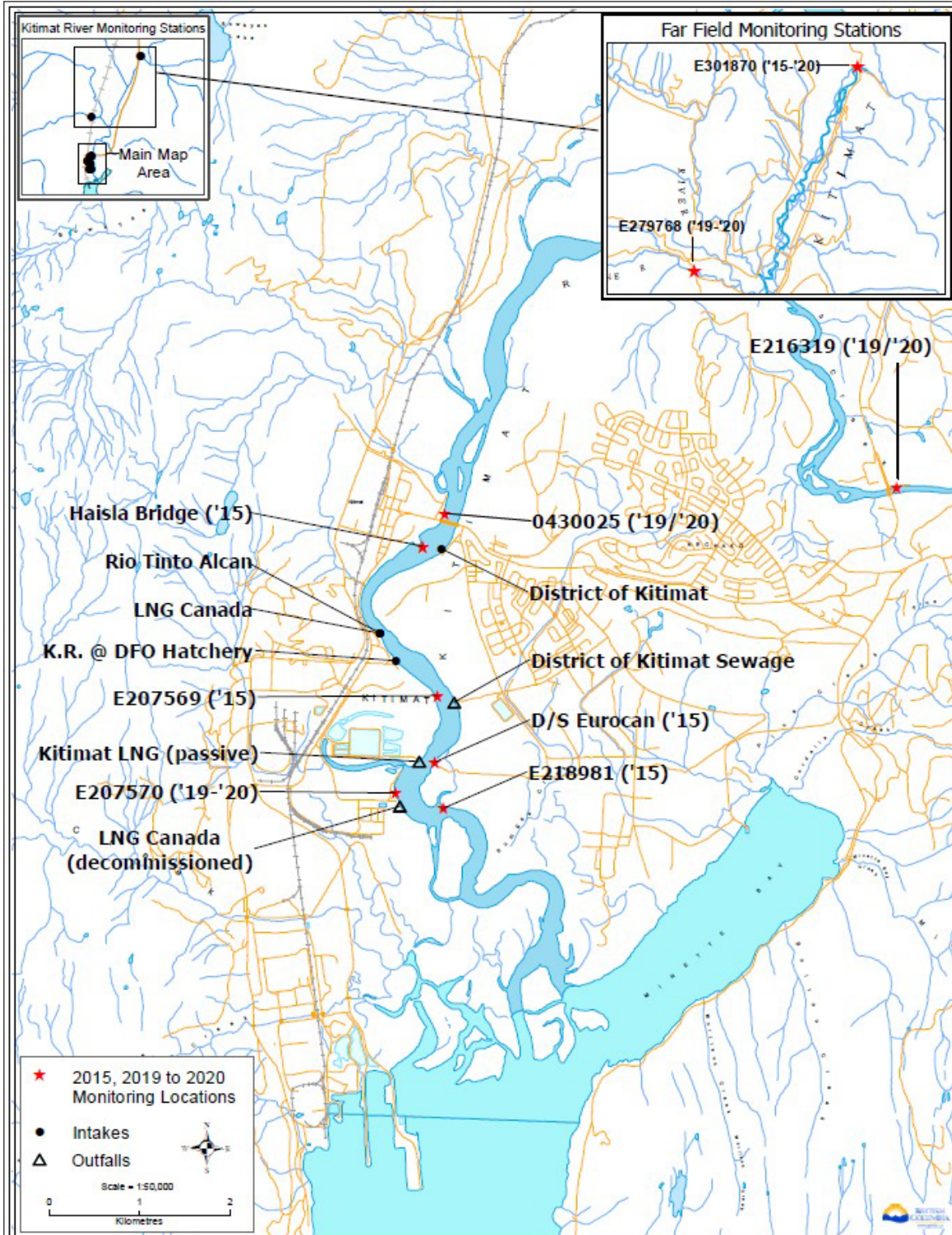


Figure 4: Map of lower Kitimat River showing 2015, 2019 and 2020 monitoring locations (red stars), intakes (black circles) and outfalls (black triangles) (B.C. FLNRO, 2022).

5.2 Data Quality Control

Quality assurance and quality control sampling was part of the B.C. ENV 2015 and 2019/20 sampling programs. Quality control was verified by collecting replicate and blank samples from randomly chosen sites. Replicate grab samples were collected by filling two sample bottles during the same sampling event (preferably one right after the other) at a site. In 2015, three sets of replicate samples were collected over the 30-day sampling period. In 2019, five sets of replicate samples were collected in seven months and in 2020, two sets of replicates samples were collected in three months. Data for five sets of field blanks were included in the dataset reviewed for this study.

Replicate samples identify environmental variability in a water body. Flowing water tends to have greater variability and during high flows, variability between samples can increase. Typically, the maximum acceptable percentage difference between replicate samples and corresponding regular samples is 25 percent. However, this interpretation is more reliable if the results are at least five times the MDL for a given parameter (Cavanagh *et al.*, 1998). Accuracy of a sampling result close to the MDL has less certainty and often shows more variability than with sampling results that are well above the MDL. Additionally, some parameters (notably bacteriological indicators) are not homogeneous throughout the water column and therefore a higher degree of variability may occur between replicate samples.

Blank samples are collected to establish that the sampling protocols and handling procedures including shipping have not caused contamination and effected the results. According to Cavanagh *et al.* (1998) contamination has occurred when five percent or more of the sample blanks show results above the MDL. If the blanks are within these specifications, then the sampling results are considered acceptable and uncontaminated.

Replicate and regular samples analyzed for general chemistry and metals (total and/or dissolved) were evaluated for the relative percent difference (RPD) between the results of each pair for each parameter. The RPD of the evaluated pairs was small for most parameters and 92 percent of the pairs were within the acceptable 25 percent range of environmental variability. However, the parameter pairs sampled on May 13, 2015, exceeded the 25 percent range but the results were near the MDL and therefore were not likely to affect the interpretation of water quality.

Blank samples were analyzed for total metals, with one blank sample also analyzed for ammonia, total nitrogen and phosphorus and total organic carbon. In 2019 samples, one blank sample result was above the MDL for total zinc concentration (0.00034 mg/L) at the Kitimat River Haisla Bridge site on July 23, 2019. In 2020, blanks were above the MDL for total chromium (0.00013 mg/L) at the upstream Kitimat River reference site. Also, in 2020, calcium (0.226 mg/L), total strontium (0.000128 mg/L) and total zinc (0.00043 mg/L) had concentrations above the MDL from a blank sample collected at the Hirsh Creek site. The sample results are considered acceptable and uncontaminated since less than five percent of the sample blanks showed results above the MDL.

Based on the duplicate and blanks results, all sample results are considered within acceptable limits for data quality.

6. WATER QUALITY ASSESSMENT

In this assessment, we examine the existing water quality of the lower Kitimat River and used the 95th percentile to recommend updates to the provisional WQOs based on current water values and uses, known sources for a given parameter, potential impacts, and major changes in the watershed since 1987. The data used to determine background levels considered the natural temporal variability of water quality at the upstream reference site on the Kitimat River. To be consistent with other ENV policies and procedures (e.g., the Contaminated Sites Regulation), the 95th percentile of available data was used to determine the upper limit of background concentrations, and in some cases, background levels were examined seasonally, for example, turbidity during both dry and wet seasonal periods. Water uses and values were considered, and possible water quality parameters of concern were identified based on the 1987 provisional WQOs and more recent technical reports. Water quality data was reviewed to identify any parameters that were elevated above background or exceeded long-term water quality guideline (WQG) levels or any parameters that showed increases despite being below WQG levels.

The following sections describe the characteristics considered in assessing the water quality of the lower Kitimat River and two tributaries. Parameters of interest in the Kitimat River include pH, dissolved oxygen, turbidity and total suspended solids (TSS), ammonia and nitrite (the 1987 WQO parameters), temperature, true color, chloride, fluoride, dissolved nitrate, sulphate, ortho-phosphorus, dissolved aluminum and copper, and total and dissolved iron (Table 3). These represent indicators of productivity and parameters potentially linked with anthropogenic activities in the watershed. The range of the data did not allow for examining trends.

All water quality data were assessed to identify parameters that were elevated above the provisional WQOs or the most sensitive WQG values. Sampling results were not compared to three of the provisional WQOs. There was insufficient chlorophyll *a* information to assess periphyton growth. The toxicity and total sulphide as hydrogen sulphide WQOs were no longer relevant as the Eurocan pulp mill has closed.

Table 3: Water quality parameters assessed against 1987 provisional WQOs or relevant WQGs.

Parameter of Interest	WQO ⁴ or long-term WQG ¹	Parameter of Interest	WQO ⁴ or long-term WQG ¹
pH	6.5 to 9.0 ^{1,4}	Nitrite	< 0.02 mg/L ^{1,4}
Temperature	< 16 ° C ^{1,2}	Sulphate	< 500 mg/L ² , < 128 mg/L
Dissolved Oxygen	> 7.8 mg/L ⁴	Dissolved Aluminum	< 50 µg/L seasonal average ¹
Nitrogen -Ammonia	< 2 mg/L ^{1,4}	Dissolved Copper	B.C. dissolved cooper BLM ¹
Chloride	< 150 mg/L ¹	Total / Dissolved Iron	< 1 mg/L, / < 0.35 mg/L ¹
Fluoride	< 1.0 mg/L ² , < 0.12 mg/L ³	True Color	< 5 TCU change from background ¹
Nitrate	< 10 mg/L ² , < 3 mg/L ¹		
Turbidity	< 5 NTU change when background <50 NTU or < 10% when background >50 NTU ^{1,4}		
Total Suspended Solids	< 10 mg/L change when upstream < 100 mg/L or <10% when upstream > 100 mg/L ^{1,4}		

¹B.C. aquatic life WQG chronic unless otherwise stated

²B.C. drinking water WQG

³CCME long-term aquatic life guideline

⁴1987 provisional WQO

6.1 pH

pH measures the concentration of hydrogen ions (H^+) in water. The concentration of hydrogen ions in water can range over 14 orders of magnitude, so pH is defined on a logarithmic scale between 0 and 14. A pH between 0 and less than 7 is acidic (the lower the number, the more acidic the water) and a pH between 7 and 14 is alkaline (the higher the number, the more basic the water). The optimal pH range for household water use is 6.5 to 8.5 as corrosion of plumbing or scaling and encrustation can occur outside of this range. The effectiveness of chlorine as a disinfectant for domestic water use is also reduced if pH is outside of this range (McKean & Nagpal, 1991). The water quality guideline for the protection of aquatic life is a pH between 6.5 and 9.0 for freshwater environments. If the background pH is outside of that range, then there should be no statistical change to pH levels (ENV, 2021d).

The pH of water is an important control of metal solubility and toxicity. Industrial emissions have the potential to result in the lowering of pH levels in water bodies causing acidification and could promote the solubility of metals making them more bioavailable to aquatic organisms. As pH lowers, metal cations such as aluminum, lead, copper, and cadmium are released into the water instead of being bound to sediment. This can result in increased bioavailability of metals which increases their toxicity to aquatic life (Fondriest, 2013).

pH in the surface waters of B.C. is determined primarily by three factors: the amount of precipitation, the geology of the area, and the rate of bedrock and soil weathering. The Kitimat River's location in the Cascade Mountain region on the west coast of the B.C. mainland is characterized as a high rainfall area having uniform granitic geology with thin soils. As such, slow weathering and high precipitation runoff rates produce very dilute levels of carbonate making surface waters weakly acidic (ENV, 2021d). This also means there is little buffering capacity in the water to manage acidic inputs from industrial emissions and therefore the potential risk for freshwater acidification which can lead to changes in metal availability and impacts to aquatic life.

The pH provisional WQO for the Kitimat River is based on the WQG for the protection of aquatic life, ranging from 6.5 to 9.0 pH units. Across all sites in the Kitimat River between 2015 and 2020, the pH ranged from 6.03 to 8.14 pH units with an average of 7.13 pH units. The pH ranged from 6.91 pH units to 7.29 pH units for the Little Wedeene River and from 7.07 pH units to 7.71 pH units for Hirsch Creek. There was no upstream or downstream trend in pH within the watershed. pH were values below the minimum aquatic life guideline of 6.5 in May 2015 and at some sites in the winter of 2020 during periods of high rainfall. Rainfall tends to have a low pH (6.0 - 6.5 pH units), and therefore heavy rainfall can temporarily drive down the pH in a river, which is likely in the Kitimat River. Despite depressions in pH measurements around rainfall events, pH averages remained within the provisional WQO and the WQG. It is recommended that the provisional WQO for pH range of 6.5 to 9.0 pH units be retained.

6.2 Temperature

For the protection of aquatic life in streams, the B.C. WQG recommends a temperature change of $\pm 1^\circ C$ from optimal temperature ranges depending on species and lifestage. Although the Kitimat River is used extensively for rearing by juvenile salmonids (MacDonald & Shepherd, 1983), Dolly Varden, present throughout the year, are a more sensitive species and require the optimal temperatures to be below $15^\circ C$. Steelhead and cutthroat trout remain in the watershed for the longest duration, including throughout the summer, and have temperature requirements similar to those of Dolly Varden (Oliver & Fidler, 2001),

Water temperature was measured in the Kitimat River at the reference site, upstream of the Haisla Bridge and downstream of the former Eurocan mill monthly from May 2019 to March 2020, excluding December 2019 and April 2020. Temperatures varied seasonally, with maximum temperatures occurring in late July to early August. Surface temperatures in the lower Kitimat River ranged between $0^\circ C$ and $14.7^\circ C$ (Table

4). The average summer temperature was 12.2°C and the average winter temperature was 2°C. The Kitimat River is mostly glacially fed and many snowfields and at least two glaciers, the Davie and Wedeene, help sustain the flow and keep the temperatures low. During a drought in 2018, Provincial Fisheries noted that the Kitimat River still had flows and the temperatures did not exceed 16°C. While glacial meltwater currently maintains the Kitimat River, glaciers are receding and contributions will likely be gone within the next two decades as the small, vulnerable glaciers of the watershed continue to recede.³ Lower Kitimat River temperatures measured in 2019 and 2020 met WQGs for both the protection of aquatic life and the aesthetic for drinking water.

The lower Kitimat River is identified as a drinking water source for the town of Kitimat and a migration route and spawning and rearing habitat for a variety of fish species including Dolly Varden. For the long-term protection of the fish species and use of water for drinking, it is recommended that the temperature of 16°C be added to the WQOs for the Kitimat River.

Table 4: Summary of water temperatures (°C) measured at the three Kitimat River sites as well as at Hirsch Creek and Little Wedeene River between 2019 and 2020. Sites are listed from upstream to downstream and tributaries in the order they enter the Kitimat River mainstem.

EMS	Site Name	Minimum	Maximum	Mean	Summer Average ¹ (Jun-Sept)	Winter Average ¹ (Dec-Mar)	No. of Samples
E301870	Kitimat River U/S ² Reference	2.7	14.1	6.4	12.3(5)	2.8(3)	16
E279768	Little Wedeene River	3.8	12.6	10	11(3)	-	7
E216319	Hirsch Creek U/S ² of Hwy37 Bridge	0	14.4	7.4	11.8(3)	0.7(2)	8
430025	Kitimat River U/S ² of Haisla Bridge	1	14.7	7.5	12.3(4)	2.2(3)	18
E207570	Kitimat River D/S ² Eurocan	1.3	14.5	7.8	12.1(4)	1.4(4)	19

¹ The number of samples used to calculate the summer and winter averages are in brackets.

² U/S and D/S denote upstream and downstream.

6.3 Dissolved Oxygen

Dissolved oxygen levels are important for the survival of aquatic organisms, especially species sensitive to low oxygen levels, such as salmonids. Dissolved oxygen concentrations throughout the river ranged from 9 mg/L to 14.3 mg/L (Figure 5), which met the minimum WQO of 7.8 mg/L for the Kitimat River and the B.C. long-term chronic (30-day mean) WQGs for the protection of aquatic life (MOE, 1997). High dissolved oxygen levels in the river suggest that the area is well flushed and oxygenated. Due to the short residence time in the river, there is not expected to be any dissolved oxygen depletion caused by the biological oxygen demand (BOD) from the District of Kitimat sewer treatment system discharge.

Any new LNG facilities or increases in NOx emissions from existing facilities, could have the potential to impact water quality by increasing nutrients and encouraging algal growth (as discussed in Section 4.3) which could reduce dissolved oxygen concentrations.

It is recommended that the provisional WQO for dissolved oxygen of >7.8 mg/L be retained. This value is consistent with the B.C. aquatic life WQG minimum concentration for salmonid species and Dolly Varden.

³ Matthew J. Beedle, PhD Coast Mountain College, personal communication, February 21, 2024.

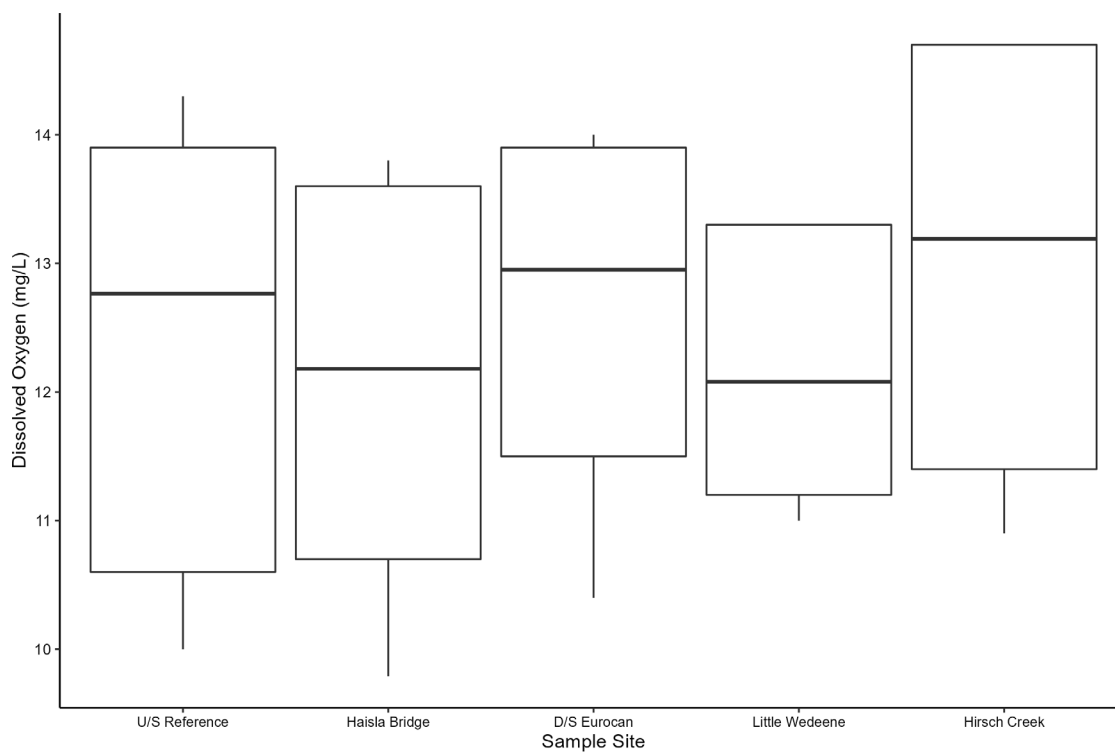


Figure 5: Range of dissolved oxygen concentrations (mg/L) across the Kitimat River (first 3 boxes from upstream to downstream), Little Wedeene River and Hirsch Creek sites, 2015 to 2020 data. Boxplot elements bottom to top: minimum, 10th percentile, mean, 90th percentile, maximum.

6.4 True Colour

Colour in water is caused by dissolved and particulate organic and inorganic matter. True colour is a measure of the dissolved colour in water after the particulate matter has been removed, while apparent colour is a measure of the dissolved and particulate matter in water. Colour can affect the aesthetic acceptability of drinking water and recreation and can indicate higher levels of organic matter. For the protection of aquatic life, the true colour long-term guideline is a 30-day average value that does not exceed background by more than five True Colour Units (TRU) in clear water systems (<20 TCU) or 20 percent in a coloured system (>20 TCU) (Moore & Caux, 1997). TRU are equivalent to mg/L of Platinum-Cobalt units and so these units are used interchangeably in this report.

When organic matter is chlorinated, it can produce disinfection by-products (DBPs) such as trihalomethanes, which poses a risk to human health. However, organic matter is also known to modify the toxicity of certain contaminants, such as metals. For instance, the toxicity of aluminum, copper, and zinc are reduced by organic matter because they form complexes that render these metals biologically unavailable. These effects may play a significant role in determining toxicity of contaminants in waters that are naturally coloured (MOE, 1999a).

Drinking water intakes are upstream of the municipal wastewater treatment discharge and all industrial discharges so effluent is not an influence on drinking water. Table 5 compares true colour at ENV sampling locations from upstream to downstream on the Kitimat River. With all background values at the reference site less than 20 TCU, the Kitimat River was identified as a clear water system. The general observations of the 2015 to 2020 data agree with the 2020 technical assessment (BWP & ENV, 2020). Figure 6 shows that in the summer months (June to August), during clear low flows, colour values are low (< 5 TCU) and

below the guidelines at all sites. During early spring and fall high flows, colour values at both sites downstream of the reference site are more than 5 TCU above the background values, exceeding the long-term aquatic life WQG. The highest values occurred in the river at the Haisla Bridge which were up to six times higher than the reference site. Below the Haisla Bridge, colour values decreased although remained slightly above the WQG limits.

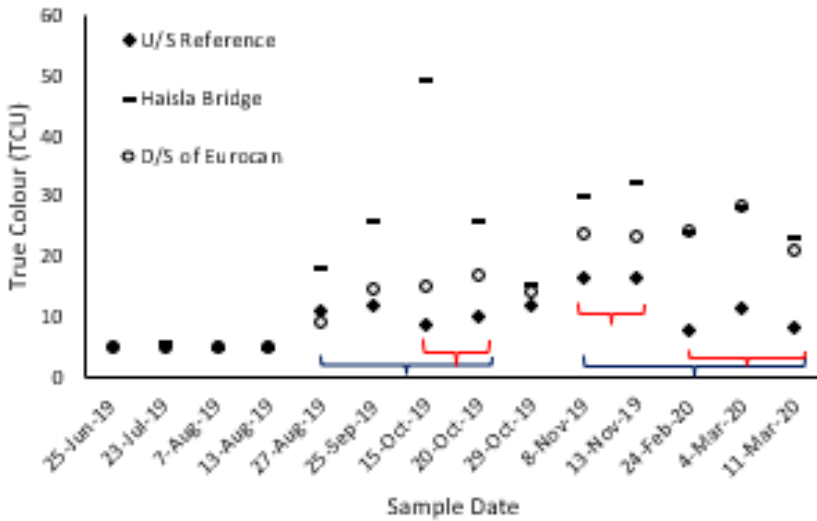


Figure 6: True colour values across the Kitimat River sites, 2019 and 2020 data. The blue brackets indicate exceedances of the WQG at Haisla Bridge site and red brackets indicate exceedances at both Haisla Bridge and D/S of the former Eurocan sites.

A similar trend was identified when the summer seasonal average (over 2 months) and a fall average based on five samples in 30 days were compared to the long-term aquatic life guidelines.

There is currently no true color WQO for the Kitimat River. The recommendation for a true colour WQOs is a maximum of 5 mg/L Pt above the upstream reference values when the values are less than 20 mg/L Pt or 20 percent above the reference value when those values are greater than 20 mg/L Pt .

Table 5: Summary of changes in true colour (TCU) in a downstream direction in the Kitimat River, 2015 to 2020. Shading highlights the summer and fall values used to calculate the average. Bold values exceed the B.C. long-term WQG for aquatic life.

Sample Date	Kitimat River U/S ¹ Reference	Kitimat River at Haisla Bridge	Kitimat River D/S ¹ of Eurocan	Concentration Difference
2015-05-03	18.7			
2015-05-13	11.7			
2015-06-03	5			
2019-06-25	5		5	0
2019-07-23	5	5.7	5	0
2019-08-07	5	5	5	0
2019-08-13	5	5	5	0
2019-08-27	11	18.3	9.2	-1.8
2019-09-25	12	25.9	14.7	2.7
2019-10-15	8.4	49.6	15.1	6.7
2019-10-20	10	26.3	16.9	6.9
2019-10-29	11.6	15.6	14.2	2.6
2019-11-08	16.6	30.2	23.8	7.2
2019-11-13	16.4	32.6	23.3	6.9
2020-01-30			27.2	
2020-02-24	7.7	24.3	24.2	16.5
2020-03-04	11.2	28.3	28.3	17.1
2020-03-11	8.3	23.5	20.8	12.5
Number of Samples	12	13	15	
Minimum value	5	5	5	
Maximum value	18.7	49.6	28.3	
Summer 30-day Average	6	8.5	5.84	-0.16
Fall 30-day Average	12.6	30.86	18.66	6.06

¹ U/S and D/S denote upstream and downstream respectively.

6.5 Turbidity

Turbidity is a measure of the clarity or cloudiness of water and is measured by the amount of light scattered by the particles in the water as nephelometric turbidity units (NTU). Events such as sedimentation from road surfaces, surface runoff peak flows, landslides and debris flows increase turbidity. Turbidity can be impacted by organic matter and total suspended sediments. Elevated turbidity levels can decrease the efficiency of disinfection, allowing microbiological contaminants to enter a drinking water system. Turbidity can also impact aquatic life by clogging gills and making it difficult to avoid predators and see prey. There are also aesthetic concerns with cloudy water, and particulate matter which can clog water filters and leave a film in plumbing fixtures.

Turbidity in the Kitimat River is naturally high, in part because it is glacier fed. As glaciers move, they erode underlying strata producing glacial flour and till. The flour and fine tills remain suspended in glacial fed streams, causing increased suspended sediments and turbidity. Turbidity typically increases with flow (i.e. during heavy fall rains) as runoff from land carry particulate matter into streams. Low-gradient landslides in the upper part of the river and eroding tributary streams, including Little Wedeene River and Hirsch Creek, also contribute sediment to the river.

The Kitimat River is the source of drinking water for the DOK. Elevated turbidity levels can impact the effectiveness of chlorine to adequately disinfect the water and increases the risk of pathogens, which can result in water advisory or boil water notices (Health Canada, 2012).

Given the large variation in natural background turbidity levels across B.C., aquatic life and drinking water quality guidelines for turbidity are based on a change from background turbidity. For the lower Kitimat River, the WQOs for turbidity are set at the B.C turbidity WQG limits for both drinking water and aquatic life where induced turbidity should not exceed 5 NTU when background turbidity is less than or equal to 50 NTU and when background is greater than 50 NTU, the induced turbidity should not be more than 10 percent of background levels (ENV, 2020). Background is defined as the turbidity level at an upstream reference site that is as close as possible to the site where the guideline is being assessed. The WQOs recognize that turbidity levels are not static and fluctuate with the seasons and that background values in the Kitimat River are naturally high.

Table 6 is a summary of turbidity values from the Kitimat River on sampling dates for which turbidity was measured at more than one site on the same day. The downstream change in the final column represents the difference in NTU from the sample collected at the upstream site (as close as possible to the site where the guideline is being assessed) and that of the sample collected furthest downstream of discharges in the watershed. A positive number denotes an increase in turbidity, and a negative number denotes a decrease between the two sites. During drier low-flow periods, turbidity tended to be relatively similar throughout the river monitoring sites. More pronounced increases occurred downstream in the high flow periods, such as near the Haisla Bridge and downstream of municipal and industrial outfalls. High flow events preceded the August 27 and November 8 sampling events in 2019.

Table 6: Summary of changes in turbidity (NTU) in a downstream direction (left to right) in the Kitimat River, 2019 to 2020.

Sample Date	Kitimat River U/S ¹ Reference (A)	Kitimat River at Haisla Bridge (B)	Kitimat River D/S ¹ Eurocan (C)	Difference between A & B	Difference between A & C
2019-06-25	0.86	1.29	1.42	0.43	0.56
2019-07-23	3.06	2.14	3.02	-0.92	-0.04
2019-08-07	4.47	3.65	3.67	-0.82	-0.8
2019-08-13	2.07	1.85	1.91	-0.22	-0.16
2019-08-27	227	3.45	9.31	-223.55	-217.69
2019-09-25	4.32	5.36	13.6	1.04	9.28
2019-10-15	0.35	4.35	1.89	4.00	1.54
2019-10-20	0.38	1.51	1.5	1.13	1.12
2019-10-29	0.6	1.91	2.33	1.31	1.73
2019-11-08	39.7	63.1	104	23.4	64.3
2019-11-13	2.21	5.74	8.59	3.53	6.38
2020-02-24	0.14	1.63	3.26	1.49	3.12
2020-03-04	0.23	3.51	3.85	3.28	3.62
2020-03-11	0.17	2.03	1.97	1.86	1.8

¹ U/S and D/S denote upstream and downstream respectively.

To evaluate seasonal turbidity levels, turbidity was measured at the three Kitimat River sites during the 2019 fall-flush period, on six occasions between September and November and on five occasions between June and August during the summer low flows. The high precipitation event in August 2019 resembled what is typically observed in the fall hence these results are considered with the fall data in this assessment. The reference site upstream had the greatest range of turbidity from 0.14 NTU to 227 NTU and had more variability than the downstream sites. The two downstream sites had less variability but higher median turbidity levels suggesting that overall, the amount of turbidity was higher downstream. Seasonal mean turbidity at the upstream reference site was less than 50 NTU (Table 7). The calculations indicate that during this sampling, the turbidity WQO was mostly met in the lower Kitimat River. The exception was at the former Eurocan site where the median was slightly greater than 5 NTU above the median of the reference site during the fall period.

Table 7: Summary of 2019 average seasonal turbidity (NTU) in the Kitimat River.

Sampling Period	Kitimat River Sampling sites											
	U/S Reference (E301870)				Haisla Bridge (430025)				D/S Eurocan (E207570)			
	Min	Max	Mean	Median	Min	Max	Mean	Median	Min	Max	Mean	Median
Summer (Jun-Aug)												
2019	0.86	4.47	2.61	2.57	1.29	3.65	2.4	2.0	1.42	3.67	2.5	2.47
Fall (Sept-Nov) ¹												
2019	0.35	277	39.22	2.21	1.51	63.1	12.20	4.35	1.5	104	20.17	8.59

¹August 2019 high precipitation event results are being considered with the fall data.

The highest fall turbidity values in 2019 were preceded by significant rainfall within 24 to 48 hours (Government of Canada, 2019). As demonstrated in previous studies and by the data collected in 2019, elevated turbidity levels in the Kitimat watersheds are almost invariably associated with high rainfall events, which flush material into the creeks and the river. However, turbid summer events like that seen in August 2019 may be the result of glacial melt during hot weather conditions.

It is recommended that the provisional WQO for turbidity be retained for the lower Kitimat River to protect drinking water and aquatic life uses in the river downstream of the Haisla Bridge and notably downstream of the DOK STP and any industrial or activity runoff areas.

6.6 Total suspended solids

Total suspended solids (TSS), or non-filterable residue (NFR), include all the undissolved particulate matter in a water sample. TSS is typically correlated with turbidity; however, unlike turbidity, it is not measured by optical methods. Instead, a water sample is filtered, and the residue is dried and weighed to determine the weight of residue per volume.

The WQOs for the lower Kitimat River (Warrington, 1987) recommend that TSS increases not exceed 10 mg/L when concentrations upstream are less than or equal to 100 mg/L and when upstream concentrations exceed 100 mg/L, the maximum allowable increase in the lower watershed should not be more than 10 percent. These provisional WQOs included the understanding that naturally higher levels of suspended sediments can occur during high flow periods and are meant to measure additional TSS inputs.

TSS was measured at three sites in the Kitimat River during the 2019 fall-flush season, on six occasions between September and November and on five occasions between June and August during the summer low-flow season. The high precipitation event in August 2019 resembles what was typically observed in the fall hence these results were considered with the fall data in this assessment. Concentrations of TSS ranged from less than 3 mg/L at all sites to 601 mg/L at the upstream reference site (Table 8).

Table 8: Summary of TSS concentrations (mg/L) for water samples collected in the Kitimat River during the summer and fall of 2019. The letter “n” denotes the number of seasonal samples collected.

Sampling Period	Kitimat River Sampling sites								
	Upstream Reference (E301870)			Haisla Bridge (430025)			Downstream of Eurocan (E207570)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Summer (Jun/Aug)									
2019 ⁿ⁼⁴	<3	4.1	3.6	<3	4.5	3.4	<3	4.3	3.3
Fall (Sept/Nov¹)									
2019 ⁿ⁼⁷	<3	601	104	<3	98	22	<3	201	40

¹ Fall summary includes high precipitation August 2019 TSS value.

The closure of the pulp mill in 2010 removed its input to the lower Kitimat River and reduced the risks to aquatic life from elevated TSS. Currently, other potential inputs of TSS, outside of erosion from land use, is the DOK sewage treatment outfall and the sand hill gravel pit may contribute intermittent inputs of TSS through dust or runoff. The TSS WQOs established for the lower Kitimat River were not exceeded at either the Haisla Bridge or downstream of the former Eurocan site.

It is recommended that the provisional TSS WQOs be retained. This WQO is based on the B.C. aquatic life long-term WQG and represents concentrations protective of aquatic life.

6.7 Ammonia

Ammonia is the most reduced inorganic form of nitrogen found in water and exists in two states in equilibrium, depending on environmental conditions: ammonia (NH_3) and ammonium (NH_4^+) (ENV, 2021b). NH_3 is the most toxic form of nitrogen to aquatic life, with salmonids species being particularly sensitive. The criteria to protect aquatic life are expressed in terms of total ammonia concentrations, as a function of water temperature and pH.

Concentrations greater than 0.5 mg/L have been associated with water taste and odour problems and poor drinking water disinfection success. NH_3 can interfere with chlorination because it reacts with chlorine to increase chlorine demand (ten parts of chlorine required for one part of ammonia), and form chloramines, which have relatively poor disinfection efficiencies. Ammonia is also known to cause corrosion in water distribution systems. There is no ammonia guideline for untreated, raw drinking water.

The ammonia objective for the lower Kitimat River was based on the ammonia guideline for the protection of aquatic life, which considers water temperature and pH. The toxicity of ammonia increases with both pH and temperature. The maximum temperature (8-14 °C) and pH (7.54-7.67) values obtained from the Kitimat River reference site for the 2015 spring and 2019 summer and fall periods were used to calculate the most conservative WQG. The chronic ammonia aquatic life WQG value was calculated to be 1.8 mg/L.

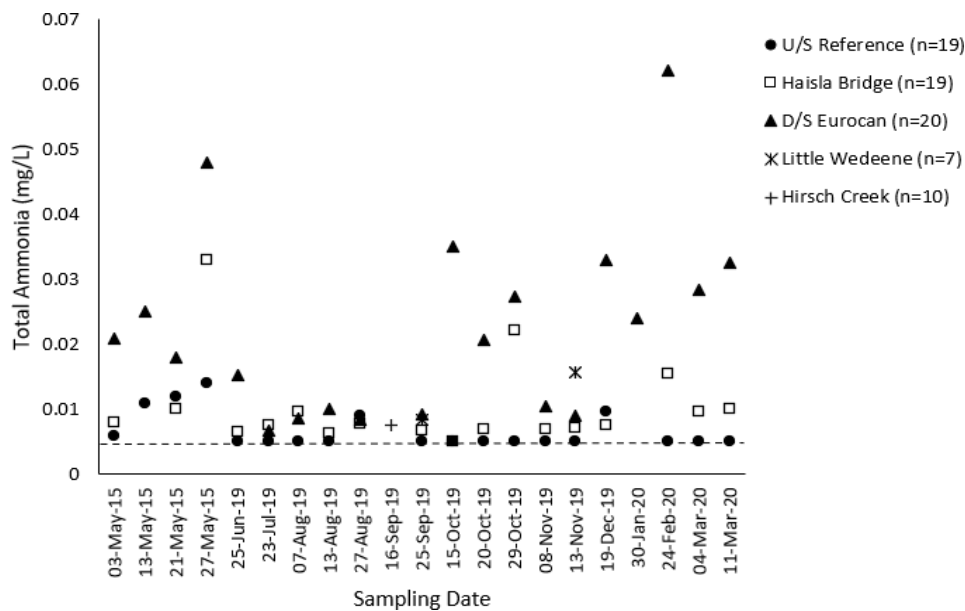


Figure 7: Range of total ammonia concentrations (mg/L) across three sites in the Kitimat River and two tributaries, 2015 to 2020 data. Only values above the detection limit at Little Wedeene River and Hirsch Creek are plotted, and visible. The black dashed line is the method detection limit of 0.005 mg/L.

Three sites on the Kitimat River were sampled for ammonia between 2015 and 2020 including seasonal five in 30-day periods. As seen in Figure 7, most reference site values were below the detection limit (<0.005 mg/L), while concentrations at all other sites were very low, under 0.07 mg/L. Monthly sampling was carried out on the two tributary sites from June to November of 2019. All values were less than the

detection limit except for one Hirsch Creek value and two Little Wedeene River values but these three were still below 0.02 mg/L. The chronic aquatic life WQG for ammonia was met at all the sampling locations.

It is recommended to change the WQO from a calculated value to a single number of 1 mg/L based on the existing water quality in the lower Kitimat River to ensure ammonia levels in the river are protective of aquatic life, especially the sensitive salmonid species.

6.8 Chloride

Primary natural sources of chloride include the oceans, atmospheric deposition, and weathering of rocks and minerals, while major anthropogenic sources of chloride include winter de-icers, fertilizers, and water treatment. To protect drinking water, the WQG for chloride is set at 250 mg/L. Above this level, water begins to taste salty. For the protection of freshwater aquatic life, the long-term chloride concentration is a 30-day average of 150 mg/L. The major effect of elevated chloride in surface water is interfering with the balance of aquatic organism's bodily fluids (Xia, 2021).

Due to the use of chlorination by the DOK to treat the municipal water system supply, discharge to the river from the DOK sewage outfall, chloride concentrations in the Kitimat River were included in the data evaluation. Between 2015 and 2020, the upstream reference chloride concentrations were consistently below the detection limit of 0.5 mg/L. Instantaneous chloride concentrations downstream of the DOK sewage outfall ranged from 0.5 mg/L to 4.7 mg/L. The results for each site are summarized in the data summary tables in Appendix A. None of the chloride monitoring results were close to either the aquatic life guideline or the drinking water guideline. There is no existing WQO for chloride in the Kitimat River. Based on the above findings and no known additional inputs to the system, a chloride WQO is not considered necessary.

6.9 Fluoride

Natural concentrations of fluoride in surface waters are typically less than 1 mg/L and many natural streams are below 0.2 mg/L (MOE, 1999b). British Columbia coastal lakes and streams are low in fluoride. However, the Rio Tinto aluminum smelter is the largest source of atmospheric fluoride emissions in the Kitimat watershed and has been for some time, therefore, true background levels are difficult to determine. The data from the period of 1975 to 1983 indicated background levels in the Kitimat River were less than 0.1 mg/L and included stack-emission fallout in the watershed (Warrington, 1987). There is no fluoride WQO for the Kitimat River but given the persistent source in the watershed, fluoride data were included in this assessment.

To remain within the acceptable human daily intake levels of fluoride from all sources, the B.C. recommended total fluoride guideline in raw drinking water is a 30-day average of 1.0 mg/L. For the protection of aquatic life, B.C. has acute maximum WQG of 0.4 mg/L, designed for soft water where *Oncorhynchus* species reproduce. The Canadian Council of Ministers of the Environment (CCME) derived an interim guideline employing a similar approach to B.C. that used more recent toxicology studies and included *Oncorhynchus* species. Both guidelines are conservative and recognize the need for additional chronic toxicological studies. Fluoride concentrations in the Kitimat River were compared to the CCME guideline as it uses a similar approach to B.C. and is based on more recent studies. The CCME chronic interim guideline for the protection of aquatic life is 0.12 mg/L.

Fluoride values across all Kitimat River and tributary sites sampled between 2015 and 2020 are summarized in Table 9. Values ranged from less than 0.02 mg/L (detection limit) to 0.195 mg/L at the Kitimat River upstream of the Haisla Bridge monitoring site. The individual fluoride concentrations and the

seasonal means met the B.C long-term 30-day mean raw drinking water quality guideline of less than 1 mg/L at all sampling locations, but individual values exceeded the CCME guideline of 0.12 mg/L on several occasions at the Haisla Bridge site in the late summer and winter.

Table 9: Summary of dissolved fluoride concentrations (mg/L) at the Kitimat River sites, Hirsch Creek and Little Wedeene River between 2015 and 2020. Sites are listed from upstream to downstream, and tributaries in the order they enter the Kitimat River mainstem (Data source: ENV EMS).

EMS	Site Name	Minimum	Maximum	Mean	95th percentile	No. of Samples
E301870	Kitimat River U/S Reference	<0.02	0.046	0.031	0.04	20
E279768	Little Wedeene River	<0.02	0.051	0.032	0.05	7
E216319	Hirsch Creek U/S of Hwy37 Bridge	<0.02	0.026	0.016	0.02	10
430025	Kitimat River U/S of Haisla Bridge	0.033	0.195	0.074	0.19	20
E207570	Kitimat River D/S former Eurocan	<0.02	0.061	0.036	0.06	20

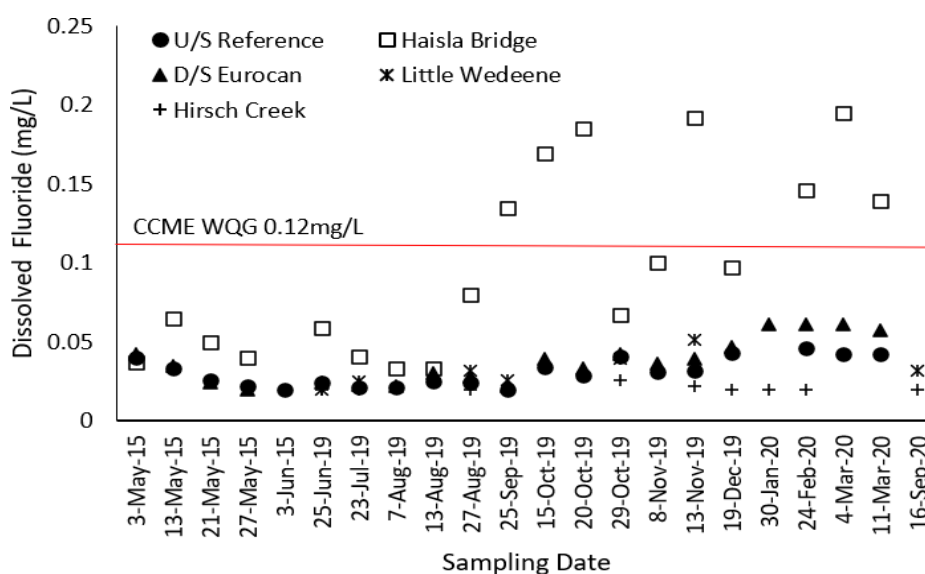


Figure 8: Dissolved fluoride concentrations (mg/L) in the Kitimat River, Little Wedeene River and Hirsch Creek sites, 2015 to 2020.

Owing to the ongoing atmospheric emissions from Rio Tinto and the numerous populations of anadromous salmon that migrate through the river, fluoride should be considered a parameter of interest in the Kitimat River watershed. To support long-term protection and management of the salmonid populations, a fluoride WQO of less than 0.12 mg/L is recommended in the lower Kitimat River.

6.10 Nutrients

Nitrogen (including nitrate and nitrite) and phosphorus concentrations tend to be the limiting nutrients in biological systems. Productivity is directly proportional to nutrient availability, with phosphorus tending to be the limiting factor in freshwater aquatic systems of B.C. In watersheds where drinking water is a priority, it is also desirable that nutrients remain low to avoid algal blooms and foul-tasting water.

Similarly, to protect aquatic life, nutrients need to be balanced enough to contribute to the food chain but not too high that excessive algal growth occurs. The primary anthropogenic source of nutrients to the Kitimat River is the DOK municipal sewage discharge. Other sewage systems, such as with LNG Canada, are discharged to the Kitimat Arm. Existing and future industrial sources include air emissions from smelter and LNG activities. Monitoring results for Kitimat River for nitrate, nitrite, and total phosphorus are summarized in the Appendix A data summary tables.

6.10.1 Nitrate

The maximum nitrate guideline concentration for drinking water and water for primary contact recreational waters is 10 mg/L as nitrogen. For the protection of aquatic life, the 30-day average concentration is 3 mg/L (Meays, 2009).

Nitrate as N ranged from 0.0067 mg/L at Hirsch Creek to a maximum of 0.187 mg/L in the Kitimat River upstream of the Haisla Bridge. All values of nitrate were well below the drinking water, recreational use, and aquatic life guidelines (Figure 9). There is no existing WQO for nitrate; however, to maintain and protect water quality, a recommended new WQO for nitrate consistent with the protection for aquatic life WQG is recommended.

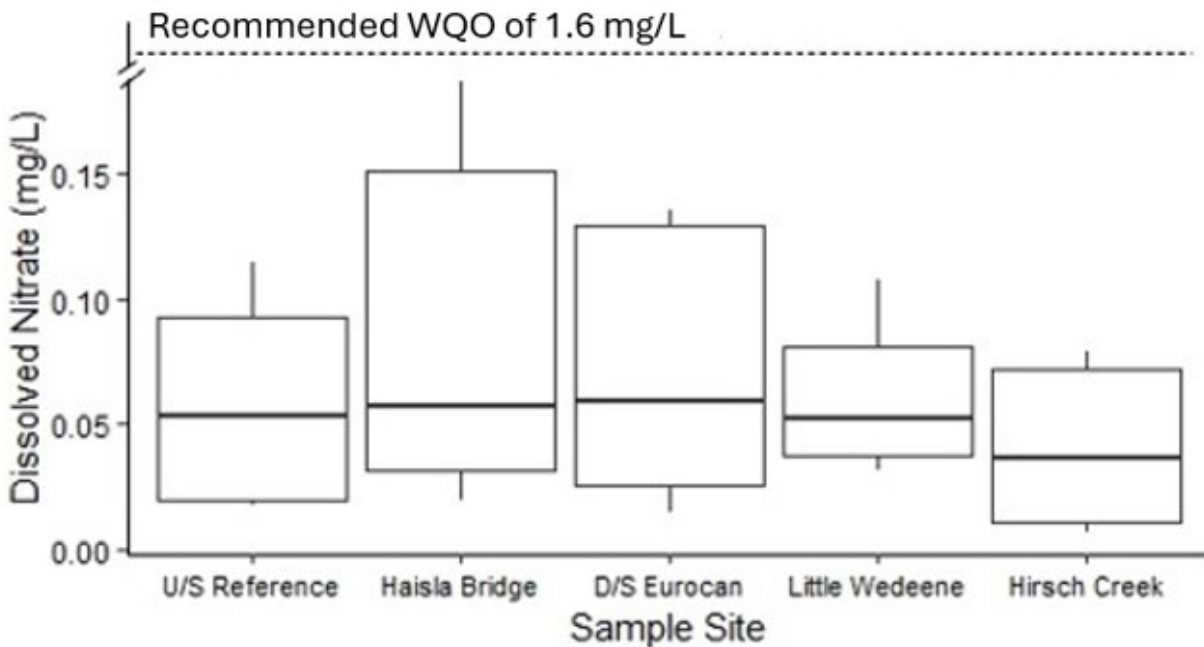


Figure 9: Range of dissolved nitrate concentrations (mg/L) across the Kitimat River (first 3 boxes from upstream to downstream), Little Wedeene River and Hirsch Creek sites, 2015 to 2020 data. Boxplot elements bottom to top: minimum, 10th percentile, mean, 90th percentile, maximum.

6.10.2 Nitrite

The nitrite guideline concentration for primary contact recreational waters is a maximum of 1 mg/L as nitrogen. However, the nitrite WQGs for the protection of aquatic life are dependent on chloride concentrations. Chloride concentrations at the reference site in the Kitimat River are below detection limits (<0.5 mg/L). For low chloride waters (i.e., less than 2 mg/L) the chronic 30-day average nitrite WQG

is 0.02 mg/L. The provisional nitrite WQOs for the Kitimat River are set at the B.C. WQGs for the protection of aquatic life.

Nitrite values were consistently low throughout the sample sites in the Kitimat watershed, with 69 out of 76 sample results below detection limits (0.001 and 0.002 mg/L). The maximum value of 0.0087 mg/L was observed at the site downstream of the former Eurocan mill. Values above detection limits only occurred at Kitimat River sites downstream of the reference site (Figure 10). All values of nitrite were well below the recreational use and aquatic life guidelines. The range of the data did not provide for the ability to look for trends.

The municipal sewage discharge will continue to be a potential nitrogen source to the lower watershed and future LNG facilities have the potential to contribute nitrogen to the watershed as well. The recommended nitrite provisional WQO in the lower Kitimat River should be retained.

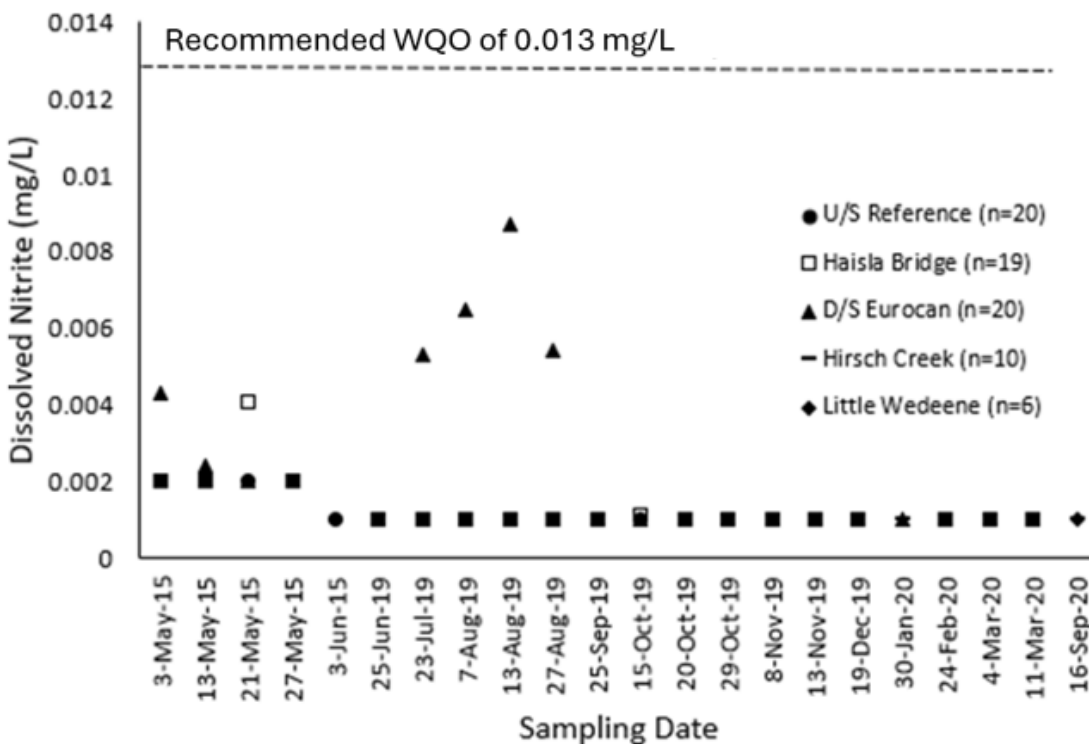


Figure 10: Dissolved nitrite concentrations (mg/L) in the Kitimat River, Little Wedeene River and Hirsch Creek sites, 2015 to 2020.

6.10.3 Phosphorus

There are no B.C. WQG for phosphorous in streams as various factors, such as water velocity, substrate, light, temperature, and grazing pressures, influence whether phosphorus will cause algae growth in streams (Nordin, 2001). Generally, elevated phosphorus is primarily a concern in aquatic environments during summer low-flow periods when elevated nutrient levels are most likely to lead to deterioration in aquatic habitat.

Table 10: Summary of total phosphorus ($\mu\text{g/L}$) measured at the three Kitimat River, Hirsch Creek and Little Wedeene River between 2015 and 2020. Sites are listed upstream to downstream and tributaries in the order they enter the Kitimat River mainstem.

EMS	Site Name	Minimum	Maximum	Average	No. Of Samples
E301870	Kitimat River U/S Reference	0.0501	434	31.6	20
E279768	Little Wedeene River	1.46	4.4	2.69	6
E216319	Hirsch Creek U/S of Hwy37 Bridge	0.638	84	13.1	10
430025	Kitimat River U/S of Haisla Bridge	2.4	98	6.4	19
E207570	Kitimat River D/S Eurocan	3.2	171	7.95	20

In the Kitimat River, elevated phosphorus values were primarily associated with elevated turbidity and TSS values which coincided with fall rains and heavy precipitation events as illustrated by the sampling results for the upstream reference site between 2019 and 2020 in Figure 11.

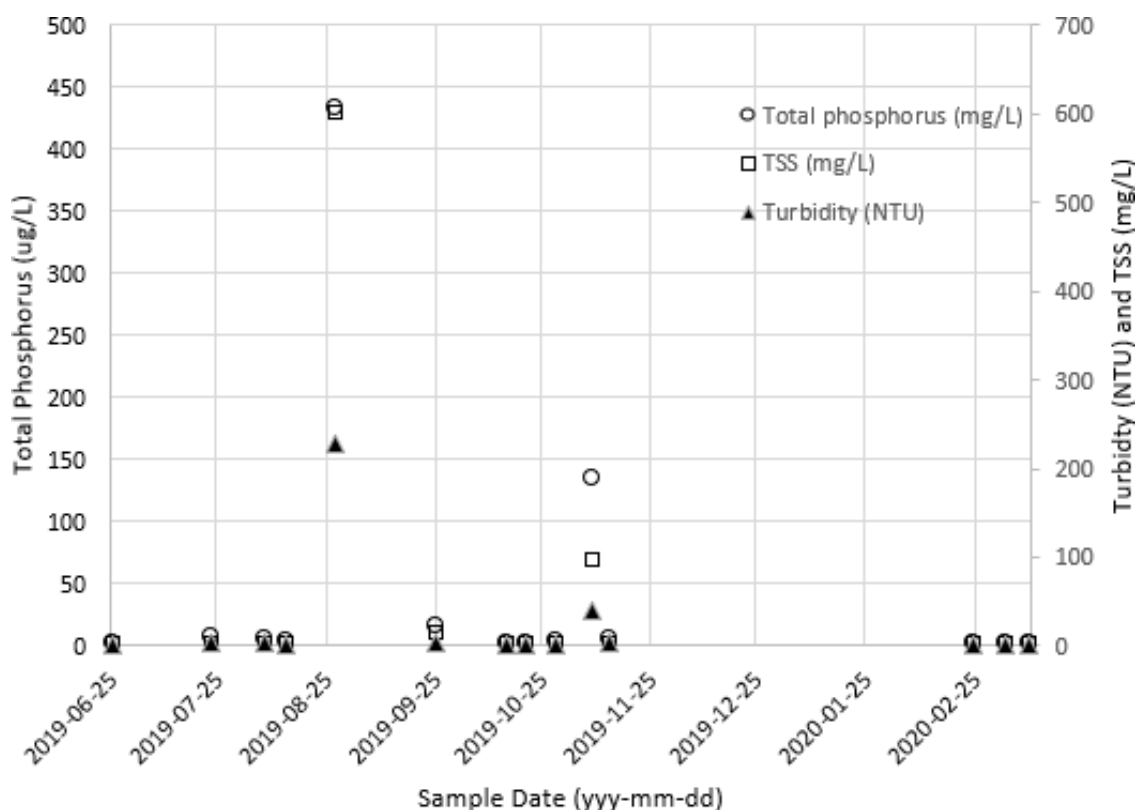


Figure 11: Kitimat River upstream reference site 2019 and 2020 total phosphorus (open circle), turbidity (black triangle) and TSS (open square) concentrations. August 27th and November 8th mark heavy precipitation events.

Total phosphorus in the Kitimat River was elevated during heavy rain events, but it did not appear to be elevated during the lower flows in the summer. As phosphorus has not been an issue, a WQO is not recommended.

6.11 Sulphate (SO₄)

Sulphate concentrations in water are the result of natural weathering of minerals, anthropogenic discharges, and atmospheric deposition with seasonally low dissolved sulphate concentrations apparent in most B.C. rivers during freshet and elevated concentrations during the drier low-flow periods (Meays & Nordin, 2013).

Sulphates can be discharged into the aquatic environment from industrial sources including smelting operations and kraft pulp and paper mills. Since the closure of the Eurocan mill, the lower Kitimat River no longer receives pulp mill discharge and there are no effluent discharges from the Rio Tinto smelting operation to the Kitimat River. However, sources of atmospheric deposition in the watershed include emissions from Rio Tinto and LNG export facilities and shipping terminal activities.

Sulphate (SO₄) WQGs for the protection of aquatic life were developed for different categories of water hardness. The guidelines provide protection for early life stage rainbow trout, which was the most sensitive species tested. The sulphate water quality guideline to protect aquatic life is 128 mg/L, based on the minimum hardness value of 10 mg/L from the Kitimat River upstream reference site. For the drinking water aesthetic objective, B.C. uses Health Canada's sulphate guideline of 500 mg/L.

Sulphate concentrations were measured 77 times in the Kitimat watershed. All values were below the drinking water and aquatic life guidelines. Values ranged from 0.93 mg/L in the river downstream of the former Eurocan to a maximum of 8.01 mg/L in the Kitimat River upstream of the Haisla Bridge (Table 11). Sulphate concentrations were regularly higher at the Haisla Bridge throughout the sampling period compared to those elsewhere in the river and on Hirsch Creek and the Little Wedeene River (Figure 12). Throughout the sampling period, values were similar between the reference site and downstream of the former Eurocan mill, with averages of 2.57 mg/L and 2.75 mg/L, respectively.

Table 11: Summary of dissolved sulphate concentrations (mg/L) measured in the Kitimat River, Hirsch Creek and Little Wedeene River between 2015 and 2020. Sites are listed upstream to downstream and tributaries in the order they enter the Kitimat River mainstem.

EMS	Site Name	Minimum	Maximum	Mean	95th percentile	No. of Samples
E301870	Kitimat River U/S Reference	1.19	4.43	2.57	4.32	20
E279768	Little Wedeene River	2.18	3.45	2.86	3.43	7
E216319	Hirsch Creek U/S of Hwy37 Bridge	1.43	3.28	1.99	2.88	10
430025	Kitimat River U/S of Haisla Bridge	1.68	8.01	4.38	7.25	20
E207570	Kitimat River D/S former Eurocan	0.93	4.38	2.75	4.29	20

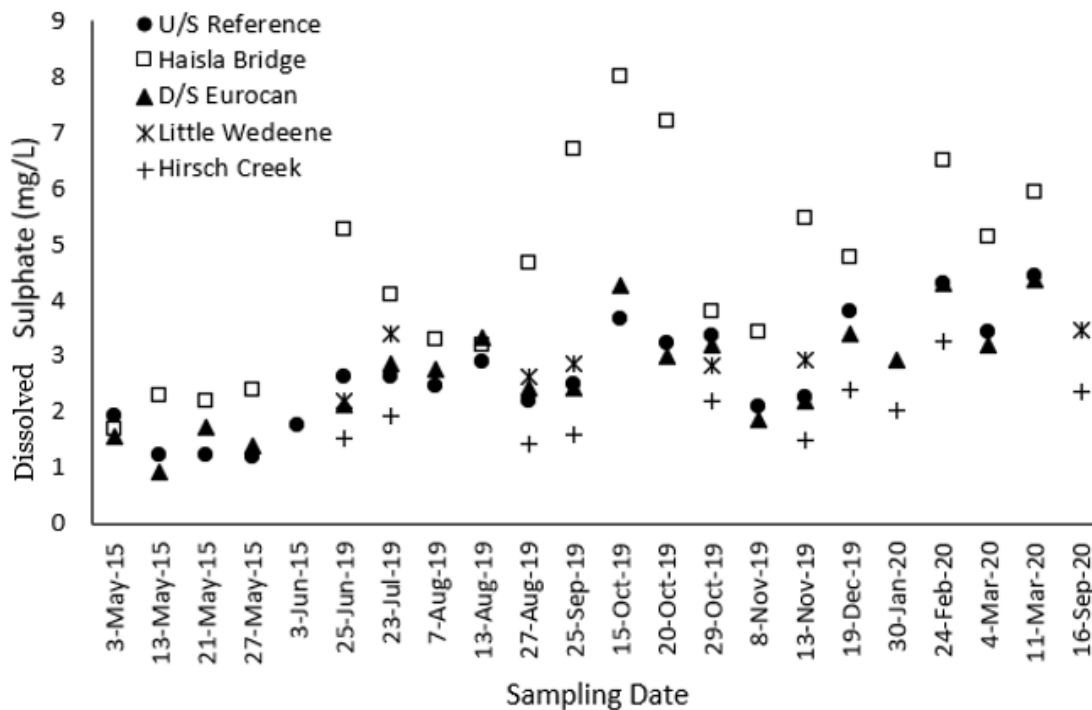


Figure 12: Dissolved sulphate concentrations (mg/L) in the Kitimat River, Little Wedeene River and Hirsch Creek sites, 2015 to 2020.

There were no exceedances of the sulphate guidelines observed during the sampling period. Mean sulphate concentrations in B.C. freshwaters range between about 5 and 30 mg/L (Meays and Nordin, 2013), and current background concentrations in the Kitimat River are below 5 mg/L. There is no sulphate WQO for the Kitimat River. However, owing to the ongoing industrial sources of sulfate in the watershed, a new WQO of 30 mg/L is recommended for the protection of aquatic life.

6.12 Metals

Total and dissolved metals concentrations were measured at three locations in the Kitimat River and in two tributaries. Seven monthly samples were collected at Hirsch Creek and Little Wedeene River from June 2019 to March 2020. The Kitimat River sites were sampled during the spring of 2015, monthly in 2019, including weekly summer low flow and fall high-flow sampling in 2019. The results were compared to the long-term average WQGs. There are no Kitimat River WQOs for metal concentrations.

For those parameters where concentrations were above detection limits, metal concentrations were compared to the B.C. ENV approved or working WQGs listed in Table 12. Metal concentrations were generally below detection limits, and well below guidelines. Exceptions were dissolved aluminum, dissolved copper, and dissolved iron where concentrations exceeded WQGs in the Kitimat River downstream of the reference site. Elevated metal concentrations typically occurred after rainfall events and were associated with elevated turbidity.

Table 12: Summary of the B.C. water quality drinking water and aquatic life guidelines for metals ($\mu\text{g/L}$).

Metal	Drinking Water Aesthetic Objective	Freshwater Aquatic Life 30-day average
Dissolved Aluminum ¹		50
Dissolved Cadmium		0.039
Dissolved Iron		0.00035
Total Antimony		g Sb (III)
Total Arsenic		5 ^{max}
Total Barium		1000
Total Beryllium		0.13
Total Boron		1200
Total Chromium		
Total Cobalt		4
Total Iron	300	0.001 ^{max}
Total Lead ¹		3.48 (3.83)
Total Manganese ²	20	649 (711)
Total Mercury		0.00125
Total Molybdenum		1000
Total Nickel ²		25
Total Selenium		2
Total Silver ²		0.05
Total Thallium		0.8
Total Uranium		8.5
Total Zinc ²	5000	7.5
¹ WQG when pH > 6.5. ² Hardness-based WQG calculated with minimum most conservative value of 10mg/L. If WQG differed using 95th percentile hardness of 24mg/L, this guideline is shown in brackets.		

6.12.1 Aluminum

Aluminum is the third most ubiquitous element in the earth’s crust and the most abundant metal (ENV, 2021a). However, because of the insolubility of the parent materials containing aluminum, the concentration of dissolved aluminum in natural waters is normally less than 1000 µg/L (Freeman & Everhart, 1971; Hem, 1970). Effluent from industrial operations including paper mills and aluminum smelters, like Rio Tinto, can be sources of aluminum. Fugitive dust can also be a source of aluminum, especially near the smelter. Anthropogenic acidic deposition and precipitation can be indirectly responsible for elevated levels of aluminum in both surface waters and groundwaters, resulting from the mobilization of aluminum from the surrounding terrestrial soils at lower pH levels and episodic releases of high aluminum concentrations that may occur during spring snowmelt (ENV, 2021a).

For the Kitimat River, where the average pH is greater than 6.5, the guideline for the protection of aquatic life recommends a mean dissolved aluminum concentration (based on a minimum of five samples collected within a 30-day period) of 50 µg/L and short-term guideline of 100 µg/L (Butcher, 2001).⁴

Dissolved aluminum results across all Kitimat River and tributary sites ranged from 13.2 µg/L in the Little Wedeene River to a maximum of 202 µg/L in the Kitimat River upstream of the Haisla Bridge (Table 13). The sampling frequency during the 2019 summer low-flow periods did not achieve five weekly samples in 30 days, but individual concentrations across all sites ranged from 13.2 µg/L to 37.9 µg/L. This was prior to the August 27th heavy rainfall event, which on that day resulted in concentrations ranging between 34 µg/L and 89 µg/L. The long and short-term aquatic life guidelines were exceeded at the Haisla Bridge and downstream of the former Eurocan mill sites during the fall high flow period as well as winter and spring flows (Figure 13). Concentrations at the reference site over the entire sampling period were mostly below the long-term WQG.

Table 13: Summary of dissolved aluminum concentrations (µg/L) in the Kitimat River, Hirsch Creek and Little Wedeene River between 2015 and 2020. Sites are listed upstream to downstream and tributaries in the order they enter the Kitimat River mainstem.

EMS ID	Sample Site	Minimum	Maximum	Mean	95th Percentile	No. of Samples
E301870	Kitimat River U/S Reference	14.8	95.2	33.9	90.2	20
E279768	Little Wedeene River	13.2	110¹	44.85	98.2	6
E216319	Hirsch Creek U/S of Hwy37 Bridge	16.7	101	49.8	93.3	9
430025	Kitimat River U/S of Haisla Bridge	14.5	202	80.7	172	14
E207570	Kitimat River D/S Eurocan	16.8	113	50.85	110	16

¹Bold values exceed the maximum dissolved aluminum WQG

⁴ This assessment was performed prior to B.C.’s adoption of a new Aluminum guideline. A re-evaluation of the proposed WQG for aluminum should be performed using the new guidelines prior to policy development.

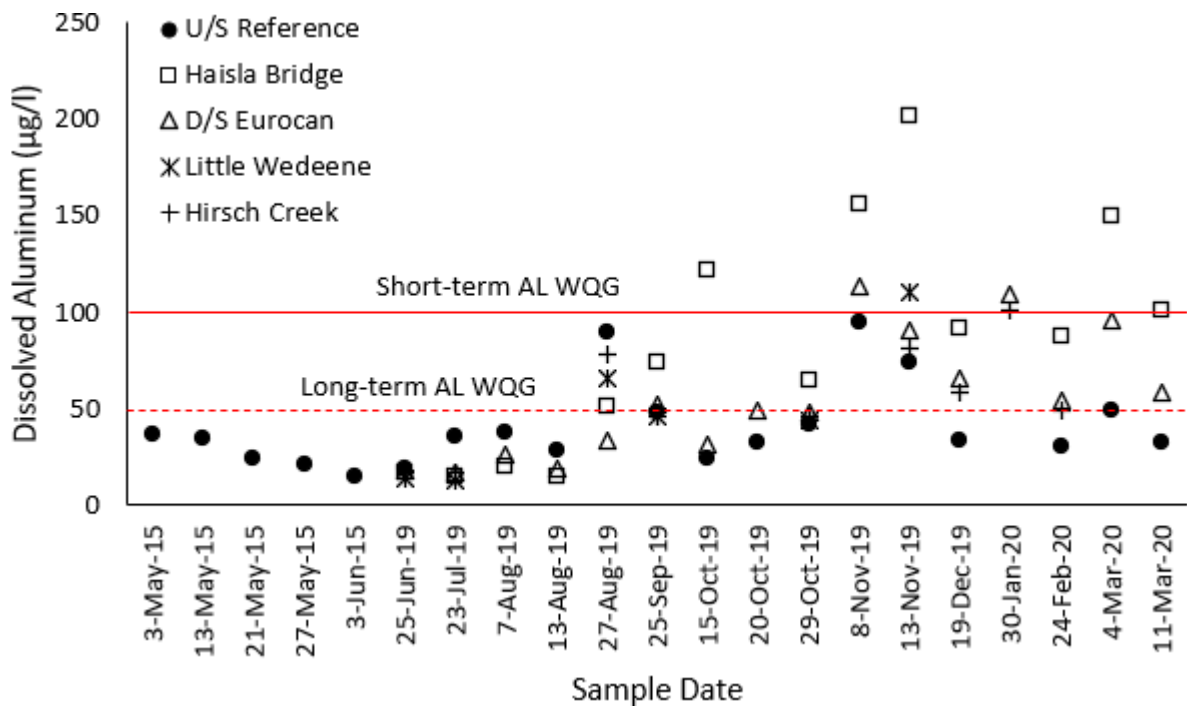


Figure 13: Range of dissolved aluminum concentrations (µg/L) across three sites in the Kitimat River and two tributaries, 2015 to 2020 data.

Although increases in dissolved aluminum were not always linked to high turbidity, higher flows and heavy rain periods are sufficient to increase dissolved aluminum concentrations above guideline levels in the Kitimat River and its tributaries. The exact cause could not be verified by this study and the range of the data did not provide the ability to look for trends over time.

One potential effect of SO_x and NO_x emissions is the acidification of terrestrial and aquatic ecosystems. Aluminum bound to soil particulate can be mobilized as soil pH drops and is transported from terrestrial to aquatic ecosystems, more so during high rain events. A long-term seasonal WQO of 50 µg/L is recommended for the lower Kitimat River based on the current upstream aluminum levels in the river, known potential industry sources and the B.C. long-term WQO for the protection of freshwater aquatic life.

6.12.2 Copper

Copper has long been a metal of concern in B.C. because of mining and other anthropogenic sources (ENV, 2019). It is also an essential metal for all organisms; however, elevated concentrations can negatively affect human health and aquatic organisms. For the protection of drinking water supplies, the total copper drinking water guideline is a maximum concentration of 2 mg/L. Total copper values in the Kitimat watershed ranged from 0.00023 mg/L to 0.0168 mg/L with an average of 0.00149 mg/L for all sites sampled (67 samples), which are below the drinking water guideline.

The B.C. Biotic Ligand Model (BLM⁵) for dissolved copper is used to calculate short-term and long-term dissolved copper guidelines for the protection of aquatic life. The guideline calculations rely on ambient water chemistry parameters of temperature, DOC, pH, and hardness. Long-term guideline values for dissolved copper are quite low because Kitimat River waters are very soft, with hardness values between 10 mg/L and 28 mg/L CaCO₃, at the upstream reference site.

The dissolved copper guidelines were calculated for the entire sampling period (2015-2020) as well as the seasonal five in 30-day sample periods using Kitimat River upstream reference site data. Mean (five weekly samples in 30 days) seasonal guideline concentrations should be less than 0.38 µg/L in the spring and less than 0.52 µg/L in the fall. The summer and winter mean seasons guideline estimate of 0.23 µg/L and 0.5 µg/L respectively were based on a reduced number of samples (<5) in 30-day sampling.

Dissolved copper values in the Kitimat River ranged from less than 0.299 µg/L at the reference site to 1.05 µg/L upstream of the Haisla Bridge (Figure 14). The raw data in figure 14 is a representation of seasonal differences (wet and drier conditions, higher and lower flows) in dissolved copper concentrations. Additional temporal and spatial data collection over time is required to explore possible trends. Where sample data was available, mean seasonal values exceeded these long-term aquatic life criteria at all sites in the river including the upstream reference site (Table 14), regardless of whether flows were low, or high and turbid.

Table 14: Summary of dissolved copper concentrations (µg/L) in the Kitimat River, Hirsch Creek and Little Wedeene River between 2015 and 2020 and mean seasonal concentrations where available. Sites are listed upstream to downstream and tributaries in the order they enter the Kitimat River mainstem.

Site Name	No. of Samples	Minimum	Maximum	Average	Spring 2015 Avg (5)	Summer 2019 Avg (4)	Fall 2019 Avg (5)	Winter 2019 Avg (3)
Average long-term guideline					0.38	0.23	0.52	0.5
Kitimat River u/s Reference	19	0.299	1.01	0.481	0.396	0.34	0.634	0.57
Little Wedeene River ¹	6	0.195	0.67	0.505				
Hirsch Creek u/s of Hwy37 Bridge ¹	9	0.333	0.841	0.711				
Kitimat River u/s of Haisla Bridge	15	0.319	1.05	0.605		0.42	0.82	0.53
Kitimat River d/s Eurocan	16	0.323	1.03	0.641		0.41	0.718	0.708
¹ Insufficient tributary sample data to calculate mean seasonal concentrations. Sample size (n) for average is in brackets. Bold indicates exceedances of seasonal average water quality guidelines. Bold and italics indicates exceedance of average reference site concentrations								

⁵ B.C. Biotic Ligand Model Available at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-qualityguidelines/approved-wqgs/copper/bc_blm_setup.exe

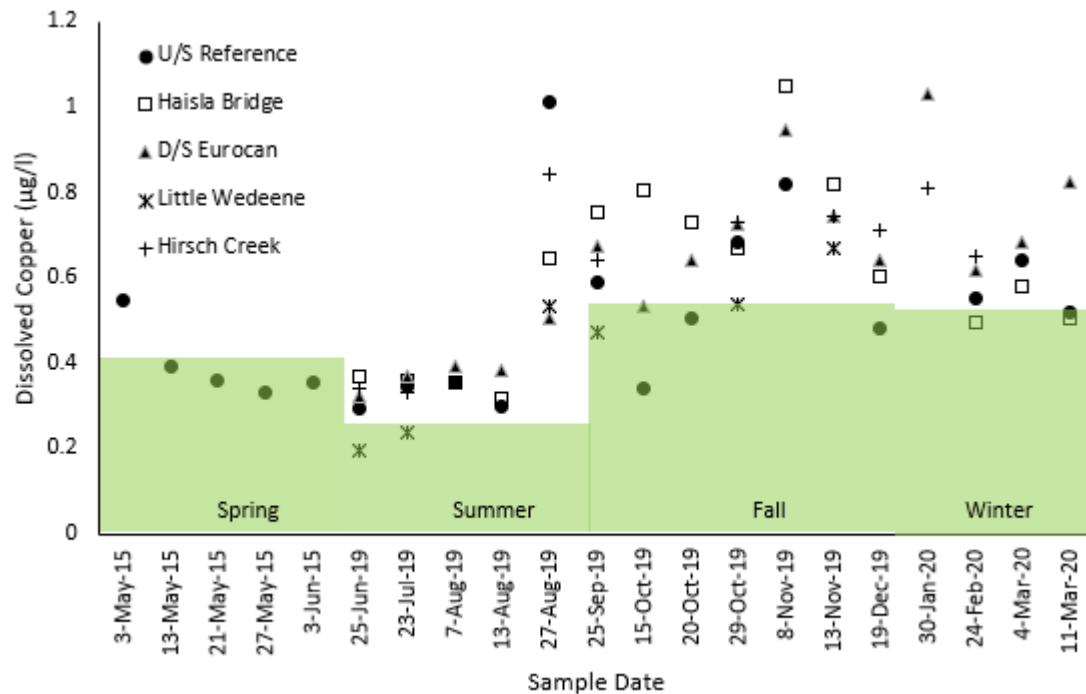


Figure 14: Kitimat River and tributaries dissolved copper concentrations. River values within the green shading are below the mean seasonal BLM WQG values calculated using the 2015 to 2020 upstream reference water quality data. (Heavy rainfall event on Aug 27, 2019.)

Over the course of the sampling period, upstream and downstream copper concentrations were observed to exceed the calculated seasonal guidelines. Exceedance of the copper guidelines does not imply that unacceptable risks are present, but that the potential for adverse effects may be increased and additional investigation and monitoring is warranted. In the absence of any known anthropogenic point or non-point sources of copper to the Kitimat River a WQO is not currently recommended but maybe considered in the future.

6.12.3 Iron

Iron is a naturally occurring element in the earth’s crust that is often a major constituent of soils (especially clays) and is found in waterways due to natural runoff, erosion of clay-based soils, and other geologic sources. Iron is essential for all forms of life and plays an important role in metabolic processes, but at higher concentrations it can be toxic (MOE, 2008). In addition to the direct toxic effects of iron to aquatic organisms, iron-hydroxide precipitates can also cause changes in habitat, thereby displacing some species and favoring others (Vuori, 1995). To protect freshwater aquatic life, the B.C. short-term maximum guideline is 1 mg/L for total iron and is 0.35 mg/L for dissolved iron (MOE, 2008).

Concerns over the extensive area of iron staining identified in Hirsch Creek, downstream of the landfill, warranted ongoing monitoring of iron concentrations in Hirsch Creek and the Kitimat River. Total iron values across all Kitimat River sites sampled between 2015 and 2020 ranged from 0.0304 mg/L to a maximum of 4.45 mg/L. At the reference and downstream Kitimat River sites, values were above the short-term guideline during a high flow, heavy rain event with high turbidity and suspended material.

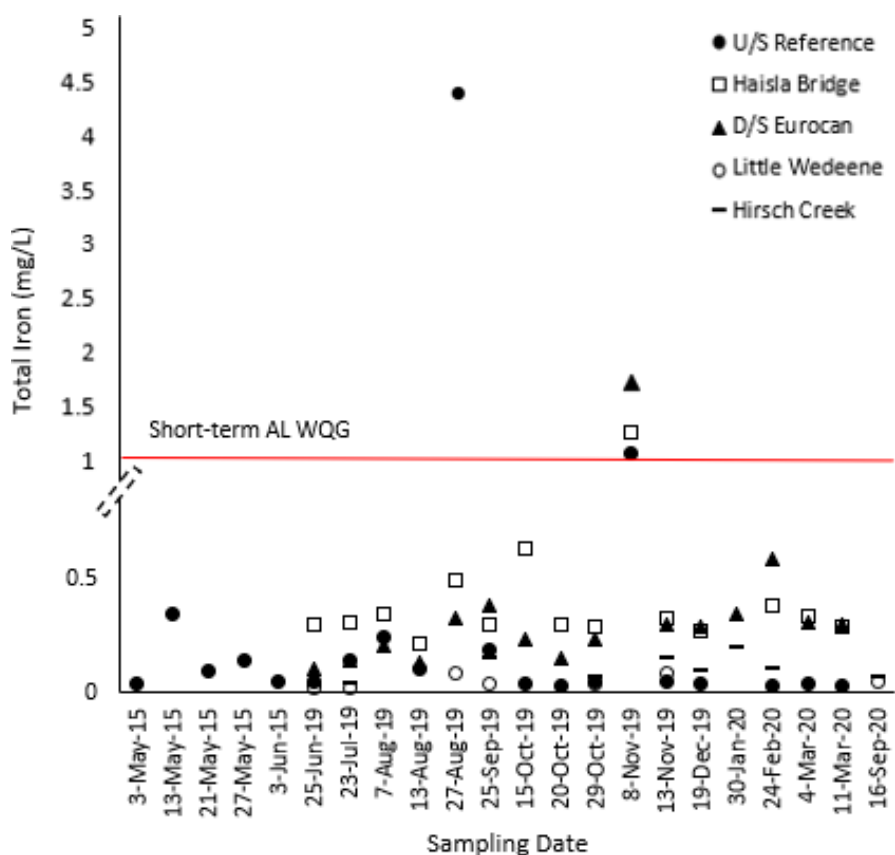


Figure 15: Range of total iron concentrations (mg/L) across the Kitimat River sites (n=51), Little Wedeene River (n=6) and Hirsch Creek (n=9), 2015 to 2020 data.

Dissolved iron values across all Kitimat River and tributary sites ranged from 0.008 mg/L at the reference site to a maximum of 0.376 mg/L in the Kitimat River downstream of the former Eurocan mill (Table 15). The dissolved iron aquatic life guideline was only exceeded on a single sampling event, February 24, 2020, at both the site upstream of the Haisla Bridge (0.36 mg/L) and downstream of Eurocan (0.376 mg/L).

Table 15: Summary of dissolved iron concentrations (mg/L) in the Kitimat River, Hirsch Creek and Little Wedeene River between 2015 and 2020. Sites are listed upstream to downstream and tributaries in the order they enter the Kitimat River mainstem.

EMS ID	Sample Site	No. of Samples	Minimum	Maximum	Mean	95th Percentile
E301870	Kitimat River U/S Reference	20	0.0080	0.0807	0.02585	0.0535
E279768	Little Wedeene River	6	0.0116	0.0618	0.03205	0.0595
E216319	Hirsch Creek U/S of Hwy37 Bridge	9	0.0178	0.0901	0.0638	0.0833
430025	Kitimat River U/S of Haisla Bridge	15	0.0807	0.3600 ¹	0.1800	0.2770
E207570	Kitimat River D/S Eurocan	16	0.0343	0.3760*	0.0997	0.2300

¹ a single exceedance of the aquatic life guideline on February 24, 2020.

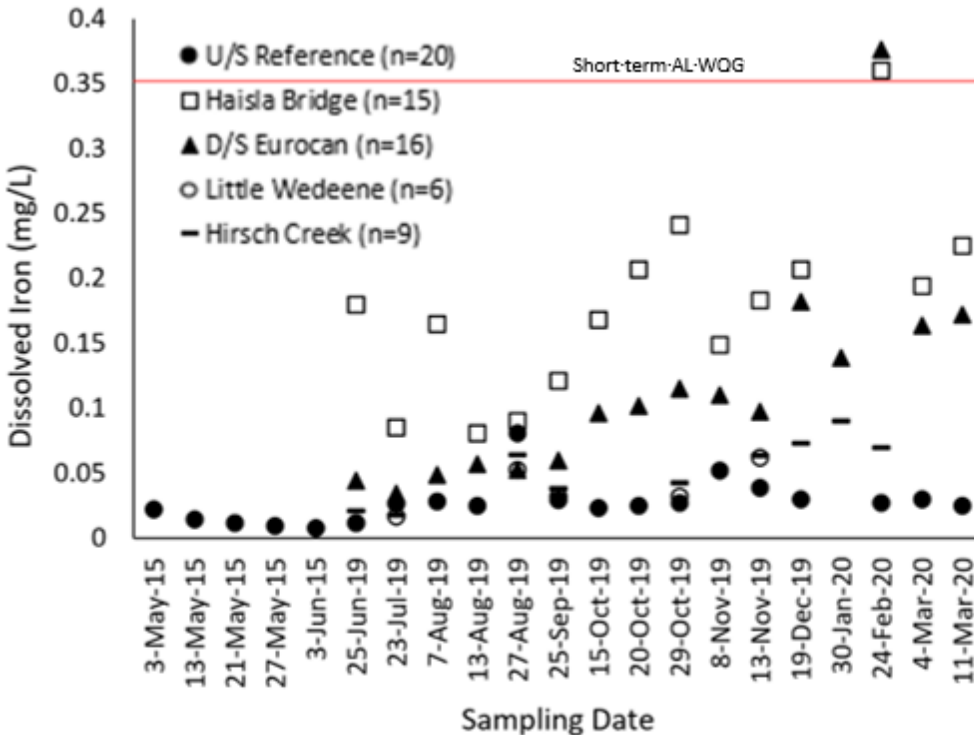


Figure 16: Range of dissolved iron concentrations (mg/L) across the Kitimat River (first 3 boxes from upstream to downstream), Little Wedeene River and Hirsch Creek sites, 2015 to 2020 data.

Since 2013, the Kitimat Landfill has had a comprehensive monitoring program of landfill leachate in groundwater and surface waters to manage for potential localized impact to the sensitive aquatic habitats in Hirsch Creek. According to reports, concentrations of leachate indicator parameters in groundwater and surface water, near Hirsch Creek, were low due to natural dilution and attenuation processes, and remained below aquatic life and drinking water standards. Iron in Hirsch Creek surface samples remain below the B.C. WQG and many results were present at concentrations below detections limits (AECOM, 2017). In the absence of any other known anthropogenic point or non-point sources of iron to the Kitimat River, a WQO is not recommended.

7. RECOMMENDED UPDATES FOR PROVISIONAL AND NEW WATER QUALITY OBJECTIVES

An unexpected pattern was observed for several parameters along the upstream–downstream gradient. In general, average water quality concentrations at the upstream reference site were lower than concentrations at the downstream sites which is somewhat expected in areas where anthropological activities are adjacent to or discharge to a river. However, concentrations of most parameters in the Kitimat River increased in a downstream direction from the upstream reference site up to the site near the Haisla Bridge. Further downstream the average concentrations for most parameters decreased relative to the values at Haisla Bridge site until they were comparable to the values at the upstream reference site. Elevated concentrations at the Haisla Bridge were evident throughout the sampling periods but focused monitoring would be required to determine the cause.

Other patterns were observed for the nitrogen-based parameters, including, ammonia, where concentrations were higher at the furthest downstream site, nitrate where average concentrations were similar throughout the Kitimat River sites and nitrite where concentrations were consistently low

throughout the watershed and only at the downstream sites were a few concentrations above detection limits.

Most chemical and physical parameters met provincial WQGs and the 1987 provisional WQOs except for turbidity, which exceeded the objective, and true colour, aluminum, copper, iron, and fluoride which exceeded WQGs for the protection of aquatic life. Higher values typically occurred during fall high flow periods and heavy precipitation events and were likely associated with suspended sediments.

Although not discussed in the main body of this document, a complete assessment of the benthic macroinvertebrate community in the Kitimat River, Little Wedeene River and Hirsch Creek was completed using existing CABIN data from 2005, 2006 and 2019. A summary report of the benthic results is provided in Appendix B.

The section of the Kitimat River upstream from the Kitimat sewage discharge contains all the water intakes for industrial, fish hatchery and domestic use. Recreational use occurs in this reach of the river as well as fish migration, spawning and rearing. Water values and uses in the lower Kitimat River that are sensitive and should be protected include cultural practices, fisheries values, aquatic life, drinking water, and recreation. Recommended updates of provisional WQOs and additional WQOs for the lower Kitimat River take into consideration the values and uses, background conditions, impacts from current land use, contributions from the tributary streams and any known future development within the watershed. The recommendations for updates and new WQOs in Table 16 below apply to the lower 10 kilometers of the Kitimat River.

Table 16: Summary of recommended updates for provisional and new WQO for the lower Kitimat River.

Variable	Objective
pH	6.5 -9.0 pH units
Temperature	Instantaneous measurement < 16°C
Dissolved Oxygen	> 7.8 mg/L (min)
True Color	≤ 5 mg/L increase when upstream values are less than or equal to 20 mg/L
	≤ 20 percent increase when upstream values are greater than 20mg/L.
Turbidity	≤ 5 NTU (max) increase when the upstream value is less than or equal to 50 NTU
	10 percent maximum increase when the upstream value exceeds 50 NTU
Total Suspended Solids (TSS)	10 mg/L maximum increase when the upstream value is less than or equal to 100 mg/L
	10 percent maximum increase when the upstream value exceeds 100 mg/L
Ammonia-nitrogen	≤ 1 mg/L average
Fluoride	≤ 0.12 mg/L average
Nitrate	≤ 1.6 mg/L average
Nitrite	≤ 0.013 mg/L average
Sulphate	≤ 30 mg/L average
Dissolved Aluminum	≤ 50 ug/L average
<p><i>Note: 1. The increase of turbidity and TSS is to instantaneous levels measured at an upstream reference site which should be located close to the downstream site if possible.</i></p> <p><i>2. Averages should be calculated from at least five weekly samples taken in a 30-day period.</i></p>	

8. MONITORING RECOMMENDATIONS AND SCHEDULE

The recommended updates and new water quality objectives should be periodically reviewed and, when appropriate, revised to capture changes to development as well as natural changes in the watershed. The recommended water quality monitoring program for the Kitimat River study area is summarized in Table 17. Due to the significant industrial development within the study area, it is recommended that future attainment monitoring occur every three years. Included in the recommended water quality sampling program are some parameters that support analysis and evaluation of water quality.

Table 17: Parameters and schedule for future water quality monitoring in the lower Kitimat River.

Sampling area	Timing	Parameters
Lower Kitimat River study area	5-in-30 sampling summer and fall	Total and dissolved metals including aluminum, copper and iron, total hardness Nutrients: total P, total N, total nitrate, total nitrite, ammonia Anions: chloride, fluoride, sulphate,
Hirsch Creek ¹ , Little Wedeene River ¹		Other parameters: turbidity, TSS, temperature, DO, pH, DOC, specific conductance, true colour and ions used in the CBANC calculation ²
	summer low flow	Parameters Periphyton biomass and chlorophyll <i>a</i> (collected from rock scrapings)

¹ Sites of interest but not associated with the WQO

² Essential ions in the calculation of ANC_a (acid neutralizing capacity) are calcium ion (Ca⁺²), magnesium ion (Mg⁺²), potassium ion (K⁺), sodium ion (Na⁺), ammonium ion (NH₄⁺), sulphate ion (SO₄²⁻), nitrate ion (NO₃⁻) and chloride ion (Cl⁻)

Attainment monitoring should use existing monitoring locations to ensure comparison to older data. The focus on the Kitimat River mainstem should represent the reference location, the near field location above all intakes and the location downstream of authorized discharges. A new location further upstream on the Kitimat River and further outside atmospheric deposition influence should be considered. Updates to industrial atmospheric emissions modeling should be reviewed ahead of any monitoring.

Water quality monitoring collecting five samples collected within a 30-day period should be conducted during the two critical periods, the summer low-flow period (between August and September) and the fall rainfall period (October and November).

For future monitoring, continuing to sample in the two tributaries entering the Kitimat River upstream of the Haisla Bridge site could capture any inputs that were observed at this location.

Chlorophyll *a* sampling should occur during summer low flows, when periphytic algal biomass is most stable and representative. This supports direct comparability with the B.C. Water Quality Guidelines for rivers, which are based on periphyton biomass indicators.

In addition to pH, monitoring should include the parameters needed to calculate the charge balance acid neutralizing capacity (CBANC) which is an indicator of change to the overall buffering capacity of the river against acidification caused by SO_x and NO_x emissions.

The sites on Hirsch Creek and Little Wedeene River should continue to be monitored and can serve as long-term trend monitoring sites within the watershed to monitor potential changes in natural dilution

and attenuation processes. It is important to monitor sites outside of the potential influence of atmospheric depositions from industrial sources.

Given the expected influence of glacial retreat on flow, temperature regimes, and water chemistry in the Kitimat River watershed, a future hydrology assessment is recommended to understand changes as the glaciers continue to shrink.

The Kitimat Valley supports ecologically and culturally important values, including salmon populations, critical freshwater and estuarine habitats, as well as recreational and subsistence fishing that remain central to regional communities. These values are sensitive to watershed-scale change and can be affected by the combined influence of multiple stressors, even when individual projects remain within regulatory limits. Owing to the many current and planned human activities occurring in the valley, assessments of water quality in the lower Kitimat River should not examine activities in isolation. Instead, any assessment of risks to key environmental components, must consider cumulative effects when designing a monitoring program, since evaluating activities independently may not capture how multiple stressors interact to influence water quality and ecosystem health.

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APPENDIX A: DATA SUMMARY TABLES

Table A- 1: Summary of general water chemistry at Site E301870, Kitimat River upstream reference.

Parameter ¹	Units	Minimum	Maximum	Average	95th Percentile	No of Samples
Physical Measures						
pH	pH units	6.39	7.67	7.35	7.6	36
Temperature	C	2.7	14.8	7.9	14.2	17
Dissolved Oxygen (field)	mg/L	10	14.3	12.41	14.1	16
Color True	col. unit	4.46	18.7	10.1	17	17
Spec. Conductance -field	us/cm	17.8	55.7	35.4	52.5	17
Turbidity	NTU	0.14	227	0.86	95.9	15
TSS	mg/L	0.0117	601	38.4	123	20
Anions and Nutrients						
Chloride Diss	mg/L	0.25	0.56	0.25	0.266	20
Ammonia -Total	mg/L	0.00161	0.014	0.00584	0.0122	19
Nitrate (NO ₃) -Diss	mg/L	0.0174	0.115	0.05295	0.104	20
Nitrate + Nitrite -Diss	mg/L	0.0174	0.115	0.05295	0.104	20
Nitrogen - Nitrite (NO ₂) - Diss	µg/L	0.5	1	0.5	1	20
Nitrogen - Total	mg/L	0.036	0.23	0.1305	0.184	20
Orthophosphate Diss	mg/L	0.000236	0.0019	0.000822	0.00177	14
Phosphorus Total Dissolved	µg/L	0.554	4.7	2.02	4.38	14
Phosphorus Total	µg/L	0.0501	434	31.6	150	20
Sulfate Dissolved	mg/L	1.19	4.43	2.565	4.32	20
Fluoride -D	mg/L	0.02	0.046	0.03	0.0431	20
TOC	mg/L	0.68	4.54	1.94	3.62	15
E. coli	cfu/100ml	0.191	14	3.01	10.4	10
Total Metals						
Total Hardness (calc)	mg/L	10.7	28.5	16.4372	24.6	20
Aluminum Total	µg/L	31.1	4010	78.2	1310	20
Antimony Total	µg/L	0.02	0.02	0.01	0.02	19
Arsenic Total	µg/L	0.0128	0.04	0.0249	0.036	17
Barium Total	mg/L	0.00948	0.095	0.01575	0.0342	20
Beryllium Total	µg/L	5.95 E-7	0.076	0.00597	0.0266	20
Boron Total	mg/L	0.005	0.05	0.0025	0.012	20
Cadmium Total	µg/L	0.0000108	0.102	0.00861	0.0316	19
Calcium Total	mg/L	3.63	8.3	5.535	7.74	20
Chromium Total	µg/L	0.00248	4.59	0.456	1.68	18
Cobalt Total	µg/L	0.0151	2.95	0.03265	0.885	20
Copper Total	µg/L	0.393	16.8	0.584	5.56	19
Iron Total	mg/L	0.0304	4.45	0.04945	1.21	20
Lead Total	µg/L	0.0058	1.16	0.0265	0.504	17
Magnesium Total	µg/L	378	2540	623	970	20
Manganese Total	µg/L	1.17	245	3.005	64.5	20
Mercury Total	µg/L	0.005	0.01	0.0025	0.01	5
Molybdenum Total	µg/L	0.0730	1.01	0.855	1	20

Parameter ¹	Units	Minimum	Maximum	Average	95th Percentile	No of Samples
Nickel Total	µg/L	0.0091	3.38	0.357	1.4	17
Selenium Total	µg/L	0.017	0.058	0.0333	0.0552	20
Silver Total	µg/L	0.00031	0.009	0.00241	0.00729	19
Sulphide Total ²	µg/L	5.4	11.5	8.03	11	16
Thallium Total	µg/L	0.0000203	0.0381	0.00349	0.0112	20
Uranium Total	µg/L	0.0634	0.657	0.122	0.327	20
Zinc Total	µg/L	0.24	18.1	1.4	11.3	13
Dissolved Metals						
Hardness (calc)	mg/L	10.1	24.2	14.9	23.2	20
Aluminum Dissolved	µg/L	14.8	95.2	33.9	90.2	20
Cadmium Dissolved	µg/L	0.0025	0.0054	0.0025	0.00279	19
Calcium Dissolved	mg/L	3.53	8.24	5.08	7.88	20
Copper Dissolved	µg/L	0.293	1.01	0.481	0.84	19
Iron Dissolved	µg/L	8	80.7	25.85	53.5	20
Magnesium Dissolved	µg/L	303	871	473	840	20
Mercury Dissolved	µg/L	0.005	0.01	0.0025	0.01	5
Selenium Dissolved	µg/L	0.02	0.044	0.02	0.0412	20

¹ B.C. Environmental Monitoring System database contains the results for the complete list of analytes sampled for E301870, Kitimat River upstream reference site.

² Detection limit exceeds water quality guideline.

Table B- 2: Summary of general water chemistry at Site 0430025, Kitimat River at Haisla Bridge

Parameter ¹	Units	Minimum	Maximum	Average	95th Percentile	No of Samples
Physical Measures						
pH	pH units	6.03	8.14	6.96	7.73	28
Temperature	C	1.1	14.7	7.45	14	18
Dissolved Oxygen (F)	mg/L	9.79	13.8	12.18	13.7	17
Color True	col. unit	5.43	49.6	21.6	37.7	15
Spec. Conductance -field	us/cm	30.9	54.3	43.9	52.4	15
Turbidity	NTU	1.29	63.1	2.49	22.9	15
TSS	mg/L	0.124	97.9	11	44.2	15
Anions and Nutrients						
Chloride Diss	mg/L	0.355	1.39	0.776	1.33	20
Ammonia -Total	mg/L	0.00333	0.033	0.0103	0.0232	19
Nitrate (NO ₃) -Diss	mg/L	0.02	0.187	0.05695	0.169	20
Nitrate + Nitrite -Diss	mg/L	0.02	0.187	0.05695	0.169	20
Nitrogen - Nitrite (NO ₂) - Diss	µg/L	0.50	2.10	0.50	1.15	20
Nitrogen - Total	mg/L	0.066	0.297	0.168	0.295	20
Orthophosphate Diss	mg/L	0.000304	0.0031	0.0013	0.00297	14
Phosphorus Total Dissolved	µg/L	1.92	6.00	3.51	4.98	13
Phosphorus Total	µg/L	2.40	98.00	6.40	33.6	19
Sulfate Dissolved	mg/L	1.68	8.01	4.38	7.25	20
Fluoride -D	mg/L	0.033	0.195	0.0735	0.192	20

Parameter ¹	Units	Minimum	Maximum	Average	95th Percentile	No of Samples
TOC	mg/L	1.03	5.93	3.19	5.32	15
E. coli	cfu/100ml	9	74	11	64.7	4
Total Metals						
Total Hardness (calc)	mg/L	14.9	20.8	17.6442	20.6	15
Aluminum Total	µg/L	48.6	1400	153	678	15
Antimony Total	µg/L	0.02	0.02	0.01	0.02	15
Arsenic Total	µg/L	0.058	0.254	0.091	0.148	15
Barium Total	µg/L	6.77	25.3	12.3	17	15
Beryllium Total	µg/L	0.005	0.027	0.005	0.0165	15
Boron Total	µg/L	5	5	2.5	5	15
Cadmium Total	µg/L	0.00259	0.0177	0.00716	0.0134	13
Calcium Total	mg/L	4.95	7.56	6.01	7.38	15
Chromium Total	µg/L	0.0612	1.41	0.288	0.745	15
Cobalt Total	µg/L	0.0655	0.851	0.109	0.465	15
Copper Total	µg/L	0.512	4.89	0.796	2.81	15
Iron Total	mg/L	0.217	1.14	0.307	0.782	15
Lead Total	µg/L	0.0153	0.515	0.0323	0.227	15
Magnesium Total	mg/L	0.461	0.791	0.567	0.787	15
Manganese Total	µg/L	10.9	54.6	20	38.3	14
Molybdenum Total	µg/L	0.205	0.617	0.321	0.586	15
Nickel Total	µg/L	0.105	1.29	0.209	0.693	15
Selenium Total	µg/L	0.013	0.059	0.0295	0.0506	15
Silver Total	µg/L	0.005	0.005	0.0025	0.005	15
Sulphide Total ²	µg/L	8.17	27	16	6.5	11
Thallium Total	µg/L	0.000155	0.0103	0.00181	0.004980	15
Uranium Total	µg/L	0.0148	0.305	0.0462	0.155	15
Zinc Total	µg/L	0.38	1.57	0.94	1.46	9
Dissolved Metals						
Hardness (calc)	mg/L	12.6	21.3	17.3	20.3	15
Aluminum Dissolved	µg/L	14.5	202	80.7	172	14
Cadmium Dissolved	µg/L	0.00363	0.0076	0.00516	0.00736	13
Calcium Dissolved	mg/L	4.39	7.29	6.03	7.28	15
Copper Dissolved	µg/L	0.319	1.05	0.605	0.89	15
Iron Dissolved	µg/L	80.7	360	180	277	15
Magnesium Dissolved	mg/L	0.4	0.773	0.524	0.72	15
Selenium Dissolved	µg/L	0.0256	0.056	0.0383	0.0511	15

¹ B.C. Environmental Monitoring System database contains the results for the complete list of analytes sampled for site 0430025, Kitimat River at Haisla Bridge.

² Detection limit exceeds water quality guideline.

Table B- 3: Summary of general water chemistry at Site E207570, Kitimat River downstream of Eurocan.

Parameter ¹	Units	Minimum	Maximum	Average	95th Percentile	No of Samples
Physical Measures						
pH	pH units	6.12	7.73	6.905	7.72	20
Temperature	C	1.3	14.5	7.8	13.7	19
Dissolved Oxygen (F)	mg/L	10.4	14	12.95	14	17
Color True	col. unit	7.09	28.3	17	27.5	16
Spec. Conductance -field	us/cm	27.2	67.4	43.1	63.3	16
Turbidity	NTU	1.42	104	3.14	36.2	16
TSS	mg/L	0.0398	201	19.3	73.8	16
Anions and Nutrients						
Chloride Diss	mg/L	0.236	4.7	1.71	4.32	20
Ammonia -Total	mg/L	0.0068	0.0621	0.0209	0.0487	20
Nitrate (NO3) -Diss	mg/L	0.015	0.135	0.0592	0.131	20
Nitrate + Nitrite -Diss	mg/L	0.0216	0.135	0.0604	0.131	20
Nitrogen - Nitrite (NO2) - Diss	µg/L	0.327	8.7	2.48	6.61	20
Nitrogen - Total	mg/L	0.076	0.324	0.179	0.287	20
Orthophosphate Diss	mg/L	0.000699	0.0054	0.0021	0.00403	14
Phosphorus Total Dissolved	µg/L	3.1	6.3	4.2	5.74	15
Phosphorus Total	µg/L	3.2	171	7.9	54.7	20
Sulfate Dissolved	mg/L	0.93	4.38	2.8	4.29	20
Fluoride -D	mg/L	0.02	0.061	0.0355	0.061	20
TOC	mg/L	0.72	4.69	2.64	4.22	16
E. coli	cfu/100ml	6	69	12	58	5
Total Metals						
Total Hardness (calc)	mg/L	12.8	21.1	16.04	20	16
Aluminum Total	µg/L	70.3	2220	119	871	16
Antimony Total	µg/L	0.01	0.022	0.01	0.013	16
Arsenic Total	µg/L	0.041	0.254	0.0645	0.151	16
Barium Total	µg/L	10.2	39.4	13.45	22.7	16
Beryllium Total	µg/L	0.005	0.035	0.005	0.0163	16
Boron Total	µg/L	5.0	5.0	2.5	5.0	16
Cadmium Total	µg/L	0.000137	0.0217	0.00379	0.0125	14
Calcium Total	mg/L	4.29	6.79	5.07	6.44	16
Chromium Total	µg/L	0.1	2.4	0.195	0.975	16
Cobalt Total	µg/L	0.0541	1.33	0.0898	0.552	16
Copper Total	µg/L	0.533	7.91	0.887	3.54	16
Iron Total	mg/L	0.105	1.71	0.289	0.866	16
Lead Total	µg/L	0.017	0.617	0.0389	0.252	16
Magnesium Total	mg/L	0.502	1.04	0.7095	1.02	16
Manganese Total	µg/L	6.85	73.8	17.25	48.4	16
Molybdenum Total	µg/L	0.19	0.626	0.446	0.626	16
Nickel Total	µg/L	0.086	1.87	0.132	0.816	15
Selenium Total	µg/L	0.02	0.043	0.02	0.0258	16
Silver Total	µg/L	0.005	0.005	0.0025	0.005	16
Sulphide Total ²	µg/L	9	29	9	24	12
Thallium Total	µg/L	0.00023	0.015	0.00241	0.0066	16

Parameter ¹	Units	Minimum	Maximum	Average	95th Percentile	No of Samples
Uranium Total	µg/L	0.0504	0.547	0.09465	0.237	16
Zinc Total	µg/L	0.5	8.07	0.89	4.21	13
Dissolved Metals						
Hardness (calc)	mg/L	10.9	21.5	14.75	19.9	16
Aluminum Dissolved	µg/L	16.8	113	50.85	110	16
Cadmium Dissolved	µg/L	0.0025	0.0051	0.0025	0.00341	14
Calcium Dissolved	mg/L	3.69	6.92	4.93	6.43	16
Copper Dissolved	µg/L	0.323	1.03	0.641	0.97	16
Iron Dissolved	mg/L	0.0343	0.376	0.0997	0.23	16
Magnesium Dissolved	mg/L	0.411	1.02	0.606	0.94	16
Selenium Dissolved	µg/L	0.02	0.042	0.02	0.042	16

¹ B.C. Environmental Monitoring System database contains the results for the complete list of analytes sampled for site E207570, Kitimat River downstream of Eurocan.

² Detection limit exceeds water quality guideline.

Table B- 4: Summary of general water chemistry at Site E279768, Little Wedeene.

Parameter ¹	Units	Minimum	Maximum	Average	95th Percentile	No of Samples
Physical Measures						
pH	pH units	6.91	7.29	7.08	7.28	7
Temperature	C	3.8	12.6	10	12.1	7
Dissolved Oxygen (field)	mg/L	11	13.3	12.08	13.3	7
Color True	col. unit	3.12	21.9	10.2	19.7	6
Spec. Conductance -field	us/cm	20.8	31.4	24.6	30.2	7
Turbidity	NTU	0.0549	0.47	0.25	0.464	7
TSS	mg/L	3	3	1.5	3	7
Anions and Nutrients						
Chloride Diss	mg/L	0.5	0.5	0.25	0.5	7
Ammonia -Total	mg/L	0.0025	0.0157	0.0025	0.0135	7
Nitrate (NO ₃) -Diss	mg/L	0.0321	0.108	0.0521	0.0945	7
Nitrate + Nitrite -Diss	mg/L	0.0321	0.108	0.0552	0.0945	7
Nitrogen - Nitrite (NO ₂) - Diss	µg/L	1	1	0.5	1	7
Nitrogen - Total	mg/L	0.057	0.196	0.1245	0.186	6
Orthophosphate Diss	mg/L	0.001	0.001	0.5	0.001	2
Phosphorus Total Dissolved	µg/L	1.82	3	2.42	2.92	5
Phosphorus Total	µg/L	1.46	4.4	2.69	4.07	6
Sulfate Dissolved	mg/L	2.18	3.45	2.86	3.43	7
Fluoride -D	mg/L	0.02	0.051	0.032	0.0474	7
TOC	mg/L	0.59	3.35	1.7	3.14	6
E. coli	cfu/100ml	1	7	3	6.6	3
Total Metals						
Total Hardness (calc)	mg/L	8.04	13	9.39419	12.3	7
Aluminum Total	µg/L	17.4	128	49.2	116	7

Parameter ¹	Units	Minimum	Maximum	Average	95th Percentile	No of Samples
Antimony Total	µg/L	0.02	0.02	0.01	0.02	7
Arsenic Total	µg/L	0.01	0.024	0.01	0.0237	7
Barium Total	mg/L	0.00627	0.00966	0.00752	0.00925	7
Beryllium Total	µg/L	0.01	0.01	0.005	0.01	7
Boron Total	mg/L	0.005	0.005	0.0025	0.005	7
Cadmium Total	µg/L	0.005	0.005	0.0025	0.005	6
Calcium Total	mg/L	2.86	4.61	3.34	4.36	7
Chromium Total	µg/L	0.1	0.1	0.05	0.1	5
Cobalt Total	µg/L	0.0137	0.0469	0.0245	0.0462	7
Copper Total	µg/L	0.23	0.656	0.46	0.656	7
Iron Total	mg/L	0.0231	0.0824	0.0423	0.0822	7
Lead Total	µg/L	0.0025	0.0118	0.0025	0.0109	5
Magnesium Total	µg/L	219	364	256	347	7
Manganese Total	µg/L	1.41	3.95	2.15	3.87	7
Molybdenum Total	µg/L	0.25	0.379	0.318	0.378	7
Nickel Total	µg/L	0.025	0.09	0.025	0.083	5
Selenium Total	µg/L	0.04	0.04	0.02	0.04	7
Silver Total	µg/L	0.005	0.005	0.0025	0.005	7
Sulphide Total ²	µg/L	18	18	9	18	4
Thallium Total	µg/L	0.002	0.002	0.001	0.002	7
Uranium Total	µg/L	0.116	0.197	0.149	0.189	7
Zinc Total	µg/L	0.45	1.02	0.59	1.01	6
Dissolved Metals						
Hardness (calc)	mg/L	7.74	10.4	9.065	10.3	6
Aluminum Dissolved	µg/L	13.2	110	44.85	98.9	
Cadmium Dissolved	µg/L	0.0025	0.0058	0.0025	0.00514	5
Calcium Dissolved	mg/L	2.75	3.7	3.235	3.66	6
Copper Dissolved	µg/L	0.195	0.67	0.5045	0.637	6
Iron Dissolved	µg/L	11.6	61.8	32.05	59.5	6
Magnesium Dissolved	µg/L	212	297	242	292	6
Selenium Dissolved	µg/L	0.04	0.04	0.02	0.04	6

¹ B.C. Environmental Monitoring System database contains the results for the complete list of analytes sampled for site E279768, Little Wedeene.

² Detection limit exceeds water quality guideline.

Table B- 5: Summary of general water chemistry at Site E216319, Hirsch Creek upstream of Highway 37 bridge.

Parameter ¹	Units	Minimum	Maximum	Average	95th Percentile	No of Samples
Physical Measures						
pH	pH units	7.07	7.71	7.28	7.68	9
Temperature	C	1.4	14.4	7.4	13.6	8
Dissolved Oxygen (field)	mg/L	10.9	14.7	13.19	14.7	9
Color True	col. unit	8.83	31.9	18.6	29.1	9
Spec. Conductance -field	us/cm	31	51.4	39.85	50.8	10
Turbidity	NTU	0.23	16.2	0.815	10.6	10
TSS	mg/L	0.014	65.7	8.27	38.8	10
Anions and Nutrients						
Chloride Diss	mg/L	0.5	0.5	0.25	0.5	10
Ammonia -Total	mg/L	0.0025	0.0076	0.0025	0.00643	10
Nitrate (NO3) -Diss	mg/L	0.0067	0.0789	0.03705	0.0754	10
Nitrate + Nitrite -Diss	mg/L	0.0067	0.0789	0.0417	0.0754	10
Nitrite (NO2) - Diss	µg/L	1	1	0.5	1	10
Nitrogen - Total	mg/L	0.033	0.186	0.146	0.177	9
Orthophosphate Diss	mg/L	0.001	0.001	0.5	0.001	5
Phosphorus Total Dissolved	µg/L	1.9	4.2	3	4.08	9
Phosphorus Total	µg/L	0.064	84	13.1	51	10
Sulfate Dissolved	mg/L	1.43	3.28	1.985	2.88	10
Fluoride -D	mg/L	0.00882	0.026	0.0157	0.0242	10
TOC	mg/L	0.96	5.2	2.6	4.82	9
E. coli	CFU/100ml	1	62	3	56.1	3
Total Metals						
Total Hardness (calc)	mg/L	14.9	22.3	17.4553	22.2	10
Aluminum Total	µg/L	25.3	863	73.75	561	10
Antimony Total	µg/L	0.02	0.02	0.01	0.02	10
Arsenic Total	µg/L	0.00803	0.077	0.027	0.0576	10
Barium Total	mg/L	0.00785	0.0183	0.0105	0.0158	10
Beryllium Total	µg/L	0.005	0.023	0.005	0.0149	10
Boron Total	mg/L	0.005	0.005	0.0025	0.005	10
Cadmium Total	µg/L	0.0025	0.0108	0.0025	0.00748	9
Calcium Total	mg/L	4.81	7.14	5.6	7.08	9
Chromium Total	µg/L	0.00922	0.8	0.17	0.548	10
Cobalt Total	µg/L	0.0207	0.922	0.0425	0.555	10
Copper Total	µg/L	0.358	4.84	0.803	3.15	10
Iron Total	mg/L	0.0328	1.17	0.0955	0.731	10
Lead Total	µg/L	0.000775	0.183	0.0409	0.153	9
Magnesium Total	µg/L	668	1180	881.5	1140	10
Manganese Total	µg/L	3.25	65.4	7.63	41.4	10
Molybdenum Total	µg/L	0.152	0.376	0.274	0.375	10
Nickel Total	µg/L	0.0232	0.834	0.176	0.563	9
Selenium Total	µg/L	0.04	0.04	0.02	0.04	10
Silver Total	µg/L	0.005	0.005	0.0025	0.005	10
Sulphide Total ²	µg/L	9	63	9	49.5	6
Thallium Total	µg/L	0.001	0.0049	0.001	0.00314	10

Parameter ¹	Units	Minimum	Maximum	Average	95th Percentile	No of Samples
Uranium Total	µg/L	0.0156	0.0766	0.0286	0.061	9
Zinc Total	µg/L	0.53	10.6	0.7	8.39	7
Dissolved Metals						
Hardness (calc)	mg/L	14.5	49.7	17.1	38.7	9
Aluminum Dissolved	µg/L	16.6	101	49.6	93.3	9
Cadmium Dissolved	µg/L	0.0025	0.0058	0.0025	0.00464	8
Calcium Dissolved	mg/L	4.74	7.04	5.33	6.68	8
Copper Dissolved	µg/L	0.333	0.841	0.711	0.829	9
Iron Dissolved	µg/L	17.8	90.1	63.8	83.3	9
Magnesium Dissolved	µg/L	653	1140	744	1050	9
Selenium Dissolved	µg/L	0.04	0.04	0.02	0.04	9

¹ B.C. Environmental Monitoring System database contains the results for the complete list of analytes sampled for site E216319, Hirsch Creek upstream of Highway 37 bridge.

² Detection limit exceeds water quality guideline

APPENDIX B: BENTHIC INVERTEBRATE ANALYSIS OF KITIMAT RIVER AND TWO TRIBUTARIES

Background

Biomonitoring using freshwater benthic macroinvertebrates (herein referred to as BI) is used to complement water quality data and provide information on ecosystem conditions (Canadian Aquatic Biomonitoring Network [CABIN] 2019). The addition of BI biomonitoring to an aquatic assessment provides a locally relevant effects measurement (i.e., the effect of a stressor on relevant biota compared to relying solely on the presence/magnitude of a stressor) (Bailey et al. 2004). BI are effective for biomonitoring because they are sedentary, site-specific, and live long enough to provide an indicator of preceding conditions in a waterbody for the weeks or months prior to sampling (CABIN, 2019).

ENV is incorporating biomonitoring data into the Kitimat River WQO process to provide a more comprehensive assessment of the state of the aquatic ecosystem. This can be used with other relevant information found in the technical assessment report, including water quality, hydrology, water uses and values, and potential stressors to characterize the existing state of the watershed and support the updated WQOs. Appendix B provides the biomonitoring assessment only.

Sampling Locations

BI community samples were collected by ENV staff at five locations, including sites in the Kitimat River upstream and downstream of authorized discharges, Hirsch Creek upstream and downstream of the landfill, and the Little Wedeene River (Figure B1). The samples were collected using CABIN protocols (Environment Canada, 2012) on September 16th -17th, 2020. In the study design, upstream sites were intended to be reference sites, outside the influence of land use activities and the exposure sites were in areas downstream of Environmental Management Act (EMA) authorized effluent discharges.

There are few anthropogenic influences in the upper watershed of the Kitimat River. The only influences on the upstream reference site are forestry and possible short-range atmospheric deposition from industry farther downstream. All authorized discharges including the District of Kitimat (DOK) wastewater treatment plant, aluminum smelter and liquified natural gas (LNG) air emission are located within the lower 10km of the river, above the Kitimat River downstream site. The land use adjacent to Hirsch Creek between the upstream and downstream sites was limited to that of the District of Kitimat (DOK landfill). The watershed upstream of the Little Wedeene River is forested.

CABIN Assessment Methods

CABIN uses a reference condition approach (RCA) study design. RCA compares a test (exposure or potentially impacted) site to a group of physically and ecologically similar reference sites, instead of depending on a single upstream site for comparison (which almost always violates statistical assumptions of independence). The goals of RCA are to 1) establish a range of natural variability in BI communities within similar reference sites (grouped based upon environmental and habitat variables) and then 2) to determine if the BI community at a test site fits within the natural variability or falls outside (divergence) (CABIN, 2019).

The CABIN program provides several options to model, assess, and interpret environmental data to determine potential impacts to BI communities. The approaches considered include 1) Benthic Assessment of Sediment (BEAST) analysis, 2) River Invertebrate Prediction and Classification System (RIVPACS) analysis, and 3) community metrics (Figure B2). Using a combination of tools increases confidence in the assessment, provides complementary results to help gain an understanding of community-level biological change and allows a more informed characterization of risk. Specific to this study, the model used was the 2015 BC Central -North Coast Model (Reynoldson and Bailey, 2015).

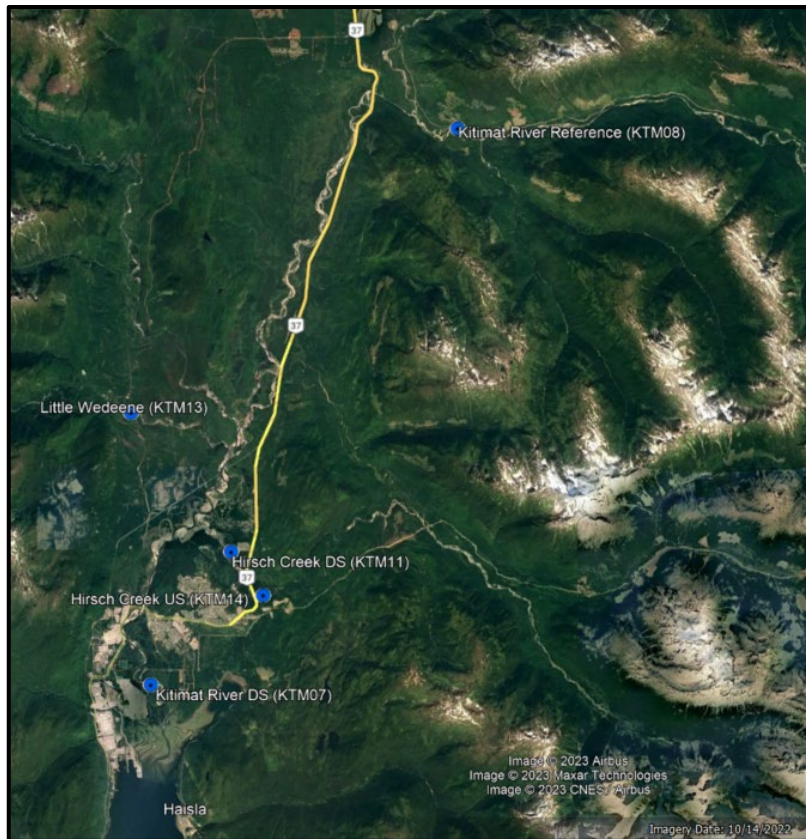


Figure B1. Google Earth satellite imagery of the Kitimat River BI sampling sites.

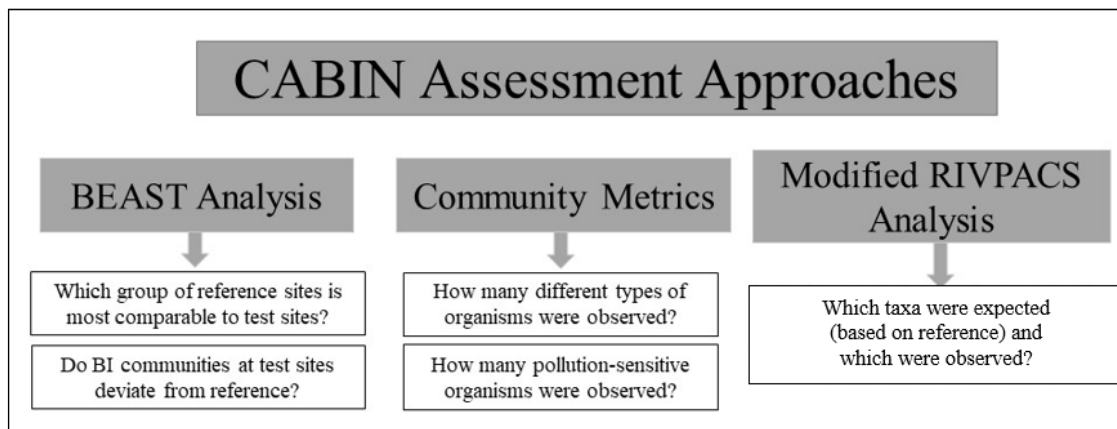


Figure B2: An overview of CABIN approaches and the questions posed by each (modified from CABIN 2019).

General Assessment of Kitimat River Watershed Sites

BEAST Analysis

The BEAST model uses classification and ordination statistical methods to group reference sites based on habitat variables and then to identify deviance of the BI community observed from the expected reference community (Strachan & Reynoldson 2014). Ordination results provide a general comparison of the BI community at a test site to a group of reference sites. While results indicate if the community at the test site is divergent from the reference condition, they do not indicate cause. The RCA model's overall Error Rate is 31 percent, with a range of 19 to 36 percent. Since the error rates are not high it indicates a high probability that the reference sites have been sorted to the correct reference group based on habitat features. Ordinations were also created for sites with multiple years of data to provide a visual representation of how conditions change over time.

Table B1. Assigned Ref. Group and Community Ellipse Results for test sites on the Kitimat River, Hirsch Creek and Little Wedeene River.

CABIN Code	Site Name ¹	Sample Date	Assigned Ref. Group (Probability)	Overall Assessment Results
Kitimat River				
KTM08	Kitimat River Us Ref Site	Aug 22 2005	2 (84.2%)	Mildly Divergent
		Sept 17 2020	2(79.1%)	Similar to Reference
KTM07	Kitimat River Ds Eurocan	Aug 22 2005	2 (71.9%)	Mildly Divergent
		Sept 17 2020	2(57.71%)	Similar to Reference
Hirsch Creek				
KTM14	Hirsch Creek Us of landfill	Sept 16 2020	2 (63.7%)	Mildly Divergent
KTM11	Hirsch Creek Ds of landfill	Aug 22 2006	2 (65.5%)	Similar to Reference
		Sept 17 2020	2(62.8%)	Similar to Reference
Little Wedeene River				
KTM13	Little Wedeene River	Sept 16 2020	2 (60.8%)	Similar to Reference
1. Similar to Reference (R)				
2. Mildly Divergent (MD)				
3. Divergent (D)				
4. Highly Divergent (HD)				

All test sites (and all sampling events) are assigned to reference Group 2 with a probability of greater than 57 percent. Therefore, the macroinvertebrate data for each test site considered in the Kitimat WQO assessment was compared to reference Group 2.

RIVPACs Analysis

RIVPACs uses presence/absence data to assess which taxa are expected at a site (based upon matched reference sites) compared to the taxa observed. If the taxa you expect to see are not present, then the assumption is that there must be some environmental impact on the community. The output of RIVPACs is an Observed:Expected (O:E) ratio. If the O:E ratio is high (approaching 1), the BI communities are similar and by extension in good condition. The lower the O:E ratio, the more taxa are missing from a site, suggesting stressors to the BI community may be present. Samples were assessed at a taxon occurrence threshold of 0.7, meaning that the O:E ratios were based only on those taxa expected to occur with a probability of >0.7. The RIVPACs analysis O:E ratio results in Table B2 show that in 2020 all six test sites are in good condition. The results suggest that the downstream Hirsch Creek site and the Kitimat River upstream site remain unchanged

over time and that the downstream site is in better condition in 2020 and potentially experiencing some enrichment compared to 2005. However, the really low downstream result in 2005 (0.275) did warrant some further consideration. The field notes, photos and coordinates for the 2005 and 2020 sampling events were compared. They suggest that the 2005 collection site was in closer proximity to a backchannel and pronounced depositional sediment gravel bar area and therefore may explain the really low O:E ratio results.

Community Metrics

Metrics were calculated using the CABIN analytical tools to describe the community structure and function and help interpret the ordination results. Except for percent Chironomidae, the following metrics are expected to decline in response to different anthropogenic stressors:

- **Total number of taxa.** This value provides an important overall measurement of taxonomic diversity, with the health of the community reflected by the variety of taxa present (Plafkin et al, 1989).
- **Number of Plecoptera taxa.** Plecoptera (stoneflies) are found on coarse substrates such as boulders, cobbles, pebbles, wood, and coarse detritus in fast-flowing water and are sensitive to human disturbance.
- **Number of Ephemeroptera taxa.** Ephemeroptera (mayflies) taxa are sensitive to pollution, with the diversity of mayfly taxa expected to decline in response to most types of anthropogenic stressors.
- **Number of clinger taxa.** Clingers include a wide range of taxa that have behavioural or morphological adaptations (e.g., streamlined body forms, suction disks, etc.) that allow them to attach to surfaces in fast-flowing waters. Clinger taxa are sensitive to sedimentation, which can reduce the complexity of stream habitats.
- **Percent EPT.** The proportion of freshwater organisms belonging to the taxa Ephemeroptera, Plecoptera, Trichoptera (or EPT for short). Species that are considered sensitive to pollution and are a measure of good environmental conditions.
- **Percent Chironomidae.** Benthic chironomid larvae are often used as a biological indicator of ecological health. The chironomid larvae are particularly tolerant to contaminants. This metric is expected to increase in response to different anthropogenic stressors.

The Environmental Effects Monitoring (EEM) recommended benthic community endpoints examined to support this assessment included the following:

- **Bray-Curtis (BC).** BC is a measure of the dissimilarity between a test site and the reference group median. This value ranges from 0 (similar to reference) to a maximum of 1 (entirely different from reference).
- **Total invertebrate abundance.** Total invertebrate density is the recommended endpoint. However, CABIN methods do not provide an area-based measure of density, so abundance (i.e., the total number of organisms) was used as a surrogate. Abundance increases in areas with nutrient enrichment, which increases productivity in the lower trophic levels. Abundance may decrease in areas where there are environmental stressors (Resh and Jackson, 1993).
- **Simpson's Evenness Index (ED).** This value measures the relative abundance of different taxa that make up the benthic community. A lower value indicates that the community is dominated by few species (i.e., the community isn't diverse), which may indicate the presence of environmental stress. A higher value indicates that several different species have similar abundance, which suggests the community is more representative of a healthy, diverse community (Morris et al, 2014).

Metrics values for each site were compared with the mean and standard deviation of the associated reference group to determine if the site fell within the natural range of variability. Test site values greater than 2 standard deviations from the mean value were considered significantly different from the reference group and were used to characterize the effect of stressors on the community. Where possible, metrics for sites on the same stream were compared spatially to determine if there were any upstream to downstream differences. Metrics were also reviewed to assess any community changes over time. Where notable spatial or temporal patterns were identified, additional details were discussed.

Kitimat River

The Kitimat River reference site (KTM08) is located approximately 5 kilometres upstream of the northernmost Kitimat River / HWY 37 bridge crossing. The Kitimat River site downstream of major anthropogenic activities (KTM07) is located approximately 5 kilometres downstream of the Haisla Blvd bridge crossing.

Both sites were sampled in 2005 and 2020. They were found to be “Mildly Divergent” in 2005, and more recently, “Similar to Reference” in 2020. At the upstream site, all metrics, and all three of the community endpoints were similar to the Group 2 reference mean or within the range of variability, in both sample years. It is unclear why in 2005 the site was identified as “Mildly Divergent”. Note that 10% of reference sites can fall outside the reference cloud, so the “Mildly Divergent” ordination alone may not be a major concern when metric results suggest otherwise.

At the downstream site, all the metrics in 2005 were outside the range of variability of the Group 2 reference mean. The available data show the benthic community here was “Mildly Divergent” in 2005, which appears to be a result of the low taxa diversity, low abundance of sensitive taxa and high percent of pollution tolerant Chironomidae compared with the Group 2 reference mean. By comparison, all metrics showed a substantial improvement in the benthic community in 2020. As noted above, these changes may be related to potentially different sampling locations, in the same area of the river, with differing substrate conditions between 2005 and 2020.

Overall, these results indicate that the benthic community in the Kitimat River at KTM08 and KTM07 is healthy and diverse in 2020.

Hirsch Creek

KTM14 is the upstream site on Hirsch Creek, a tributary to the Kitimat River. The site is located 500 metres upstream of the Hirsch Creek / HWY 37 bridge crossing and 3 kilometres upstream of the District of Kitimat (DOK) landfill. The data show the benthic community here was “Mildly Divergent” in 2020, which may be related to the lower total abundance compared with the Group 2 reference mean. However, overall, the results suggest the presence of a healthy, diverse community.

KTM11 is the site on Hirsch Creek, located 200 metres downstream of the DOK landfill. It was found to be “Similar to Reference” following the 2006 and 2020 BI sampling events. Temporally, all metrics were within the range of variability of the group 2 reference except for % Chironomidae and % EPT individuals in 2006. These results suggest there are some differences in the benthic community in the early 2000s. Overall the metric and community endpoint results suggested general improvements in the health of the benthic community at this site from 2006 to 2020.

In 2020, most of the metrics and community endpoint results indicate that the Hirsch Creek benthic community is in good condition.

Little Wedeene River

KTM13 is on the Little Wedeene River, a tributary to the Kitimat River. This site is located 100 meters upstream of the Little Wedeene River FSR bridge crossing. It was found to be “Similar to Reference” following BI sampling in 2020. All metrics and community endpoints were similar to the Group 2 reference mean. These results suggest the community here is representative of a healthy, diverse community.

Conclusions

Benthic macroinvertebrate communities are an important addition to the WQO process, as they integrate the effects of upstream stressors and provide a direct measure of the condition of aquatic biota. CABIN data from a total of 5 sites within the Kitimat River and its tributaries were analyzed using the 2017 BC MOE-FSP Skeena Region Model to support the Kitimat River WQO update. The information summarized in this Appendix document will supplement the technical WQO assessment report, which will include information on water quality, hydrology, water uses and values, and potential stressors. The technical assessment report and BI

assessment will characterize the existing state of the watershed and provide a basis for the updated WQOs. Key findings for the Kitimat River and its tributaries are provided below:

- The water quality and BI data collected from sites in the Kitimat River watershed date will provide valuable information for future assessments.
- A temporal comparison of the benthic community data suggests that there were some changes present at the downstream Kitimat River and Hirsch Creek sites relative to the upstream sites and the model reference sites, particularly with respect to increases in diversity and sensitive taxa. Conditions are more similar to reference conditions in 2020 than in 2005 or 2006 respectively.
- There is a substantial improvement in the benthic community at the downstream Kitimat River site since 2005. However, an investigation into site conditions suggests that this may be in part due to the 2005 sampling taking place near a depositional area compared to 2020 and is supported by the high number of chironomids.
- The Hirsch Creek benthic community is in good condition and the landfill is not showing an impact on the benthic invertebrate community.
- There is minimal CABIN data for Little Wedeene River, however, the data from 2020 suggests a healthy, diverse community.
- Overall, the CABIN data for the Kitimat River watershed are limited, with fifteen years between sampling events. Additional sampling would help validate the 2020 findings and properly characterize the current benthic community in the watershed.

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Table B2. Summary of site assessment for CABIN sites on the Kitimat River, Hirsch Creek and Little Wedeene River. Values in BOLD are significantly different from the Group 2 reference mean (i.e., > 2 SDs).

Site Assessment Metric	Kitimat R. Us Ref (KTM08)		Kitimat R. Ds Eurocan (KTM07)		Hirsch Cr. Us of landfill (KTM14)	Hirsch Cr. Ds of landfill (KTM11)		Little Wedeene River (KTM 13)	Group 2 Mean +/- SD
	2005	2020	2005	2020	2020	2006	2020	2020	
Ordination	MD	R	MD	R	MD	R	R	R	-
Bray Curtis	0.6088	0.4149	0.8237	0.4042	0.6257	0.7177	0.4560	0.5241	-
O:E (p>0.7)	0.946	0.953	0.275	1.088	0.834	0.971	0.975	0.928	-
Total Taxa	19	14	6	24	16	13	20	17	17.75 +/- 3.99 ¹
Clinger Taxa	15	20	2	29	21	13	19	24	19.49 +/- 4.73
Ephemeroptera taxa	4	4	1	4	3	4	4	4	3.87 +/- 0.80
Plecoptera taxa	4	4	1	6	4	4	5	5	4.83 +/- 1.19
% Chironomidae	27.75	16.06	81.75	26.28	10.94	66.83	33.56	5.93	17.22 +/- 18.23
% EPT Individuals	61.22	82.29	16.77	63.30	81.95	27.88	56.74	90.20	77.26 +/- 20.67
Simpson's Evenness	0.27252	0.383574	0.239672	0.236034	0.306923	0.16213	0.262036	0.396918	0.27 +/- 0.09
Total Abundance	512	2193	1502	625	341	2428	1443	845	2339.68 +/-1562.611

¹Example: the 2 SDs range for group 2 total taxa mean of 17.75 +/- 3.99 is from 9.77 to 25.73.