Indicator Report

Coordinated Aquatic Monitoring Program

2025

CAMP

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1.0 Introduction

The Coordinated Aquatic Monitoring Program (CAMP) is a long-term aquatic monitoring program. It was established to study and monitor waterbodies (rivers and lakes) affected by Manitoba Hydro's hydraulic generating system. CAMP was established in 2006 with a Memorandum of Understanding (MOU) between the Province of Manitoba (MB) and Manitoba Hydro (MH). Monitoring began in 2008, with the first three years serving as a pilot project. CAMP was developed by integrating components from existing MB and MH long-term monitoring programs and incorporating new components and sites to fill necessary gaps.

The need for a coordinated approach was identified during the Section 35 Aboriginal Consultations for the Wuskwatim Generating Station. Long-term aquatic monitoring will strengthen the understanding of the effects of hydroelectric activity on the aquatic ecosystem and support more informed decision making when it comes to water management.

CAMP's mandate is to study and monitor the health of bodies of water affected by Manitoba Hydro's generating system. Its aim is to create synergies between aquatic monitoring undertaken by Manitoba Hydro and the Province of Manitoba thereby to:

- Avoid duplication
- Combine critical portions of similar environmental programs and standardize methods
- Assist in developing a more complete understanding of the state of Manitoba's aquatic environment.

CAMP's objective is to monitor aquatic environments and track conditions over time by:

- Monitoring select physical, chemical, and biological components of waterbodies within Manitoba Hydro's generating system
- Monitoring waterbodies outside of Manitoba Hydro's hydroelectric generating system. These off-system waterbodies will help determine how other factors, like climate, affect the aquatic environment.

The major components currently monitored under CAMP are:

- Physical Environment
- Water Quality
- Benthic Macroinvertebrates
- Fish Community
- Fish Mercury

CAMP is in the process of undergoing an expansion. This will include additional monitoring components (e.g., shoreline monitoring), opportunities for participation by Indigenous communities and inclusion of both Indigenous and scientific knowledge.

The purpose of this report is to describe the current list of indicators monitored through CAMP and their associated metrics. It serves as a reference document to accompany CAMP data reports, to facilitate an understanding of what is monitored under CAMP and why. As CAMP monitors a broad range of ecosystem components, this report uses a pathway of effects approach to explain why select indicators are monitored and how they are connected.

The pathway of effects model helps describe the pathways between human activities – in this case, hydroelectric disturbance (and the associated stressors) – and the effect on the aquatic environment. Figure 1 shows the pathway of effects, with the indicators included in CAMP reporting highlighted in green. The figure is an overview of the many complex connections between the development and operation of Manitoba Hydro's hydroelectric system and the aquatic environment.

Hydroelectric development, or other activities that similarly affect water levels, flows, and hydrology, can affect lakes and rivers through a number of pathways. Examples of pathways of effects include:

- Flooding of terrestrial habitat: the decomposition of flooded organic materials consumes oxygen. The resulting change in dissolved oxygen levels can affect fish and other organisms living in the waterbody.
- Changes in water levels and depth: the creation of reservoirs generally increases water depth which can lead to thermal stratification and, in turn, decreases in oxygen in bottom waters due to isolation from the atmosphere. Such changes can affect the abundance and type of species living in an aquatic habitat.
- Changes in inflows and diversion: changes to the relative contribution of inflows and diversion of flows may change water temperature and dissolved oxygen concentration in different areas.

In addition to hydroelectric disturbance, many external drivers also influence the aquatic environment. These include infrastructure development, industrial and municipal activities, agriculture, climate, invasive species, fish harvesting, and water management outside of the Manitoba Hydro hydraulic operating system. Recognizing the existence of external drivers is important, as they can make it challenging to pinpoint specific causes and effects within a complex ecosystem.

This report presents the current list of indicators and associated metrics under each CAMP component, as outlined in Table 1. CAMP monitors a wide range of parameters under each component in addition to the indicators selected for reporting. CAMP data is available publicly upon request at campmb.ca.

Figure 1:

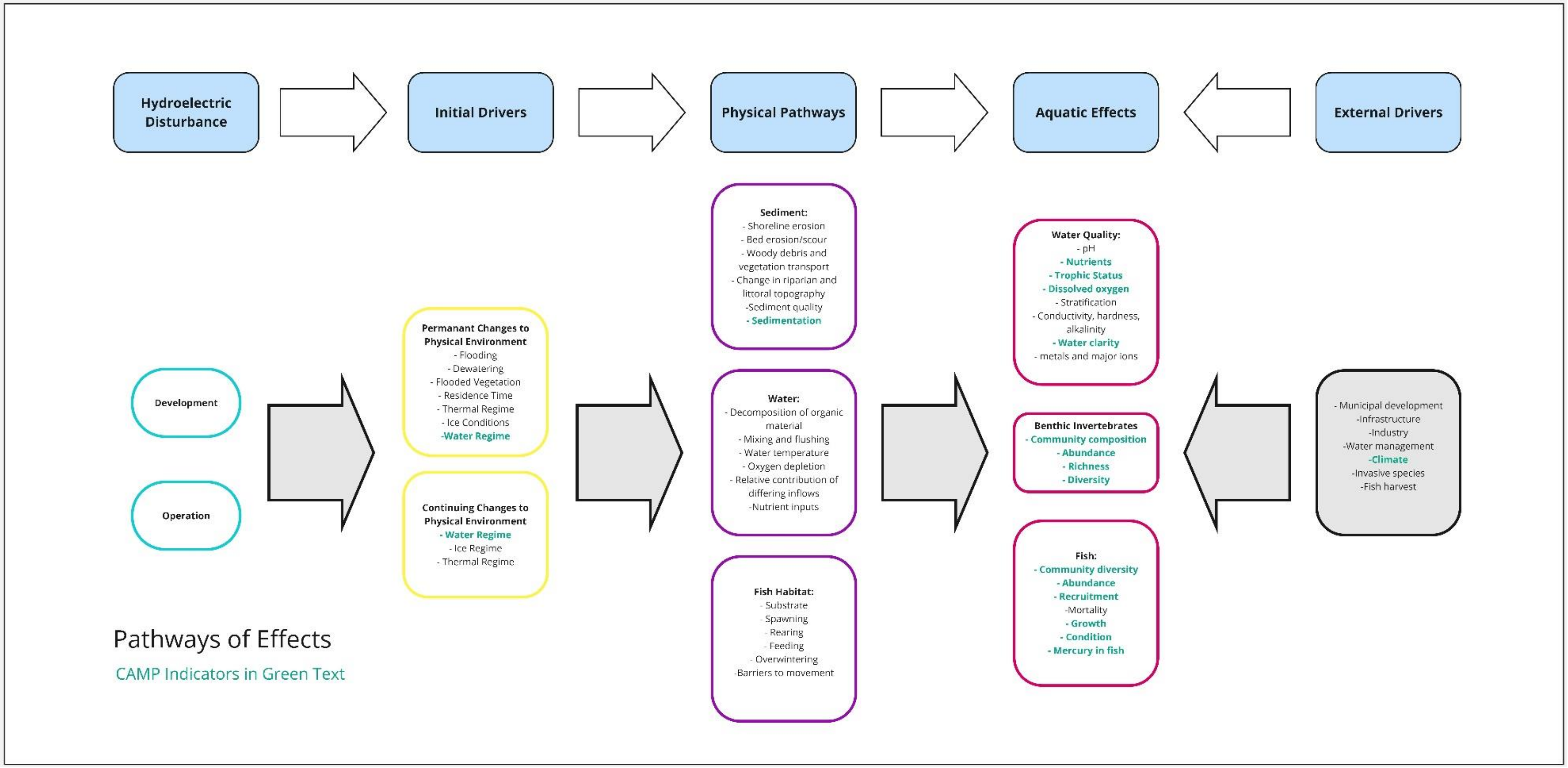
Hydroelectric Disturbance
Initial Drivers
Physical Pathways
Aquatic Effects
External Drivers
Development
Operation
Permanant Changes to Physical Environment
- Flooding
- Dewatering
- Flooded Vegetation
- Residence Time
- Thermal Regime
- Ice Conditions
-Water Regime
Continuing Changes to Physical Environment
- Water Regime
- Ice Regime
- Thermal Regime
Sediment:
- Shoreline erosion
- Bed erosion/scour
- Woody debris and vegetation transport
- Change in riparian and littoral topography
-Sediment quality
- Sedimentation
Water:
- Decomposition of organic material
- Mixing and flushing
- Water temperature
- Oxygen depletion
- Relative contribution of differing inflows
-Nutrient inputs
Fish Habitat:
- Substrate
- Spawning
- Rearing
- Feeding
- Overwintering
-Barriers to movement
Water Quality:
- pH
- Nutrients
- Trophic Status
- Dissolved oxygen
- Stratification
- Conductivity, hardness, alkalinity
- Water clarity
- metals and major ions
Benthic Invertebrates
- Community composition
- Abundance
- Richness
- Diversity
Fish:
- Community diversity
- Abundance
- Recruitment
-Mortality
- Growth
- Condition
- Mercury in fish
- Municipal development
-Infrastructure
-Industry
-Water management
-Climate
-Invasive species
-Fish harvest
Pathways of Effects
CAMP Indicators in Green Text

Table 1: CAMP Indicators

Component	***Indicator***	*Metric*
Physical Environment	**Climate**	Air Temperature
		Precipitation
	Water Regime	Flow
		Water Levels
		Water Level Variation
		Water Temperature
	Sedimentation	Turbidity
		Sediment Load
Water Quality	**Dissolved Oxygen**	DO concentration and percent saturation
		Temperature Stratification[1]
	Water Clarity	Secchi Disk Depth
		Turbidity
		Total Suspended Solids (TSS)
	Nutrients and Trophic Status	Total Phosphorous
		Total Nitrogen
		Chlorophyll a
Benthic Macroinvertebrates	**Abundance**	Total Invertebrate Abundance
		Total Invertebrate Density
	Community Composition	Proportions of Major Invertebrate Taxa
		EPT Index
		O+C Index

[1] Temperature stratification is a supporting metric for dissolved oxygen and is not tracked for change over time.

Component	***Indicator***	*Metric*
	Taxonomic Richness	Total Richness
		EPT Richness
	Diversity	Hill's Index
Fish Community	**Community Diversity**	Hill's Effective Species Richness
		Relative Species Abundance
	Abundance	Catch-per-unit-effort (CPUE)
	Species Growth	Fork Length-at-Age
	Species Condition	Relative Weight
		Fulton's Condition Factor
	Recruitment	Relative Year-Class Strength
Mercury in Fish	**Mercury in Fish**	Arithmetic mean mercury concentration
		Length-standardized mean mercury concentration of large-bodied species

2.0 Physical Environment

The physical environment is generally defined as the physical and chemical make-up of an ecosystem. It describes the area where things live and includes the air, water, and land within an ecosystem. In the context of aquatic ecosystems, changes to the physical environment affect fish habitat and water quality, which subsequently affects the fish and benthic communities. To gain a greater understanding of these effects, CAMP monitors physical environment indicators including water regime and sedimentation. CAMP does not monitor climate, but data collected by Environment Climate Change Canada is included in reporting to gain a more holistic understanding of the physical environment. Physical environment data is collected at various waterbodies across CAMP regions using continuous water level and water quality monitoring stations.

Table 2: Physical Environment Indicators

Indicator	*Metric*	*Unit*
Climate[2]	Air Temperature	Monthly Average (°C)
		Annual Average (°C)
	Precipitation	Monthly Average (mm)
		Annual Average (mm)
Water Regime	Flow	Monthly Average (cms)
	Water Level and Variability	Monthly Average (m)
		Monthly Water Level Range (m)
	Water Temperature	Average Hourly Temperature (°C)
		Duration of temperature in 5-degree increments (#days/5 °C)
Sedimentation	Continuous Turbidity	Average Monthly Turbidity (FNU)
	Sediment Load	Tonnes/day by month

[2] CAMP does not monitor climate, but data collected by Environment Climate Change Canada is included in reporting to gain a more holistic understanding of the physical environment.

2.1 Climate - Indicator

Climate describes the long-term pattern of weather in a given area. Though CAMP does not monitor climate, data from Environment Climate Change Canada is included in reporting as is it a physical environment indicator providing important context for data collected under other components. Climatic conditions influence things like river flows, water temperature and dissolved oxygen, trophic status, and biological organisms and processes.

Metrics – Air Temperature & Precipitation

The climate indicator is measured with two metrics: **air temperature** and **precipitation**. The monthly average air temperature for each monitoring year indicates warmer and cooler months in a region, while the annual average air temperature for each monitoring year indicates warmer and cooler years. This metric is included as it provides supporting information to the other program metrics by providing a means for comparing air temperature from month to month and year to year. In relation to aquatic health, air temperature provides general context for climate conditions at the time of monitoring which may help in interpreting trends in other metrics. For example, air temperature directly affects water temperature and ice cover, which in turn affect other CAMP indicators.

The monthly average precipitation for each monitoring year indicates wetter and drier months in a region, while the annual average precipitation for each monitoring year indicates wetter and drier years. This metric is included as it provides supporting information to the other program metrics in providing a means for comparing precipitation from month to month and year to year. In relation to aquatic health, precipitation provides general context to climate conditions at the time of monitoring and may help in interpreting trends in other metrics. For example, precipitation directly affects river discharge, which in turn affects other metrics under each CAMP component.

2.2 Water Regime - Indicator

Water regime is a term used to describe the prevailing pattern of water flow over a specified period of time. The water regime indicator encompasses the metrics measuring hydrological conditions in a waterbody. The water regime affects many aspects of the aquatic ecosystem such as fish community composition and water quality.

Metrics – Flow, Water Level and Variation, Water Temperature

Water **flow** measurements show much how water is moving through an area. Average monthly flow shows variations throughout the year and calculating annual average flows can allow for comparison between years. Flow data can be used to understand the timing and duration of peak/low flows and how the system operates (e.g., changes in flows at control structures), and comparisons against long term annual data can help us understand wetter and drier periods.

This metric is included in CAMP as changes in flow have a direct effect on many aspects of the aquatic environment. Data can be used to show how Manitoba Hydro operations affect flows and/or reveal year-to-year changes that are primarily driven by the amount of precipitation and water in the system. The flow metric is important as it contributes to an understanding of the changes resulting from both climate and hydro operations, and their potential effects on the aquatic environment.

Water level measurements complement the flow metric to show the effect of changes in flow, whether from climate or hydro operations. Water levels can be used to assess the amount of time a particular habitat is wet, and suitable for various forms of aquatic life. **Water level variation** is defined here as the difference between the maximum and minimum water levels for each month of each year. Water level variation is important to biota, particularly those living in shallower water or intermittently wet areas. Water levels affect and are affected by other components monitored by CAMP. For example, flow affects water levels and water levels can affect sedimentation, water quality, and fish habitat. It is therefore important to collect water level data to understand the full picture of how an aquatic ecosystem may be changing.

Water temperature is measured at continuous monitoring sites and shows the changes in water temperature over time. This includes identifying the timing of peak water temperatures and changes due to climate and system operations. This metric is included in CAMP as water temperature is important to biological activity, can be used as a proxy for ice cover, and is relatively easy to measure along with other continuous monitoring (i.e., turbidity and water levels). Water temperature is important to measure in relation to aquatic health as it influences biological processes, waterbody stratification, dissolved oxygen saturation, and ice formation. Water temperature is affected by air temperature and water conditions (e.g., shallow stagnate or fast flowing water).

2.3 Sedimentation - Indicator

The sedimentation indicator includes metrics that measure the presence and transport of sediment in a waterbody. Sedimentation affects aspects of the aquatic ecosystem such as water quality and fish habitat.

Metrics – Turbidity and Sediment Loads

Measured at continuous monitoring sites, **turbidity** is used as a proxy for total suspended solids (TSS) to show the timing and duration of increased turbidity and changes in turbidity due to changes in flow and climatic events (e.g., storms). This metric is included in CAMP as it provides the opportunity to observe how external factors such as system operations (e.g., change in water flows/levels) and climate influence turbidity and by proxy, suspended sediment. When correlated with other water quality parameters, it can also be used as an indication of changes observed in those metrics. In relation to aquatic health, continuous turbidity data can be used to assess changes in water clarity during important time windows and changes in the ecosystem (e.g., the introduction of zebra mussels). Additionally, changes in turbidity can affect biota in the water. Turbidity is affected by erosion, sediment transport, and algae processes.

The **suspended sediment load** metric allows for the identification of when peak sediment transport is occurring and for comparison of monthly average conditions. This metric is included in CAMP as sediment load is in an indicator of how much erosion and sediment transport is occurring in a region. Suspended sediment loads are affected by river discharge and the suspended sediment concentration. In relation to aquatic health, sediment processes are important to understand as they can have direct impacts of fish and fish habitats.

3.0 Water Quality

Water quality refers to the chemical, physical, and biological characteristics of water. Water quality is monitored through CAMP as it affects the suitability of an ecosystem for aquatic life. Poor water quality may be harmful to aquatic life, and may affect the condition, growth, survival, and reproduction of organisms such as fish and benthic invertebrates.

Table 3: Water Quality Indicators

Indicator	Metric	Units
Dissolved Oxygen	DO Concentration	mg/L

	DO Saturation	% saturation
	Temperature Stratification[3]	1°C water temperature change over 1m depth in water column
Water Clarity	Secchi Disk Depth	m
	Turbidity	NTU
	Total Suspended Solids (TSS)	mg/L
Nutrients and Trophic Status	Total Phosphorous	mg/L
	Total Nitrogen	mg/L
	Chlorophyll *a*	µg/L

3.1 Dissolved Oxygen (DO) - Indicator

This indicator examines levels of dissolved oxygen in water. Dissolved oxygen levels influence growth, condition, reproduction, and survival of aquatic biota. This indicator is included in CAMP because dissolved oxygen is essential for most aquatic biota and may affect numerous aspects of the aquatic ecosystem such as nutrient cycling, and the abundance, condition, distribution, and community composition of fish and benthic invertebrates. Low DO concentrations can reduce growth, condition, and survival of aquatic biota.

Metrics – DO Concentration, DO Saturation & Temperature Stratification

DO is measured using three metrics: **DO concentration**, which is measured in mg/L across depth; **DO saturation**, which is measured as the amount of oxygen dissolved in water relative to the maximum amount that could be dissolved at a given water temperature (may range from 0% in anoxic waters to greater than 100% in supersaturated waters); and **temperature stratification,** which is a function of changes in water density, often defined as a temperature change of 1°C or more over one meter of water. Temperature stratification is used as a supporting metric as it is used to interpret DO data but not tracked for change over time. Colder water can hold more DO than warmer water and saturation occurs at a higher concentration in winter than during the open-water season.

DO concentrations are influenced by water mixing (flow, wind, and waves) conditions, ice cover, temperature, the amount of organic materials in a waterbody, upstream and groundwater

[3] Temperature stratification is a supporting metric for dissolved oxygen and is not tracked for change over time.

inputs, and biota - through consumption of oxygen (e.g., fish) and through production of oxygen (e.g., algal photosynthesis).

3.2 Water Clarity - Indicator

This indicator examines the clarity of water. Water clarity impacts the aquatic environment as it determines how much light can reach plants and animals. Water clarity may affect the amount and distribution of plants and algae and the behaviour, condition, and survival of aquatic biota (e.g., predation success of visual fish predators).

Metrics – Secchi Disk Depth, Turbidity & Total Suspended Solids (TSS)

Water clarity is measured through three inter-related metrics.

Secchi disk depth refers to the depth at which a black and white disk lowered into the water column is no longer visible. Higher Secchi disk depth measurements indicate greater light penetration in the water column. The amount of light penetrating the water column may affect growth of primary producers, and behaviour, growth, and survival of other aquatic biota.

Turbidity is a measure of scattering of light by suspended particles in water and it reflects the transparency of water caused by dissolved and suspended substances. **Turbidity** is generally positively correlated with **Total Suspended Solids (TSS)** and may affect aquatic biota through similar pathways.

Total suspended solids (TSS) is a measure of the amount (by weight) of suspended solids, both organic (e.g., algae) and inorganic (e.g., sediment matter), in water. At high concentrations, TSS can affect growth, condition, reproduction, survival, and behaviour of fish, can reduce abundance of fish diet items, and harm benthic habitats.

TSS is affected by factors that contribute to the introduction or loss of suspended solid materials in water including hydrology (e.g., flow, velocity, water level), ice regimes (e.g., scouring), waterbody morphometry (e.g., depth, water residence times, fetch), wind, shoreline composition and erodibility, substrate composition (e.g., cobble, sand, clay), and activities in the watershed that may introduce sediments to aquatic ecosystems (e.g., forestry). All of these factors may also similarly affect Secchi disk depth and turbidity as well as factors that affect the amount of substances dissolved in water – notably organic materials. The amount of algae suspended in the water column also affects each of these metrics and factors affecting algal abundance may therefore also influence water clarity.

3.3 Nutrients and Trophic Status - Indicator

This indicator examines levels of nutrients and algae in water. Nutrients are not toxic at the concentrations normally found in surface waters. However, nutrient enrichment can stimulate excessive growth of plants and algae (i.e., eutrophication), which can subsequently lead to the degradation of aquatic habitat through physical changes (e.g., excessive plant or algal growth), and through changes to water quality (e.g., reduced DO at night, reduced water clarity due to phytoplankton, and possible production of toxins by some forms of algae). Conversely, low levels of nutrients may limit the productivity of aquatic ecosystems. Sources of nutrients in surface waters include the breakdown of organic matter, excretion by organisms, wastewater discharges, erosion and run-off from the watershed, sediment resuspension, and atmospheric deposition.

Metrics – Total Phosphorous, Total Nitrogen & Chlorophyll a

CAMP measures nutrients and trophic status in waterbodies through three metrics - **total phosphorous, total nitrogen**, and **chlorophyll a** concentration. Phosphorous is the most common nutrient limiting the growth of phytoplankton in lentic freshwater systems and concentrations are often related to the productivity of aquatic systems. In some cases, nitrogen may be limiting – or it may be co-limiting along with phosphorous - in aquatic ecosystems. Chlorophyll a, a green pigment found in aquatic macrophytes and algae, is a commonly used indicator of phytoplankton biomass and the productivity and trophic status of aquatic ecosystems.

4.0 Benthic Invertebrates

Benthic invertebrates are small animals that live at the bottom of lakes and rivers. They include aquatic invertebrates such as snails, worms, and clams, and aquatic stages of some insects (e.g., mayflies and caddisflies). The benthic invertebrate community is determined by the physical and chemical characteristics of the substrate and water they live in; therefore, they are important indicators of aquatic habitat quality. Benthic invertebrates are ecologically important because they are a key component in the aquatic food web and are a link between primary producers (e.g., phytoplankton) and higher trophic level consumers (e.g., fish).

Benthic invertebrate samples are collected in nearshore (shallow) and offshore (deep) areas. Nearshore refers to the aquatic habitat occurring at the shoreline along a perpendicular transect out to about 1 meter water depth. Offshore refers to the aquatic habitat located farther from shore, usually within water depths between 5 and 10 meters.

Table 4: Benthic Macroinvertebrate Indicators

Indicator	Metric	Units
Abundance	Total Invertebrate Abundance	Number per kicknet sample
	Total Invertebrate Density	Number per m^2
Community Composition	Relative Proportions of Major Invertebrate Groups	%
	EPT Index	%
	O+C Index	%
Taxonomic Richness	Total Richness	Total number of distinct families
	EPT Richness	Total number of distinct families
Diversity	Hill's Index	

4.1. Abundance - Indicator

Abundance is the number of individuals present and is influenced by changes in hydrology, water quality, and aquatic habitat. For example, invertebrate abundance may decrease under increased suspended sediment events or increase under nutrient-enriched conditions.

Metrics – Total Invertebrate Abundance & Total Invertebrate Density

For nearshore, the metric for abundance is **total invertebrate abundance**, which measures the total number of invertebrates found in each kicknet sample. The metric for offshore abundance is **total invertebrate density**, measuring the total number of invertebrates collected per benthic sample in sampling dredge measuring 0.023m^2 (approximately 15cm/6inch squared) in area. Total invertebrate abundance and density may be affected by changes in water and/or habitat. For example, abundance may decrease with increased frequency of water level fluctuations.

4.2 Community Composition - Indicator

This indicator examines the makeup (e.g., types of different invertebrate families) of an invertebrate community. Hydrology, water quality, and aquatic habitat conditions influence benthic invertebrate community composition. Changes in aquatic habitat may be reflected by a shift in the relative abundances of different kinds of invertebrates in a community. For example, an increase in the frequency of water level fluctuations may lead to a decrease in the relative proportion of mayflies and an increase in the relative abundance of aquatic worms. As benthic invertebrates are an important part of the aquatic ecosystem, changes to community composition may affect other components monitored through CAMP.

Metrics – Relative Proportions of Major Invertebrate Groups, EPT Index, and O+C Index

Community composition is measured through three metrics. **Proportions of major invertebrate taxa** refers to the relative abundance of major invertebrate groups divided by the total invertebrate abundance. **EPT index** refers to the relative abundance of the EPT Orders (Ephemeroptera [mayflies], Plecoptera [stoneflies], Trichoptera [caddisflies]) divided by the total invertebrate abundance. **O+C Index** refers to the relative abundance of Oligochaeta (aquatic segmented worms) + Chironomidae (non-biting midges) Orders. Changes in water and/or habitat can affect invertebrate community composition. For example, proportions of sensitive invertebrate taxa may decrease with increased sedimentation or changes in water clarity.

4.3 Taxonomic Richness - Indicator

The taxonomic richness indicator characterizes the benthic invertebrate community in terms of numbers of distinct taxa at the family level. The number of different taxa reflects diversity and is influenced by hydrology, water quality, and aquatic habitat. For example, higher numbers of EPT taxa may indicate a stable and diverse nearshore habitat.

Metrics – Total Richness & EPT Richness

Taxonomic richness is measured through two metrics. **Total richness** refers to the total number of distinct invertebrate taxa at the family-level. **EPT richness** is the total number of distinct taxa at the family-level within the EPT Orders (Ephemeroptera [mayflies], Plecoptera [stoneflies], Trichoptera [caddisflies]). Taxonomic richness of the invertebrate community can be affected by changes in water and/or habitat quality. For example, a higher number of taxa may indicate a stable nearshore habitat in terms of substrate composition and texture.

4.4 Diversity - Indicator

The diversity indicator characterizes the benthic invertebrate community in terms of family-level richness and relative abundance. Diversity is influenced by hydrology, water quality, and aquatic habitat and may decrease in response to physical and/or chemical disturbances.

Metric – Hill's Index

Diversity is measured using **Hill's Effective Richness (Hill's index),** where the total number of taxa (i.e., richness) is weighted according to the corresponding proportional abundances (i.e., evenness). The Hill's index value indicates the number of dominant taxa in a community. The diversity of an invertebrate community can be affected by changes in water and/or habitat. For example, the Hill's index value may decrease with increased habitat disturbance.

5.0 Fish Community

The fish community represents the species of fish and the interactions between them within a waterbody. Fish are monitored as part of CAMP as they are reflective of the condition of the aquatic ecosystem. Since different fish species rely on different habitat types and food sources, they are directly affected by changes in the physical, chemical, and biological components of aquatic ecosystems.

Table 5: Fish Community Indicators

Indicator	Metric	Units
Community Diversity	Hill's Effective Species Richness	species
	Relative Species Abundance (RSA)	% of Catch
Abundance	Catch-per-unit-effort (CPUE)	Standard Gang – CPUE, # fish/100m/24h; Small Mesh Gang – CPUE, # fish/30m/24h
Species Growth	Fork Length-at-Age	mm
Species Condition	Relative Weight (Wr)	
	Fulton's Condition Factor (KF)	
Recruitment	Relative Year-Class Strength (RYCS)	

5.1 Community Diversity - Indicator

The community diversity indicator examines the makeup of a fish community. In the context of CAMP, fish community diversity is ecologically relevant as higher or lower diversity/evenness index values can be responses to changes in the aquatic ecosystem resulting from hydroelectric influences on the physical, chemical, and/or biological components of the aquatic environment.

Metrics – Hill's Effective Species Richness & Relative Species Abundance

The metrics for fish community diversity are **Hill's Effective Species Richness,** which is a measure of the number of species (i.e., richness) and the distribution of the different species (i.e., evenness) making up the community in an area, and **Relative Species Abundance** which refers to the proportion of individuals of each species in the overall catch. Healthier ecosystems typically support more diverse fish communities, although there are inherent differences in diversity in different waterbodies. For example, fish community diversity is generally higher in southern ecosystems relative to more simple communities in the north. Changes in the environment can be reflected in higher or lower diversity index values, where diversity may decrease with increased environmental stress, leaving only the most resilient species.

5.2 Abundance - Indicator

The abundance indicator examines the total size of a fish population.

Metric – Catch-per-unit-effort (CPUE)

The abundance of fish can reflect changes in environmental conditions. Abundance is measured through the metric **catch-per-unit-effort (CPUE)**, which is a commonly used metric to track changes in fish over time by using an index of abundance that is standardized by the fishing effort (length of gill net and set duration). Changes in abundance, reflected in higher or lower CPUE, can reflect changes in the aquatic environment. It may also be affected by external factors like harvesting.

5.3 Species Growth - Indicator

This indicator examines growth of fish for CAMP target species: Northern Pike, Lake Whitefish, Walleye, and Sauger. Changes in fish growth may indicate changes in the environment such as increases or decreases in habitat quality and/or quantity, prey availability, and/or competition.

Metric – Length-at-Age

Species growth is measured using the mean length of fish at a selected age that includes fish that are large enough to be recruited in the sampling gear but are still young enough to be immature or at the age of first maturity (i.e., when fish are allocating energy to growth rather than reproduction). This metric is referred to as **length-at-age**.

5.4 Species Condition - Indicator

This indicator examines the condition – girth or relative fatness - of fish for different species. Lack of food, poor water quality, or disease can result in lower condition of fish. Changes to the condition in a population reflects the nutritional status and health of fish, and may indicate environmental changes (e.g., decreases in food resources).

Metrics – Relative Weight & Fulton's Condition Factor

Species condition is measured using two metrics: **relative weight**, which is an index value comparing the relationship between the actual weight of an individual fish to a standard weight calculated from a published weight-length regression developed for the species across its geographical range; and **Fulton's Condition Factor**, which is an index of fish condition based on the ratio of fish length and weight of each fish. While the condition of a fish can change with habitat type (e.g. fish caught in riverine environments can have lower condition factor then fish caught in lake environments), low relative weight or condition factor can also be indicative of unhealthy fish populations (e.g., due to changes in diet items).

5.5 Recruitment - Indicator

This indicator tracks how young, small fish survive and are added to the fished component of a fish population each year. Tracking changes in the number of fish that are recruited into the population from each cohort can help identify changes in fish populations and potentially environmental changes occurring in a particular year.

Metric – Relative Year-Class Strength

Recruitment is measured using the metric **relative year-class strength**, an index that compares the proportion of a population born in the same year (i.e., a year class or cohort) to the total population. This metric is commonly used to identify year classes that have high or low proportions relative to the other year classes (often described as "strong" or "weak" year classes).

6.0 Mercury in Fish

The concentration of mercury in fish can affect the suitability of fish for consumption by humans. The creation of reservoirs, for hydroelectric development or other purposes, commonly causes increases in mercury concentrations in fish. As CAMP is an ecosystem health monitoring program, it does not analyze mercury in fish data in relation to human health. Data collected is made available to the relevant experts and authorities for human health related analysis.

Table 6: Mercury in Fish Indicator

Indicator	Metric	Units
Mercury in Fish	Arithmetic mean mercury concentration	ug/g wet weight
	Length-standardized mean concentration in large-bodied species	ug/g wet weight

6.1 Mercury in Fish - Indicator

This indicator examines the concentration of mercury in fish.

Metrics – Arithmetic mean concentration (large- and small-bodied fish) & Length-standardized concentration (large-bodied fish)

Mercury in fish is measured using two metrics: the **arithmetic mean concentration** of mercury in the muscle of large-bodied fish (Northern Pike, Walleye, Lake Whitefish) and the carcasses of 1-year-old Yellow Perch; and a **length-standardized concentration** which refers to mercury concentrations standardized to a specified length of fish to account for effects of fish size (i.e., mercury typically increases with increasing length and/or age of fish). The standard lengths used are 550 mm for Northern Pike, 400 mm for Walleye, and 350 mm for Lake Whitefish and were selected based on those used in previous mercury monitoring studies in Manitoba.

7.0 Conclusion

CAMP is a long-term ecosystem monitoring program that adapts over time through continuous learning. As the program evolves, indicators and metrics may change. The content of this report represents indicators monitored by CAMP at the time of the 12-year report, which covers the period of 2008-2019. For more information, visit campmb.ca.