Assessing Watershed Health Indicators: Strengthening Indigenous Co-Governance and Embracing Climate Adaptation in Support of Watershed Resilience

by

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Abstract

This study examines watershed health indicator (WHI) frameworks across North America by assessing their alignment with the holistic principles of Integrated Water Resources Management (IWRM). The research highlights collective gaps within these frameworks, particularly regarding Indigenous leadership and climate change in mainstream WHI development. It also reveals disparities and commonalities between western science and Indigenous knowledge systems, arguing that there is power in co-creative partnership approaches. This underscores the need for a more inclusive, collaborative, and co-creative WHI development that can effectively monitor and track the array of environmental, social, and economic challenges unique to the Okanagan Basin. The findings will inform policymakers and watershed managers about the importance of holistic and culturally sensitive WHI frameworks, and advocate for continuing legislative support for Indigenous leadership in WHI development via the Declaration on the Rights of Indigenous Peoples Act, Water Sustainability Act, and Watershed Security Strategy and Fund.

Keywords: watershed health indicator; eco-cultural indicator; Okanagan Basin; integrated water resources management; Syilx Okanagan Nation Alliance; Syilx Okanagan Peoples; Okanagan Basin Water Board; climate change; watershed resilience; Indigenous leadership; co-creation

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ECI	Eco-cultural Indicator
IWRM	Integrated Water Resources Management
NSI	Natural Solutions Initiative
OBWB	Okanagan Basin Water Board
ONA	Okanagan Nation Alliance
SFU	Simon Fraser University
WHI	Watershed Health Indicator
WSA	Water Sustainability Act
WSS	Watershed Security Strategy
WSSF	Watershed Security Strategy & Fund

Chapter 1. Introduction

Freshwater is critically linked to the functioning of healthy, biodiverse, and productive ecosystems as well as the social, cultural, and economic well-being of human societies worldwide (Wilson et al., 2019). This is especially true in Canada, a country which contains only 0.5% of the global human population, but an enviable 20% of the world's freshwater reserves and 9% of global runoff within its national borders (Government of Canada, 2018; Shrubsole et al., 2016). Significant challenges persist concerning the equitable and sustainable management of this valuable resource, however.

This challenge becomes particularly relevant given the complexity and diversity of watersheds, which are the overarching units through which freshwater systems are understood and managed. In simple terms, a watershed is a hydrologically connected area of land whereby at any point within, freshwater can drain into any number of waterbodies such as lakes, rivers, and marshes (among others). These water bodies in turn collectively discharge into a common outlet point dictated by regional topography (Agriculture and Agri-Food Canada, 2020). A watershed is also more than just a physical landscape, as the unique communities of various flora, fauna, and microorganisms that live within, also share unique reciprocal relationships with its non-living environmental components (Muskoka Watershed Council, 2023a, p. 146). While the defining functional characteristics of watersheds are globally applicable across all types of landscapes, each watershed is also inherently unique depending on a variety of place-based characteristics (British Columbia, 2022). This includes the unique topography and land composition, climate, scale of anthropogenic development, and ecosystem condition of a place, of which each collectively influences the direction, movement, and cycle of water (British Columbia, 2022). These place-based characteristics also become cumbersome for the implementation of broadly replicable approaches to regulatory management and governance of watersheds, given that political boundaries are immaterial to the delineation of a watershed's boundary (Regional District of Nanaimo, 2022). Because of this, more tailored, collaborative, and dynamic approaches are increasingly being required to effectively monitor, manage, and mitigate the various stressors to a watershed that are imparted by anthropogenic and climate-induced sources (ACT, 2023; Zubrycki & Bizikova, 2014).

The implementation of key legislative frameworks and strategic initiatives in British Columbia plays an increasingly pivotal role in shaping tailored, collaborative approaches for watershed stewardship, particularly with an increasing emphasis on climate change monitoring and Indigenous leadership. This includes the newly adopted Water Sustainability Act (WSA), Declaration on the Rights of Indigenous Peoples Act (Declaration Act) and Action Plan (Action Plan), as well as the anticipated Watershed Security Strategy (WSS) and Fund (WSSF). Each further supports an alignment with the objectives of integrated water resources management (IWRM), as well as an opportunity to integrate climate change considerations and First Nations perspectives into water management practices across BC.

The primary purpose of the WSA is to facilitate the equitable and sustainable management of all surface and groundwater resources in the province by unifying management practices within all provincial watersheds (British Columbia, 2022). It also mandates changes to water licensing requirements, stronger aquatic ecosystem and flow regime regulations, and expanded protections for groundwater (British Columbia, 2022). While this unifying approach will be theoretically beneficial in limiting jurisdictional fragmentation by strategically aligning conflicting management objectives between regulatory bodies in a shared watershed, many of the associated policy tools are still in their infancy or unreleased (ACT, 2023; Conservation Ontario, 2010). Further attention will need to be given to the real-world success of this goal.

The primary mandate of the Declaration Act is to provide a framework that guides the alignment of all provincial laws in accordance with the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) (British Columbia, 2023) This compliance is important, as Article 25 of UNDRIP provides a “basis for a ‘liberty’ or ‘welfare’ right to water” by articulating how Indigenous peoples "have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, [and] waters" (United Nations, 2007; Larson, 2011, p. 11). Finally, the newly proposed WSS and WSSF collectively aim to bolster investment in watershed restoration, monitoring, and planning across the province and in alignment with the Declaration Act (Ministry of Environment and Climate Change Strategy, 2022; Tawaw Strategies, 2021).

The above key provincial legislative frameworks and strategic initiatives present a unique opportunity for Indigenous leadership and collaboration in watershed management. This is especially evident in areas like the Okanagan Basin (the Basin) which have some of the lowest freshwater supply rates across the country and a rapidly growing population becoming increasingly vulnerable to the accelerating impacts of climate change (Environment and Climate Change Canada, 2023; James Littley, 2023; Regional District of North Okanagan et al., 2020; South Okanagan Real Estate Board, 2019). The Okanagan Nation Alliance (ONA) has a well-established and strong presence in the Basin and has been proactively developing water declarations, planning methodologies, and strategies to justify their "inherent and implicit Aboriginal Title, Rights and Responsibilities to siwɬkʷ" (Okanagan Nation Alliance, 2014, p. 5). In addition, the Okanagan Basin Water Board (OBWB) plays a unique and valuable role in facilitating regional collaboration across three Regional Districts by bringing together a diverse array of partners and stakeholders for water stewardship action (Melnychuk et al., 2016). Please refer to **Section 1.5.2** of this report for additional information on each of these groups and the important work they undertake.

Indigenous leadership, the legislative environment, and the unique organization around water management in the Okanagan Basin, suggest that watershed-based management approaches may be ready to apply more a holistic and equitable lens reflective of a vast to implement an interconnected array of environmental, sociocultural, and economical considerations (Shrubsole et al., 2016).

1.1 Study Purpose

With the above context in mind, this study reviews 16 existing Watershed Health Indicator (WHI) Frameworks across North America to address the following research objectives:

1. Identify gaps in active WHI frameworks across North America, from an Integrated Water Resources Management (IWRM) framework, by comparing the overarching distribution of all WHIs under nine dimensions of watershed resilience.

2. Evaluate how existing WHI frameworks prioritize climate change and Indigenous Knowledges and leadership.

3. Provide insight into the development process of a robust, proactive, and equitable WHI framework to enhance watershed resiliency in the Okanagan Basin.

The lessons learned from this project serve to motivate watershed managers like the Okanagan Basin Water Board (OBWB), and First Nations communities like the Syilx Okanagan Peoples and Okanagan Nation Alliance (ONA), in considering the potential of jointly implementing a co-creative approach to developing a Basin-tailored WHI framework.

The structure of this paper is as follows: *Chapter 2 (Literature Review)* discusses the concept of IWRM, opportunities for WHI framework implementation under an IWRM lens, and the important role that Indigenous communities like the Syilx Okanagan Peoples and ONA can play in exploring co-creation potentials for a robust and holistic WHI Framework in the Basin. *Chapter 3 (Methodology)* outlines the formal process used to conduct this research and how the results were analyzed. *Chapter 4 (Research Findings)* discusses the findings of this study per the following three themes: (1) Geographical distribution of WHIs by resilience category; (2) Distribution of Indigenous and western priorities in WHI framework development, and; (3) Existing prioritization of WHI types. *Chapter 5 (Discussion)* explores aspirational opportunities for collaboration and co-creation in the process of developing a Basin-centric WHI framework.

1.2 The Okanagan Basin

The Okanagan Basin (the Basin) is a narrow strip of land 200 km long and 8,000 km^2 in area located within the southern interior of British Columbia, stretching from the Armstrong in British Columbia to the US border (Melnychuk et al., 2016). It is a complex and dynamic area that contains six primary lakes (Okanagan, Kalamalka, Wood, Skaha, Vaseux and Osoyoos) and is surrounded by a variety of mountain ranges (Okanagan Water Stewardship Council, 2019, p. 3). As a part of the Interior Plateau, which is bound by “moderately steep valley sides” and a broad flat bottom, the Basin’s lake system drains south via the Okanagan River to the US Border (Okanagan Water Stewardship Council, 2019, p.3). The Basin itself provides crucial habitat for a biodiverse range of species, including the sockeye salmon which is an important cultural keystone species to the Syilx Okanagan Peoples (Melnychuk et al., 2016, p. 410). It also hosts 23 species which have been designated an ‘at risk’ status, including various birds, reptiles, fish, mammals, and plants, further hinting at the extensive anthropogenic and climate pressures occurring within the Basin as a whole (Melnychuk et al., 2016).

Unlike the western coast of British Columbia, the Basin is semi-arid and generally receives < 30cm of rain per annum at a highly variable rate “ranging from 100 million m3 to over 1300 million m^3 annual inflow to Okanagan Lake” (Melnychuk et al., 2016, p. 410; Okanagan Basin Water Board, ND). Freshwater reserves in the Basin are annually recharged by snowpack and subsequent spring runoff, with the coastal mountains enhancing the Basin’s semi-arid climate through the generation of a rain-shadow effect (Melnychuk et al., 2016). This effect results in one of the lowest rates of precipitation in the province, with Jatel (2013) identifying three indicators driving the overall water supply for the region: “spring snow pack, spring reservoir levels and spring/summer rain” (p. 10).

The Basin is also set within a broader unceded territory range of the Syilx Okanagan Peoples which comprises of approximately 69,000 km^2 of land and is home to 7 Syilx First Nations tribes north of the American border (Okanagan Water Stewardship Council, 2019). As noted by the Okanagan Nation Alliance (2022), within their unceded territory are “21 watersheds, 1,403 saʔsaʔtitkʷ (rivers), 13,065 npəspislaʔxʷ (wetlands), 14,158 t̓uk̓ʷt̓ik̓ʷat (lakes), and hundreds of sub-basins…, each with their own personality, needs, and ways of being” (p. 15) From a colonial (or western) perspective, the Basin is home to three regional district governments including North Okanagan, Central Okanagan, and Okanagan-Similkameen. Each regional district independently ensures various services to a sub-group of the 12 basin-centric municipalities, including freshwater provisioning for consumption and agriculture, parks management, and solid waste management, among others (Regional District North Okanagan, 2024). Collectively, the total human population in the Basin totals at 403,955 (as of 2021) with a variety of strong industry presences, including agricultural & viticulture, construction and manufacturing, and tourism (Statistics Canada, 2022; Central Okanagan Economic Development Commission, 2023; City of Vernon, 2023).

As previously noted, the Basin’s per capita water use is the highest in Canada and water supply is amongst the lowest despite a growing population and industry, making the region increasingly more vulnerable to climate disasters (Environment and Climate Change Canada, 2023; James Littley, 2023; Regional District of North Okanagan et al., 2020; South Okanagan Real Estate Board, 2019). Compounding this issue is the high consumption rates of Basin residents, who individually consume approximately 675 liters of water per day (Melnychuk et al., 2016; Okanagan Basin Water Board, ND). At a rate of more than double the Canadian average, this consumption puts extreme strain on its already fragile water resources (Melnychuk et al., 2016; Okanagan Basin Water Board, ND). This vulnerability is concerning, as many of the Basin's primary economic and industrial drivers are also heavily dependent on the health of local water resources for their continual operation (Regional District of North Okanagan et al., 2020). For example, the Basin's agricultural industry alone consumes 55% of all water use by volume (Hammond & Cooke, 2023). In addition, the last comprehensive water assessment for supply and demand was completed in 1974, with many of the overland streams now classified as maxed out in terms of water-taking allocations by industry and community (Okanagan Basin Water Board, ND).

The consequences of impaired water security, exacerbated by high residential and industrial consumption, diminish environmental flows to all of the surrounding watercourses (British Columbia Agriculture & Food Climate Action Initiative, 2016; Okanagan Nation Alliance, 2022, p. 15; Regional District of North Okanagan et al., 2020). As many of these watercourses are also augmented with water control infrastructure (e.g. dams) to provide hydroelectricity generation and flood control, these reduced environmental flows also enhance concerns for energy security in times of drought or high usage (British Columbia Agriculture & Food Climate Action Initiative, 2016; Okanagan Nation Alliance, 2022, p. 15; Okanagan Water Stewardship Council, 2019; Regional District of North Okanagan et al., 2020). In addition, reduced environmental flows can also critically impair the ability of both local aquatic species to carry out their biological functions to thrive in a continually stressed environment, as well as regional efforts to provide drinking water and mitigate the increasing likelihood of future wildfire risk (British Columbia Agriculture & Food Climate Action Initiative, 2016; Okanagan Basin Water Board, ND; Regional District of North Okanagan et al., 2020). Given the precarious nature of the Basin with regard to water security and climate risk, a tipping point is fast approaching with regard to the basic provision of this fundamental element (Schwann, 2018; Regional District of North Okanagan et al., 2020).

1.3 Projected Climate Change Impacts in the Okanagan Basin

In the past, human communities have relied on predictable weather patterns and seasonal shifts to ensure an adequate supply of food and fresh water. Supplementing this reliance was the responsible stewardship of the local ecosystems that provide consistent regulating, provisioning, cultural, and supporting services for all aspects of daily life (Food and Agriculture Organization of the United Nations, 2023). However, climate change is rapidly stressing environmental conditions across the planet and disrupting this consistency with earlier melts, less water over hotter and drier summer months, along with more volatile temperatures and more unpredictable weather (Bush et al., 2020; Regional District of North Okanagan et al., 2020). This dynamic shift, driven by various anthropogenic activities and their resultant externalities imparted to the land, water, and air, will in turn continue to present an increasing array of environmental and socio-economic challenges to the Okanagan Basin and the people and animals that live within (Cohen et al., 2003; Regional District of North Okanagan et al., 2020; South Okanagan Real Estate Board, 2019). This includes expectant shifts in average temperatures, precipitation patterns, and extreme weather events (among others), which collectively present systemic-level threats to the social and physical fabric of the Basin as a whole (Regional District of North Okanagan et al., 2020; South Okanagan Real Estate Board, 2019).

Despite the potential for agricultural benefits garnered by a net increase in temperature, including higher grape productivity and better suitability for specific varietals, as noted by Schwann (2018), the resiliency of all Basin-centric water resource systems (and beings residing within) will become increasingly stressed over the next 50 years (Regional District of North Okanagan et al., 2020). More specifically, climate projections mapped in the Basin point to an alarming future state in which a variety of environmental stressors will impart serious harm to local industries, ecosystems and human and non-human communities (Environment and Climate Change Canada, 2023; James Littley, 2023; Regional District of North Okanagan et al., 2020; South Okanagan Real Estate Board, 2019). These projected impacts are concisely outlined in the recently released Climate Projections for Okanagan Region (2020) report, which provides science-based predictions on the Basin's evolving climate patterns over the next 60 years.

Two temporal scenarios for the future state of the Basin are presented within this analysis. They include conditions in the 2050s under a probable trajectory of climate change (irrespective of global emissions reductions), and projections for the 2080s reflecting minimal progress in societally transitioning away from a fossil fuel–based economy (Regional District of North Okanagan et al., 2020). While the intent of these predictions is not meant to specifically inform direct policy or guideline design, they do support a regional understanding of a climate-impacted future and how regional climate plans can bolster resiliency in anticipation of these climactic shifts (Regional District of North Okanagan et al., 2020). Included in these predictions are extreme temperature fluctuations, altered precipitation patterns, changing stream flows and droughts, among others (Okanagan Water Stewardship Council, 2019; Regional District of North Okanagan et al., 2020; Schwann, 2018, p. 175; South Okanagan Real Estate Board, 2019). For a more detailed outline of these anticipated regional climate change impacts and associated stressors (cumulatively projected for 2050 & 2080), please refer to **Table 1** below.

These cumulative climactic stressors are accelerating wicked problems requiring regional collaboration and leadership to address them and increasing the need for alternative voices and leadership in watershed management. Fundamentally, this includes the voices of the host Syilx Okanagan Peoples who have lived on these lands since time immemorial (Hammond & Cooke, 2023; Okanagan Nation Alliance, 2017a, 2022).

Table 1. Okanagan Region: Relevant Climate Impacts and Stressors

Regional Impact	Associated Stressor(s)
Ecosystems and Biodiversity	• Reduced summer precipitation combined with warmer summer temperatures • Warmer temperatures and increased variability • Warmer temperatures • Flooding, wildfires, and landslides
Health	• Summer Air Quality (e.g., smoke) • Compromised air quality and extreme heat • Shock of extreme events, the loss of local food and cultural values, and other stresses related to the changing climate
Water Quantity and Quality	• Warmer winters • Spring flooding • Flooding and water shortages

Regional Impact	Associated Stressor(s)
Stormwater Infrastructure	• Increased storm intensity in spring and autumn seasons
Agriculture	• Warmer temperatures • Warmer winters and fewer frost days
Local Economy	• Warmer summers with dry conditions • Flooding caused by extreme rain in the shoulder seasons • Warmer winters and fewer frost days

(Regional District of North Okanagan et al., 2020)

1.4 The Importance of Watershed Resiliency

Watershed resiliency is defined by Lane et al. (2023) as “the ability of a watershed to maintain its characteristic system state while concurrently resisting, adapting to, and reorganizing after hydrological… or biogeochemical… disturbances” (p. 1–2). This dynamic flexibility is crucial to the overall health of a watershed as once thresholds are crossed, the watershed itself “can undergo a [permanent] regime shift resulting in a measurable and marked change in state-defining storages, process rates, and interactions” with permanent repercussions for all life residing within (Lane et al., 2023, p. 3). Maintaining resiliency at the watershed scale is crucial to ensuring the continual provision of various key ecosystem functions and services that all communities rely upon, including those within the Okanagan Basin (Agriculture and Agri-Food Canada, 2009; Alberta Environment and Sustainable Resource Development, 2012b; Lane et al., 2023).

When strategizing on ways to maintain this resiliency, ecological functioning must also be monitored at the watershed scale to support the resiliency of local biodiversity and ecological processes (ACT, 2023). Adaptive, ecosystem-based management methods need to be used to anticipate and respond to projected demographic and climate changes and track key indicators to enhance overall watershed resilience. Land and water managers can utilize Watershed Health Indicators (WHIs) as a tool to gain insight into the changing health or state of the local watershed. WHIs help by “simplifying an inherently complicated system” through the identification and long-term monitoring of targeted statistical datasets necessary for documenting and comparing watershed health over time (Conservation Ontario, 2018; Fraser Basin Council, 2014; Smith et al., 2022, p. iii). Please refer to **Section 2.3** of this report for additional information on the importance and limitations of WHIs. Finally, de Bruin & Barron (2012) also emphasize the significance of considering the appropriate spatial scale when determining specific WHIs to monitor resiliency. For example, indicators like “area under crops and grazing forest area” are effective when targeting a community-scale monitoring approach to resilience. When scaling up to an entire watershed, however, alternative indicators with the same focus area could include "area used by different livelihood strategies for crops, grazing, forest and off-farm income” (de Bruin & Barron, 2012, p. 6).

1.5 Basin-Centric Organizations Enhancing Watershed Resilience

The Okanagan Basin is an incredibly complex system when perceived from a physical, cultural, and regional governance standpoint, which in turn, necessitates strong leadership amongst all governance partners for effective stewardship action. Several organizations are working to enhance resilience in the Basin, including the Okanagan Nation Alliance (ONA) and Okanagan Basin Water Board (OBWB), among others.

1.5.1 Okanagan Basin Water Board

A unique watershed agency called the Okanagan Basin Water Board (OBWB) fills a significant vacuum in facilitating regional collaboration for water stewardship action across three regional districts (Melnychuk et al., 2016; Okanagan Water Stewardship Council, 2019). Created in the 1970s, the OBWB is unique from a governance standpoint as it coordinates water stewardship initiatives for all six sub-watersheds in the Basin, as well as the Basin as a whole (Hammond & Cooke, 2023, p. 41). In addition to being “legislated under the Municipalities Enabling and Validating Act, and the Supplementary Letters patent,” the OBWB draws a consistent pool of funds through regional taxation (Hammond and Cooke, 2023, p. 55). This sustainable funding source is necessary for applying an Integrated Water Resources Management (IWRM) strategy at the Basin level to support long-term strategic planning initiatives that maintain collective buy-in at all levels of government, private industry, and public (Hammond and Cooke, 2023, p. 58).

The OBWB is not a formal regulatory agency and lacks jurisdictional authority to enforce any laws, including those related to water levels, licensing, or groundwater (Hammond & Cooke, 2023, p. 44; Melnychuk et al., 2016). Despite this absence of ‘hard power' in the watershed governance sphere, the OBWB nevertheless plays a valuable role in bringing together a diverse array of partners and stakeholders by emphasizing its 'soft power' in the arena of collaboration (Melnychuk et al., 2016). This includes the ability to pool funds, share "priorities and information gathering and dissemination, as well as [drive the implementation of] collaborative initiatives" like the 'Okanagan WaterWise' program, the 'One Valley One Water' campaign, and the 'Okanagan Sustainable Water Strategy Action Plan 2.0.,' among others (Okanagan Water Stewardship Council, 2019).

Notwithstanding the above, one critique provided by Hammond and Cooke (2023) includes the uncertainty "surrounding the limitations [of the OBWB's]… engagement and decision making with the Okanagan Nation Alliance," driven in part by "unresolved rights, title claims and lack of capacity" (Hammond & Cooke, 2023, p. 49). In addition, the OBWB cannot directly exercise authority or control over important water management issues related to groundwater or water flows & licensing, which are still held by the province. This is despite numerous OBWB proposals to enact "basin-wide management policies, licenses for water uses, control of aquifers" or water pricing enforcement (Hammond & Cooke, 2023, p. 49).

1.5.2 The Syilx Okanagan Peoples and the Okanagan Nation Alliance

The challenge of supporting watershed resilience in the Basin presents a unique opportunity for collaborative leadership driven by Syilx worldviews and knowledge. As previously noted, the Syilx Okanagan Peoples have resided in their Unceded Territory (69,000 km^2), which includes and extends past the Basin, for the last 10,000 years (Okanagan Nation Alliance, 2022; Hammond & Cooke, 2023; Sam, 2006). The Syilx Okanagan Peoples have a deep history and understanding of the land that vastly pre-dates the western concept of 'ownership and management,' with seven Syilx communities currently residing within this Unceded Territory north of the American border (Okanagan Nation Alliance, 2014, 2022; Hammond & Cooke, 2023).

Formed in 1981, the Syilx Okanagan Nation Alliance (ONA) represents these seven Syilx communities with regard to collective Syilx governance in the Okanagan Basin "through the Chiefs Executive Council" (CEC) (Okanagan Nation Alliance, 2017b). In the water governance sphere, the ONA (2022) views their role as one of support to "provide technical expertise, produce results and discuss potential—and at times obvious and needed—alternatives to uphold these responsibilities for the sake of *siwɬkʷ (water)* …[and future generations]" (p. 4). Despite no formal treaties existing between the Syilx Okanagan Peoples and the province of British Columbia, the ONA nevertheless fills a crucial gap in the sphere of water governance and management, particularly when it concerns fisheries and resource management (Melnychuk et al., 2016, p. 410; Okanagan Nation Alliance, 2017a, 2022).

The ONA also has a strong track record of leadership regarding the development and public circulation of various water declarations, planning methodologies, and strategies to justify their "inherent and implicit Aboriginal Title, Rights and Responsibilities to siwɬkʷ" (Okanagan Nation Alliance, 2014, p. 5). This includes the foundational 'siwɬkʷ Water Declaration' (2014) which describes the Syilx Okanagan Peoples' sacred relationship with siwɬkʷ (water) and their inherent duties and responsibilities for stewarding water within their Unceded Territory (Okanagan Nation Alliance, 2014). This declaration also highlights the increasing over-allocation, abuse, and pollution of siwɬkʷ within Syilx Territory, and affirms the Syilx Okanagan Peoples' "deep intrinsic and spiritual relationship with" siwɬkʷ and how "Syilx People must be at the forefront of all siwɬkʷ planning, siwɬkʷ protection and siwɬkʷ operational processes including allocation and generation" (Okanagan Nation Alliance, 2014, pp. 2–4).

Following this initial declaration, the 'Syilx (Okanagan) Water Planning Methodology' (2017) was created to highlight a "methodology for applying Syilx knowledge in both established watershed governance and management processes, and new Syilx-led governance processes" in the Basin (Okanagan Nation Alliance, 2017a, p. 23). Altogether, this methodology provides a new vision for how watershed management processes across the Basin can be shaped to align with Syilx Okanagan water laws, principles, and practices (Okanagan Nation Alliance, 2017a). Finally, the 'Syilx Strategy to Protect and Restore Siwɬkʷ' (2022) outlines how the "Syilx Nation intends to care for… [their] territory and work to ensure that siwɬkʷ is properly respected and available for all living things" (ONA, 2021, p. 3). The strategy highlights several priority actions in support of this responsibility, including the need to identify "a series of TEK [(traditional ecological knowledge)] indicators to monitor environmental changes over time" (Okanagan Nation Alliance, 2022, p. 25). Through this strong track record of leadership and responsible action in support of watershed protection and resiliency, the Syilx Okanagan Peoples and

Okanagan Nation Alliance collectively offer a unique opportunity for Indigenous leadership in Basin-wide watershed management.

Chapter 2. Literature Review

2.1 Evolutions in Watershed Management

Environmental management approaches are continually evolving to more effectively address the complex interplay between human societies and their consequential stresses on the environment, including the local watersheds affected by development and resource extraction (Melnychuk et al., 2016). Given the inherent importance of water to all life and the growing emergence of water security across Canada, comprehensive and holistically focused regulatory oversight is needed to ensure the sustainable management of this crucial resource (van Bee & Arriens, 2014). This includes the practice of watershed management, which Wang et al. (2016) note as traditionally involving the "organizing and guiding [of] land, water, and other natural resources [contained within a watershed]…" to ensure a sustainable provision of goods and services, while at the same time minimizing consequential adverse impacts to the watershed as a whole (p. 968). Driving this practice was the recognition "that people are affected by the interaction of water with other resources conversely and that people can [also] influence the nature and magnitude of those interactions" (Wang et al., 2016, p. 969).

The application of watershed management, and its evolution over time, is especially relevant here in Canada due to the country's significant freshwater reserves that equate to 7% of all global supply (Government of Canada, 2018). Transitioning from a predominately utilitarian perspective focused on economic growth in the early 20th century to a more integrated perspective by the early 2000s, national water stewardship approaches were precipitated by a growing awareness of the environmental impacts of water use and the need to balance economic, social, and environmental considerations (Canadian Council of Ministers of the Environment, 2016). A confluence of early events helped to drive this change, including early legislative developments like the Fisheries Act (1868) and Boundaries Waters Treaty with the United States (1909), various scientific and water quality monitoring advancements, as well as greater scrutiny towards mitigating aquatic chemical contamination of fisheries habitat via the 1972 Great Lakes Water Quality Agreement (Canadian Council of Ministers of the Environment, 2016). But with accelerating population growth and net demand for a dwindling resource base, along with a growing understanding of environmental baseline conditions, thresholds, and risks, a more holistic and integrated ethos was required to care for and protect the “biological, physical, and social elements in a landscape within a watershed’s boundaries” (Wang et al., 2016, pp. 968–969).

2.2 Integrated Water Resources Management

Integrated water resources management (IWRM) has emerged as the predominant approach to effectively addressing the limitations of traditional watershed management by applying a holistic lens to the variety of uses, dynamics, and relationships, of and between water and society (Galvez & Rojas, 2019; Melnychuk et al., 2016). Through this holistic approach, Wang et al. (2016) note that IWRM aims to “address the complexity of interactions between ecosystems and socio-economic systems” (p. 16). This is achieved by promoting and sustaining “the health, productivity, and biodiversity of ecosystems through strategies that integrate the needs of society and the economy” (Wang et al., 2016, p. 970).

While the concept was first introduced at the Mar de Plata global water conference in 1977, the 1992 UN World Summit on Sustainable Development and Agenda 21 further propelled this governance approach into the global spotlight (United Nations, ND). IWRM has also been touted by Galvez & Rojas (2019) as “the most well-known water management approach due in part to its promotion in Goal 6 of the United Nations Sustainable Development Goals” (Galvez & Rojas, 2019, p. 180). This includes Target 6.5 of SDG Goal 6, which advocates for the international implementation of “IWRM at all levels by 2030,” including those at the transboundary level for shared jurisdictional authority of water resources (e.g. Great Lakes Commissions) (United Nations, 2023, p. 24; Galvez & Rojas, 2019, p. 180). More specifically, Indicator 6.5.1 under SDG 6.5 aims to track the “degree of integrated water resources management implementation” via a score of 0-100 (Anna Canny et al., 2022; United Nations, n.d.).

2.2.1 Benefits of Integrated Water Resources Management

As a formal practice, IWRM prioritizes inclusivity and collaboration for managing physical and social landscapes in a manner that is fundamentally distinct from traditional watershed governance approaches implemented by western democracies (Sale et al., 2020; Veale & Cooke, 2016; Wang et al., 2016). While Sale et al. (2020) note that traditional watershed management actions tend to operate "as a set of separate, siloed tasks undertaken by different tiers" of government and sectors of society, IWRM promotes collaboration and "requires significant commitment from participating levels of government, ministries, agencies, and all community sectors" in order to achieve success (p. 10). It not only acknowledges the health of a watershed as fundamentally linked to both the environment and relative socioeconomic conditions, but also prioritizes and depends on collaboration and support from a broad cross-section of society (Smith et al., 2022). In its most ideal form, Smith et al. (2022) note how this approach strives to implement the full spectrum of "community interests and concerns… [while also] inform[ing] the identification of issues, goals, and actions, and the subsequent implementation of plans and strategies" (Smith et al., 2022, p. 10). In support of its holistic and inclusive mandate, IWRM recognizes the following 11 principles as necessary in any IWRM planning approach (Canadian Council of Ministers of the Environment, 2016, pp. 8–9):

1. Geographical Scale
2. Ecosystem Approach
3. Adaptive Management
4. Integrated Approach
5. Cumulative Impacts
6. Precautionary Principle and No Regrets Actions
7. Proactive Approach
8. Shared Responsibility
9. Engaging Communities and Aboriginal Peoples
10. Sustainable Development
11. Natural Capital

IWRM also affords significant awareness and respect for the various uses and cultural and biophysical dynamics of water (Melnychuk et al., 2016, p. 410). According to Melnychuk et al. (2016), this includes recognizing the inherent interconnectivity between water systems and human/non-human societies, and the various sustainability considerations interrelated to economic, social, and environmental lenses that value "a broad range of solutions… for dealing with water problems" (p. 410). Inherent to this holistic grounding, Wang et al. (2016) note this approach seeks to "balance healthy ecological, economic, and cultural/social conditions within a watershed" (p. 968). This is achieved through "an adaptive, comprehensive, integrated multi-resource management planning process" with equal consideration given to surface and groundwater flow (Smith et al., 2022; Wang et al., 2016, p. 96). In addition, IWRM aims to apply a western science framework "for community planning and decision making" that operates within the confines of a grounded, complex, and interconnected ecosystem, rather than an artificial governance framework that risks fragmenting and misinterpreting a complex and unique ecological system (ACT, 2023; Smith et al., 2022, p. 1).

Given this acknowledgement of a complex interplay between environment, economy, and society, a cornerstone of successful IWRM is an adaptive collaborative approach to consensus-making (Canadian Council of Ministers of the Environment, 2016; Melnychuk et al., 2016; Veale & Cooke, 2016; Wang et al., 2016). Culture is another key consideration. More traditional watershed governance approaches often lack collaborative and adaptive management approaches, yet it is crucial in IWRM to facilitate effective knowledge exchange, integrated strategies and shared responsibility among a diverse set of project partners and stakeholders, while also reducing the potential for duplication under a siloed governance approach (ACT, 2023; Galvez & Rojas, 2019). As water problems are collectively shared by all communities, partners, and stakeholders residing within a watershed's boundary, collaborative approaches that are both flexible and adaptive help encourage horizontal leadership, improve organizational efficiency and flexibility, reduce the risk of implementation failure, and strengthen the foundation for future cooperative efforts (Galvez and Rojas, 2019).

Finally, given how the accelerating impacts of climate change affect all aspects of watershed health, adaptive and collaborative response measures are increasingly required to refine and improve adaptive management actions over time (ACT, 2023). In its idealized form, IWRM can meet this challenge through an embedded prioritization of "adaptive environmental management" which involves implementing a management plan, addressing key issues, monitoring indicators, reporting on progress, and updating in response to evolving or new stressors (Conservation Ontario, 2010, p. 11; Joosten & Kilawe, 2017). This approach is especially important given the rapid stressors imparted by climate change. Otherwise, IWRM planning approaches risk becoming static and incapable of meeting the long-term and dynamic needs of both ecosystems and communities (Toronto and Region Conservation Authority et al., 2021).

2.2.2 Limitations of Integrated Watershed Management

Despite the many benefits of IWRM as an idealized watershed governance framework, challenges persist for operationalizing equitably and holistically. For instance, Sale et al. (2020) note how provinces like Ontario and British Columbia (among others) are “mostly siloed, top-down and regulatory, which prevents “various [Indigenous communities], agencies and stakeholders [from] acting collectively on a voluntary basis” (Sale et al., 2020, p. 15). In addition, jurisdictional fragmentation at the provincial level risks the potential to duplicate planning efforts while also creating conflicting management objectives between regulatory bodies (ACT, 2023; Conservation Ontario, 2010, p. 12). Adding to this confusion, Galvez & Rojas (2019) note how agencies and partners “frequently speak different languages when addressing IWRM,” which can limit the potential of overarching consensus on important issues (p. 181).

These issues limit the capacity of institutions, communities, and grassroots organizations to effectively lead and participate in prolonged collaborative efforts. This is problematic from an IWRM perspective, which Sale et al. (2020) note “requires significant commitment from participating levels of government, ministries, agencies, and all community sectors” in order to achieve success (Sale et al., 2020, p. 10). Prolonged participation requires significant resources, with many project partners lacking either the technical and/or financial reserves necessary to effectively collaborate over an extended period of time (Melnychuk et al., 2016; Rizvi et al., 2013; Sam & Armstrong, 2013; Simms, 2015).

Finally, successful IWRM requires long-term planning and support for management actions that may seem ineffective in the short term (Rizvi et al., 2013; Sale et al., 2020; United Nations, ND). Support in the public realm can also be difficult to obtain, especially when citizen awareness around water usage and the importance of prioritizing ecological functioning is limited, and/or management decisions are perceived to impact individual lifestyles in isolation (e.g. water use restrictions) (Donnelly et al., 2007; Muskoka Watershed Council, 2023a; Smith et al., 2022). Shrubsole et al. (2016) note how a fine balance exists between “recognizing and understanding the big picture” of pressing issues impacting a watershed or basin system, while also understanding the need to prioritize local values and perspectives (p. 253). Given the increasing expectation of the public to participate in the “planning, implementation and monitoring stages of IWM” (Shrubsole et al., 2016, p. 253), effective public engagement must support community-driven governance and leadership as opposed to passively informing or consulting (Rosa Gonzalez, 2019).

2.3 Watershed Health Indicators

As previously outlined in **Section 2.1**, a crucial best practice of IWRM is the operationalization of watershed-scale management actions considerate of the unique and interconnected conditions of the biophysical landscape, embedded human communities, and water quality and quantity characteristics (Smith et al., 2022, p. 1; ACT, 2023). Simmes et al. (2022) note how the goal of this process is to develop a broad list of watershed health thresholds "and a common set of "rules" (or targets and goals)… [for] the land and water base" that can be collectively owned by all regional and local governance bodies, Indigenous communities, and water and land managers alike (p. 7). Given the ability to consider the "complexity, multiplicity and interconnections of current environmental problems, and their linkages with both social and economic well-being" that consistently arise at the watershed level, the Muskoka Watershed Advisory Group (2020) notes how an IWRM framework can also be operationalized as the driving force behind WHI selection (p. 52). This best practice cannot be achieved, however, until such conditions within the target watershed are technically and experientially understood and documented in their current form (Donnelly et al., 2007; Muskoka Watershed Council, 2023a; Smith et al., 2022). This includes tracking and monitoring any observed changes to these conditions over time and deliberating on why such changes are even occurring in the first place (Smith et al., 2022, p. iii).

Several barriers can arise when effectively implementing a coordinated and multijurisdictional IWRM strategy, including "the complexity of multifaceted issues, incomplete and inaccessible data, jurisdictional fragmentation, transboundary issues and poor communication between stakeholders" as noted by Bizikova et al., (2015, p. 1). To address these often-systemic roadblocks, watershed managers are increasingly utilizing WHIs as a key tool to efficiently flag vulnerabilities, promote public participation and understanding, and facilitate coordinated management strategies across jurisdictional boundaries (Conservation Ontario, 2018; Smith et al., 2022; The District Municipality of Muskoka, 2022).

2.3.1 What Are Environmental Indicators?

Environmental indicators are an essential, yet often overlooked element that is crucial to the management and success of various conservation efforts (Liberati et al., 2020). In a basic sense, the Fraser Basin Council (2014) notes how environmental indicators are targeted statistical datasets that can provide key insights into the changing "health, or state, of a resource or overall ecosystem" (p. 6). They are also utilized as a tool for measurement due to their ability to simplify highly "complex ecological states and processes that are difficult to quantify" (Smith et al., 2022, p. 2), as well as their ability to capture a wide variety of holistic watershed attributes under an IWRM application (Government of Alberta, 2008; Conservation Ontario, 2018; Fraser Basin Council, 2014; Sihler, 2005). Finally, environmental indicators are also versatile in their ability to assist watershed managers in setting and tracking progress, developing and implementing conservation strategies, and communicating the success or failure of conservation efforts (Liberati et al., 2020). While they can be applied to a broad array of geographical locations and ecosystem types, common motivations for utilizing indicators for environmental monitoring purposes include identifying critical environmental baselines and trends, as well as quantitatively tracking the impacts of associated governance actions to further refine planning processes and policy in support of improved environmental health (Fraser Basin Council, 2014, p. 6; Anna Canny et al., 2022).

Depending on the expected goals and outcomes of a monitoring project, a variety of indicator types can be utilized. This includes condition oriented (or lagging) indicators, which are necessary for establishing environmental baselines, tracking deviations over time, and measuring the ultimate impact of various factors on a system. However, this indicator type is generally limited when it comes to understanding both the 'why' behind an environmental change, as well as the effectiveness of policy or program interventions for enhancing watershed resiliency (Government of Alberta, 2008; South East Alberta Watershed Alliance, 2020; The District Municipality of Muskoka, 2022). Alternatively, pressure (or stressor) oriented indicators focus on natural processes and/or anthropogenic impacts that might adversely impact a baseline environmental state, thereby aiding in tracking or predicting future environmental change over time (Government of Alberta, 2008; South East Alberta Watershed Alliance, 2020; The District Municipality of Muskoka, 2022). Finally, response oriented indicators are action oriented by nature as they track the impact of active policies, watershed stewardship, and/or communal behaviours aimed at "halt[ing], mitigate[ing], adapt[ing] to, or prevent[ing] damages to the environment" (South East Alberta Watershed Alliance, 2020). This indicator type is especially helpful in supporting public awareness to mobilize community action and unite various stakeholders and community members under a common framework of environmental health and understanding (Fraser Basin Council, 2014, p. 6).

2.3.2 Best Management Practices for Indicator Selection

Sihler (2005) notes the importance of ensuring a well-rounded selection of indicators that are "comprehensive enough to capture the major components and processes that constitute watershed health, yet… measurable at a scale and frequency that are practical" (p. G-1). Further emphasized by Smith (2022), this selection process is especially important when "assessing the current state of the system,… [identifying] changes and… [predicting] risks, taking into consideration the effects of land use, climate change, and human activities" (p. 2). To ensure a comprehensive distribution of WHIs "that are measurable, comparable, and consistent" for the target watershed, a variety of best management criteria are recommended (US EPA, 2023).

To begin with, effective WHIs should align directly with relevant environmental policy goals and standards at different levels of planning. This includes various scales ranging from global conventions to local biodiversity action plans, as each can provide targeted insight to watershed managers in their ongoing management planning process (Donnelly et al., 2007, p. 169; Fraser Basin Council, 2014). Selected WHIs should also be able to convey an understanding of ecosystem functions by providing clear insight into the cause-and-effect dynamic generated by known environmental stressors (Donnelly et al., 2007; Fraser Basin Council, 2014; Sihler, 2005, p. 2; Smith et al., 2022). According to Donnelley et al (2007), this includes the prioritization of WHIs that "respond to a broad range of environmental conditions related to the impact being evaluated" to both better reflect the inherent ecological interconnectivity of a watershed, as well as reduce "costs and duplication of effort while at the same time…[ensuring] maximum use of resources" (p. 169).

Existing WHI frameworks in Canada should in theory align with the broad scope of IWRM by holistically prioritizing environment, economy, and social considerations, but tend to fall short when respecting Indigenous knowledges; colonial narratives of watershed management and health have been prioritized (ACT, 2023; Stenekes et al., 2020). This imbalance tends to drive the prioritization of a “technical perspective on what can be measured, rather than what should be measured, particularly due to limited data on qualitative data” (Anna Canny et al., 2022, p. 2; Petit, 2016). To address this systemic bias, Smith et al. (2022) argue that baseline data “should [also respectfully] include Indigenous knowledge systems because all those stories gained through hunting, trapping and gathering on the land will tell you how things used to be, and how things are today” when compared to more recent insights gained from technical monitoring regimes (p. 65). Without a respectful inclusion of these parameters, watershed managers must be cognizant of this bias in all aspects of their work. Otherwise, they risk developing a WHI framework that fails to reflect the watershed’s true state by omitting more qualitative and culturally informed observations (Anna Canny et al., 2022, p. 2; Petit, 2016). Please refer to **Section 2.4.2** below for additional nuance on this challenge.

Despite the above, the majority of available data sources informing WHI analysis do not cross neighbouring watersheds to facilitate regional collaboration and appropriate target setting, and are not available at a sufficient temporal scale to ensure an appropriate time period for trend analysis (Donnelly et al., 2007; Fraser Basin Council, 2014, p. 8). Ensuring access to this more holistic, regional, and timely data is challenging to implement in practice, given issues of jurisdictional fragmentation imparted by the natural boundaries of watersheds (Zubrycki & Bizikova, 2014). Finally, there is an existing policy vacuum in Canada to cohesively orient watershed reporting towards a singular target, whether that be provincial water quality standards, federal water quality guidelines, or local objectives. This limitation incentivizes watershed managers to implement unique approaches to WHI development that may not align with neighbouring efforts situated in the same watershed (Zubrycki & Bizikova, 2014), with this fragmented and siloed approach reinforcing barriers to IWRM as highlighted in **Section 2.2.2** of this report. In addition, consistent awareness is required of the unique ontologies of water held by Indigenous communities across North America, as each community will have their perspectives and insights informed by a grounded land-based ethic and connection (Caillon et al., 2017; Houde, 2007; N. J. Wilson & Inkster, 2018; Yates et al., 2017).

As previously outlined in **Section 1**, the inherent biophysical, sociocultural, and geographical conditions of each watershed are consistently unique. To address this, Donnelley et al. (2007) recommend that a WHI framework “highlight the areas at greatest risk of damage, thereby identifying priority issues that may require a greater amount of attention" (p. 169). This could include tracking the impacts of a regional forestry plan via soil and water quality WHIs, population fluctuations of various cultural keystone species (e.g., salmon, bitter root), and/or climate change impacts on travel and harvesting activities for local Indigenous communities (Donnelly et al., 2007; Okanagan Nation Alliance, 2022). The suite of utilized WHIs should also be flexible and adaptable via a continual monitoring process to ensure their continued relevance and effectiveness over time (Donnelly et al., 2007). This is especially important when considering the changing dynamics of climate change and how all aspects of a watershed may be progressively stressed in differing ways over time. For example, response oriented WHIs like 'impacts to local food and cultural values generated from extreme climate events' might not have been relevant to monitor 20 years ago in the Basin, but are highly relevant now in a changing climate (Regional District of North Okanagan et al., 2020).

Finally, chosen WHIs should be legible to the general public, with the selection process reflective of broad community concerns to drive support and long-term community buy-in (Donnelly et al., 2007; Muskoka Watershed Council, 2023a; Smith et al., 2022). This consensus should be obtained from dialogue facilitation through a wide range of community groups and interests, especially with any local Indigenous communities. For example, forums like the Muskoka Area Indigenous Leadership Table (MAILT) allow for western and First Nations leaders in the District of Muskoka to "strengthen relations between Indigenous Nations and municipalities and to identify actions that will benefit all residents and communities within Muskoka" (MAILT, 2022). In addition, the ONA (2022) suggests the establishment of a "siwɬkʷ Caucus of Syilx TEK, water experts, grassroots activists, scholars, and ecosystem champions" in order "to discuss and recommend ideas to the Natural Resource Committee (NRC), the Chiefs Executive Council (CEC), and to provide insights to ONA projects and priority water initiatives" (Okanagan Nation Alliance, 2022, p. 24).

2.4 Indigenous Perspectives, Opportunities, and Barriers to Collaborative Water Stewardship

Pre-dating the onset of colonial discovery and conquest of Canada (North America more broadly), land governance approaches were incentivized and enforced through an entirely different set of rules and social constructs. This includes the many Indigenous cultural approaches that found success through a deep grounding in cultural practices, communal responsibility and social capital, applied through a boundary-less lens of relationality (Fukuyama, 1995; McHalsie, 2008; Stefanovic & Atleo, 2021; Whyte, 2016). The breadth and scope of these cultural perspectives and rights are immensely diverse, but a commonality shared by many includes an ethos of responsibility and reciprocity to the natural world (N. Wilson et al., 2019). In the context of water, Wilson et al. (2019) note how responsibility denotes a specific duty for humans to follow "protocols or rules for behaviour about water," while reciprocity points to ways of engaging with water by protocols that ensure mutual survival between human and non-human beings (p. 8).

Post-colonization however, many of these cultural practices faced significant disruption from colonial institutions determined to ensure the utilization of resources in support of progress and individualism under the paradigm of neo-liberalism (Maracle, 2008; Simpson, 2004; Whyte, 2016). Given the increasing urgency imparted by climate change and the present failures of technical science approaches to equitably share and preserve water (Bradford et al., 2017), there is a growing recognition of the need for leadership driven by unique and multifaceted Indigenous water perspectives to sustainably steward and reimagine a future reciprocal relationship (Blackstock, 2002, 2008).

2.4.1 Syilx Okanagan Peoples Connection with siwɬkʷ

First Nations like the Syilx Okanagan Peoples continue to meet this need by growing their capacity to demonstrate and educate settler communities on the important role that water can play in strengthening their self-governance, self-determination, and cultural ties to the land (Okanagan Nation Alliance, 2014; Sam, 2006; N. J. Wilson & Inkster, 2018). Given the ONA's recent push to share various water declaration and governance reports (Okanagan Nation Alliance, 2014, 2017a, 2022), as well as their leadership in the emerging kɬúsx̌nítkʷ (Okanagan Lake) Responsibility Planning Initiative, significant opportunity exists for the ONA to drive future watershed stewardship with support from the OBWB and Regional Districts.

As respectfully interpreted through the western perspective of this report's author, water is not just a physical resource to the Syilx Okanagan Peoples, but rather a vital component of their cultural identity, legal rights, and environmental stewardship (Sam & Armstrong, 2013). This place-based communal relationship and responsibility is continually reinforced via captikʷɬ. The Okanagan Nation Alliance (2022) and Armstrong (2009) note how captikʷɬ includes "the intergenerational history and oral record of the Syilx Okanagan Peoples" and "contain[s] a collection of laws, principles, and teachings" to "define and inform… [Syilx] rights and responsibilities to the siwɬkʷ, to the land, and one another" (Okanagan Nation Alliance, 2022, p. 11). Acting "as a feed-back loop reconstructing the social paradigm as an environmental ethic," Armstrong (2009) further notes how captikʷɬ plays the crucial role of "a distinctly Indigenous human adaptive response scheme within a natural system" to continually drive sustainable human behaviour from a Syilx centred ethic (p. 2).

Embedded within captikʷɬ is siwɬkʷ, a key cultural perspective which extends the concept of water beyond its physical form to the spiritual and cultural realms (J. Armstrong, 2013; Okanagan Nation Alliance, 2017a, 2022). Recognized "as a familial entity, a relation, and a being with a spirit who provides life for all living things," siwɬkʷ is revered as a sacred element, central to Syilx ceremonies and teachings, and fundamental to the Syilx Okanagan Peoples' worldview and their inherent responsibilities to the Creator (Okanagan Nation Alliance, 2022, 2014, p. 3).

> "For the syilx Okanagan Nation, when you speak about siwɬkʷ, you speak about everything: the land, the animals, the plants —everything, all living things." (Okanagan Nation Alliance, 2022, p. 10)

Through this specific cultural paradigm (among many others omitted from this literature review), siwɬkʷ transcends anthropogenic views of water as a physical resource to a more egalitarian perspective whereby humans, water, and other elements of nature are seen as equal and interdependent (Sam & Armstrong, 2013). This is emphasized by Armstrong (2009) through Syilx reverence towards tmixʷ, which "is deeply connected to the concept of life-force" of a place and consisting of "many strands which are continuously being bound" together (p. 3). The regenerative capacity of tmixʷ is further illustrated in captikʷɬ stories of the Four Food Chiefs (Chief sexist (Black Bear), Chief spiƛ̓əm (Bitter Root), Chief ntityix (King Salmon), and Chief siya (Saskatoon Berry)), each of which embody different aspects and roles within the framework of tmixʷ (J. C. Armstrong, 2009, p. 166).

2.4.2 Emerging Considerations for Holistic Approaches

Indigenous knowledges and perspectives, like those of the Syilx Okanagan Peoples, afford tremendous opportunities to lead in the development of WHIs that are holistic, robust, and grounded in practice. This is in support of the community-led development, co-creation, and implementation of eco-cultural indicators (ECIs) that transcend the conventional scope of western science by incorporating cultural, spiritual, and social dimensions that are reflective of the intricate relationships between Indigenous communities and their ancestral lands (Krieg & Toivanen, 2021; Parlee et al., 2005; Stenekes et al., 2020).

2.4.2.1 Eco-Cultural Indicators

ECIs are not a new creation, as Parlee et al, (2005) note how Indigenous peoples have been utilizing them for millennia as vital elements in cultural narratives and oral histories "to understand and communicate about ecological change" (p. 1). Their historical utilization also serves as a vital element of perpetuating cultural narratives and oral histories by conveying crucial experiences and observations in a simple and effective manner (Mantyka-Pringle et al., 2017). In contemporary resource management, the distribution of ECIs can also reflect the community's environmental perceptions and values to aid in the stewardship of cultural keystone species like caribou and salmon (Parlee et al., 2005; Stenekes et al., 2020). This includes present day applications of ECIs that facilitate the sustainable harvesting and management of various resources essential for survival and wellbeing, which Parlee et al. (2005) relate to "the way Indigenous peoples interpret changes in the health of their environment" like the body fat percentage from harvested animals (p. 2).

ECIs also support Indigenous health and well-being by tracking how physical landscape changes impact a community's ability to practice culturally informed harvesting and travel actions (Parlee et al., 2005). Given the health of the land can be intimately tied to the physical and spiritual health of the local Indigenous community, (Burger et al., 2022;

Houde, 2007; Krieg & Toivanen, 2021), ECIs provide a strategic tool for Indigenous peoples to monitor the strength of this connection, identify any stressors impacting the holistic state of their Traditional and/or Unceded Territory, and trigger the implementation of responsive management actions if required (Conservation Ontario, 2010, p. 11; Joosten & Kilawe, 2017). In demonstration of “sustainable self-determination in action,” Reed et al. (2020) argue how Indigenous community-based monitoring (ICBM) programs like Indigenous Guardians can assist in monitoring and tracking community-oriented ECIs in “support [of] cultural revitalization and intergenerational knowledge sharing” and “community-based environmental stewardship” (p. 7).

Finally, the Muskoka Watershed Advisory Group (2020) notes how a respectful framework integration of ECIs and western science indicators can lead to additional insight into the “changes in the timing of established relationships” of a watershed by discovering “new information about what is affecting the system” (p. 36). For example, a local Indigenous community may have generational insight into the historical timing of spring peeper frog migration to the river for walleye harvest. Recognizing a present-day shift in this timing may trigger an investigation into a variety of fish spawning stressors like “shifts in spring temperature patterns, water temperature patterns, [and] wetlands and riverways icing out at different times,” that would otherwise have not been considered (Muskoka Watershed Advisory Group, 2020, p. 36).

Despite the increasing attention placed on ECIs as a way to strengthen existing WHI frameworks, Indigenous communities continue to experience systemic and inequitable challenges related to water security, access, and consumption, when compared to settler populations across North America (Castleden, 2016; Stefanovic & Atleo, 2021). They also face tremendous challenges in asserting their rights to self-determination for co-governing, protecting and communing with water within and surrounding their Traditional and/or Unceded Territory (Castleden, 2016; Shrubsole et al., 2016; Simms et al., 2016; Stefanovic & Atleo, 2021). Coupled with anthropogenic impacts to global climate systems significantly altering hydrologic cycles and flow regimes (Milly et al., 2008), along with immediate stresses imparted through resource consumption and sociopolitical governance failings with neighbouring settler communities, the deck is ‘systemically’ stacked against meaningful partnerships and co-creative approaches to watershed co-governance and WHI development.

As previously mentioned, Indigenous communities across North America have their own unique perspectives and relations to water that frequently contrast with the common threads shared by western democracies (Stefanovic & Atleo, 2021). Enhanced by systemic power imbalances, the predominant cultural landscape of colonial institutions tends to inform "the development of meaningful indicators for monitoring at local and regional scales" (Stenekes et al., 2020, p. 2) that are ignorant of Indigenous community needs, perspectives, "baselines, indicators, and thresholds centred upon local values" (Reed et al., 2020, p. 6).

The contextual and place-based nature of traditional ecological knowledges can also complicate the co-creative process of WHI development with western governance bodies. As with the physical and ecological landscape of watersheds, the traditional knowledges held by individual Indigenous communities are unique and tied to the land in which they developed as "there is no single Indigenous culture" (Stefanovic & Atleo, 2021, p. 10). While Stefanovic & Atleo (2021) note the possibility of identifying "some common currents among various Indigenous cultures," an emphasis on remaining "mindful of specific Indigenous communities" is required to prevent any broad sweeping claims (p. 10). In addition, the holders of certain Indigenous knowledges may choose to either share or not share it. These types of decisions are affected by internal consensus about use and/or recipient, and the risk of language barriers degrading its original significance during translation, among others (Reed et al., 2020).

As the Truth and Reconciliation Commission advocates for a shared pathway forward based on mutual recognition and respect, Shrubsole et al. (2016) note how IWRM can "provide the opportunity for watershed authorities and Aboriginal communities to jointly develop new relations" via equitable and co-creative partnerships and collaborations (p. 357). Castleden (2016) provides further context for this goal, in "that integration is not an end point because one does not exist" (p. 2). Rather, the principles of two-eyed seeing, interweaving, and co-creation, between western and Indigenous cultures embody a never-ending journey that requires continual consent and trust (Blackstock, 2017; Castleden, 2016; Mantyka-Pringle et al., 2017).

2.4.3 Challenges for Indigenous Leadership and Co-Creation in Water Governance

Navigating potential opportunities for Indigenous leadership in IWRM governance and WHI development invites a transition toward a more inclusive and equitable approach. However, it is important to understand the various challenges that may arise in pursuit of a truly collaborative and co-creative pathway forward.

To begin with, there is a significant lack of 'consultation' afforded to Indigenous communities in all aspects of watershed management, as Shrubsole et al. (2016) note their "perspectives [are] frequently excluded from planning and decision-making processes" (p. 357). With western governance bodies historically failing to obtain free and prior informed consent in all manners of interaction, they further note how Indigenous community "perspectives are often not part of the planning, implementation, monitoring or adaptation processes" (Shrubsole et al., 2016, p. 357). This is historically evident in the province of British Columbia, which Sam & Armstrong (2013) note has attempted "to settle unresolved water issues with as little confrontation as possible" by applying "a narrow definition of water use rather than the wider definition of aboriginal water use tied to the wider and underlying question of unceded land and water" (p. 248–249).

The capacity to lead and develop strategic IWRM applications is also lacking in many First Nations communities across North America. Significant resources are required when implementing any type of governance initiative, especially those at the watershed scale that require collaborative and holistic applications of IWRM (Shrubsole et al., 2016; Wang et al., 2016). Unfortunately, many of these communities lack the technical and/or financial resources necessary to co-create or lead water governance initiatives (Rizvi et al., 2013; Simms, 2015), with certain communities even refusing to engage with regional or municipal governments due to past betrayals (Sam & Armstrong, 2013).

The contextual and place-based nature of Indigenous knowledges and traditional ecological knowledges also challenges the successful co-creative process of watershed health and management with western partners. These unique and grounded perspectives limit the application of western 'cookie cutter' approaches to collaboration and watershed management, and resist the systemic preference of western science to reproduce and extrapolate models of knowledge in support of water and climate sciences (Bush et al., 2020).

Finally, western institutions can impart significant risk by co-opting Indigenous knowledges in an attempt to support and validate western scientific findings (Simpson, 2004). Often driven by a sense of unconscious entitlement, this extractive process reinforces an incomplete understanding of “colonial attitudes toward Indigenous peoples” (Castleden, 2016; Krieg & Toivanen, 2021, p. 184; McGregor, 2004; Rees, 2023; Simpson, 2004). Stenekes et al. (2020) argue that this western misperception can sometimes inform “the development of meaningful [western] indicators for monitoring at local and regional scales,” but generally tends to reinforce governance actions that are ignorant and dismissive of Indigenous community needs and perspectives (despite claims of inclusion and equity) (p. 2).

Chapter 3. Methodology

3.1 Research Context

The examination of WHI frameworks is a pivotal component for understanding and managing the health of aquatic ecosystems within North America and the Okanagan Basin. Each of the WHI frameworks targeted and reviewed in this study are essential tools for assessing the condition of their respective watersheds, while also serving as holistic barometers for ecological, social, cultural, and economic resilience. Reflecting the dynamic and multifaceted nature of these frameworks, this research project aimed to critically review a repository of 16 existing WHI frameworks that not only encapsulate existing watershed management efforts, but also embody the diverse perspectives of those who live on and steward the land.

3.2 Research Methodology

This data collection initiative, informed through a qualitative content analysis, aimed to catalogue a diverse array of WHI frameworks developed within, and pertaining to, watersheds in North America. These frameworks were required to be contemporary, with an age limit of 15 years to ensure relevance to current watershed health assessment practices. The frameworks of interest include those created by western, Indigenous, or co-creative efforts, which were specifically designed to evaluate the current condition of various watershed elements using a comprehensive array of well-defined indicator types.

Keyword Search Strategy

To locate relevant frameworks, a targeted search was conducted using a set of predetermined keywords. These keywords were carefully chosen to encompass the scope of the research and were used both individually and in combination to maximize search efficacy. The platforms utilized for this search included Google, Google Scholar, and the SFU Library Web Portal. The keywords implemented in the search are outlined as follows:

Watershed Health Indicator; Ecological Indicator; Local Indicators; Indicator Framework; Watershed Report Card; Traditional Ecological Knowledge; Indigenous Indicator; First Nations Indicator; Eco-Cultural Indicator; Canada; Province; Climate Change

Review and Data Transcription Process

The initial search yielded a collection of 16 indicator frameworks, each of which was subjected to a thorough review to identify individual WHI details. Criteria for utilization included the presence of distinct WHIs employed to monitor, track, and asses, the current state of the environment/watershed. These WHIs, along with their corresponding measurement metrics, were meticulously recorded into a comprehensive spreadsheet database. To maintain the integrity of the database, a dual verification process was employed. This involved double-checking each entry post-transcription to mitigate any potential errors and prevent the incorporation of inaccurate or misaligned data.

Overall, the geographical scope of this dataset includes 12 provincial or territorial frameworks, 2 frameworks that span multiple provinces, 1 Canada-wide framework, and 1 international framework. 9 of the WHI frameworks were western derived and contributed 138 of the total recorded WHIs to this database, while 7 of the frameworks were either Indigenous or co-created and accounted for 83 of the total recorded WHIs. Please refer to **Table 2** below for a detailed summary chart of this collected data.

Table 2. Watershed Health Indicator Framework Distribution

Geographical Distribution of Assessed Indicator Frameworks	Indicator Count by Framework Worldview		Total Indicator Count
	Indigenous / Co-created	Settler	
Alberta	**-**	**32**	**32**
Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance, 2022)	-	22	22
State of Watershed Reports - Common Watershed Indicators for Alberta (Government of Alberta, 2009)	-	10	10
British Columbia	**6**	**21**	**27**
Aspirational Targets for Watershed Health (Cowichan Watershed Board, 2019)	6	-	6
Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance, 2016)	-	21	21
Canada (National)	**-**	**12**	**12**
Watershed Reports 2020 (World Wildlife Foundation, 2020)	-	12	12
North West Territories	**20**	**-**	**20**
Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation, 2019)	20	-	20
Nunavut	**3**	**-**	**3**
Linking Inuit knowledge and meteorological station observations (Clyde River Inuit, 2009)	3	-	3
Ontario	**-**	**61**	**61**
Watershed Health Assessment and Monitoring project (Ottawa River Keepers, 2023)	-	14	14
Resource Categories & Indicators (Conservation Ontario, 2023)	-	9	9
Muskoka Watershed Report Card 2023 (Muskoka Watershed Council, 2023)	-	17	17
Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority, 2023)	-	21	21
Yukon	**11**	**-**	**11**
Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations, 2019)	11	-	11
Western Canada*	**43**	**-**	**43**
State of the Aquatic Ecosystem Report - Conceptual Framework (Mackenzie River Basin Board, 2021)	10	-	10
Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership, 2017)	22	-	22
Indicators - Mackenzie Basin (Tracking Change Initiative, 2016-2019)	11	-	11
United States of America (National)	**-**	**12**	**12**
USEPA Watershed Health Index (USEPA, 2021)	-	12	12
Indicator Totals	**83**	**138**	**221**

* Western Canada = British Columbia, Yukon, Northwest Territories, Saskatchewan and Alberta (collectively)

Database Structure and Coding

The database was organized into 10 columns, with each designed to capture specific information related to the recorded WHIs. For transparency and ease of reference, the column titles are listed below in **Table 3** while the complete database is accessible in **Appendix A** of this report.

Table 3. Database Column List

1. *Watershed Resilience Category*	**6.** Framework Worldview
2. Indicator	**7.** Framework Name
3. Indicator Type (Condition, Pressure, Response)	**8.** Governing Body / Community
4. Metric or Index?	**9.** Year
5. Unit or Scale of Measurement	**10.** Province / Country

The coding system for Column #1 allowed for a detailed classification of each WHI by employing nine distinct watershed resilience categories. This coding scheme aimed to help facilitate a more detailed understanding of how each resilience category was prioritized within the overall dataset and identify any gaps or strengths in prioritization amongst all reviewed WHI frameworks.

Table 4. Watershed Resilience Categories (Column #1)

1. Biodiversity
2. Climate Change
3. Community & Health
4. Economy
5. Land Use & Condition
6. Ecological Services & Use
7. Traditional Ecological Knowledges
8. Water Quality
9. Water Quantity & Security

Columns #2 and #5-10 (**Table 3**) were populated with precise data extracted or directly inferred from each reviewed WHI framework. This approach ensured that information such as the Indicator Name, Type, Metric/Index distinction, Unit of Measurement, etc., are recorded verbatim from the source material (where present). In contrast, columns #4 and #5 were coded via a technical understanding of how each indicator either: (A) fits into a formally classified type (Condition, Stressor, Response); or (B) draws its scope of measurement (Metric or Index).

Data Analysis and Trend Identification

After the database table was finalized per the above steps, the pivot table and pivot chart functions were utilized in Microsoft Excel to discern trends and causal relationships, as well as identify gaps, weaknesses, and strengths among the compiled WHIs. The final stage of analysis concentrated on comparing the two coding schemes (as outlined in columns #1 and 2) with the data in columns #3-4, 7, and 9.

3.3 Limitations

While the database and associated findings of this study provide additional insight into the comprehensiveness of the 16 WHI frameworks from an IWRM perspective, there is also an inherent set of limitations the reader should be aware of. These limitations not only inform the author's interpretation of the general findings, but also underscore the complexities of watershed monitoring for resiliency across the diverse geographic and cultural landscapes of North America.

Methodological and Analytical Considerations

The data collection methodology focused on keyword searches within English-language databases and excluded frameworks documented in Indigenous languages or French. This has led to an underrepresentation of non-English WHI or eco-cultural frameworks in the database. Moreover, the WHI frameworks used in this study are abstractions of complex environmental systems, often involving multiple interconnected factors. The coding methodology permitted the association of each WHI with only one watershed resilience category, potentially oversimplifying the numerous ecological associations of certain WHIs and thereby limiting the nuance in this analysis. Finally, it is important to note that many Indigenous communities in North America have likely chosen to not publicly share their culturally informed indicator framework(s). As such, this data collection methodology cannot be deemed comprehensive in terms of representing the totality of WHI and eco-cultural indicator frameworks authored by Indigenous communities across North America.

Geographic and Cultural Variability

The significant regional diversity of each watershed also introduces significant complexity to this study. Geographic and ecological variations, such as those found among different bioregions and ecoregions, affect the applicability and relevance of the specific WHIs included in each of the 16 recorded frameworks. This is particularly evident with WHIs sourced from Indigenous communities or co-creative partnerships that are deeply rooted in the local context and not transferrable or pertinent to other regions. Furthermore, the need for cultural sensitivity when interpreting and applying Indigenous knowledges in WHI frameworks cannot be overstated. As a result, the broad themes and patterns identified in this data analysis are likely not fully representative or scalable, particularly concerning specific watersheds that are not included in the database (like the Okanagan Basin).

Scope and Generalizability

As this research focused on existing and documented WHI frameworks, it may very well overlook informal or emergent practices in watershed health assessment that have not yet been captured in scholarly or grey literature. While comprehensive, this database should in no way be considered absolute or fully reflective of the diverse WHI frameworks currently operationalized across North America.

Ethical and Collaborative Dynamics

Finally, it is crucial to acknowledge that the development and analysis of this database occurred without the direct involvement of any external partners or Indigenous communities, including any of the Syilx Okanagan communities, Okanagan Nation Alliance, or Okanagan Basin Water Board. Rather, this project was undertaken solely as a desktop research exercise by the author as a requirement of the Master in REM (Planning) program. This distinction is particularly important to note when considering the Indigenous and co-created Watershed Health Indicator (WHI) frameworks referenced both within Chapter 4 (Research Findings) and Chapter 5 (Discussion) of this report, along with any representations of Syilx cultural perspectives or priorities. Traditional Ecological Knowledges, by their very nature, are intimately tied to the locations from which they originate, as well as the reciprocal relationships and lived experiences that their host Indigenous communities maintain with their Traditional and Unceded Territories (Krieg & Toivanen, 2021, 2021; Wyllie De Echeverria & Thornton, 2019). Interpretations of such knowledges within this database have been predominantly filtered through the western perspective of the author. Consequently, these western-framed interpretations will likely miss the full resonance of the original context, as well as the more nuanced layers of meaning and connection inherent to each specific cultural worldview (despite best efforts for respectful representation).

Chapter 4. Findings

A variety of themes emerged from the collection and analysis of the WHI database, with the results of three key themes reviewed in detail. The findings of this study are summarized in the following order: (1) Indicator Distribution by Watershed Resilience Category; (2) Western and Indigenous (or co-created) WHI framework Priorities; and (3) WHI Distribution by classified Type. It is important to note that together, these findings highlight numerous commonalities, but also a divergence in the inherent priorities of western and Indigenous / co-created WHI frameworks, especially when regarding climate change preparedness and Indigenous leadership. The utilization of response oriented WHIs also stands out more prominently in Indigenous frameworks. These findings highlight the potential of a balanced approach to WHI development that both considers ecological and cultural aspects in watershed resilience planning, while also emphasizing a future need to address gaps in water quantity monitoring, Indigenous knowledge, and the utilization of response-oriented indicators.

4.1 Distribution of Watershed Resilience Categories by Location

This first theme reviews an aggregated distribution of watershed resilience categories across the various geographic locations under which each WHI framework is based. The below table (**Table 5**) is designed to give an overarching assessment of how all the collected WHIs are represented across each location, highlighting the collective efforts of each WHI framework in maintaining watershed health and sustainability from a holistic IWRM perspective.

Table 5. Distribution of Watershed Health Indicators by Location and Resilience Category

Province / Location of WHI Framework	Watershed Resilience Category								
	Biodiversity	Climate Change	Community & Health	Economy	Land Use & Condition	Indigenous Knowledges & Leadership	Water Quality	Water Quantity & Security	Ecological Services & Use
Alberta	9%	6%	22%	6%	22%	0%	13%	19%	3%
British Columbia	37%	4%	7%	0%	26%	0%	15%	7%	4%
Canada (national)	42%	0%	0%	0%	0%	0%	25%	33%	0%
North West Territories	60%	5%	0%	0%	0%	0%	30%	5%	0%
Ontario	25%	15%	0%	0%	16%	0%	39%	3%	2%
Nunavut	0%	0%	0%	0%	0%	100%	0%	0%	0%
Yukon	0%	0%	0%	0%	0%	18%	82%	0%	0%
Western Canada*	26%	19%	12%	2%	5%	16%	5%	9%	7%
United States of America (national)	33%	0%	0%	0%	17%	0%	33%	17%	0%
Grand Total	**27%**	**10%**	**6%**	**1%**	**13%**	**5%**	**25%**	**10%**	**3%**

* Western Canada = British Columbia, Yukon, Northwest Territories, Saskatchewan, and Alberta (collectively)

4.1.1 Strong Representation

Biodiversity is the most prioritized watershed resilience category as it accounts for 27% of all recorded WHIs and is tied for the strongest geographical representation (7 of the 9 locations). These recorded WHIs collectively aim to monitor the abundance and health of various species, assess the quality and extent of their habitats, identify threats from external factors such as invasive species and industrial activities, and evaluate the conservation status of at-risk species. The consistent prioritization of biodiversity across different locations highlights a common understanding of the need for indicators that monitor the health and habitats of priority non-human species.

Water Quality also emerged as a significantly prioritized resilience category. Recorded WHIs under this category address a variety of monitoring factors, including chemical aspects like nutrients and trace metals, and physical properties such as water clarity, taste, temperature changes, and turbidity. In addition, WHIs for human impacts focus on eutrophication, livestock presence near water bodies, and the effects of industrial activities like agriculture and forestry. This strong representation is unsurprising, as the Canadian Council of Ministers (2015) notes how "water quality monitoring is one of the most important components in environmental management of aquatic ecosystem[s]" given its straightforward focus on sampling, standardized monitoring practices, and provincially enforced quality standards (p. i). Ontario is leading all provinces in terms of overall representation for this category (39% of all WHIs), which may be indicative of the significant prevalence of freshwater (including the bordering Great Lakes), lessons learned from the Walkerton Inquiry (e.g. Clean Water Act), and collective Conservation Authority Leadership which ensures that "Ontario's water resources are properly safeguarded, managed and restored" (Conservation Ontario, 2023a). Western Canada (including the individual British Columbia and Alberta Frameworks) and Nunavut appear to be laggards in prioritizing this resilience category for WHI development.

4.1.2 Weak Representation

It is apparent from the results in **Table 5** that the Indigenous Knowledges and Leadership WHI category is significantly underrepresented in the database (5% total representation), despite a high prevalence in Nunavut, the Yukon, and Western Canada. WHIs in this category are sourced exclusively from Indigenous or co-created WHI frameworks and encompass a broad spectrum of themes. This includes insights into environmental changes driven by cultural knowledge and experience (e.g., changes in wind patterns, ice significance, and knowledge of contamination sources), changes in cultural and knowledge-based response actions (e.g., storytelling, plant usage), and insights driven from a reciprocal relationship with the land (water vitality, the health of fish and other animals, and well-being). Many of these WHIs are also future oriented and tie ecosystem health to future community well-being (e.g. what about the future). From a geographical standpoint, factors driving this predominately northern distribution could include the Territories having "the highest [proportional] share of Indigenous population out of the total population," along with the least amount of industrialized and urbanized land (OECD, 2020).

There is also a notable underrepresentation of overall *Water Quantity & Security* related WHIs, particularly in provinces like Ontario and British Columbia. This finding is concerning as WHIs under this category are crucial for monitoring and ensuring a safe supply of water for both human societies and the various ecological functions necessary for continued watershed heath. These indicators can be distilled into two key themes: (1) the dynamics associated with water flows and levels (e.g., snow & ice levels, surface and groundwater variations, and flow rates); and (2) water allocation management (e.g., license allocations, well density, and flow commitments).

While *Climate Change* as a watershed resilience category fell in the middle in terms of total WHI representation (5^{th} most represented WHI at 10%), it is significantly bolstered by contributions from WHI frameworks in Ontario and Western Canada (2% database representation outside of these locations). The WHIs in this category encompass the monitoring of a wide range of climatic factors and impacts, including direct measurements for air quality, ice thickness, and temperature changes (highs and lows), as well as broader assessments for flooding extent, land use change, and shifting weather patterns over time. This underrepresentation indicates a significant gap in the database regarding the ability of WHI frameworks to monitor watershed health and resilience in an uncertain climactic future.

4.2 Distribution of Watershed Resilience Categories by Framework Worldview

Drilling further into watershed resilience category representation in the database, the below graph (**Figure 1**) compares the distribution of recorded WHIs against each watershed resilience category and the authoring western or Indigenous / co-created worldview. It aims to outline the differences and commonalities of each worldview regarding the distribution of WHIs under an IWRM approach. Finally, this analysis also aims to provide insights, though limited, into distinct cultural prioritizations of ecological resilience and health in watershed stewardship.

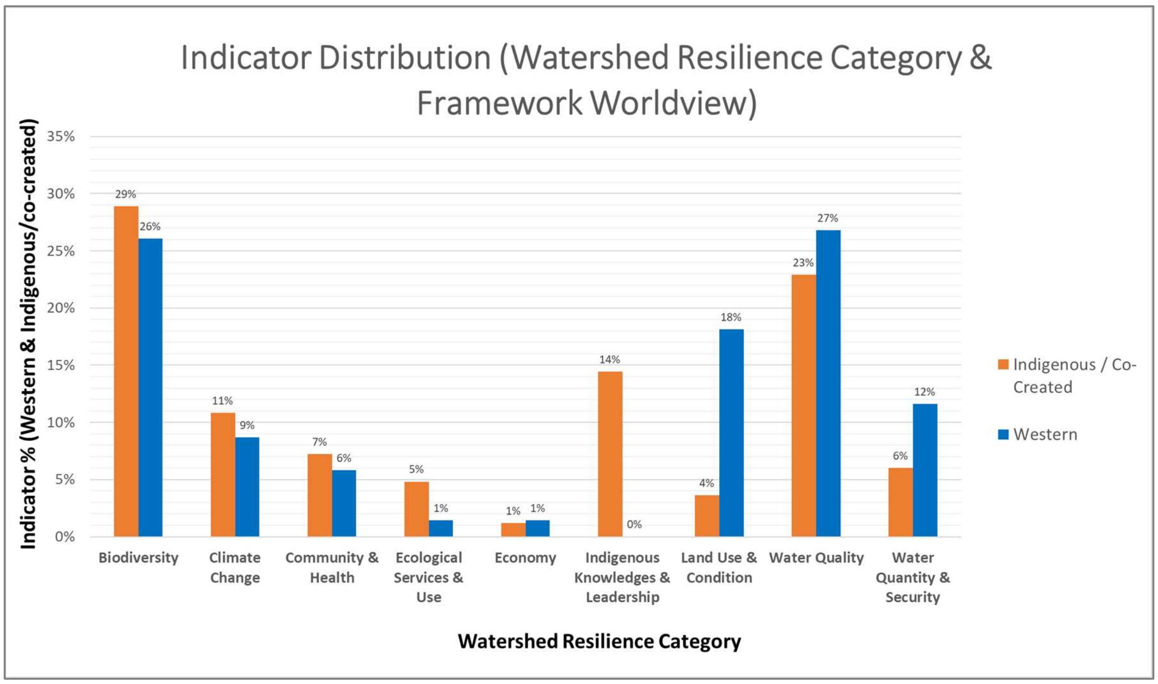

Figure 1. Distribution of Watershed Health Indicators by Framework Worldview and Resilience Category

4.2.1 Possible Similarities in WHI Frameworks

The most apparent (and somewhat unexpected) finding from this analysis reveals a largely similar set of priorities for both western and Indigenous worldviews when it comes to holistic WHI framework development. These commonalities are most evident when comparing the proportional representation of each worldview for the watershed resilience categories of *Biodiversity, Climate Change, Community and Health, and Water Quality*.

For *Biodiversity*, each worldview emphasizes a concern for species health, with western WHIs focusing on ‘fish health’ and ‘bird populations,’ and Indigenous WHIs focusing on ‘fish usage’ and "abundance and fish populations,’ among others. However, the recorded western WHIs generally prioritize concepts like conservation status and scientific measurement (e.g., species richness, benthic macroinvertebrates, species at risk), while Indigenous WHIs tended to apply a cultural lens of relationality between the animal and community (e.g., the health of fish and other animals, colour of fish gills, and fish taste).

While the WHIs created under each worldview for *Climate Change* recognize the tangible climate impacts on local environments and communities, western WHIs prioritized data-driven indicators (e.g., future precipitation, temperature changes, and air quality). The Indigenous recorded WHIs, in turn, focused on more immediately observable or experiential indicators from a communal impact standpoint (e.g., how is the land changing, and flood extent). In addition, the recorded Indigenous WHIs also focus more on the necessities of communal adaptation (e.g., adaptation, ice thickness, and is it safe to travel?).

For *Community Health*, the recorded WHIs for each worldview recognize the interconnectivity between the health of the watershed and the community. This is evident when comparing the recorded western WHIs focusing on ‘chronic diseases or conditions,’ ‘climate related health impacts,’ and ‘personal physical health,’ and the recorded Indigenous WHIs like ‘how healthy are we?’ and ‘what about the youth?’ In addition, while each worldview also prioritizes health metrics and well-being for this resilience category, there are some stark differences. For example, western recorded WHIs utilize more conventional metrics (e.g., climate-related health impacts and mental health), while the Indigenous recorded WHIs were more intimately focused on communal impacts (e.g. cultural changes, food source impacts, and what about the youth?).

For *Water Quality*, the recorded western and Indigenous WHIs both address measures for assessing the quality and safety of water for human consumption and ecological health. However, the recorded western WHIs prioritize quantitative measurement and regulatory compliance through indicators addressing ‘exceedances of water quality thresholds,’ ‘nutrient concentrations,’ and ‘variances in water quality scores,’ among others. Conversely, the recorded Indigenous WHIs tend to prioritize experiential and cultural assessments by focusing on the more practical applications of water quality. This includes the provision of WHIs like 'suitability for making tea,' 'perceived contamination risk,' 'nothing growing,' and 'taste,' among others.

4.2.2 Potential Differences in the Reviewed WHI Frameworks

Despite the similarities outlined above, there were also several divergent priorities noted for each worldview when examining the WHI framework database. These differences are most evident when comparing the proportional representation of each worldview for the categories of *Land Use and Condition, Water Quantity & Security, and Indigenous Knowledge and Leadership*.

For *Land Use and Condition*, there were 4.5 times the amount of western WHIs recorded in the database (3rd highest at 18%) when compared to the recorded Indigenous WHIs (8th highest at 4%). While this small subset of Indigenous recorded WHIs mirrors western WHIs in terms of sustainable land management (e.g., hydro development, land use, riparian habitat), the discrepancy in proportional representation between worldviews is notable. In addition, the recorded western WHIs for *Land Use and Condition* also make considerable reference to impacts from anthropogenic activities (e.g., % change in forest cover, agriculture, parks & recreation, and impact of forestry activities on riparian zones).

In the *Water Quantity and Security* category, the recorded western frameworks featured double the number of relevant WHIs when compared to those documented in Indigenous/co-created frameworks (12% vs. 6%). Furthermore, the western WHIs were more broadly focused on regulatory compliance (e.g., flow commitments and licensed water volume by sector), quantitative trend analysis (e.g., water level fluctuations, long-term trends, and variations in monthly/annual flow), and predictive modelling for infrastructure impacts (e.g., pre- vs. post-dam). This contrasts with only one of the five recorded Indigenous WHIs focusing on 'water levels (qualitative observations),' which reflects a more experiential approach to monitoring this resilience category. Despite these differences, each framework worldview also highlighted the significance of maintaining sustainable water levels, flows, and snowpack.

4.3 Indicator Distribution by Type (Condition, Pressure, Response)

The final theme of this data analysis includes the overall distribution of WHI types (condition, pressure, response) by both their total representation, as well as their general distribution by framework worldview. Understanding this distribution provides some insight into the general priorities of watershed health monitoring across North America. For example, how proactive and resilient are existing watershed planning approaches, especially in an uncertain future driven largely by climate change and water scarcity? Understanding the distribution of WHI types by framework worldview also offers additional insight into the prioritization of watershed health dimensions across varying cultural perspectives. This insight can highlight potential areas for collaboration, as well as any gaps or blind spots that a co-creative approach to WHI selection could address.

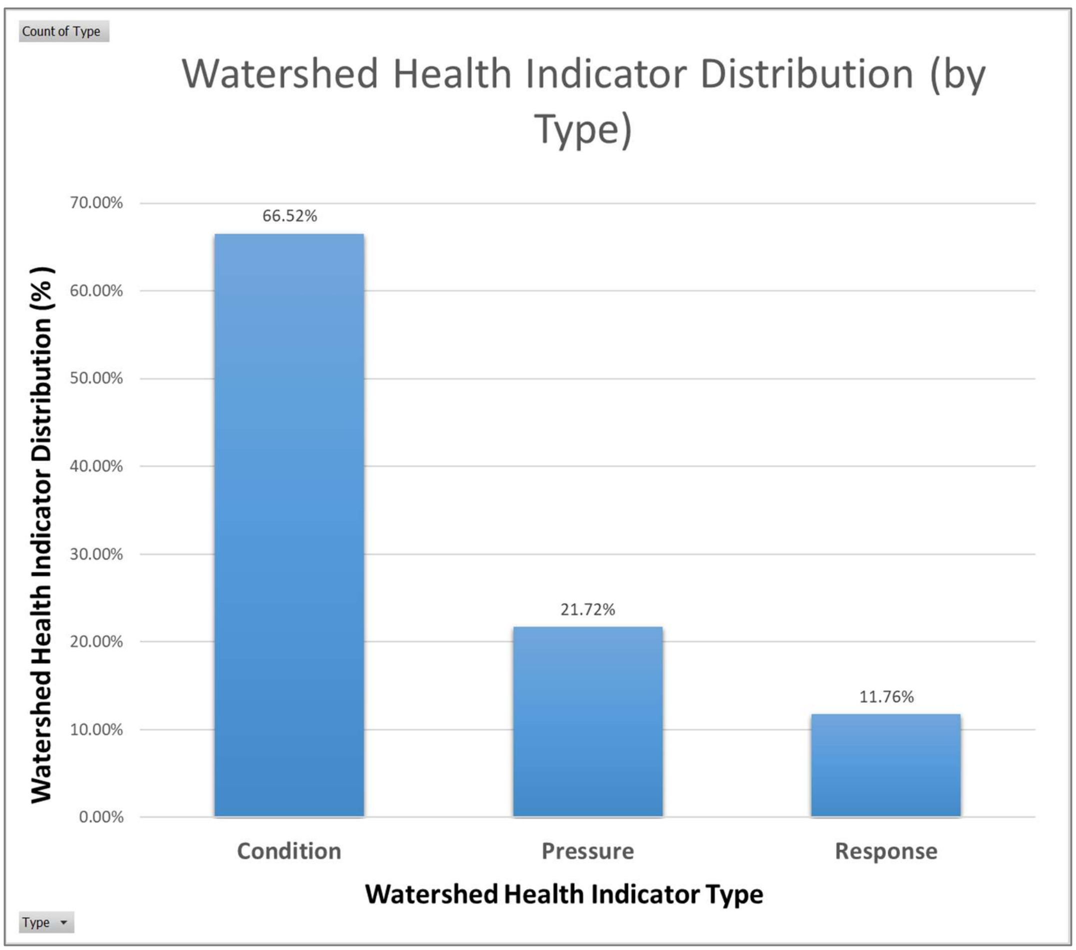

Figure 2. Watershed Health Indicator Distribution (by Type)

4.3.1 Distribution by Indicator Type

When reviewing the total distribution of WHIs by type (**Figure 2**), it is apparent that the vast majority of all recorded WHIs are condition-oriented (70%), while pressure and response oriented WHIs are significantly underrepresented at 22% and 12% of the database, respectively.

Condition oriented WHIs have significant representation in the database (66.52%), which indicates a universal prioritization towards environmental baseline tracking. This is reflected in common themes associated with ecological health metrics (e.g., biological integrity and fish health) and water quality parameters (nutrient concentrations, TSS, and water quality standards), among others.

Pressure (or stressor) oriented indicators are second in terms of prioritization in the WHI database at 21.72%. They are reflected in the database via themes associated with environmental degradation (e.g., % change in forest cover and land use change), pollution sources (e.g., combined sewer overflows and pollutant loadings), and climate variability (e.g., future precipitation and temperature changes). The lower representation of this indicator type also coincides with the limited amount of recorded WHIs addressing climate change (as previously outlined in **Section 4.1.2**), revealing a systemic gap in preparedness for watershed resilience in a more uncertain climate future.

Response oriented indicators held the lowest priority in the WHI framework database, with a total reference rate of 11.76%. They are reflected in the database under a variety of themes, including cultural adaptation (e.g., cultural changes, and enhanced communal "watershed intelligence") and community health and engagement (e.g., civic engagement, what about the youth, and how healthy are we?). Additionally, these recorded indicators encompass themes of environmental stewardship (e.g., Nechako watershed stewardship initiatives, and eco sections and protected areas) and resource utilization (e.g., mammal, fish, and plant usage).

The distribution of response oriented indicators in the WHI database also changes when categorized by framework worldview. As outlined below in **Figure 3**, the recorded Indigenous WHI frameworks placed a significantly higher emphasis on this indicator type when compared to the recorded western WHI frameworks (22% vs 5%, respectively). This difference is driven through the prioritization of Traditional Ecological Knowledges integration with environmental stewardship, with Indigenous/co-created WHIs not only considering the physical state of the watershed (e.g., abundance and fish populations,) but also the reciprocal connection between community and land (e.g., enhance communal "watershed intelligence," storytelling, harvesting, and can I eat the fish?). In contrast, response-oriented indicators from the western frameworks appear to focus on more immediate, measurable, and culturally removed environmental actions (e.g., area of concern status, Nechako Watershed Stewardship Initiatives, and civic engagement).

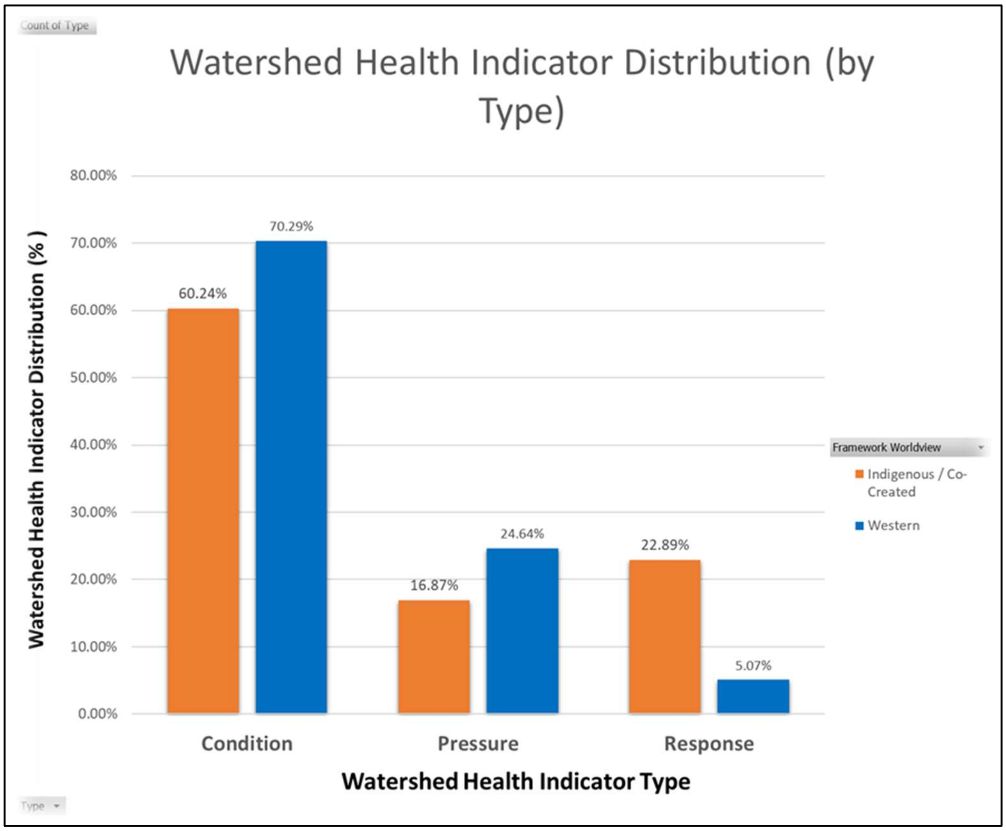

Figure 3. Watershed Health Indicator Distribution by Type and Worldview

This disparity underscores a systemic bias by showing that Indigenous communities are pressured to develop indicators that allow them to adjust and monitor their practices in response to environmental degradation and climate change effects. This is likely most relevant for local Indigenous communities that rely on local travel and harvesting activities for cultural expression and sustenance (Donnelly et al., 2007; Okanagan Nation Alliance, 2022). In comparison, the reliance on globalized trade and a greater cultural disconnect from the land may shield western governance bodies from needing to prioritize response oriented indicator development and tracking.

Chapter 5. Discussion

5.1 Preventing a Duplication of Efforts

A core component of successful IWRM is the recognition of a complex interplay between water systems and human and non-human societies, while also incorporating a well-rounded array of watershed resilience categories into all aspects of management and decision-making (Canadian Council of Ministers of the Environment, 2016; Melnychuk et al., 2016; Smith et al., 2022; TRCA, n.d.; Wang et al., 2016). The results of this research flag the difficulties of aligning theory and practice, however, due to the complexities of integrating multiple water use demands, diverse stakeholder interests, and dynamic and interconnected environmental considerations in a collaborative WHI framework (Galvez & Rojas, 2019; Jeffrey & Gearey, 2006; Shrubsole et al., 2016; Wang et al., 2016)

As previously noted, one key limitation to IWRM is the limited capacity of institutions, as well as western and Indigenous governance bodies, to effectively lead and participate in prolonged collaborative management efforts for watershed resilience (Sale et al., 2016; Sam & Armstrong, 2013; Shrubsole et al., 2016; Wang et al., 2016). In the context of the Okanagan Basin, an understanding of existing categorical gaps and strengths in WHI development across North America can prevent the OBWB and ONA from duplicating research into well-established WHIs under the resilience categories of water quality and biodiversity. Rather, attention can be effectively directed towards building targeted 'in-house' WHIs for less applied resilience categories that are highly relevant to the Basin from a physical and cultural dimension (e.g., *Water Security, Climate Change, Community Health, Indigenous Knowledges and Leadership*). By leveraging existing research and WHI framework sections (where relevant) into a 'Made in Okanagan' WHI framework, groups like the ONA and OBWB can collectively streamline their efforts to where they matter most.

For example, the data identified Ontario as a leader in the development of WHIs centring around water quality, which aligns with the prevalence of both its significant freshwater reserves and Conservation Authority leadership in implementing province-wide watershed report cards (Conservation Ontario, 2018, 2023a). Closer to home, WHI frameworks in British Columbia were leaders in the development of *Biodiversity and Land Use Condition* WHIs but lacking in *Water Quantity & Security*. The importance of closely monitoring water security becomes particularly evident in regions like the Okanagan Basin, where this urgency is amplified due to existing and future water scarcity issues on the overallocation of water licenses and climate change driven drought conditions (Melnychuk et al., 2016; Okanagan Nation Alliance, 2022; Okanagan Water Stewardship Council, 2019). This underrepresentation supports the need for a more focused and strategic allocation of resources for tracking water quantity, as well as climate change impacts, community & health, and economic changes, as critical categories of health and resilience in the Okanagan Basin (Okanagan Water Stewardship Council, 2019; Regional District of North Okanagan et al., 2020; Schwann, 2018, p. 175; South Okanagan Real Estate Board, 2019).

5.2 Opportunities for Collaboration in WHI Development

An encouraging finding of the analysis included the numerous similarities and targeted differences in WHI prioritization between the reviewed western and Indigenous/co-created WHI frameworks. These commonalities were most evident for the watershed resilience categories of *Biodiversity, Climate Change, Community and Health, and Water Quality*, and most divergent for *Land Use and Condition, Water Quantity & Security,* and *Indigenous Knowledges and Leadership*. In addition, both worldviews prioritized condition and stressor oriented WHIs, while the Indigenous/co-created frameworks also tended to prioritize response-oriented indicators to a greater extent. This analysis reveals that while each worldview may have certain limitations in providing a comprehensive and holistic approach to WHI development in isolation, their combined strengths present a unique opportunity for watershed resilience monitoring in the Okanagan Basin. This includes the potential to illuminate each other's blind spot(s) and develop more resilient and robust WHI frameworks that not only address diverse environmental challenges, but also respect and integrate varied cultural perspectives and knowledge systems.

Given the above, and that successful IWRM requires strong inclusivity and collaboration (Sale et al., 2020; Veale & Cooke, 2016; Wang et al., 2016), tremendous opportunity exists for regional Syilx leadership in the co-creation of a 'made in the Okanagan' WHI framework. This collaborative and reconciliatory approach is supported by numerous Indigenous scholars like Kyle Whyte (2013), who argues that "Indigenous and non-Indigenous environmental professionals alike should direct their efforts towards creating long-term [collaborative] governance processes that facilitate a thorough and responsible consideration of how diverse approaches to knowledge impact stewardship and management priorities" (Whyte, 2013, p. 2). In addition, Michael D. Blackstock (2002; 2008, 2017) also supports this co-creative partnership approach through the "transformation of sovereign knowledge into collaborative knowledge" via the water-centric theory of Blue Ecology (Blackstock, 2017, p. 3)

From a Basin perspective, Syilx Okanagan scholars like Marlowe Sam and Jeannette Armstrong advocate for En'owkin (or En'owkinwixw) in the sphere of Indigenous water governance (J. Armstrong, 2013, 2020; Sam, 2006, 2013). As summarized by Yates et al. (2017), En'owkin refers to "a whole systems approach [to consensus-making dialogue] that encourages the exchange of diverse perspectives" (p. 808), especially from minority groups with alternative perspectives on what is working, what is being neglected, or what "we're being aggressive about or overlooking" (J. Armstrong, 2020, p. 166). Through this, Armstrong notes the four informal principles of En'owkin that all participants must continually adhere to for long-term success:

> "That we solicit the most opposing views; that we seek to understand those views using non-adversarial protocols; that we each agree to be willing to make adjustments in our own interests to accommodate diverse needs expressed; and that we collaboratively commit to support the outcomes" (J. Armstrong, 2020, p. 166)."

While the OBWB has already undertaken tremendous work in facilitating regional collaboration for water stewardship action, the ONA (2022) and broader Syilx Okanagan Peoples are also strategically poised to drive their action plan to uphold "the CEC's [(Chiefs Executive Council)] mandate to ensure accessible, clean and health water for generations to come" (p. 4) and also "improve and enhance syilx Okanagan siwɬk^{w} governance" (p. 5). For example, strategic priority #4 of the 'Syilx Strategy to Protect and Restore Siwɬkw' aims to identify various ecosystem health and traditional ecological knowledge indicators. This proposal supports both developing "working watershed inventories and archives of information regarding climate change," as well as the Nation's "advances, decision-making, and archiving knowledge for future generations" (Okanagan Nation Alliance, 2022, pp. 29, 31).

In addition, the ongoing Okanagan Lake Responsibility Planning Initiative (OLRPI) continues to provide tremendous potential for co-creative Basin-wide partnerships between the ONA and OBWB, conservation groups, and government entities at all levels. The OLRPI initially emerged in 2019 "as a Syilx-led response to the large-scale loss of natural areas reported in the Okanagan Lake Foreshore Inventory and Mapping (FIM) reports," which included a 61% loss of natural shoreline in the lake (as of 2016) due to land use change, development, and sedimentation (Okanagan Collaborative Conservation Program, n.d.). The project's main goal is to establish new engagement and decision-making processes that enhance environmental and cultural protection, thereby reinforcing Syilx Rights in regional environmental policy (Okanagan Collaborative Conservation Program, n.d.). To date, the Project team has conducted various interviews, a legislative policy gap analysis, and capacity-building workshops to identify over 100 solutions for environmental and cultural protection (Okanagan Collaborative Conservation Program, n.d.).

5.3 Legislative and Policy Emergence in Support of a 'Made in the Okanagan' WHI Framework

As previously mentioned, the implementation of key legislative frameworks and strategic initiatives like the WSA, Declaration Act, WSS and WSSF will increasingly play a pivotal role in shaping the development of indicator monitoring, particularly with an emphasis on climate change and Indigenous leadership.

The WSA also aims to support integrated water and land use planning through the application of water sustainability plans (WSPs). WSPs are monumental, as Curran & Brandes (2019) note their unique position in Canada as the only statutory instrument able to link both land and water decision-making to "a long-term watershed-or ecosystem-based framework," while also facilitating co-governance agreements between the province and First Nations communities (Curran & Brandes, 2019, p. VI). In the context of the Okanagan Basin, the ONA can look towards the recently adopted Xwulqw'selu Watershed Planning Agreement (between the Cowichan Tribes First Nations and the province of British Columbia) as a successful template of Indigenous leadership in provincial watershed governance (Cowichan Tribes & Government of B.C., 2023; Compass Resource Management, 2023). However, Curran & Brandes (2019) duly note that "WSPs cannot adequately account for Indigenous law and aboriginal rights" given their power is sourced from provincial state law (p. 7). While this limitation flags an opportunity for WSPs to be receptive to expressions of Indigenous legal determinations by supporting and improving “the re-emergence of these legal orders,” it remains to be seen if this can be achieved within the current western legal and governance framework, or if the political will exists to drive such a relinquishment of western legislative control (Curran & Brandes, 2019, p. 7).

While the province will formally launch the WSSF in Winter 2023/24 and implement in Winter 2024 onwards, it presents a tremendous opportunity to finance the development, implementation, and refinement of a ’Made in the Okanagan’ WHI framework. In support of this, policy intention #1 the *WSSF Intentions Paper* emphasizes the need for Indigenous collaboration and stewardship by enabling “Indigenous Peoples to be fully involved partners with recognition of their rights, needs, values and worldviews” (Ministry of Environment and Climate Change Strategy, 2022, p. 8). This includes fiscal support for “establishing collaborative processes that involve Indigenous Peoples,” which could present an opportunity for the ONA to lead in this work with the consensus-making process of En’owkin (**Section 5.2**) (Ministry of Water, Land and Resource Stewardship, 2023, p. 9). Finally, policy intention #5 directly supports a critical gap for the Basin by aiming to balance “water supply and demand at the watershed scale [to] address the needs of people, the environment and the economy” via a holistic IWRM approach (Ministry of Water, Land and Resource Stewardship, 2023, p. 15). This aligns with the findings of this study, which highlighted a national shortfall in monitoring *Water Security & Quantity*. Consequently, this policy intention can drive enhanced support for targeted WHI development and monitoring in the Basin via “enforcement, new conservation and economic tools, and other planning processes such as Drinking Water Protection Plans, Forest Landscape Plans and Land Use Plans” (Ministry of Water, Land and Resource Stewardship, 2023, p. 16).

Finally, Action 2.7 of the supplementary Action Plan to the Declaration Act compels the province to embrace “government-to-government relationships” with regard to watershed stewardship and First Nations leadership (Ministry of Indigenous Relations and Reconciliation, 2022, p. 14). This includes the requirement to collaborate with First Nations to co-create and enact sustainable water management strategies, including both policy reforms and shared decision-making, as well as co-develop and implement the WSS at the local watershed scale (Ministry of Indigenous Relations and Reconciliation, 2022, p. 15). With a deadline of 2027 to implement, this Action Plan (in its idealized form) can drive the critical role of partnership building between the province and First Nations in advancing water management practices respectful and integrative of Indigenous knowledges and legal systems. The ONA and Syilx Peoples of the Okanagan are collectively well-positioned to leverage this action item, given their strong track record of leadership in asserting their “inherent and implicit Aboriginal Title, Rights and Responsibilities to siwɬkʷ” (Okanagan Nation Alliance, 2014, p. 5).

Chapter 6. Conclusion

When navigating the complexities of IWRM, watershed managers and policymakers must acknowledge the intricate relationship between freshwater systems, ecological health, and community well-being, to effectively strengthen watershed resilience. This work holds particular significance in the Okanagan Basin, a vast and arid area grappling with rapid population growth, dwindling water security, and diverse challenges posed by a changing climate. WHIs emerge here as tools for monitoring, but also as catalysts for planning and initiating vital watershed management action.

The research conducted in this study aims to highlight critical gaps in existing WHI frameworks across North America, most notably discovering an underrepresentation in watershed resilience categories of *Indigenous Knowledges and Leadership*, as well as *Water Quantity & Security* and *Climate Change*. Additionally, a disparity in prioritizing response oriented WHIs was observed between western and Indigenous/co-created frameworks. These findings indicate an urgent need to evolve towards a more collaborative and Indigenous-led approach in WHI development both in the Basin and elsewhere. Recent legislation like the WSA and policy like the WSSF, also present significant opportunities in support of evolving towards a just and equitable co-creative approach for WHI development in the Okanagan Basin. By doing so, we can not only pave the way for more sustainable and resilient ecosystems but also uplift communal relationships in support of reconciliation in an uncertain climate future.

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Appendix A. Watershed Health Indicator Database

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Biodiversity	Where are the fish?	Condition	Index	- New fish are appearing - Some fish are becoming less common - Traditional practices	*Indigenous / Co-Created*	Indicators - Mackenzie Basin (Tracking Change Initiative)	Western Canada*
Biodiversity	Salmon and steelhead pre-smolt abundance	Condition	Index	Abundance meets or exceeds target population densities set by DFO and FLNRORD	*Indigenous / Co-Created*	Aspirational Targets for Watershed Health (Cowichan Watershed Board)	British Columbia
Biodiversity	Fish Aesthetics	Condition	Index	Worse = the fish look worse now than in the past Same = the fish look the same now as they did in the past Better = the fish look better than in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Biodiversity	Fish Usage	Response	Index	Less = I use less fish now than I did in the past Same = I use the same amount of fish now than I did in the past More = I use more fish now than I did in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Biodiversity	Mammal Usage	Response	Index	Less = I use less mammals now than I did in the past Same = I use the same amount of mammals now as I did in the past More = I use more mammals now than I did in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Biodiversity	Oil sands and mining	Pressure	Index	- Shifts in water systems Increased toxins - Declining fish health and populations - Downstream impacts	*Indigenous / Co-Created*	Indicators - Mackenzie Basin (Tracking Change Initiative)	Western Canada*
Biodiversity	Spawning and Fish Eggs	Condition	Index	Recent changes in fish spawning patterns (e.g., difficult to predict when fish spawn up the Hay River in the fall time).	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Biodiversity	Abundance and Fish Populations	Condition	Index	Are there more or less fish? Are there new fish species? Are there more trout, pickerel being caught in recent years?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Biodiversity	Size (Fish)	Condition	Index	Are the fish skinny/bony? Are the fish round/fat?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Biodiversity	Presence of Abnormalities/Deformities (Fish)	Condition	Index	- Presence of scars, sores, bruising, puncture wounds (pus), growth, worms, and/or bugs found outside or inside of the fish? - Are the fish safe for humans to consume? - Are the fish safe to feed to dogs?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Biodiversity	External and Internal Colour (Fish)	Condition	Index	- Are the whitefish pale/white? - Is the meat or liver discoloured?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Biodiversity	Fat Content (Fish)	Condition	Metric	Do the fish have more or less fat than normal?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Biodiversity	Texture (Fish)	Condition	Metric	Is the flesh of the fish firm or soft?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Biodiversity	Colour of Fish Gills (Fish)	Condition	Metric	Are the fish gills dark pink/red?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Biodiversity	Smell (Fish)	Condition	Metric	Do the fish smell funny? Do the fish smell like diesel?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Biodiversity	Taste (Fish)	Condition	Metric	Do the fish taste soapy?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Biodiversity	Stomach Content (Fish)	Condition	Metric	Is the stomach of the fish clean? Is there dirt or silt in the stomach?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Biodiversity	The Health of Fish and Other Animals	Condition	Index	Are other animals (fish, wildlife) healthy?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Biodiversity	Wetlands & Forests	Condition	Metric	- Stories & oral histories - Local observations - Number, location, areas, species diversity of wetlands - Number, location, areas, species diversity of forests	*Indigenous / Co-Created*	State of the Aquatic Ecosystem Report - Conceptual Framework (Mackenzie River Basin Board)	Western Canada*
Biodiversity	Aquatic Life	Condition	Metric	- Oral histories of water birds and aquatic furbearing species, including abundance, health, and distribution	*Indigenous / Co-Created*	State of the Aquatic Ecosystem Report - Conceptual Framework (Mackenzie River Basin Board)	Western Canada*

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Biodiversity	Mammal Aesthetics	Condition	Index	Worse = the mammals look worse now than they did in the past Same = the mammals look the same now as they did in the past Better = the mammals look better now than they did in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Biodiversity	Invasive Plants	Pressure	Index	Less = there are less unfamiliar/invasive plants now than in the past Same = there are the same amount of unfamiliar/invasive plants now than in the past More = there are more unfamiliar/invasive plants now than in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Biodiversity	Bird Usage	Response	Index	Less = I harvest and use less birds now than I did in the past Same = I harvest and use the same amount of birds now than I did in the past More = I harvest and use more birds now than I did in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Biodiversity	Bird Aesthetics	Condition	Index	Worse = the birds look worse now than they did in the past Same = the birds look the same now as they did in the past Better = the birds look better now than they did in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Biodiversity	Benthic macroinvertebrates	Condition	Index	Integrated information on water quality and habitat conditions for aquatic life (e.g., fish)	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Biodiversity	Fish species richness	Condition	Index	Not Provided	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Biodiversity	Invasive species	Pressure	Metric	# of non-native aquatic species in an area	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Biodiversity	Benthic Macroinvertebrates	Condition	Index	Modified Family Biotic Index	Western	Resource Categories & Indicators (Conservation Ontario)	Ontario
Biodiversity	Fish Health	Condition	Index	Index Biological Integrity - Fish Health	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Biodiversity	Species Intactness	Condition	Index	Species Intactness (Bird/Plant/Mammal)	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Biodiversity	Population size	Condition	Index	Number of individuals of species	Western	USEPA Watershed Health Index	United States of America
Biodiversity	Population structure	Condition	Metric	Population age structure	Western	USEPA Watershed Health Index	United States of America
Biodiversity	Signs of disease or trauma	Condition	Index	- Presence of parasites or pathogens (e.g., in fish) - Tree defoliation	Western	USEPA Watershed Health Index	United States of America
Biodiversity	Benthic Macroinvertebrates	Condition	Index	%EOT (relative abundance)	Western	Muskoka Watershed Report Card 2023	Ontario
Biodiversity	Fish Populations	Response	Index	Success of Fisheries Management Zone 15 (Plan Implementation) - Reduced length of open season - minimum size limits (lake specific) - Fish Stocking - Educational initiatives for public)	Western	Muskoka Watershed Report Card 2023	Ontario

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Biodiversity	Fragmentation	Pressure	Metric	**Extent of natural area (ha)** = Watershed Area - ((Altered Landscape Area - 17 largest lakes) + 100-metre buffer applied to each feature) As the size of quaternary watersheds vary across Muskoka, the relative proportion of each watershed covered by a given fragmentation class was calculated to allow for comparison.	Western	Muskoka Watershed Report Card 2023	Ontario
Biodiversity	Bird Populations	Condition	Index	**Various, including:** 1) Results from 3rd Ontario Breeding Bird Atlas (2023 is 3rd year of this iteration, with 1980 & 2000 as previous iterations) 2) eBird web-based tool (citizen science)	Western	Muskoka Watershed Report Card 2023	Ontario
Biodiversity	Invasive Species	Pressure	Metric	**Invasive Species Monitoring Efforts:** Phragmites, spiny waterflea, rusty crayfish, round goby, rainbow smelt, purple loostrife, japanese knotweed, giant hogweed, eurasian water milfoil, **Pathogen Case Monitoring:** lyme disease cases (black legged ticks), West Nile virus	Western	Muskoka Watershed Report Card 2023	Ontario
Biodiversity	Beech Bark Disease	Pressure	Index	# of recorded beech bark disease infections	Western	Muskoka Watershed Report Card 2023	Ontario
Biodiversity	Species at Risk	Condition	Metric	Changes to identified "Species at Risk in Ontario" (SARO) located in Muskoka Watersheds, including: - # of identified species - change in species classification (e.g. at risk > threatened)	Western	Muskoka Watershed Report Card 2023	Ontario
Biodiversity	Terrestrial Biodiversity	Condition	Index	Average regional floristic quality - Rural vegetation quality - Urban vegetation quality - % exotic species (urban & rural)	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Biodiversity	Fish Communities in Streams	Condition	Index	Index of Biotic Integrity (scoring trend analysis)	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Biodiversity	Benthic invertebrate Community Status	Condition	Index	Benthic: Family Biotic Index (scoring trend analysis)	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Biodiversity	Nearshore Fisheries	Condition	Index	Nearshore Fish Communities	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Biodiversity	Change in Native Fish Species Richness	Condition	Index	Presence of statistically significant decline in number of total species observed per year.	Western	Watershed Reports 2020 (World Wildlife Foundation)	Canada-wide
Biodiversity	Change in Native Fish Species Richness	Condition	Index	Presence of statistically significant decline in median species richness for the basin.	Western	Watershed Reports 2020 (World Wildlife Foundation)	Canada-wide
Biodiversity	Index of benthic community composition based on sensitivity to disturbance	Condition	Index	Median Hilsenhoff Biotic Index (HBI) score for the basin. Reported as a weighted average for the most recent five years	Western	Watershed Reports 2020 (World Wildlife Foundation)	Canada-wide
Biodiversity	Index of benthic community composition based on sensitivity to disturbance	Condition	Index	Variance of annual HBI scores	Western	Watershed Reports 2020 (World Wildlife Foundation)	Canada-wide
Biodiversity	Index of benthic community composition based on sensitivity to disturbance	Condition	Index	Significant Mann- Kendal time-series test to determine directional trend in HBI over time.	Western	Watershed Reports 2020 (World Wildlife Foundation)	Canada-wide
Biodiversity	Benthic invertebrate Community Status	Condition	Index	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Biodiversity	Species at Risk – Red and Blue Listed Species	Condition	Index	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Biodiversity	Nechako River White Sturgeon	Condition	Metric	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Biodiversity	Mountain Caribou Population Status	Condition	Metric	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Biodiversity	Salmon Escapement	Condition	Metric	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Biodiversity	Moose	Condition	Metric	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Biodiversity	Stand-level Biodiversity	Condition	Index	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Biodiversity	Ecosections and Protected Areas	Response	Index	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Biodiversity	Fisheries Project Registry	Condition	Index	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Biodiversity	Biological Integrity	Condition	Index	- Index of Biotic Integrity (IBI) - Fish Sustainability Index - Fish Community Index	Western	State of Watershed Reports - Common Watershed Indicators for Alberta (Government of Alberta)	Alberta
Biodiversity	Community extent	Condition	Index	- Extent of native ecological communities - Extent of successional states	Western	USEPA Watershed Health Index	United States of America
Climate Change	Climate	Pressure	Index	- Local observations & oral histories - Temperature, precipitation normals, and extremes over time	*Indigenous / Co-Created*	State of the Aquatic Ecosystem Report - Conceptual Framework (Mackenzie River Basin Board)	Western Canada*
Climate Change	Air Pocket Density	Pressure	Metric	Less = there are few air pockets in the ice now than in the past Same = there are an average number of air pockets in the ice now than in the past More = there are more air pockets in the ice now than in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Climate Change	How is the land changing?	Pressure	Index	- Changes to water levels - Permafrost thaw - Increasing forest fires - Changes in wildlife patterns	*Indigenous / Co-Created*	Indicators - Mackenzie Basin (Tracking Change Initiative)	Western Canada*
Climate Change	Climate Impacts	Pressure	Index	- Changing seasonal patterns - Changing water levels - Changing water temperatures - Erosion and landslides - Vegetation and wildlife - Forest Fires	*Indigenous / Co-Created*	Indicators - Mackenzie Basin (Tracking Change Initiative)	Western Canada*
Climate Change	Ice Thickness	Condition	Index	- Is ice thickness decreasing? - Are winter temperatures warming?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Climate Change	Flood Extent	Condition	Index	Less = the floods cover less area/land now than they did in the past Same = the floods cover the same amount of area/land now than they did in the past More = the floods cover more area/land now than they did in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Climate Change	Length of Ice Period	Pressure	Metric	Short (< 5.5 months) - ice freeze up happens later (December) and thaws sooner (i.e., March) than in the past Medium (5.5 - 6.5 months) - ice freeze up happens the same as in the past (October - April/May) Long (> 6.5 months) - ice freeze up happens sooner and lasts longer than in the past (September/October - May)	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Climate Change	Adaptation	Response	Metric	Less = I adapt my livelihood less now than I did in the past because of changes in the river and delta Same= I use the same livelihoods now as I did in the past More = I adapt my livelihood more now than I did in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Climate Change	Is it safe to travel?	Response	Index	- Impacts to seasonal travel - How are people adapting?	*Indigenous / Co-Created*	Indicators - Mackenzie Basin (Tracking Change Initiative)	Western Canada*
Climate Change	Timing of ice on/off	Condition	Metric	Date / duration that ice forms and disappears from water surface	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Climate Change	Climate Change and weather patterns	Pressure	Index	Extreme weather events, plant hardiness zone change	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Climate Change	Temperature Changes	Pressure	Metric	1) Seasonal mean change of daily maximum temperatures for winter (January, February, and March) 2) # of Days Maximum Temperature > 20C 3) # of Days Maximum Temperature < 0C	Western	Muskoka Watershed Report Card 2023	Ontario
Climate Change	Precipitation Changes	Pressure	Metric	1) Change in Annual Total Precipitation (rain + snow) 2) Change in Annual Total Snow 3) Change in Annual Total Rain 4) # of days with precipitation > 1mm	Western	Muskoka Watershed Report Card 2023	Ontario
Climate Change	Winter Ice	Condition	Metric	1) Ice-on Dates since 1975 (per annum) 2) Ice-off days since 1975 (per annum) 3) Days of Ice Cover since 1975	Western	Muskoka Watershed Report Card 2023	Ontario
Climate Change	Extreme Weather Events (flooding)	Pressure	Metric	**Muskoka flood risk factors (decision tree), 250-300mm water threshold:** - Snow water equivalent above normal - Rapid Melting - Heavy Rain > 50mm - Additional Rain > 25mm	Western	Muskoka Watershed Report Card 2023	Ontario
Climate Change	Flooding (Riverine & Lake Ontario Shoreline)	Pressure	Metric	% Change in Flood Vulnerable Clusters	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Climate Change	Climate Trends	Pressure	Index	*No unit of measurement provided*	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Climate Change	Future Precipitation	Pressure	Index	% Change in Baseline for: - Annual Average Precipitation - Annual Extreme Precipitation - Seasonal Extreme Precipitation	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Climate Change	Future Temperatures	Pressure	Index	% Change in Baseline for: - Annual Average Temperature - Extreme Heat	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Climate Change	Climate Change	Pressure	Index	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Climate Change	Air Quality	Pressure	Index	C02 emissions, air quality parameters	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Community & Health	Food Sources	Pressure	Metric	- Decrease in country food consumption (overall or specific species); access or safety considerations - Statistics on number of people eating wild food vs. store food	*Indigenous / Co-Created*	State of the Aquatic Ecosystem Report - Conceptual Framework (Mackenzie River Basin Board)	Western Canada*
Community & Health	Enhance communal "watershed intelligence"	Response	Index	Provide all Grade 4/5 students with a hands-on watershed experience. Enhance Cowichan residents knowledge and value of their watershed.	*Indigenous / Co-Created*	Aspirational Targets for Watershed Health (Cowichan Watershed Board)	British Columbia
Community & Health	Cultural Changes	Response	Index	More = our culture is now shifting away from what it was in the past because of changes to the delta (less trapping, less fishing, etc.) Same = our culture is not changing now Less = our culture is shifting more now to what it was like in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Community & Health	Travel	Response	Index	Less = I rely less on traveling in the delta now than in the past to maintain my livelihood Same = I travel the same amount in the delta than in the past More = I rely more on traveling in the delta now than in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Community & Health	How healthy are we?	Response	Index	- Expensive and less nutritious store-bought food - Adapting to change - Decision making in support of community health - Fishing and fostering holistic health of communities - Building healthy futures	*Indigenous / Co-Created*	Indicators - Mackenzie Basin (Tracking Change Initiative)	Western Canada*
Community & Health	What about the youth?	Response	Index	- Concerns for the future - Ways of engaging youth - Goals for youth learning - Youth Action	*Indigenous / Co-Created*	Indicators - Mackenzie Basin (Tracking Change Initiative)	Western Canada*
Community & Health	Chronic Diseases or Conditions	Condition	Index	Diabetes, Hypertension, COPD	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Community & Health	Personal Physical Health	Condition	Index	Healthy Alta Trends Index	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Community & Health	Mental Health	Condition	Index	- Self-perceived mental health - % of population with mental health conditions - Sense of belonging	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Community & Health	Climate related health impacts	Pressure	Index	- heat-related illnesses, edema, heatstroke - allergy / athsma due to pollen or temperature	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Community & Health	Crime Rate, access to community health services	Pressure	Index	*No unit of measurement provided*	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Community & Health	Community wellbeing	Condition	Index	Community wellbeing index & Indigenous community wellbeing index	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Community & Health	Civic Engagement	Response	Index	Watershed stewardship activities & voter turnout	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Community & Health	Nechako Watershed Stewardship Initiatives	Response	Index	Measurement of community support for active/successful stewardship initiatives in the Nechako Watershed. Specific measurement formula unknown.	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Ecological Services & Use	Harvesting	Response	Index	Less = we rely less on harvesting from the delta now than in the past because of changes to the delta Same = we harvest the same from the delta now as we did in the past More = we rely on harvesting more from the delta now than in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Ecological Services & Use	Can I eat the fish?	Response	Index	- Is the fish flesh soft? - Are there irregularities in the fish? - Does the fish have parasites? - Is the fish skinny? - Has the fish been tested for toxins (e.g. mercury)? - Are the eggs healthy? - Are local harvesters afraid to sell fish? - What is upstream? - Are there changes to the land and water that could affect fish health?	*Indigenous / Co-Created*	Indicators - Mackenzie Basin (Tracking Change Initiative)	Western Canada*
Ecological Services & Use	Can I drink the water?	Condition	Index	*- Is the water colourless and clear?* *- How does the water taste?* *- Are there animals nearby?* *- What is upstream?* *- Are there known contaminants?*	*Indigenous / Co-Created*	Indicators - Mackenzie Basin (Tracking Change Initiative)	Western Canada*
Ecological Services & Use	Shellfish harvesting (designated areas of Cowichan bay by 2020)	Pressure	Metric	End the government-imposed harvest closure (since 1973) due to pollution concerns	*Indigenous / Co-Created*	**Aspirational Targets for Watershed Health (Cowichan Watershed Board)**	British Columbia
Ecological Services & Use	Ecosystem Services	Condition	Index	Value of Ecosystem Services	Western	**Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)**	Alberta
Ecological Services & Use	Ecological Integrity	Condition	Metric	TBD (no formal appraoch has been devised to reliably track and quantify this indicator (see rationale)	Western	**Muskoka Watershed Report Card 2023**	Ontario
Economy	Ecotourism	Response	Index	Less = there is less ecotourism now than in the past because of changes in the delta Same = there is the same amount of ecotourism now than in the past More = there is more ecotourism now than in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Economy	Economic Development	Condition	Index	GDP by industry, businesses incorporated	Western	**Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)**	Alberta
Economy	Economic well-being	Condition	Index	Income Labour Force participation rate Cost of Living	Western	**Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)**	Alberta
Indigenous Knowledges & Leadership	Changes in Variability of Winds and Weather	Condition	Index	"Wind and weather variability are strongly linked, acting together as both indicators and agents of environmental changes that have affected local activities"	*Indigenous / Co-Created*	**Linking Inuit knowledge and meteorological station observations (Clyde River Inuit)**	Nunavut
Indigenous Knowledges & Leadership	Knowledge of sources of contamination	Pressure	Index	There should be nothing above the water source in the watershed (e.g., no outhouses, septic fields, or resource extraction).	*Indigenous / Co-Created*	**Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations)**	Yukon
Indigenous Knowledges & Leadership	Changes in Wind Direction	Condition	Metric	- Uangniq or Kuuviniut Miksaanit: North - Ikiqsuaq Northeast Niggiq: East - Nigirlak or Uqquata Miksipauanit: Southeast - Uqqua or Kivak South Uqquqsuq: Southwest - Ualiniq West Avangnarniq: Northwest	*Indigenous / Co-Created*	**Linking Inuit knowledge and meteorological station observations (Clyde River Inuit)**	Nunavut
Indigenous Knowledges & Leadership	Changes in Wind Speed	Condition	Metric	- Ikulliaqtuq: Calm - Anurajaarujuktuq: A breeze; - Anurajaaktuq: Gentle wind; - Natiruviaqtuq: Blowing snow along the ground (<15-20m high) - Atiruttijaqtuq: Blowing snow along the ground (>15-20m high - Piqsiqtuq, Anuraaqtuq: Blizzard; visibility varies 3 to 500 m; large white caps in summer - Piqsiqtualuk, Anuraaqtualuk Blizzard; visibility < 10 m or less -Anuraajuaqtuq: Severe wind	*Indigenous / Co-Created*	**Linking Inuit knowledge and meteorological station observations (Clyde River Inuit)**	Nunavut

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Indigenous Knowledges & Leadership	Prior Use	Condition	Index	The water source has been used by many generations.	*Indigenous / Co-Created*	Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations)	Yukon
Indigenous Knowledges & Leadership	Water Vitality	Condition	Index	Dead = Indigenous users no longer feel a spiritual connection to the water Alive = Indigenous users feel alive when they think about the water Full of Spirit = Indigenous users feel alive and full of spirit in the presence of the water	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Indigenous Knowledges & Leadership	Plant Usage	Response	Index	Less = I use less traditional plants now than I did in the past Same = I use the same amount of traditional plants now as I did in the past More = I use more traditional plants now than I did in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Indigenous Knowledges & Leadership	Storytelling	Response	Index	Infrequent = we use storytelling infrequently now to share our beliefs than in the past because of changes to the delta. Frequent = we use storytelling frequently now to share our beliefs than in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Indigenous Knowledges & Leadership	Animal Ethics	Response	Index	Poor = people have poorer ethics/respect towards animals now than in the past? Same = people have the same ethics/respect towards animals now than in the past Better = people have better ethics/respect towards animals now than in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Indigenous Knowledges & Leadership	Ice Significance	Response	Index	Less = the ice and floods mean less to me personally than in the past Same = the ice and floods mean the same to me personally as they did in the past More = the ice and floods mean more to me personally than they did in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Indigenous Knowledges & Leadership	What about the future?	Response	Index	- Monitoring and stewardship - Exploring strategies for sustainable fishing providing opportunities for cross community, cross regional, and cross cultural knowledge and skills transfer - Documenting traditional and evolving systems for knowledge transfer - Developing policy and water related climate adaptation strategies	*Indigenous / Co-Created*	Indicators - Mackenzie Basin (Tracking Change Initiative)	Western Canada*
Indigenous Knowledges & Leadership	Well-being	Condition	Metric	- Stories and oral histories about important places, sense of belonging, subsistence, cultural and spiritual uses and connection to the land and changes to these things	*Indigenous / Co-Created*	State of the Aquatic Ecosystem Report - Conceptual Framework (Mackenzie River Basin Board)	Western Canada*
Land Use & Condition	Land Use	Condition	Metric	- Stories & oral histories - Maps & statistics	*Indigenous / Co-Created*	State of the Aquatic Ecosystem Report - Conceptual Framework (Mackenzie River Basin Board)	Western Canada*
Land Use & Condition	Riparian Habitat	Condition	Index	50% of "intact" riparian habitats protected by 2021 10% of impacted riparian habitats restored by 2021	*Indigenous / Co-Created*	Aspirational Targets for Watershed Health (Cowichan Watershed Board)	British Columbia
Land Use & Condition	Hydro development	Pressure	Index	- Impacts to water - Access to healthy fish - Animal harvest changes - Impacts to spirituality and culture	*Indigenous / Co-Created*	Indicators - Mackenzie Basin (Tracking Change Initiative)	Western Canada*
Land Use & Condition	Riparian connectivity	Condition	Metric	% of undeveloped shoreline 25 to 50 m inland	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Land Use & Condition	Land use change	Pressure	Metric	Area of land converted from one use to another over time	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Land Use & Condition	Forest Cover (includes upland and wetland forest)	Condition	Metric	% cover in watershed	Western	Resource Categories & Indicators (Conservation Ontario)	Ontario
Land Use & Condition	Forest Interior	Condition	Metric	% forest cover of lands > 100 m from outside edge;	Western	Resource Categories & Indicators (Conservation Ontario)	Ontario
Land Use & Condition	Forested Riparian Zone	Condition	Metric	% forest cover of lands within 30 m of open waterscources	Western	Resource Categories & Indicators (Conservation Ontario)	Ontario
Land Use & Condition	Wetland Cover	Condition	Metric	% land cover of wetlands	Western	Resource Categories & Indicators (Conservation Ontario)	Ontario
Land Use & Condition	Land Cover	Condition	Metric	Natural Vegetative Cover	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Land Use & Condition	Riparian Health	Condition	Index	Riparian Health Assessment	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Land Use & Condition	Parks & Recreation	Response	Index	Parks, conservation & protected areas	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Land Use & Condition	Wetlands Inventory	Condition	Index	Merged wetlands inventory, % area covered by wetlands	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Land Use & Condition	Land Use	Pressure	Index	Agricultural Land Use, Linear development, Land development	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Land Use & Condition	Extent of each habitat type or ecological system	Condition	Index	Area, Perimeter-to-area ratio, Core area	Western	USEPA Watershed Health Index	United States of America
Land Use & Condition	Landscape Composition	Condition	Index	- Number of habitat types Number of patches of each habitat - Presence/absence of native plant communities	Western	USEPA Watershed Health Index	United States of America
Land Use & Condition	Interior Forests	Condition	Metric	Not Stressed: > 50% of the land surface of the quaternary watershed is interior forest. Vulnerable: 20-50% of the land surface of the quaternary watershed is interior forest. Stressed: < 20% of the land surface of the quaternary watershed is interior forest	Western	Muskoka Watershed Report Card 2023	Ontario
Land Use & Condition	Erosion (Riverine & Lake Ontario Shoreline)	Pressure	Metric	Active vs. resolved riverine erosion sites	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Land Use & Condition	Land Cover	Condition	Index	Low Impact Development (LID): - % of watersheds with < 10% impervious cover	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Land Use & Condition	Natural Cover (Quantity & Quality)	Response	Index	Minimum 35% regional areal coverage (2022 target). Protect 23% existing natural cover and restore 12% potential natural cover.	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Land Use & Condition	% Change in Forest Cover	Pressure	Metric	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Land Use & Condition	Impact of Forestry Activities on Riparian Zones	Pressure	Index	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Land Use & Condition	Resource Roads and Stream Crossing	Pressure	Index	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Land Use & Condition	Forestry	Pressure	Metric	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Land Use & Condition	Agriculture	Pressure	Metric	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Land Use & Condition	Mining Activity	Pressure	Metric	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Land Use & Condition	Land Use/Land Cover	Condition	Index	*Land Use / Types* '- Natural Areas (water bodies/wetlands • Coniferous forest • Deciduous forest • Mixed forest • Shrubland • Grassland - Agricultural Land (Annual cropland, Perennial cropland and pasture, Rangeland) - Industrial Areas (Non-vegetated/barren land, Forest clear-cuts - Urban/residential (Urban residential, development/settlement, Non urban residential development) - Other (Roads and rail lines, other) - Linear Disturbances (roads, power transmission lines, seismic lines, and pipelines)	Western	State of Watershed Reports - Common Watershed Indicators for Alberta (Government of Alberta)	Alberta
Land Use & Condition	Riparian Health	Condition	Index	Different methodologies have been used in Alberta for assessing riparian health (e.g., on-site biophysical inventories, and aerial videography). Each of these examples consider and weigh different parameters, and have different scoring methods and ratings.	Western	State of Watershed Reports - Common Watershed Indicators for Alberta (Government of Alberta)	Alberta
Water Quality	No animals in the vicinity	Pressure	Index	There should be no animals around to contaminate the water. Ducks swimming in water can be a sign that it is not contaminated.	*Indigenous / Co-Created*	Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations)	Yukon
Water Quality	E. coli	Condition	Metric	# colonies/100 mL (within acceptable provincial and health authority guidelines for swimming and recreation)	*Indigenous / Co-Created*	Aspirational Targets for Watershed Health (Cowichan Watershed Board)	British Columbia
Water Quality	Total Suspended Solids	Condition	Metric	mg/L (meet PWQ targets)	*Indigenous / Co-Created*	Aspirational Targets for Watershed Health (Cowichan Watershed Board)	British Columbia
Water Quality	Water Quality State	Condition	Metric	- Local observations & oral histories - Ambient surface water, groundwater, and sediment concentrations - Relative abundance of aquatic macroinvertebrates - Local approaches to water quality assessment	*Indigenous / Co-Created*	State of the Aquatic Ecosystem Report - Conceptual Framework (Mackenzie River Basin Board)	Western Canada*
Water Quality	Colour	Condition	Metric	Water should be clear with no color (e.g., tap water can be grayish or yellow).	*Indigenous / Co-Created*	Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations)	Yukon
Water Quality	Turbidity	Condition	Metric	The term "White Water" refers to clear water that you could see through. This means that water with limited turbidity is desirable.	*Indigenous / Co-Created*	Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations)	Yukon
Water Quality	Running Water	Condition	Metric	Water should be fast flowing and not stagnant.	*Indigenous / Co-Created*	Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations)	Yukon
Water Quality	Nothing Growing	Pressure	Index	No moss or plants should be growing on the rocks.	*Indigenous / Co-Created*	Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations)	Yukon
Water Quality	Makes good tea	Condition	Metric	Water should make red tea. Bad water makes black tea that leaves stains in your cup.	*Indigenous / Co-Created*	Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations)	Yukon
Water Quality	Odor	Condition	Metric	There should be no smell.	*Indigenous / Co-Created*	Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations)	Yukon
Water Quality	Taste	Condition	Metric	It should have a "fresh" taste. It should taste "good." It should not taste like chlorine.	*Indigenous / Co-Created*	Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations)	Yukon
Water Quality	Physical Appearance	Condition	Index	Worse = water looks worse now than in the past Same = water looks the same now as in the past Better = water looks better now than in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Water Quality	Access to Clean and Safe Drinking Water	Condition	Index	- Do you have to travel further to access clean and safe drinking water on Great Slave Lake? How many kms from the mouth of Hay River? - Where and when is it safe to drink water? - Are there times and places where it is no longer safe to drink the water? - Does the water have to be boiled before it is safe to drink?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Water Quality	Colour of Water and Clearness	Condition	Metric	Has the colour or clearness of the water changed? Is the water dark, murky, dirty or yellow?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Water Quality	Perceived Risk of Contamination (Water)	Condition	Index	- Is the body of water in close proximity or downstream of industry? - Are contaminants like diesel present in the water?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Water Quality	Algae Growth	Condition	Metric	Is there "green stuff" or algae on the water?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Water Quality	Taste	Condition	Metric	Does the water taste fresh?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Water Quality	Temperature Change (water)	Condition	Metric	Is the water temperature warming?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Water Quality	Water quality testing	Condition	Index	Several Elders noted that they would like water quality sampling to be conducted at the water sources they use.	*Indigenous / Co-Created*	Relationships to Treated and Traditional Water Sources (Tr'ondëk Hwëch'in First Nations)	Yukon
Water Quality	Total phosphorus	Condition	Metric	mg/L	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Water Quality	Dissolved oxygen	Condition	Metric	mg/L	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Water Quality	Maximum annual water temperature	Condition	Metric	ºC	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Water Quality	Chlorophyll-a	Condition	Metric	mg/L	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Water Quality	Water mercury	Condition	Metric	mg/L	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Water Quality	Combined sewer overflows	Pressure	Metric	# of sewage releases	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Water Quality	Blue-green algal blooms	Condition	Metric	# of blooms	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Water Quality	Total Phosphorus	Condition	Metric	mg/L	Western	Resource Categories & Indicators (Conservation Ontario)	Ontario
Water Quality	E.Coli	Condition	Metric	# colonies/100 mL	Western	Resource Categories & Indicators (Conservation Ontario)	Ontario
Water Quality	Nitrite + Nitrate	Condition	Metric	mg/L	Western	Resource Categories & Indicators (Conservation Ontario)	Ontario
Water Quality	Chloride	Condition	Metric	mg/L	Western	Resource Categories & Indicators (Conservation Ontario)	Ontario
Water Quality	Water related advisories	Condition	Index	algae, fecal coliform, drinking water	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Water Quality	Water Quality	Condition	Index	River water quality index, tributary stream quality	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Water Quality	Nutrient concentrations: Nitrogen Phosphorus Other nutrients (e.g., calcium, potassium, silicon)	Condition	Index	mg/L	Western	USEPA Watershed Health Index	United States of America

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Water Quality	Trace metals in sediments and suspended particulates: Copper Zinc	Condition	Index	μg/L	Western	USEPA Watershed Health Index	United States of America
Water Quality	pH	Condition	Metric	pH	Western	USEPA Watershed Health Index	United States of America
Water Quality	Dissolved oxygen	Condition	Metric	mg/L	Western	USEPA Watershed Health Index	United States of America
Water Quality	Calcium	Condition	Metric	mg/L	Western	Muskoka Watershed Report Card 2023	Ontario
Water Quality	Phosphorus	Condition	Metric	μg/L	Western	Muskoka Watershed Report Card 2023	Ontario
Water Quality	Chloride	Condition	Metric	mg/L + consideration for Road Density	Western	Muskoka Watershed Report Card 2023	Ontario
Water Quality	Algal Blooms	Pressure	Index	# of recorded annual "Harmful Algal Blooms"	Western	Muskoka Watershed Report Card 2023	Ontario
Water Quality	Total Phosphorus	Condition	Metric	mg/L	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Water Quality	Nitrogen (nitrite and nitrate)	Condition	Metric	mg/L	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Water Quality	Chloride	Condition	Metric	mg/L	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Water Quality	E.Coli	Condition	Metric	100 CFU/100 ml	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Water Quality	Total Suspended Solids	Condition	Metric	mg/L	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Water Quality	Metals	Condition	Metric	μg/L	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Water Quality	Water Quality Index	Condition	Index	# of PWQO exceedances for: - total suspended solids - chloride - copper - iron - zinc - phosphorus - nitrogen - E. coli	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Water Quality	Western Durham Nearshore Water Quality	Condition	Index	Nearshore Total Phosphorus Nearshore E.coli	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Water Quality	Exceedance of water quality thresholds (weighted averages past 5 years).	Condition	Index	Aluminum, Ammonia , Arsenic, Cadmium, Chloride, Copper, Dissolved Oxygen, Iron, Lead, Mercury, Nickel, Nitrite, Nitrogen, pH, Phosphorus, Uranium, Zinc (mg/L & μg/L)	Western	Watershed Reports 2020 (World Wildlife Foundation)	Canada-wide
Water Quality	Variance of annual water quality scores	Condition	Metric	Not Provided	Western	Watershed Reports 2020 (World Wildlife Foundation)	Canada-wide
Water Quality	Directional trend in proportion of exceedance of water quality thresholds.	Condition	Index	Significant Mann-Kendal time- series test	Western	Watershed Reports 2020 (World Wildlife Foundation)	Canada-wide
Water Quality	Water Quality Impacts from Forestry Activities	Pressure	Index	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Water Quality	Freshwater Temperature	Condition	Metric	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Water Quality	Nutrient Concentrations	Condition	Index	**Possible Options:** - Single Metric Indicators - River Nutrient Index — Larger Rivers Only - Trophic Status — Lakes	Western	State of Watershed Reports - Common Watershed Indicators for Alberta (Government of Alberta)	Alberta

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Water Quality	Bacteria Concentrations	Condition	Index	**Possible Options:** - Sectoral Water Allocation Index - Licensed Water Allocations over Time - Licensed Allocations Compared to Average Natural Flow	Western	State of Watershed Reports - Common Watershed Indicators for Alberta (Government of Alberta)	Alberta
Water Quality	Area of Concern Status	Response	Index	Beneficial Use Impairments (BUIs) BUI: Degradation of Aesthetics BUI: Beach Closures	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Water Quantity & Security	Snow & Ice	Condition	Index	- Available modeling information & statistics - Seasonal Statistics	*Indigenous / Co-Created*	State of the Aquatic Ecosystem Report - Conceptual Framework (Mackenzie River Basin Board)	Western Canada*
Water Quantity & Security	Flows & Levels	Condition	Metric	- Local observations & oral histories - Seasonal statistics	*Indigenous / Co-Created*	State of the Aquatic Ecosystem Report - Conceptual Framework (Mackenzie River Basin Board)	Western Canada*
Water Quantity & Security	Water Use & Pollutant Loadings	Pressure	Metric	- Local important community water sources - Water demand from various sectors - Number of water licenses, purpose, volume - Volume of effluent discharges	*Indigenous / Co-Created*	State of the Aquatic Ecosystem Report - Conceptual Framework (Mackenzie River Basin Board)	Western Canada*
Water Quantity & Security	Water Levels (Qualitative Observations)	Condition	Index	- Are water levels declining in rivers and lakes? - Are small creeks and streams drying up? - Are there new sandbars/islands appearing in the Hay River, on Buffalo River? - Is the shoreline changing on Great Slave Lake? - Are certain traditional areas difficult to access (e.g., Alexandra Falls, Buffalo River)? - Are you able to walk across certain rivers in the summertime? - Is the body of water located downstream of hydroelectric development?	*Indigenous / Co-Created*	Traditional Ecological Knowledge Indicators (Kátł'odeeche First Nation)	North West Territories
Water Quantity & Security	Water Flow	Condition	Index	Less = there is less water flow now than there was in the past Same = there is the same water flow now than there was in the past More = there is more water flow now than there was in the past	*Indigenous / Co-Created*	Traditional knowledge Indicators for Bayesian Network Model (Slave River and Delta Partnership)	Western Canada*
Water Quantity & Security	Water flow	Condition	Metric	Minimum and maximum river flows [m3/s] per year, and ratio of maximum to minimum flow	Western	Watershed Health Assessment and Monitoring project (Ottawa River Keepers)	Ontario
Water Quantity & Security	Water Quantity	Condition	Index	Water usage, water flow & availability	Western	Battle River Watershed Health Indicator Framework (Battle River Watershed Alliance)	Alberta
Water Quantity & Security	Pattern of surface flows (rivers, lakes, wetlands)	Condition	Index	- Flow magnitude and variability (including frequency, duration, timing and rate of change) - Water level fluctuations in wetlands and lakes	Western	USEPA Watershed Health Index	United States of America
Water Quantity & Security	Water level fluctuations in wetlands and lakes	Condition	Index	- Distribution of plants tolerant to flooding - Area flooded by 2-year and 10-year floods	Western	USEPA Watershed Health Index	United States of America
Water Quantity & Security	Groundwater Quantity (change)	Condition	Metric	GW change (rise/ fall in meters) - timespan???	Western	Watershed and Ecosystems Reporting Hub (Toronto Region Conservation Authority)	Ontario
Water Quantity & Security	Long-Term Trends in Monthly Flow	Condition	Index	Average percentage change in median monthly flow, measured as the relative change in median monthly flow per year, reported as an average across studied stations and weighted by the median annual flow per station.	Western	Watershed Reports 2020 (World Wildlife Foundation)	Canada-wide
Water Quantity & Security	Recent-Term Trends in Monthly Flow	Condition	Index	Average percentage change in median monthly flow, measured as the relative change in median monthly flow per year, reported as an average across studied stations and weighted by the median annual flow per station	Western	Watershed Reports 2020 (World Wildlife Foundation)	Canada-wide

Watershed Resilience Category	Watershed Health Indicator	Indicator Type	Metric or Index	Unit or Scale of Measurement	Framework Worldview	Watershed Health Indicator Framework Title	Province / Country
Water Quantity & Security	Long-Term Trends in Annual Flow	Condition	Index	Average percentage change in median annual flow, reported as an average across studied stations and weighted by the median annual flow per station.	Western	Watershed Reports 2020 (World Wildlife Foundation)	Canada-wide
Water Quantity & Security	Pre- vs. Post-Dam or Recent vs. Historical Analsis of Monthly Flow	Pressure	Index	Percentage of total months, for all stations analyzed, with significantly different variance in monthly flow pre-vs. post-dam operation or for historical vs. Recent time periods in undammed systems. % change in median monthly flow (pre-and post-dam) ***or*** for historical vs. recent time periods in undammed systems, Results averaged across studied stations by mean annual flow	Western	Watershed Reports 2020 (World Wildlife Foundation)	Canada-wide
Water Quantity & Security	Water Quantity and Flow	Condition	Index	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Water Quantity & Security	Licensed Water Volume by Sector	Pressure	Index	Not Provided	Western	Nechako Watershed Strategy (Fraser River Basin Council & Nechako Watershed Alliance)	British Columbia
Water Quantity & Security	Licensed Allocations	Pressure	Index	- Bacterial Index — Large Rivers Only	Western	State of Watershed Reports - Common Watershed Indicators for Alberta (Government of Alberta)	Alberta
Water Quantity & Security	Variations in Annual Flow and Lake Levels	Condition	Index	**Possible Options:** - Historical Lake Level Index - River Flow Quantity Index	Western	State of Watershed Reports - Common Watershed Indicators for Alberta (Government of Alberta)	Alberta
Water Quantity & Security	Flow Commitments	Pressure	Index	**Possible Options:** - Water Conservation Objectives (Alberta Water Act) - In Stream Flow Needs	Western	State of Watershed Reports - Common Watershed Indicators for Alberta (Government of Alberta)	Alberta
Water Quantity & Security	Groundwater Allocations	Pressure	Index	Possible Options: - Licensed Allocations - Unlicensed Allocations and Withdrawals	Western	State of Watershed Reports - Common Watershed Indicators for Alberta (Government of Alberta)	Alberta
Water Quantity & Security	Groundwater Well Density	Pressure	Index	Possible Options: - Distribution of Water Wells in Alberta	Western	State of Watershed Reports - Common Watershed Indicators for Alberta (Government of Alberta)	Alberta