COLUMBIA BASIN WATER MONITORING FRAMEWORK

PLANNING FOR WATERSHED SECURITY

PILOT IMPLEMENTATION REPORT 2022

Prepared by Living Lakes Canada

DUNCAN LAKE I PHOTO BY TRAVIS ADAMS

BACKGROUND AND ACKNOWLEDGEMENTS

This report acknowledges the collaboration between water stewardship groups, Indigenous and non-Indigenous communities, academia, industry and government, who are working together to increase climate adaptation options within the region known as the Columbia Basin. This collaborative work is intended to support the longer-term viability of natural ecosystem health and the water security services they provide.

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The pilot implementation of the Columbia Basin Water Monitoring Framework was made possible thanks to support from:

Province of BC, Healthy Watersheds Initiative partners (Stronger BC, Real Estate Foundation of BC, Watersheds BC), Province of BC, Columbia Basin Trust, Canada's Digital Technology Supercluster partners (Carl Data Solutions, Teck Resources Ltd., Microsoft, Astra Smart Systems, i4C Innovation, the University of Victoria and Genome BC), MakeWay, RBC Tech for Nature, Regional District of Central Kootenay, Sitka Foundation, Slocan Valley Legacy Fund, and the Vancouver Foundation.

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LAND ACKNOWLEDGEMENT

Living Lakes Canada acknowledges that this project is taking place in the unceded traditional territories of the Ktunaxa, Lheidli T'enneh, Secwepemc, Sinixt and Syilx Nations who have stewarded these lands for generations. Recognizing Indigenous People as the rightful caretakers of their unceded territories, we work to complement their intergenerational work and Indigenous-led water stewardship initiatives.

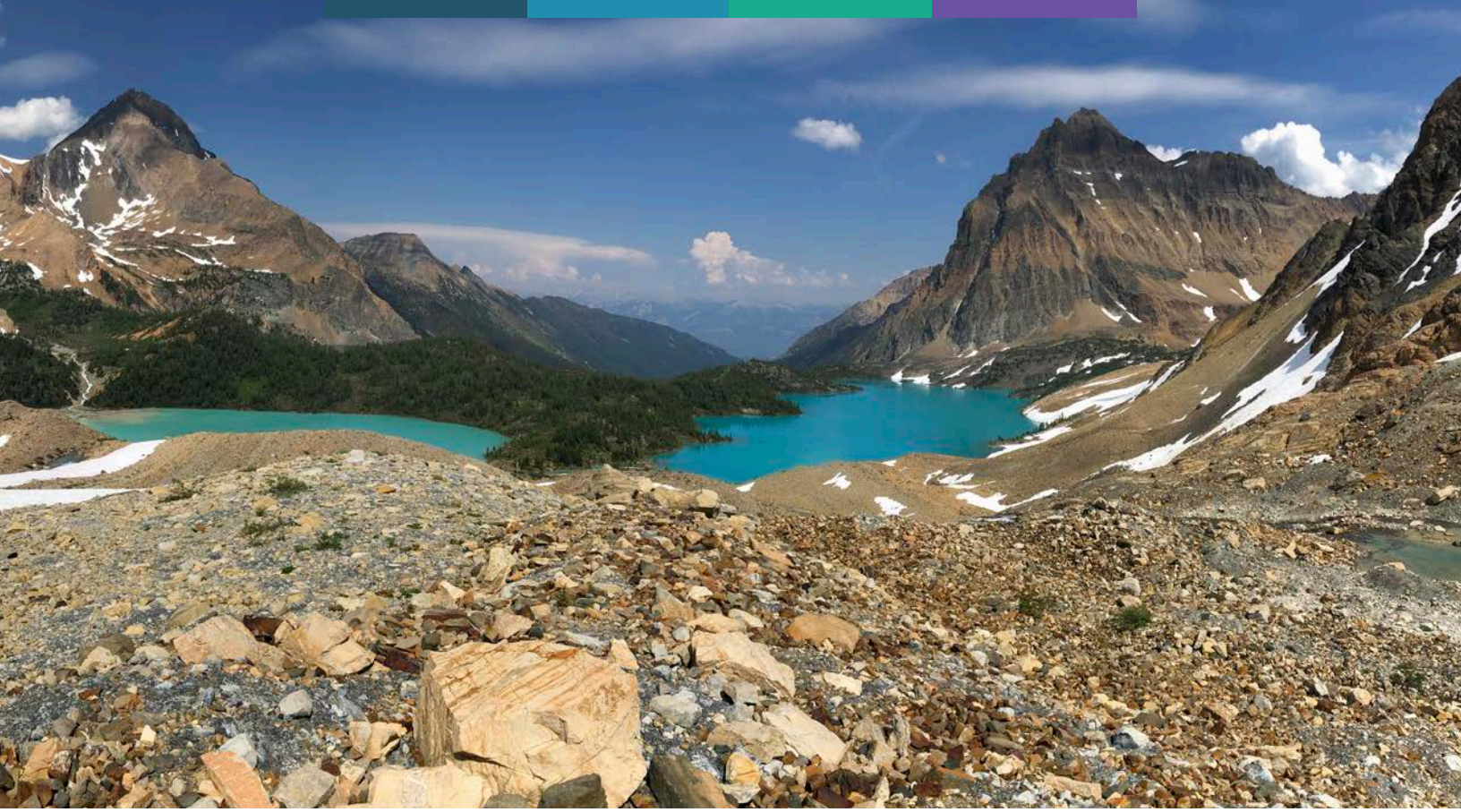


PHOTO BY NICOLE TRIGG

EXECUTIVE SUMMARY

The critical issues of water resource management amid climate change impacts in the Upper Columbia Basin have been identified in a series of reports from the Pacific Climate Impacts Consortium dating back to 2006. These reports highlighted the requirement to increase monitoring and research to more appropriately understand climate impacts, while developing a collective, large-scale effort to prepare communities and industry for change.

The goal of the Columbia Basin Water Monitoring Framework is to establish a unified monitoring network based on a Priority Monitoring Matrix that reflects local community priorities and concerns within a scientific water balance approach. This collaborative approach, facilitated by Living Lakes Canada, will improve and strengthen the monitoring configuration for tracking and understanding a broader range of implications of climate change on the water supply for Basin ecosystems and its people. It will also support local and regional efforts to increase adaptation options and support the longer-term viability of natural ecosystems and ecosystem services.

The groundwork for a monitoring framework was established in 2020 when Living Lakes Canada convened a meeting of senior hydrologists from government, consulting agencies, and academia, who reached consensus that a water balance approach was needed to fill the water data gaps in the Columbia Basin. Guided by the meeting outcomes, Living Lakes Canada contracted local experts in 2021 to develop the methodology used to develop the monitoring network.

Integral to the process is the selection of monitoring sites using a Priority Monitoring Matrix which is developed to collate scientific and community priorities, identify synergies, and select sites which will meet multiple objectives, resulting in a nested, cost-effective approach to monitoring.

In 2022, Living Lakes Canada piloted this innovative approach to water monitoring in three pilot areas:

- Mid-Columbia Kootenay - (North Kootenay Lake/Slocan Valley in the West Kootenay)
- Columbia-Kootenay Headwaters - (Columbia Valley in the East Kootenay)
- Elk River Valley - (in the East Kootenay - in partnership with the Elk River Watershed Monitoring Collaborative led by Elk River Alliance)

A Local Reference Group was formed for each pilot area, to gather local water monitoring priorities and concerns. Living Lakes Canada's Applied Reconciliation Coordinator worked closely with Indigenous groups in the pilot areas to create meaningful engagement and to incorporate Indigenous water priorities into this project. Geospatial data gap analysis and stratification of watersheds were conducted by a consultant to identify monitoring needs for a Water Balance.

Locations were identified for 23 hydrometric stations, nine lake level stations and three climate stations in 2022. In 2023, further monitoring will be implemented and preliminary data from the pilot project will be available on the Columbia Basin Water Hub.

The data on the Water Hub can be used by community members, researchers, the private sector, all levels of government and decision makers. This data will support efforts to build a more comprehensive understanding of the state of water supply and water quality in local jurisdictions and to establish adaptation options.

The watershed security and adaptation work being facilitated by Living Lakes Canada in the Canadian Columbia Basin can serve as a paradigm-changing template that can be applied in other regions.

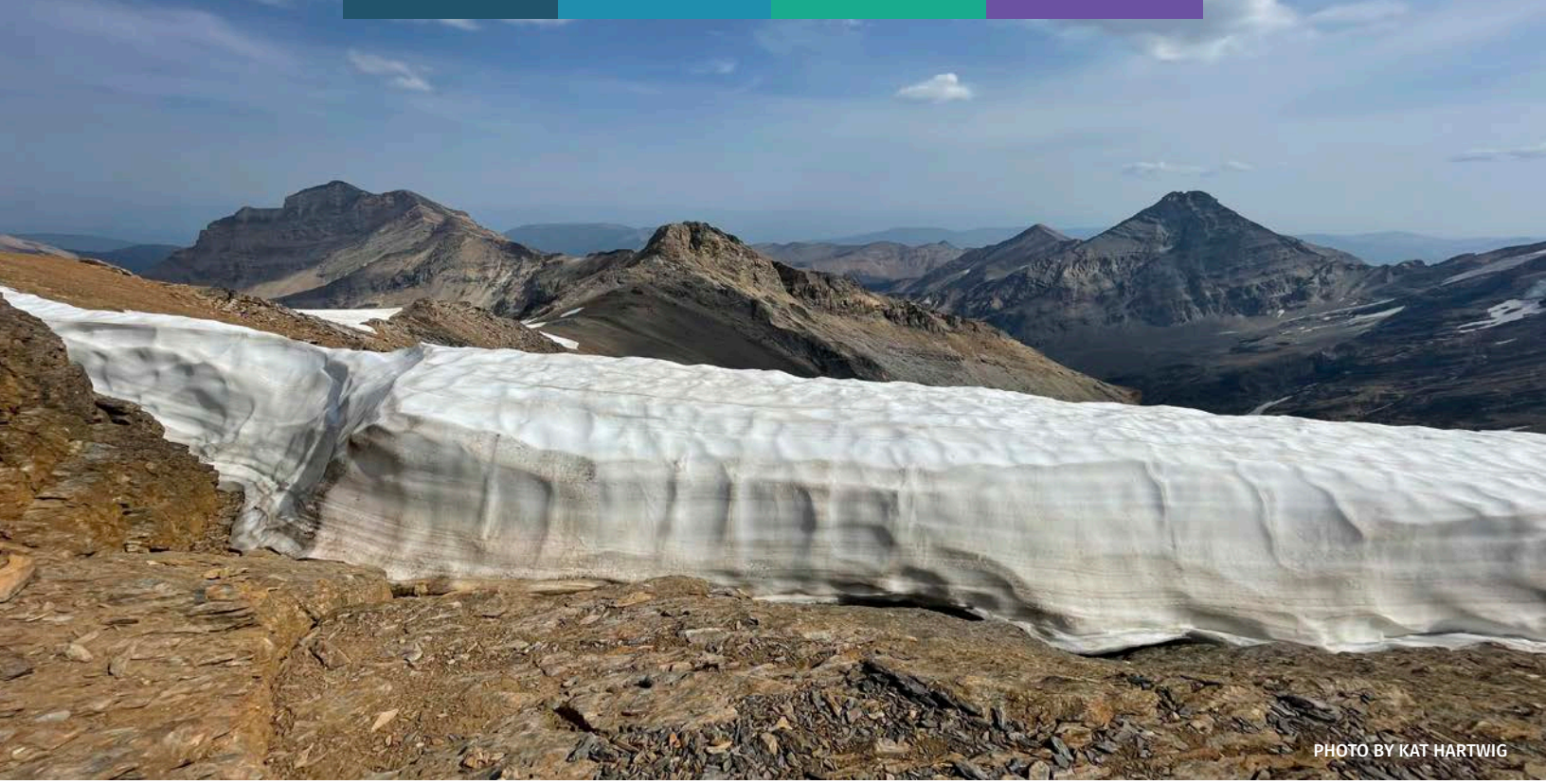


PHOTO BY KAT HARTWIG

ABBREVIATIONS

CABIN - Canadian Aquatic Biomonitoring Network

CBWMF - Columbia Basin Water Monitoring Framework

CKH - Columbia-Kootenay Headwaters

ERV - Elk River Valley

LLC - Living Lakes Canada

LRG - Local Reference Group

MCK - Mid-Columbia Kootenay

PCIC - Pacific Climate Impacts Consortium

RISC - Resources Information Standards Committee

STREAM - Sequencing The Rivers for Environmental Assessment and Monitoring

WSC - Water Survey of Canada

INTRODUCTION

Program Goal

The goal of the Columbia Basin Water Monitoring Framework (CBWMF) is to establish a unified monitoring network based on a Priority Monitoring Matrix that reflects local community priorities and concerns within a scientific water balance approach. This collaborative approach, facilitated by Living Lakes Canada, will improve and strengthen the monitoring configuration for tracking and understanding a broader range of implications of climate change on the water supply for Basin ecosystems and its people. It will also support local and regional efforts to increase adaptation options and support the longer-term viability of natural ecosystems and ecosystem services.

Background

The critical issues of water resource management amid climate change impacts in the Upper Columbia Basin have been identified in a series of reports from the Pacific Climate Impacts Consortium[1], [2] (PCIC) dating back to 2006 and from the Columbia Basin Trust[3] in 2017. These reports highlighted the requirement to increase monitoring and research to more appropriately understand climate impacts, while developing a collective, large-scale effort to prepare communities and industry for change.

Living Lakes Canada began implementing report recommendations in 2017 by holding a conference (Living Lakes Canada, 2017)[4] that brought together 120 water data experts, as well as Indigenous and non-Indigenous community members, to discuss what a water monitoring framework and an accompanying open-source water data hub would look like for the Canadian Columbia Basin.

Living Lakes Canada then led a collaborative, multi-year development process involving volunteer and paid steering committee members, various agencies, industry, academia, First Nations and community organisations. This process culminated with the launch of the Columbia Basin Water Hub[5] (www.cbwaterhub.ca) in 2021 as the central platform to access water data in the Columbia Basin region.

PAT MORROW PHOTO

Development of Methodology

The groundwork for a monitoring framework was established in 2020 when Living Lakes Canada convened a meeting of senior hydrologists from government, consulting agencies, and academia, who reached consensus that a water balance approach was needed to fill the water data gaps in the Columbia Basin[6]. Guided by the meeting outcomes, Living Lakes Canada contracted local experts in 2021 to develop the methodology used to develop the monitoring network, outlined in the Terms of Reference[7] document.

According to the methodology, a Priority Monitoring Matrix is developed to collate scientific and community water monitoring priorities. The process allows for site selection to meet multiple objectives, resulting in a nested, synergistic, and cost-effective approach to monitoring.

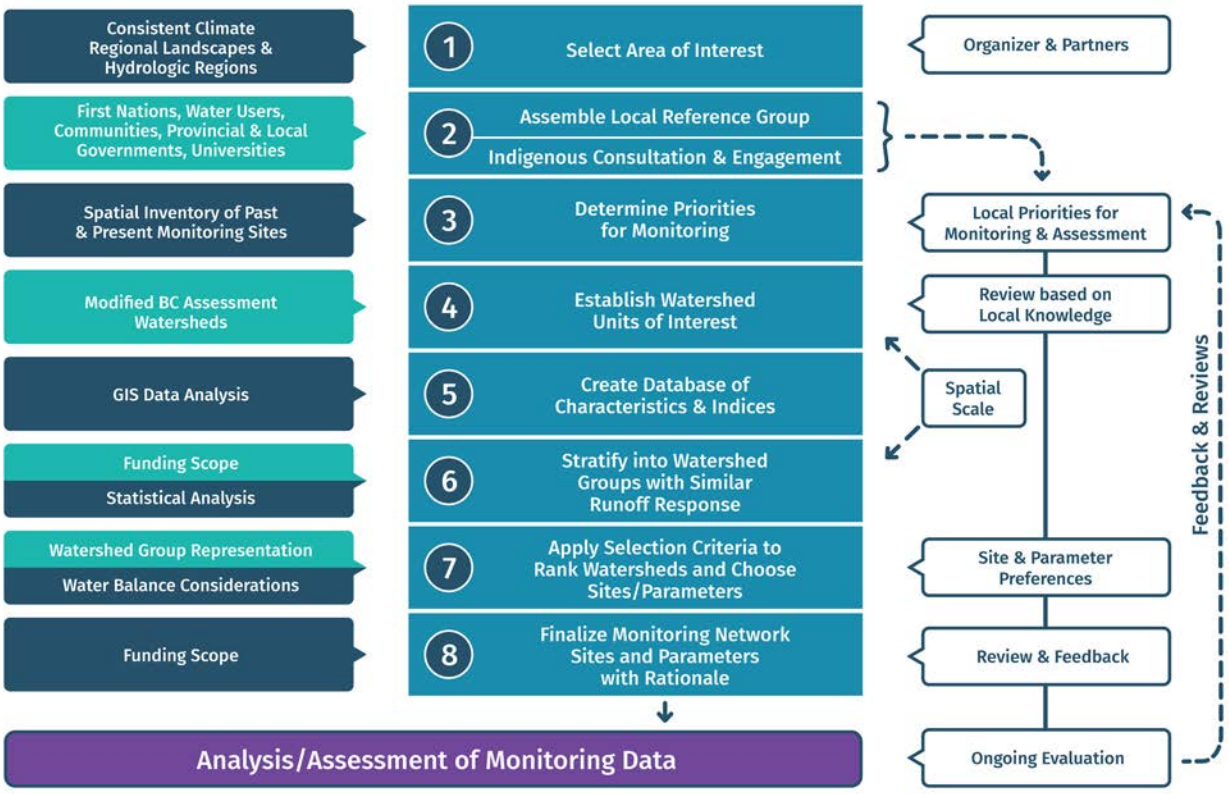
Watersheds are stratified into groups that tend to respond similarly to climate impacts. A GIS data gap analysis is conducted to understand the number and types of watersheds that are already being monitored. Sites are selected to ensure that each watershed grouping is represented in the expanded network.

Local priorities for expanded monitoring are identified through consultation with First Nations and the creation of a Local Reference Group (LRG) for each Area of Interest, composed of water stewardship groups; community members; First Nations; industry/commercial water users; and local, regional, and provincial governments.

Scientific needs and community priorities are both considered during the site selection process. Sites are identified for streamflow; groundwater, lake and wetland level; water quality; and biomonitoring using the federal Canadian Aquatic Biomonitoring Network (CABIN) protocol, and the Sequencing the Rivers for Environmental Assessment and Monitoring (STREAM) eDNA protocol. Data is collected according to the appropriate standards and third-party protocols to ensure that it can be used for analysis, research and decision making.

The methodology is broadly outlined in the Terms of Reference[8] document. The Methods section of this report expands on how the methodology was implemented in three pilot areas of the Columbia Basin in 2022.

FIGURE 1. OVERVIEW OF THE CBWMF METHODOLOGY AND THE INPUTS REQUIRED AT EACH STEP. FOR A FULL-SIZE VERSION SEE APPENDIX ON PAGE 50.

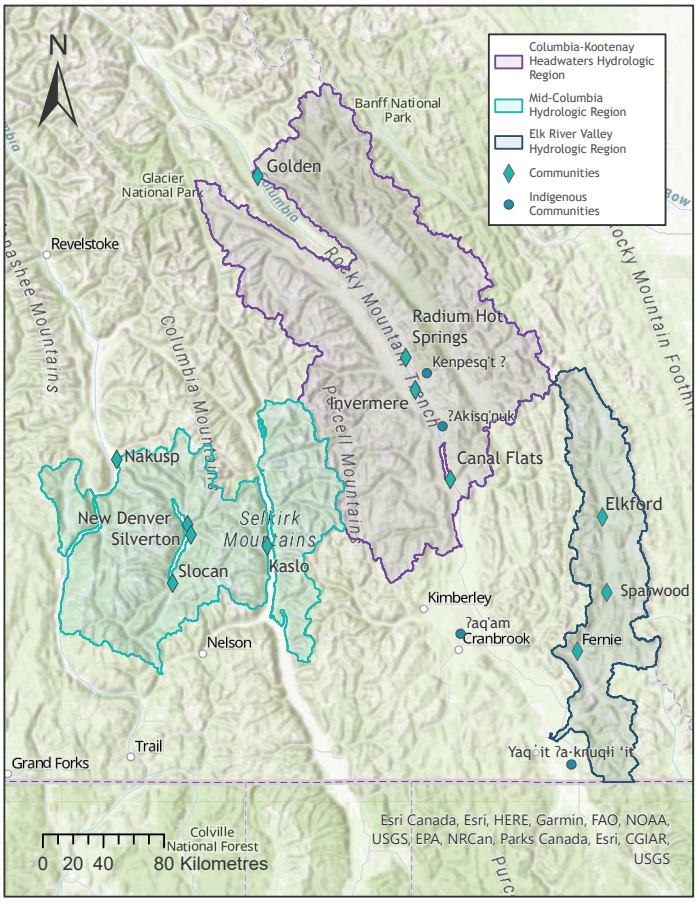


2022 Pilot Implementation

In 2022, Living Lakes Canada piloted this innovative approach to water monitoring in three pilot areas:

- Mid-Columbia Kootenay - (North Kootenay Lake/Slocan Valley in the West Kootenay)
- Columbia-Kootenay Headwaters - (Columbia Valley in the East Kootenay)
- Elk River Valley - (in the East Kootenay - in partnership with the Elk River Watershed Monitoring Collaborative led by Elk River Alliance)

Living Lakes Canada applied the methods outlined in the Terms of Reference[9] in each of these pilot areas. The 2022 pilot of this project marked a major milestone in efforts to begin addressing identified data gaps in the Columbia Basin. Lessons were learned by all members of the project team, with open-ended feedback gathered from Indigenous and non-Indigenous community members, stewardship groups, all levels of government, and expert advisors. Learnings, feedback, and recommendations will be used in the refinement of the methodology.



COLUMBIA BASIN WATER MONITORING FRAMEWORK PILOT AREAS.

Preliminary data from the pilot project will be available on the Columbia Basin Water Hub in early 2023. The data can then be used by community members, researchers, the private sector, and all levels of government to inform water management and stewardship decisions.

METHODS

Community Engagement

LOCAL REFERENCE GROUP ENGAGEMENT

Assembly of Local Reference Groups

A Local Reference Group (LRG) was formed for each pilot area, and participants shared information through several virtual meetings, online surveys, an interactive mapping tool and interviews with individuals or in small groups.

An LRG Coordinator was contracted for each pilot area, and assigned to build connections, conduct community engagement, and communicate the interests of the Local Reference Group to the rest of the project team. The first task for each LRG Coordinator was to build a database of contacts within all levels of government, First Nations, stewardship groups, and the private sector to serve as a preliminary list of invitees. These lists were expanded upon as new connections were made throughout the process.

In the Elk River Valley, the Elk River Alliance had already formed a working group for the Elk River Watershed Monitoring Collaborative. Members of this working group comprised the LRG for that area, and the Project Manager for that project also served as the LRG Coordinator. Efforts were made to identify shared objectives and synergies between the CBWMF and the Elk River Watershed Monitoring Collaborative, leading to more cost-effective and impactful delivery.

An inaugural meeting was held via Zoom for each LRG. At these meetings, the purpose of the project was introduced, and preliminary conversations were facilitated to broadly identify local concerns and water monitoring priorities. Summary reports for the inaugural meetings for the Mid-Columbia

Kootenay and Columbia-Kootenay Headwaters are available on the Living Lakes Canada website. After this inaugural meeting, a survey was circulated to understand how LRG participants would prefer to engage in this process and provide the opportunity for participants to recommend other individuals or groups that should be included.

Indigenous Engagement

It is a priority for Living Lakes Canada to support Indigenous priorities, such as Indigenous-led salmon reintroduction and the monitoring required for identifying enduring climate refugia for fish.

Living Lakes Canada's Applied Reconciliation Coordinator worked with Indigenous groups in the pilot areas to facilitate meaningful engagement and to incorporate Indigenous water priorities into this project. Each nation and band within the pilot areas was invited to participate in the LRG meetings, and to also take part in one-to-one interviews, Elder Engagement sessions, and follow-up discussions with the Applied Reconciliation Coordinator and the project team to ensure that their water monitoring priorities were recognized. Data sharing and privacy preferences, site access permissions and other cultural considerations were also incorporated into site selection, equipment installation and monitoring.

AKISQNUK FIRST NATION ELDERS ENGAGEMENT
PHOTO BY CHADD CAWSON

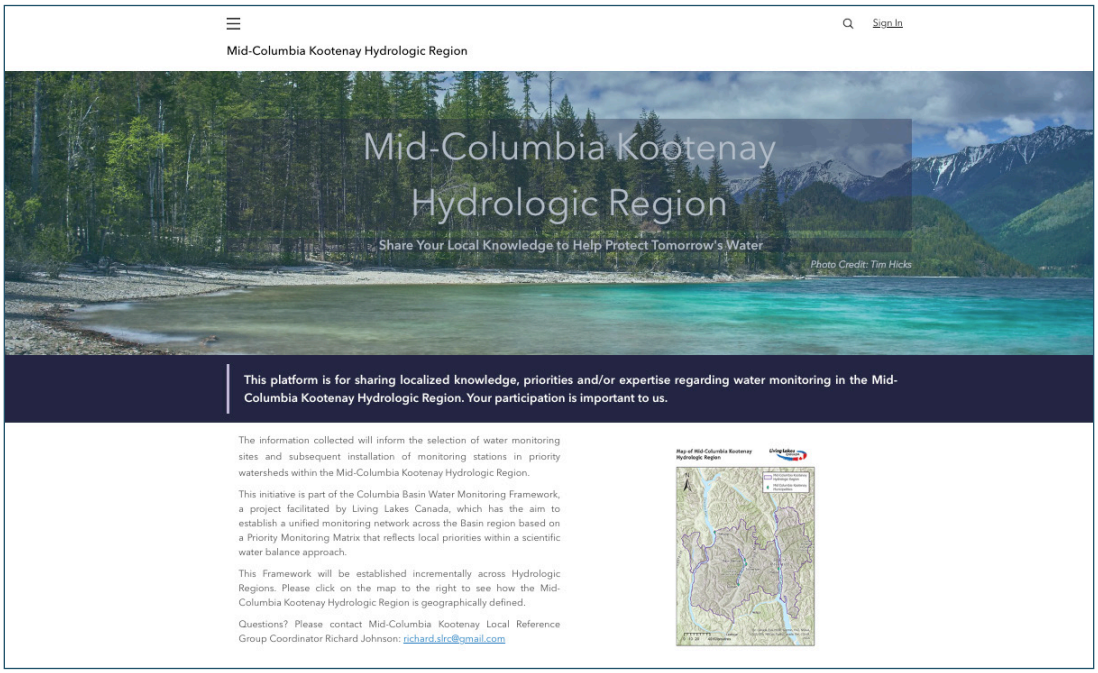
Digital Community Engagement Tools

To collect and interpret local knowledge, concerns, and values, Living Lakes Canada developed an online public engagement portal for each pilot area. The portal consisted of a central webpage with several digital tools, where LRG participants could access and share information.

Each portal displayed a map of the pilot areas so participants could easily understand the geographical boundaries of the pilot area they were providing feedback on.

A second online survey was provided to encourage participants to share their water monitoring priorities. Questions were formatted to gather broad values and priorities (such as drinking water, or species at risk habitat), as well as site specific concerns or recommendations.

An interactive "Collector" map application was also added to each portal. The Collector map displayed the suggested monitoring sites suggested by MacHydro as a result of the data gap analysis. Through the Collector map, users were able to "drop a pin" and leave a comment on the map to share values and concerns, as well as local knowledge. Information contributed through this app was very valuable. Contributions included suggestions for alternative sites, local knowledge such as barriers to accessing certain sites, current or historic monitoring, and areas of concern.



ONLINE PUBLIC ENGAGEMENT PORTAL FOR THE MID-COLUMBIA KOOTENAY PILOT AREA.

The third tool included on the portal for each pilot area was an "Explore Your Watershed" map. It provided the locations of past and present monitoring locations including locations of water quality and quantity stations, snow stations, climate stations, historical disturbance. This map also included other spatial information such as insect infestations, wildfire affected areas, cutblocks, and water licences. This map was for informational purposes only.

A project overview was provided at the second LRG meeting along with an update on the status of the data gap analysis, watershed stratification, and Indigenous engagement. Instruction was provided on how to access the LRG public engagement portals and use the digital tools. Time was allocated for open discussion and questions. Participants were encouraged to complete the online survey, review the suggested monitoring sites, and provide feedback on the Collector map.

GEOSPATIAL DATA GAP ANALYSIS AND WATERSHED STRATIFICATION

A technical report detailing the methods used for the geospatial data gap analysis and watershed stratification is available (Lapp & MacDonald, 2022)[10]. The following is a summary of the methods used for data gap analysis and watershed stratification:

To group watersheds of similar hydrologic character and form the Watershed Groups, MacHydro performed a cluster analysis on the Freshwater Atlas watersheds in each pilot area. The hydrologic characteristics included in the cluster analysis for each Freshwater Atlas watershed were glacier fraction, infiltration rating, forest fraction, wetland fraction, relative humidity, snow fraction, precipitation, temperature, slope-aspect, maximum elevation, mean elevation and basin shape index. From here, Watershed Groups were formed based on the clustering of the hydrologic characteristics. This process was also informed by qualitative aspects, such as the study goals (i.e., how many groups of watersheds could be monitored) and local knowledge (how "different" are these watersheds within the Area of Interest).

The objective of this study was to ensure that at least one representative watershed from each Watershed Group was being monitored to understand the runoff regime. This would allow the results to be extrapolated to other watersheds within the same Group. To identify areas with limited monitoring, the Watershed Groups were overlaid with all monitoring station locations (i.e., active and inactive) for each pilot area. This allowed the amount or density of monitoring sites within each Watershed Group to be quantified. The team was then able to identify Watershed Groups that had limited climate or hydrometric monitoring and make recommendations. The results from this final step provided a quantitative and qualitative analysis of major monitoring data gaps in each Area of Interest.

This analysis yielded a suite of suggested sites for each pilot area. These suggested sites were shared with the LRG participants for review, and additional sites suggested by the community were considered during the site selection process.

SITE SELECTION USING PRIORITY MONITORING MATRIX

The results of the Data Gap Analysis and community engagement were used to create a Priority Monitoring Matrix for each pilot area. Potential sites which had been identified through the Data Gap Analysis were included, as well as additional sites which were suggested by the LRG. Each site was assessed based on how well it would meet scientific needs while also addressing community priorities. Monitoring logistics such as site access, watershed size and flows were also considered.

A proposed network of sites for hydrometric (streamflow), lake level and climate monitoring was outlined for each pilot area. A list of proposed sites, and a map, was shared with the LRG participants via email, with the opportunity to provide feedback on the proposed network.

Local hydrology consultants then conducted site reconnaissance, which led to several proposed locations being deemed unsuitable. Additional feedback from LRG participants, local hydrology consultants and scientific advisors guided the selection of replacement sites.

From the watersheds selected for hydrometric monitoring, several sites were selected for biomonitoring using the federal CABIN (Canadian Aquatic Biomonitoring Network) protocol as well as the STREAM (Sequencing The Rivers for Environmental Assessment and Monitoring) protocol. Biomonitoring sites may vary from year to year as no equipment is installed on site.

Living Lakes Canada also operates the Upper Columbia Basin Groundwater Monitoring Program, High Elevation Monitoring program and Kootenay Watershed Science, all of which have active monitoring sites within the pilot areas. Opportunities to expand those programs in conjunction with the CBWMF are being explored.

Additional needs for hydrometric, climate, groundwater, and high elevation monitoring; and for addressing First Nations priorities around cold water refugia monitoring for fish, will continue to be identified in 2022/2023. Water quality monitoring will also be implemented on select water bodies based on community priorities.

MID-COLUMBIA KOOTENAY

PHOTO BY NICOLE TRIGG

MID-COLUMBIA KOOTENAY PILOT AREA SUMMARY

Mid-Columbia Kootenay Community Priorities

Based on discussions during LRG meetings, survey results and one-to-one consultations, key priorities for the Mid-Columbia Kootenay LRG were identified for monitoring of water quantity, quality and climate[11]. Concerns about impacts of forestry activities, climate change and wildfire on water quality, quantity and timing of flow were a theme. "My interest is in the smaller tributaries to all these systems, [tributaries] that can support fishes. Climate change impacts on these smaller systems is my priority interest, as well as watershed anthropogenic changes, predominantly forest road development (access, culverts, siltation) and harvest impacts," stated one LRG participant. In addition to these broader values and concerns, LRG participants and First Nations also recommended specific water bodies and locations for monitoring according to local needs.

WATER QUANTITY

For monitoring of stream flow and water level, participants identified lakes and streams that are sources of drinking water sources as high priorities. Watersheds that are habitat for Species at Risk, and fish-bearing streams were also identified as priorities for monitoring. Questions around adequate water supply for community use and to support fish populations were raised by several LRG participants.

PHOTOS BY RORY GALLAUGHER

WATER QUALITY

Drinking water sources were also the top priority for water quality monitoring. Industrial activity, Species at Risk habitat and fish-bearing streams were also identified as priorities for water quality monitoring.

CLIMATE

The representation of a diverse range of microclimates was considered a priority for climate monitoring in the Mid-Columbia Kootenay. There was interest in climate monitoring at low, mid and high elevations.

GROUNDWATER

Aquifers identified as "more stressed" in the BC Aquifer Stress Tool were identified as a priority for groundwater monitoring as well as those identified as sources of drinking water.

Mid-Columbia Kootenay Data Gap Analysis Results

Watersheds in the Mid-Columbia Kootenay were stratified into five groups. Table 1 outlines the Watershed Groups that were identified for the Mid-Columbia Kootenay region, and the number of active and inactive Water Survey of Canada (WSC) sites in watersheds of each group.
In general, the higher elevation watersheds with high glacier contribution were not well represented. In addition, relatively remote watersheds towards the west of the Mid-Columbia Kootenay were not represented. Therefore, the focus of this year was to implement mid to higher elevation hydrometric sites and higher elevation climate sites.

TABLE 1. THE NUMBER OF ACTIVE AND INACTIVE WSC STATIONS IN THE WATERSHED GROUPS OF THE MID-COLUMBIA KOOTENAY REGION.

Watershed Group	Description	Number of Active WSC Stations	Number of Inactive WSC Stations
MCK - A	Glaciers	0	1
MCK - B	High elevation, cooler, wetter	1	4
MCK - C	Middle elevation, warmer, drier	1	22
MCK - D	High elevation, warmer	1	7
MCK - E	Lower elevation, warmer, drier	3	48

Sites Selected for Mid-Columbia Kootenay for 2022

Table 2 summarizes the hydrometric, lake level, and climate sites that were selected for installation in 2022. CABIN and STREAM biomonitoring samples were collected on Lemon Creek and Silverton Creek. Sites for water quality and wetland level, as well as additional climate, high elevation, and groundwater monitoring sites are currently being considered for future implementation.

Following the table is a map that shows the locations of the hydrometric, climate, and lake level stations selected for the CBWMF program for 2022. Sites monitored by LLC's Kootenay Watershed Science, Upper Columbia Basin Groundwater Monitoring and High Elevation programs are also included, as the data collected by these programs will contribute to the CBWMF program's objectives.

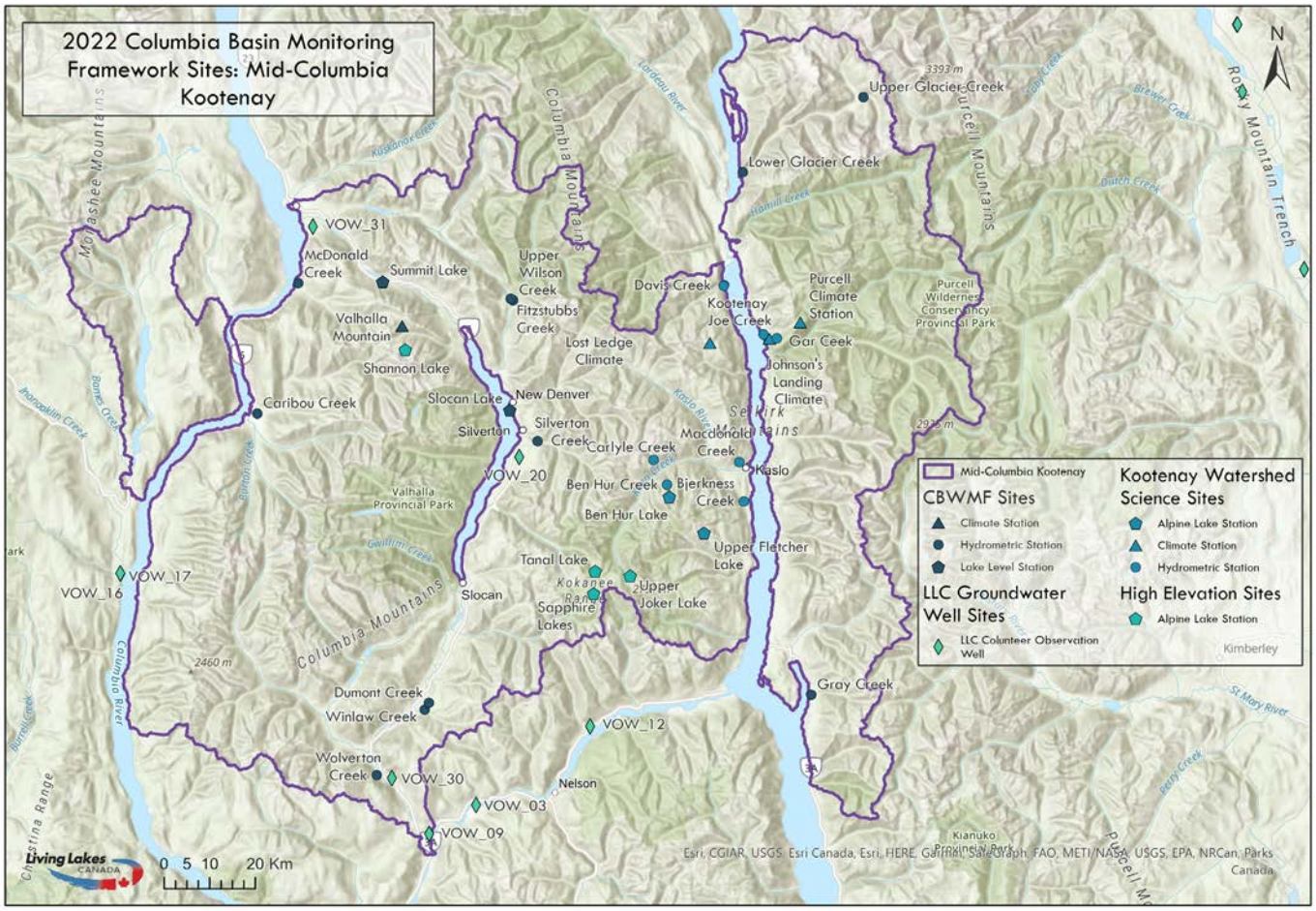
PHOTO BY CLAIRE POLLOCK-HALL

TABLE 2. MONITORING SITES INSTALLED IN 2022 FOR THE PILOT IMPLEMENTATION OF THE COLUMBIA BASIN WATER MONITORING FRAMEWORK IN THE MID-COLUMBIA KOOTENAY REGION.

Name	Watershed Group	Station Type	Latitude	Longitude	Site Selection Rationale
Valhalla	MCK-B	Climate	50.09185	-117.590072	Valhalla Mountain Touring is a local sponsor for this climate station. This location covers a geographic data gap, and is at an elevation of 1710 metres.
Summit Lake	MCK-C	Lake Level	50.14715	-117.6282	This ecosystem is important habitat for the Western toad which is a Schedule 1 Species at Risk under SARA. Smaller lake, with little surrounding development.
Slocan Lake	MCK-E+C	Lake Level	49.98466	-117.37756	The LRG indicated that lake levels on Slocan Lake are of interest due to the relationship between lake level and Slocan River level. Slocan Lake is the largest lake in the MCK that is not regulated by a dam.
Glacier Creek Lower	MCK-A	Hydrometric	50.28502	-116.91844	This is one of the few glacier-fed streams in the MCK that is logistically possible to monitor. There is scientific value in having glacier-fed monitoring sites and the nesting of two sites on one stream to provide a better understanding of processes in the watershed.
Glacier Creek Upper	MCK-B	Hydrometric	50.37954	-116.68015	This is one of the few glacier fed streams in the MCK that is logistically possible to monitor. There is scientific value in having glacier-fed monitoring sites and the nesting of two sites on one stream to provide a better understanding of processes in the watershed.
Upper Wilson Creek	MCK-A+B	Hydrometric	50.12329	-117.371	Wilson Creek is a community priority, identified by LRG as an important tributary to Slocan Lake. This watershed is influenced by glaciers in the higher reaches.
Gray Creek	MCK-B	Hydrometric	49.62267	-116.783	Gray Creek supports numerous water users, improves geographic distribution and coverage of the East Shore of Kootenay Lake.

Name	Watershed Group	Station Type	Latitude	Longitude	Site Selection Rationale
Silverton Creek	MCK-C	Hydrometric	49.94502	-117.323	Identified as a priority by LRG participants. Many water users on this stream.
Fitzstubbs Creek	MCK-C	Hydrometric	50.12507	-117.375	Fitzstubbs Creek is a tributary to Wilson Creek (which was too large to monitor at the mouth), both were identified as community priorities.
McDonald Creek	MCK-C	Hydrometric	50.14522	-117.794	Important stream for fish. There are few active stations in the Lower Arrow Lakes valley so this supports improved geographic coverage of the network.
Caribou Creek	MCK-C	Hydrometric	49.98013	-117.875	Caribou Creek is a source of drinking water for many community members. Monitoring this stream also increases geographic coverage of the Lower Arrow Lakes valley.
Winlaw Creek	MCK-D	Hydrometric	49.60356	-117.545	Good geographic coverage. Adds additional coverage of Group D (high elevation, warmer, drier) which is underrepresented by the current network. This stream is currently monitored by Slocan River Streamkeepers Society. LLC will provide support as needed to keep the site operating in the long-term.
Wolverton Creek	MCK-D+E	Hydrometric	49.519839	-117.639636	Adds a station on the west side of the Slocan Valley, which was requested by the LRG. Community members report that the lower stream temperatures on Wolverton Creek make it an important habitat for fish during summer, and a significant source of cold water to the Slocan River.
Dumont Creek	MCK-E	Hydrometric	49.61239	-117.537	Dumont Creek is a lower elevation, warmer and drier watershed type which is relatively small. There is currently very little monitoring of that type of watershed in the Mid-Columbia Kootenay region. There are numerous water users on this stream.

MAP OF MID-COLUMBIA KOOTENAY MONITORING SITES SELECTED FOR 2022



COLUMBIA-KOOTENAY HEADWATERS

PHOTO BY NICOLE TRIGG

COLUMBIA-KOOTENAY HEADWATERS PILOT AREA SUMMARY

Columbia-Kootenay Headwaters Community Priorities

Based on discussions during LRG meetings, survey results and one-to-one consultations, key priorities for the Columbia-Kootenay Headwaters LRG were identified for monitoring of water quantity, quality and climate. The Columbia Wetlands, restoration and fish habitat were topics of interest mentioned by several LRG participants. “Of particular concern to me is the significant increase in human activity (i.e., motorised recreation, etc.) and the subsequent impacts to fish, wildlife and their habitats,” said one survey respondent. In addition to these broader values and concerns, LRG participants and First Nations also recommended specific water bodies and locations for monitoring according to local concerns and priorities.

WATER QUANTITY

For monitoring of stream flow and water level, participants identified lakes and streams that are sources of drinking water sources as the highest priorities. Watersheds that are habitat for Species at Risk, and wetlands subject to drying trends were also identified as a high priority for the Columbia-Kootenay Headwaters region. Water supply for agriculture was mentioned as a concern in this region. Sedimentation and debris flows were a concern on several streams in this region.

WATER QUALITY

Drinking water sources were also the top priority for monitoring water quality in lakes and streams. Species at Risk habitat, fish-bearing streams and areas where restoration may be proposed were also identified as priorities for water quality monitoring. Wetlands which may be impacted by agricultural activities were identified as another area of interest for water quality monitoring.

CLIMATE

Representing a diverse range of microclimates was identified as a priority. Due to the mountainous terrain in this area, one participant commented that “the climate is so variable, especially where the outflow and thermals related to the glaciers influences local ecosystems.” Climate monitoring at high elevation sites was another priority for this region.

GROUNDWATER

Aquifers identified as “more stressed” in the BC Aquifer Stress Tool were identified as a priority for groundwater monitoring as well as aquifers that are sources of drinking water.

Columbia-Kootenay Headwaters Data Gap Analysis Results

Watersheds in the Columbia-Kootenay Headwaters were stratified into six Watershed Groups. Table 3 outlines the Watershed Groups that were identified for the Columbia Kootenay Headwaters region, and the number of active and inactive WSC sites in watersheds of each group.

Hydrometric monitoring in this region has historically been constrained to the Rocky Mountain Trench, with several inactive sites throughout the lower to mid elevation watersheds. Higher elevation, eastern (Kootenay), and northern portions of the region have been relatively poorly represented. The focus for this year was to implement higher elevation sites and to represent glaciated watersheds. In addition, watersheds identified by the LRG as priorities were selected.

TABLE 3. THE NUMBER OF ACTIVE AND INACTIVE WSC STATIONS IN THE WATERSHED GROUPS OF THE COLUMBIA-KOOTENAY HEADWATERS REGION.

Watershed Group	Description	Number of Active WSC Stations	Number of Inactive WSC Stations
CKH - A	Middle elevation	1	21
CKH - B	High elevation, cooler, wetter Rocky Mountains	0	2
CKH - C	Low elevation, warmer, drier, wetlands	5	44
CKH - D	High elevation, cooler, drier	0	1
CKH - E	Glaciers	0	0
CKH - F	High elevation, cooler, wetter, Purcell Mountain range	1	0

Sites Selected for Columbia-Kootenay Headwaters for 2022

Table 4 summarizes the hydrometric, lake level and climate sites that were selected for installation in 2022. CABIN and STREAM biomonitoring samples were collected on Bugaboo Creek and Kindersley Creek. Sites for water quality and wetland level, as well as additional climate, high elevation and groundwater monitoring sites are currently being considered for future implementation.

Following the table is a map which shows the locations of the hydrometric, climate and lake level stations selected for the CBWMF program for 2022. Sites monitored by LLC's Upper Columbia Basin Groundwater Monitoring are also included, as the data collected by this program will also contribute to the CBWMF's objectives.

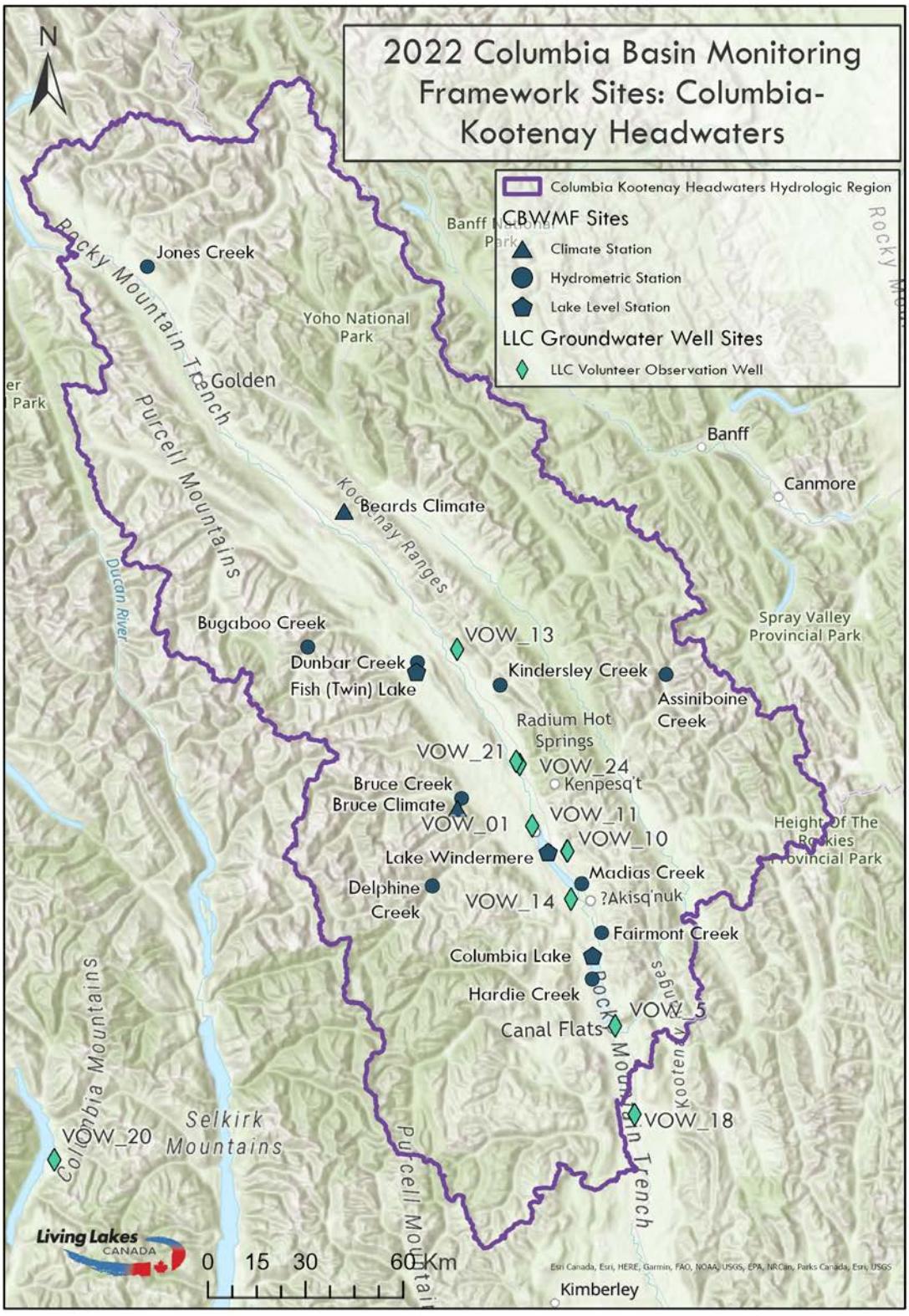
TABLE 4. MONITORING SITES SELECTED FOR THE 2022 PILOT IMPLEMENTATION OF THE COLUMBIA BASIN WATER MONITORING FRAMEWORK IN THE COLUMBIA-KOOTENAY HEADWATERS REGION

Name	Watershed Group	Station Type	Latitude	Longitude	Site Selection Rationale
Kindersley Creek	A	Hydrometric	50.762598	-116.129612	Opposite aspect to Dunbar, selected for geographic distribution.
Bruce Creek	D	Hydrometric	50.563931	-116.236086	Historic WSC station 08NA060
Hardie Creek	C	Hydrometric	50.245285	-115.875226	Smaller, proposed development in the area that is causing concern for neighbouring communities that use it for a drinking water source, potentially impacted by private land logging in 2021.
Delphine Creek	D	Hydrometric	50.409508	-116.316715	Delphine Creek is a higher elevation watershed, and a tributary to Toby Creek, which flows through the Panorama Mountain Resort and is an important water source for several uses.

Name	Watershed Group	Station Type	Latitude	Longitude	Site Selection Rationale
Fairmont Creek	C	Hydrometric	50.326826	-115.849417	We received numerous requests to monitor Fairmont Creek from community members and local governments, as it has historically been affected by debris flows and sedimentation.
Windermere Creek	A	Hydrometric	50.478	-115.947	Concerns around flooding and erosion. Stream identified as a priority for several Indigenous groups. To be installed in 2023.
Bugaboo Creek	E	Hydrometric	50.828949	-116.659305	This creek was identified as a priority by an LRG participant. This watershed sees a wide range of uses including forestry to recreation and adventure tourism. This watershed is influenced by Bugaboo Glacier.
Dunbar Creek	A	Hydrometric	50.802074	-116.356666	Glaciers in headwaters, above mid-elevation wetlands, will support understanding contribution to Columbia Wetlands from small tributaries.
Madias Creek	A	Hydrometric	50.413562	-115.903767	Identified as a priority by the community.
Jones Creek	C	Hydrometric	51.487292	-117.102779	Concerns include drawdowns from human consumption, including farming, increased human habitation, new structures to facilitate forest harvesting, loss of forest cover and changes to snowpack.
Assiniboine Creek	B	Hydrometric	50.786918	-115.665704	This site was selected because it is higher elevation and towards the northern portion of the region, which is poorly represented.

Name	Watershed Group	Station Type	Latitude	Longitude	Site Selection Rationale
Fish Lake	A	Lake Level	50.785962	-116.359651	Fish Lake flows into Dunbar Creek and represents a mid-elevation lake.
Columbia Lake	C	Lake Level	50.28769	-115.87381	Columbia Lake was identified as a priority by the LRG and represents an important source water lake for the Columbia River system. LLC will support an upgrade to the existing Columbia Lake Stewardship Society station in 2023.
Lake Windermere	C	Lake Level	50.46989	-115.99626	Lake Windermere was identified as a priority by the LRG and is under increasing pressure from multiple users. Station to be installed 2023.
Beards	B	Climate	51.06699	-116.559801	Mid elevation location. Representing a broad range of climatic conditions.
Bruce	D	Climate	50.547954	-116.24747	Mid elevation location. Representing a broad range of climatic conditions. Paired with Bruce Creek hydrometric station.

MAP OF COLUMBIA-KOOTENAY HEADWATERS MONITORING SITES SELECTED FOR 2022



ELK RIVER VALLEY

PHOTO BY ELK RIVER ALLIANCE

ELK RIVER VALLEY PILOT AREA SUMMARY

Elk River Valley Community Priorities

Based on discussions during LRG meetings, survey results and one-to-one consultations, key priorities for the Elk River Valley LRG were identified for monitoring of water quantity, quality, and climate. Capturing the geographic variability of climate and hydrology patterns across this region was an area of interest for this LRG. There are significant interests in fish habitat in the Elk Valley, given the presence of the native Westslope Cutthroat trout population listed as a Special Concern under the federal SARA legislation, and the Elk Valley being a marquee destination for tourists, anglers, and recreationalists. Fish habitat concerns cover physical attributes (flows, water temperature), chemical attributes (water quality) and biological attributes (benthic invertebrate communities).

It is important to note that the Elk Valley has many third-party monitoring activities occurring, so partnership building and collaboration are critical here, to build synergies and avoid duplication of efforts. The Elk River Alliance is acting as the implementation partner for the project in this pilot area, with the monitoring activities undertaken by the Elk River Alliance on behalf of the Columbia Basin Water Monitoring Framework (CBWMF) and the Elk River Watershed Monitoring Collaborative.

WATER QUANTITY

In one-on-one interviews and in the online survey, LRG participants identified Westslope Cutthroat Trout (WCT) fish-bearing streams, in particular those streams known for WCT spawning habitat, as high priorities for the monitoring of stream flow, stream water levels, and stream water temperature. Respondents were concerned about “the impact of extended low-flow periods on fisheries” and felt that the “Westslope Cutthroat Trout is an isolated population in the Elk Valley with unique opportunity for protection”. Respondents wanted to target fish-bearing streams in the Elk Valley that are at risk of over-allocation from competing water uses (eg. Fairy Creek used as municipal source of drinking water), acknowledging that most of the East Kootenay streams are naturally flow-limited (for fish) in the winter, which makes them vulnerable to overuse/overallocation. Respondents representing municipal interests also indicated that streams prone to flooding with potential damage to public infrastructure were additional priorities for hydrometric monitoring.

WATER QUALITY

The monitoring of water quality was also assessed by respondents to be a high priority in fish-bearing streams, specifically those known to be habitat for Westslope Cutthroat Trout, and in streams that are used as sources of drinking water.

CLIMATE

The Elk River Valley LRG was mostly uncertain about climate monitoring priorities; however, responses from the outreach indicated that climate monitoring would probably need to target snowpack and glacier extents, in particular in the higher elevation terrain, so as to cover the diverse range of microclimates observed in the Elk Valley. One respondent stated that existing climate stations are dominantly installed at the valley bottom, so priority should be given to mid and high elevations, and the rain shadow effect in the valley disproportionally splits precipitation across the windward and leeward side of mountain ridges, so consideration should be given to climate monitoring on the east and west sides of the Elk River.

GROUNDWATER

The Elk River Valley LRG responded that groundwater aquifers are important for fish species like Westslope Cutthroat Trout and Bull trout, both listed under SARA, dependent on groundwater discharge to streams to maintain surface flows — especially during winters when stream flows are low. The LRG assigned high priority to groundwater aquifers identified as “more stressed” in the BC Aquifer Stress Tool and also prioritized aquifers used as sources of drinking water by communities.

PHOTO BY ELK RIVER ALLIANCE

Elk River Valley Data Gap Analysis Results

Watersheds in the Elk River Valley were stratified into four groups. Table 5 outlines the Watershed Groups that were identified for the Elk Valley, and the number of active and inactive WSC sites in watersheds of each group. Sites were selected for 2022 based on a need to pair with existing water quality sites implemented by the Elk River Alliance and to account for mid to higher elevation watersheds. Watershed Group D had no active WSC stations, so emphasis was placed on this group for site selection.

TABLE 5. THE NUMBER OF ACTIVE AND INACTIVE WSC STATIONS IN THE WATERSHED GROUPS OF THE ELK RIVER VALLEY REGION.

Watershed Group	Description	Number of Active WSC Stations	Number of Inactive WSC Stations
ERV - A	Low elevation, warmer, drier	4	10
ERV - B	High elevation, cooler, wetter	1	1
ERV - C	Middle elevation, drier	1	5
ERV - D	Middle elevation, wetter	0	1

Sites Selected for Elk River Valley for 2022

Table 6 summarises the hydrometric, lake level and climate sites that were selected for installation in 2022. Wetland level sites, additional hydrometric, climate, high elevation and groundwater monitoring sites will be considered for future installation. Additional biomonitoring of benthic invertebrate communities in this region is led by the Elk River Alliance.

In consultation with community members, the Regional District of East Kootenay and the Yaq̓it ʔa·knuqƛi ‘it, significant concerns and priorities were also identified in the ‘South Country’, which is the area of land adjacent to the outlet of the Elk River in Lake Koocanusa. While the South Country lies outside the Elk Valley, or the drainage area of surface water into the Elk River, the concerns of South Country communities on water quantities warranted attention. One hydrometric station and four lake level monitoring stations were therefore selected for installation in the South Country outside of the pilot area. The intention is to expand the CBWMF program over time, so these sites will fit into the broader network in the future. These sites will be maintained by LLC contractors, as they are outside of the Elk River Alliance operating area.

PHOTO BY ELK RIVER ALLIANCE

TABLE 6. MONITORING SITES SELECTED FOR THE 2022 PILOT IMPLEMENTATION OF THE COLUMBIA BASIN WATER MONITORING FRAMEWORK IN THE ELK RIVER VALLEY REGION.

Name	Watershed Group	Station Type	Latitude	Longitude	Site Selection Rationale
Lizard Creek	ERV-A	Hydrometric	49.470661	-115.077	Lizard Creek is one of the most important Westslope cutthroat trout (WCT) breeding streams in the Elk Valley, according to Anglers and Fly-Fishing Outfitters. The community is interested in assessing base flows and peak summer water temperatures to ensure these are viable for the WCT population, which is listed as a species of Special Concern in British Columbia under SARA.
Forsyth Creek	ERV-A+B	Hydrometric	50.231674	-114.968607	Forsyth Creek is a known breeding stream for Westslope Cutthroat trout, listed as a species of Special Concern in British Columbia under SARA. Forsyth Creek drains Connor Lakes, one of the biggest alpine lakes in the Elk Valley watershed, and the Abruzzi glacier. Forsyth Creek is one of two glacier-fed tributaries of the Elk River, along with Cadorna Creek.
Coal Creek	ERV-D	Hydrometric	49.49528	115.0678	The City of Fernie is monitoring water levels at the mouth of Coal Creek for flood mapping purposes, and Elk River Alliance will work with the City of Fernie to support long-term flow monitoring. In addition to municipal interests in flow monitoring, Coal Creek is a known breeding stream for Westslope Cutthroat trout, listed as a species of Special Concern in British Columbia under SARA, and anglers and outfitters are expressing concerns about diminishing flows in this stream in particular in recent years, with summer flows now becoming too low in this stream in mid-summers to sustain fishing. Anglers and outfitters are interested in understanding the effects of forestry on flows in Coal Creek.

Name	Watershed Group	Station Type	Latitude	Longitude	Site Selection Rationale
Morrissey Creek	ERV-D	Hydrometric	49.35806	115.0000	Morrissey Creek (draining 83 km2) is a known habitat of WestSlope Cutthroat trout and can be used as a proxy to Coal Creek (draining 96 km2), as both subwatersheds pertain to the ERV-D climate group, to help understand impacts of forestry. Forest activities in Morrissey Creek's subwatershed are older (dating mostly before 2005) so that forests have recovered most of the Morrissey Creek subwatershed, while forestry activities in Coal Creek's subwatershed are taking place as of the last 6 years (as of 2006).
Willie Phillips Creek	N/A	Hydrometric	49.096555	-115.084156	Identified as a priority by the Yaq̓it ʔa·knuqƛi ʻit.
Baynes Lake	N/A	Lake Level	49.233453	-115.224688	Local concerns about decreasing water levels on Baynes Lake. To be installed in 2023.
Edwards Lakes	N/A	Hydrometric	49.092286	-115.118312	Identified as a priority by the Yaq̓it ʔa·knuqƛi ʻit.
Indian Lake	N/A	Hydrometric	49.092286	-115.118312	Identified as a priority by the Yaq̓it ʔa·knuqƛi ʻit.

MAP OF ELK RIVER VALLEY MONITORING SITES SELECTED FOR 2022

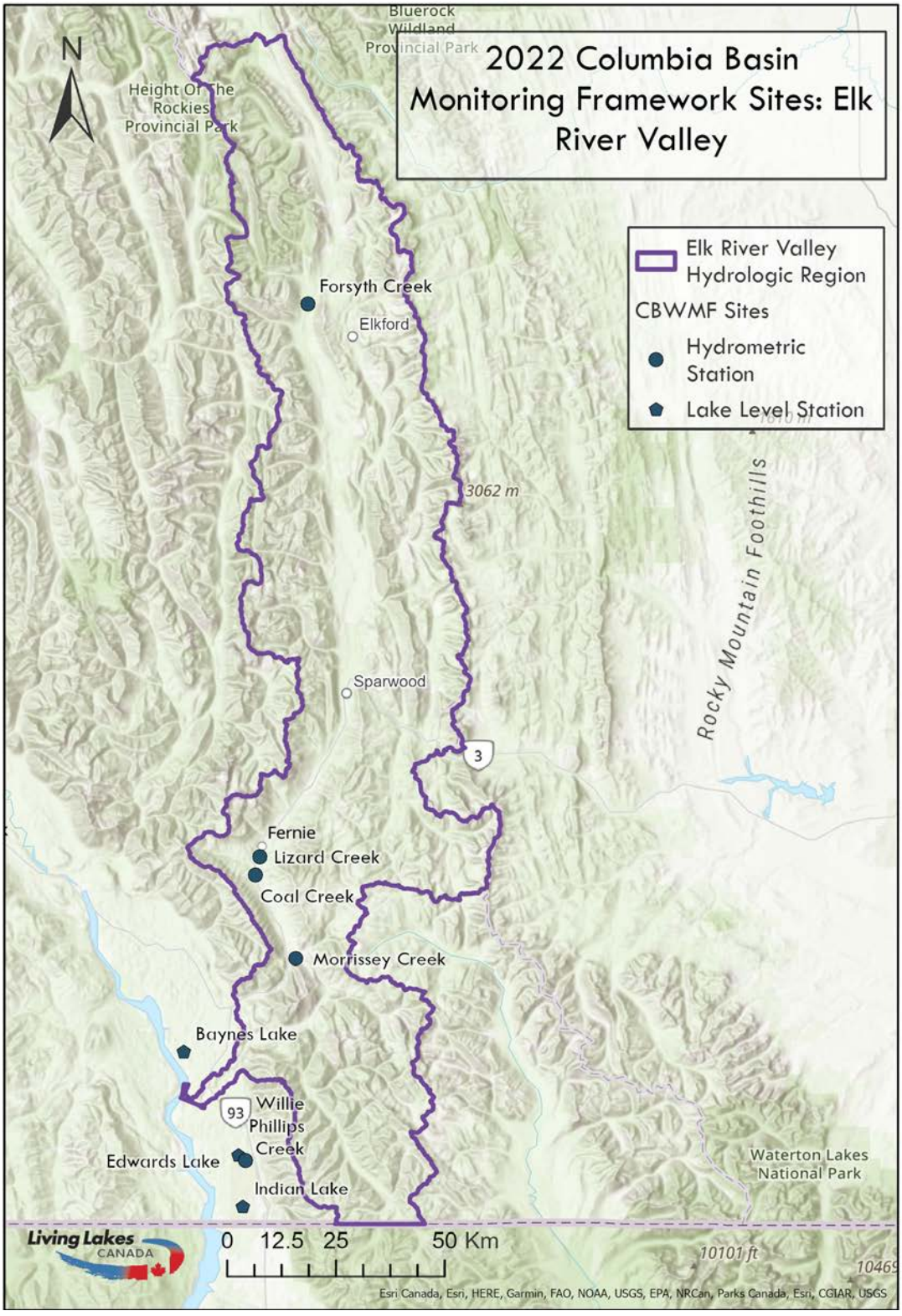


PHOTO BY MACHYDRO

INSTALLATION AND MONITORING

Overall, in 2022, locations were identified for 26 hydrometric stations, eight lake level stations and three climate stations. Equipment installation was carried out from August through to October. Hydrometric, lake level and climate stations were installed by local hydrology consultants. These consultants will continue to collect data and maintain these stations over time, as well as processing and grading the data according to the provincial Resources Information Standards Committee (RISC) standards.

Community Capacity Building

Where appropriate, volunteer and/or paid opportunities for community members to support the monitoring work will be developed. LLC is actively engaged in building capacity among Indigenous and non-Indigenous communities in the water monitoring and stewardship sector. The growing watershed security sector provides meaningful career opportunities for young people and transitioning workers.

In September 2022, LLC hosted three hydrometric training sessions led by the BC Ministry of Environment. These practical workshops on hydrometric data collection were held in Canal Flats, Invermere, and Winlaw and saw 25 participants in total. Participants included members and representatives of the Kimberley Youth Action Network, Columbia Headwaters Aquatic Secwepemc Strategy, Yaq̓it ʔa·knuqƛi ‘it band, Okanagan Nation Alliance, Lake Windermere Ambassadors and Slocan River Streamkeepers Society.

LLC also delivers training in the CABIN and STREAM protocols and offers additional community education programming related to groundwater and hydrometric monitoring, as well as data management.

DATA SHARING AND ANALYSIS

The long-term objective of this project is to create a water balance for the Columbia Basin, as was agreed upon by senior hydrologists at the 2020 workshop[13].

Once processed and graded, data will be made available through the Columbia Basin Water Hub database which is managed by LLC. The data can then be used by community members, researchers, the private sector and all levels of government to inform water management and stewardship decisions, in addition to supporting the broader goal of developing a water balance for the Columbia Basin. The data gathered through this project will The data gathered through this project will support efforts to build a more comprehensive understanding of the state of water supply and water quality in local jurisdictions and to establish adaptation options..

LLC is in dialogue with counterparts in the Fraser Basin and Okanagan Basin to build joint criteria for regional State of the Basin water data reports

Once sufficient data has been collected, LLC will support analysis and reporting of results in relation to climate impacts and other research questions.

PHOTO BY ALI SCHROEDER

LEARNINGS AND RECOMMENDATIONS

The successful pilot implementation of this project yielded many learnings to be carried forward into future implementations of this project.

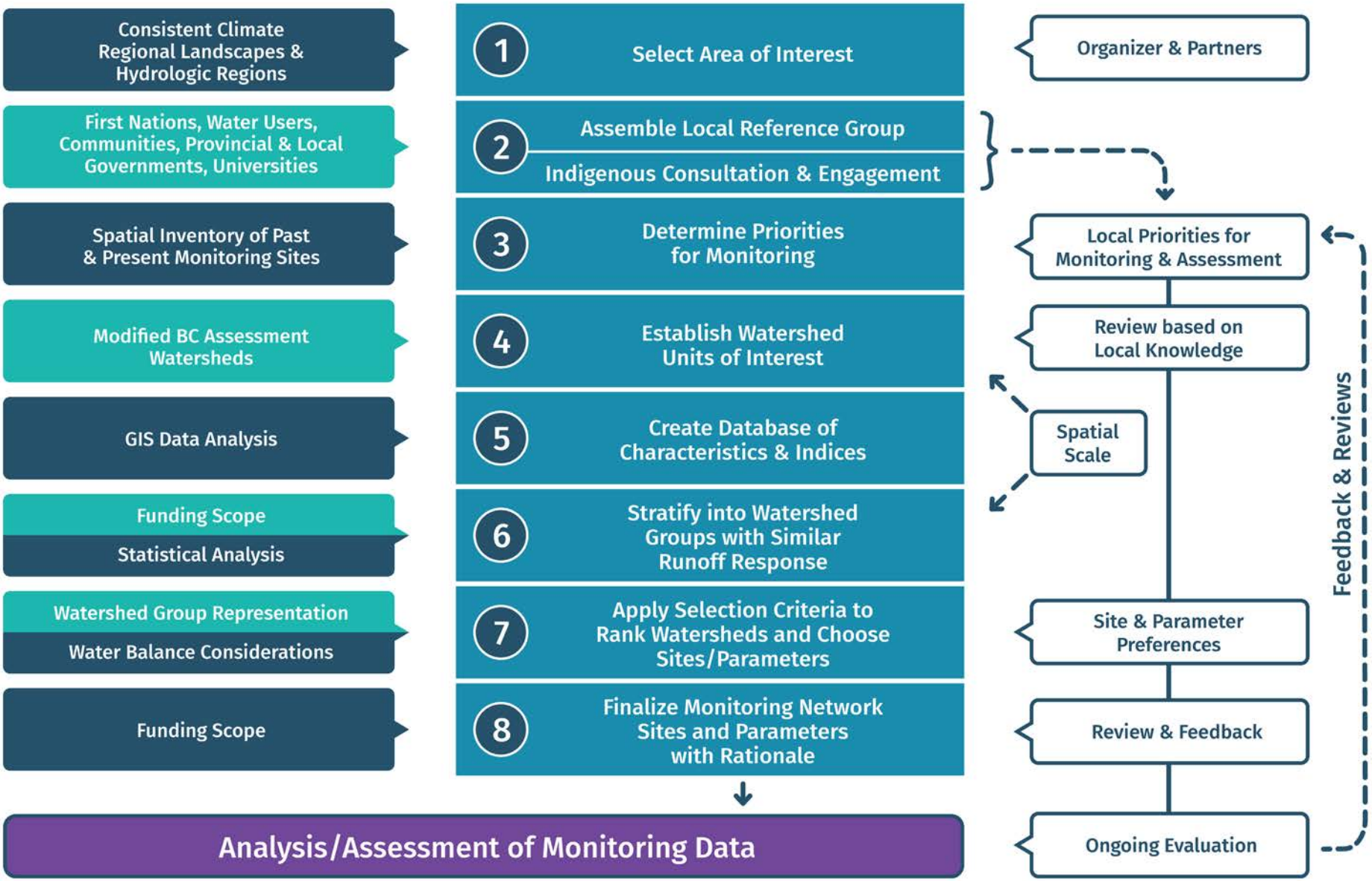
- The local knowledge contributed by LRG participants and local consultants provided significant contributions to the Priority Monitoring Matrix. Several locations which looked to be ideal from the desktop review were actually unsuitable for monitoring for various reasons which were raised by LRG participants, and more suitable alternatives were suggested.
- The depth of community engagement required to identify local priorities and gather local knowledge was significant. Allowing additional time for this process is suggested going forward. In particular, additional time should be allocated for Indigenous participation, in recognition of the need for multi-level consultation with band councils, elders circles and others within each community.
- Additionally, nearly all the community engagement was conducted virtually due to geographic limitations and the COVID-19 pandemic. In-person meetings and forums may be more effective where possible.
- LRG participants have also offered to support the operation of the stations by conducting gauge level checks, monitoring for damage or malfunctioning equipment, providing insight into potential timing of peak flows and other contributions. The value of local knowledge and support cannot be understated.
- Representatives from the Province, as well as regional and municipal governments were invited to participate in the LRG for each pilot area and provided valuable information through that process. However, enhanced consultation with all levels of government is recommended going forward to identify additional opportunities for collaboration.
- While priorities of the LRGs were clearly identified, metrics for assessing how well a watershed meets those criteria should be further defined. For example, drinking water was the top priority for several of the LRGs. The number of water licences that are authorized by the Province was used as the metric, but this may not be an adequate measure of the actual number of households relying on that water source, or the volume of water being extracted, and does not differentiate between commercial, industrial or residential use of the water.

Living Lakes Canada intends to continue to expand this program to include additional areas over the next 10 years, continuing to adapt and refine the methodology in response to learnings from this pilot project. This comprehensive approach will provide a proven example for other watersheds to support local and regional efforts to increase adaptation options and support the longer-term viability of natural ecosystems and ecosystem services. The watershed security and adaptation work being facilitated by Living Lakes Canada in the Canadian Columbia Basin can serve as a paradigm-changing template that can be applied in other regions.

PHOTO BY RORY GALLAUGHER

APPENDIX

OVERVIEW OF THE CBWMF METHODOLOGY AND THE INPUTS REQUIRED AT EACH STEP



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