



Bridge River Project Water Use Plan

Monitoring Program Terms of Reference

BRGMON-11A Lower Bridge River Riparian Vegetation Monitoring

**Revision 2
March 28, 2022**

BRGMON-11A: Lower Bridge River Riparian Vegetation Monitoring Monitoring Program Terms of Reference Revision 2

1.0 Monitoring Program Rationale

1.1 Introduction

This BRGMON-11A Terms of Reference (TOR) Revision 2 supports a submission package for an Interim Flow Decision and subsequent Order(s) anticipated from the Comptroller of Water Rights in addition to the original Bridge River Project Water Use Plan Order (Bridge WUP Order) dated March 30, 2011 (Schedule A, Clause 8a) as follows:

- a. Monitor influence of the flow conditions on the riparian community of the Lower Bridge River;

The wildlife monitoring continues to be addressed in the BRGMON-11B TOR.

1.2 Background

1.2.1 Water Use Planning

In 1998 an agreement between BC Hydro and regulatory agencies was adopted in response to public, First Nations, and agency concerns about the lack of continuous flow releases from the Terzaghi Dam into the Lower Bridge River. The agreement specified that an instream flow release and monitoring program be developed and implemented to resolve uncertainty about response of the Lower Bridge River aquatic ecosystem to reservoir releases. The agreement specified that an experimental flow release program was to be initiated and continued until a Water Use Plan (WUP) was developed for the Bridge-Seton watershed.

On July 28, 2000, the Comptroller of Water Rights issued an Order under the Water Act (now the Water Sustainability Act) to initiate an annual water budget of 3 m³/s shaped into a seasonal hydrograph plus associated monitoring studies to estimate the effect of that flow treatment on the aquatic ecosystem. Previous flow assessment studies (1993-1995) and ecological monitoring (1996-2000) provided some baseline data on zero flow from Terzaghi Dam into the Lower Bridge River to compare with the three m³/s flow trial.

Based on the recommendations of the WUP Consultative Committee (CC), a WUP Order was issued by the Comptroller of Water Rights on March 30, 2011 requiring a second treatment with an increase in the annual water budget to six m³/s shaped into a seasonal hydrograph. This WUP Order also included the implementation of monitoring studies to inform future flow decision.

In terms of vegetation and wildlife, the CC identified that the test program associated with these flows should explicitly evaluate the impacts of the flow conditions on riparian habitat conditions. It was recognized that the temporal dynamics of the riparian plant community occur over much longer time scales than the aquatic community. The monitoring program was intended to document how the flow conditions affect the riparian community in terms of spatial extent, relative recruitment rate of plant species, the overall productivity of the riparian community and the consequent impact on wildlife populations.

1.2.2 Long-Term Flow Decision

The results from WUP studies on the Lower Bridge River were intended to inform a long-term flow release strategy recommendation by 2015.

In 2015 and in subsequent years leading up to 2022 when a request for an Interim Flow Decision was submitted by BC Hydro, the Comptroller of Water Rights conditionally approved delaying decision on the long-term flow release strategy.

The water management challenges posed since 2016 (see Section 1.2.3) necessitated further deferral of the long-term flow release strategy until an interim flow strategy could be developed. The Interim Flow Decision requested by BC Hydro in 2022 considers the flexibility needed for flows from Terzaghi Dam until BC Hydro infrastructure upgrades are substantially complete and water management capacity in the Bridge River-Seton system is restored.

1.2.3 High Flow Challenges in the Lower Bridge River

In 2016, BC Hydro Dam Safety issued a directive to reduce storage capacity of Downton Reservoir by ~50% to manage seismic risk. In the same year, BC Hydro advanced critical infrastructure upgrades at the Bridge River 1 and 2 Generating Stations to address the added water management risks associated with reduced storage in Downton Reservoir. The infrastructure upgrades affected the volume of water that could be diverted through Bridge River 1 and 2 from Carpenter Reservoir to Seton Lake. As a result, releases higher than the annual average 6 m³/s (specifically in the springtime freshet period) may be discharged from Terzaghi Dam down Lower Bridge River in some years based on inflows into the reservoirs and the capacity of Bridge 1 and 2 to pass those inflows. This increased risk of higher flows into the Lower Bridge River is expected to continue until water management capacity in the Bridge River-Seton system is restored through completion of major infrastructure upgrades.

BC Hydro received variance approvals (March 14, 2016, February 16, 2017, February 22, 2018, December 19, 2018 and May 4, 2021) from the Comptroller of Water Rights to vary the Terzaghi Dam discharges from those specified in the WUP, and to implement a more flexible flow regime at Terzaghi Dam following a set of Guiding Principles to inform within season flow release decisions. The discharge variance approvals permitted BC Hydro to exceed the annual average 6 m³/s treatment hydrograph and specifically the 15 m³/s maximum peak discharge during the annual freshet flow period (~March to August). Outside of the freshet flow period, BC Hydro has been able to operate Terzaghi Dam according to the seasonal WUP hydrograph limits. These actions to pre-emptively release higher flows during the freshet period substantially reduce the risk of a late summer/fall high flow release which would pose a much greater impact to the aquatic life in the Lower Bridge River (i.e., spawning salmon).

1.2.4 Joint Water Management

From 2016 to 2018 the hydrograph peak and duration during the high flow period were shaped by inflow volumes, with Terzaghi Dam discharges reaching 97 m³/s in 2016, 127 m³/s in 2017, 100 m³/s in 2018 and 25 m³/s in 2021. Spring freshet flows in these years were managed using the *Guiding Principles* developed jointly in meetings with representatives from St'át'imc, BC Hydro and regulatory agencies where water management options and risks to aquatic life were discussed collaboratively.

The planning meetings were formalized in late 2019 into what is now known as the Joint Planning Forum (JPF) with membership from St'át'imc and BC Hydro, invited participants from regulatory agencies, and occasionally also invited guests from the St'át'imc communities and other supporting parties.

The JPF meets on a monthly basis (or more frequently as required) and has a mandate that includes reviewing water conveyance operations and flow management at the Bridge-Seton Generation Facilities, both on a near and long-term basis, and as part of a potential *interim long-term flow strategy*. The JPF has been successful in providing joint recommendations for water management decisions ultimately made by BC Hydro. The JPF has provided a venue for joint problem solving between St'át'imc and BC Hydro for water management and environmental mitigation projects associated with the impacts of BC Hydro operations.

Revision 2 of this Terms of Reference outlines environmental monitoring associated with the interim flow recommendations provided by the JPF to support BC Hydro's request to the Comptroller of Water Rights for an interim flow decision on the Lower Bridge River.

1.3 Revision Rationale and Summary of Key Changes

In Revision 1 of this TOR, the uniquely separate goals and tasks related to the riparian vegetation and wildlife monitoring was fully recognized and a decision was made to split BRGMON-11 into two separate components BRGMON-11A for vegetation monitoring and BRGMON-11B for wildlife monitoring. The rationale for that decision was as follows:

- Clarity with respect to the Management Questions for each BRGMON-11 component.
 - The original TOR had a single general Management Question related to vegetation; in Revision 1 the wording of this question was modified to include community persistence.
 - Revision 1 introduced definitions of cottonwood establishment and recruitment as additional relevant ecological measures, providing clarity to the program.
- Some of the management hypotheses were refined in Revision 1 to better define the response variables to be tested.
- Additional monitoring to provide quantitative data on variables that may affect riparian community persistence was also included in Revision 1.
- New methods were added for cottonwood seed timing, seedling establishment and recruitment in Revision 1.
- Since the vegetation and wildlife components are delivered by two separate contactors, Revision 1 clarified the scope for each contractor.

Revision 2 of the TOR adjusts the focus to include the concept of variable flow conditions and to support decisions made considering the Guiding Principles. Specific considerations for Revision 2 include:

- Opportunistic evaluation of cottonwood seed dispersal in years where flows exceed WUP baseline peak flows including evaluation hydrograph shape
- Opportunistic evaluation of the duration of peak flow and its effect on riparian vegetation communities (i.e., comparing the affects of prolonged flooding on both seed dispersal as well as the encroachment of later successional vegetation into the riparian area)
- Evaluate the trade offs of riparian vegetation impacts relative to other values such as fish and fish habitat values considered in the Guiding Principles
- Clarity on reporting expectations that align with annual reviews by the JPF and collaboration with study teams to foster adaptive management of this study
- Conditionally implemented protection measures to protect cottonwood damage from beavers at the discretion of the JPF

1.4 Management Questions

Management Questions 1 and 2 in the original BRGMON-11 TOR (2012) were intended to improve understanding of changes in Lower Bridge River riparian vegetation community under the flow treatments. Management Question 2 addressed wildlife population response to riparian community change; this question is addressed in the new BRGMON-11B TOR Revision 2.

This BRGMON-11A TOR Revision 2 incorporates new information and updates the management question and hypothesis to assure that the most relevant ecological measures are being considered. Revision 2 took out the word “regime” with respect to flows and replaced it with “conditions” to better reflect the expected period of variable peak flows.

Management Question 1 (slightly modified in Revision 1 and 2):

1. What is the influence of the instream flow conditions on the persistence of the riparian vegetation community of the Lower Bridge River?¹

The intent of this monitoring program is to document how the riparian community is affected by flow releases and how the changes in flow conditions impact the riparian community in terms of community persistence (spatial extent, diversity, richness, cover, relative recruitment rate of plant species, their relative productivity using biomass as a metric and black cottonwood establishment and recruitment success).

Black cottonwood response and growth is the main species of focus (keystone species), as this is the dominant riparian vegetation along the Lower Bridge River, a key vegetation species for wildlife habitat. Without black cottonwoods, the function of the riparian community would be drastically changed (Hall et al. 2009).

1.5 Detailed Hypotheses about the Impacts of Instream Flow on Riparian Vegetation in Lower Bridge River

The explicit hypotheses to be tested from the results of the monitoring program relate both to the entire community as well as focusing on differential success of annual and perennial species. Management hypotheses are intended to guide the selection of response variables; however, the hypotheses presented here are not an exhaustive list and other response variables could be examined. Alternative hypotheses were not developed because explanatory variables may change with further implementation and development of monitoring. These hypotheses include:

H₀: (null hypothesis) There is no relationship between the magnitude of instream flow release and riparian vegetation along the Lower Bridge River.

¹ Wording modified slightly from original TOR. Original MQ-1: What is the influence of instream flow regime on the spatial extent, species diversity, and relative productivity of the riparian community of the Lower Bridge River?

- H1: The species composition of the riparian vegetation community in the Lower Bridge River corridor is related to the instream flow release from Terzaghi Dam
- H2: The relative productivity (biomass) of the riparian vegetation in the Lower Bridge River corridor is related to the instream flow release from Terzaghi Dam.
- H3: The abundance of invasive or exotic plant species in the Lower Bridge River corridor is related to the instream flow release from Terzaghi Dam.
- H4: The relative rate of recruitment of perennial plant species and especially woody plants (i.e. black cottonwood) in the Lower Bridge River corridor is directly related to the instream flow release from Terzaghi Dam.
- H5: The rate of growth of perennial plant species in the Lower Bridge River corridor is directly related to the instream flow release from Terzaghi Dam.

The definition and methods to be used for black cottonwood seedling establishment, survival and recruitment is as follows:

- “Establishment” represents the germination or colonization of a seedling.
- “Recruitment” represents the successful establishment and survival of a seedling through the vulnerable first three growing seasons; the subsequent saplings are more likely to contribute to the floodplain forest population (Rood et al. 2007).

Methods to determine recruitment include tracking their survival through three growing seasons. Recruitment is the result of two sequential but somewhat independent processes of establishment (or colonization) and survival:

- $\text{Recruitment} = \text{Establishment (colonization)} + \text{Survival}$

For example: seedlings established in 2016 (that survived to the October 2018 field sampling) would be considered successful recruits. Therefore, the 2016 seedlings will shift to be part of the vegetation monitoring design, utilizing cover by species to assess growth and cover expansion during the subsequent year of riparian vegetation monitoring.

Higher flows may limit colonization of marginal areas because inundation thresholds will be exceeded, and it is expected that lower flow levels will increase the spatial extent of riparian vegetation. However, it is also believed that very low flows may limit riparian vegetation because of insufficient groundwater or hyporheic flow to support vegetation development or sustain high levels of productivity over the entire floodplain of the river.

1.6 Key Water Use Decision Affected

The key water use planning decision affected by BRGMON-11A will be continuing to support the original WUP monitoring objectives and decision processes anticipated during the WUP Order review while also supporting year by year decision making using the Guiding Principles during a period of variable instream flows for the Lower Bridge River.

2.0 Monitoring Program Proposal

2.1 Objective

The objective of BRGMON-11A is to document how riverine and riparian vegetation in the Lower Bridge River respond to flow conditions. Results will be used to inform the upcoming WUP Order Review process and the anticipated year by year water management decisions using the Guiding Principles.

2.2 Approach

Provide quantitative data on variables that may affect riparian community persistence. Analysis will integrate all monitoring results to inform what factors affect riparian community persistence and follow the standardized protocols for ecological sampling and data collection. This general approach will ensure the continuity of data across all instream flow conditions.

The proposed monitoring program has four components:

1. Aerial photograph analysis.
2. Repeated vegetation transect surveys and large vegetation plots at fixed locations.
3. Black cottonwood seed timing and seedling establishment and recruitment.
4. Dendrochronological surveys.

The sampling design will be treated as a repeated measures design for sampling changes in riparian community associated with change to the instream flow conditions. The approach will continue to build on learning from previous years of study.

2.3 Methods

2.3.1 Task 1 Project Coordination

Project coordination involves the general administrative and technical oversight of the program. This will include but not be limited to 1) budget management; 2) staff selection; 3) logistic coordination; 4) technical oversight in field and analysis components; and 5) liaison with regulatory and First Nations groups.

2.3.2 Task 2 Riparian Vegetation, Data Collection and Analysis

Aerial Photography

To assess the overall impacts of the instream flow conditions on riparian vegetation aerial photography will be used at specified intervals. Low level spatial geo-referenced colour air photos will be used to develop GIS based maps of the riparian vegetation and to compute changes in the spatial extent and location of vegetation occurring the study period. This task will be completed concurrently with any other proposed aerial photography for BC Hydro programs to reduce additional costs for duplicate flights.

Transect Surveys and Large Vegetation Plots

Transect surveys are proposed to 1) ground truth assessments of general changes in species composition occurring over the entire spatial area of the Lower Bridge River riparian area; 2) provide detailed geo-referenced topographic data of the transect; and 3) provide a detailed assessment of the changes in species composition and relative productivity and persistence of riparian habitats resulting from the implementation of the flow treatment.

Previous monitoring methods completed will be repeated. These included: 1) permanent benchmarking of transects to allow repeated vegetation surveys through time; 2) supplemental sampling at the transects to quantify relative riparian productivity (biomass sampling); 3) monitoring of newly established 10 m X 40 m permanent large vegetation plots; 4) permanent photo point monitoring sites; 5) repeating all vegetation surveys (including the biomass sampling) after approximately 10 years; 6) based on the data collected, undertake a quantitative assessment of the changes in riparian community health, and growth in relation to flow.

In high freshet flow years, vegetation plots have been established in the Yalakom River and act as a non-regulated river vegetation composition, successional, and potentially cottonwood recruitment comparison. Plots will be sampled again in the final year of data collection.

Black cottonwood seed timing and seedling establishment and recruitment

The local timing of the Lower Bridge River black cottonwood seed development and dispersal timing will be observed, and local timing established in the spring of scheduled years and during high flow years. Select sites will be monitored along Reaches 3 and 4 for the timing of cottonwood seed development and seed rain release. In the fall of scheduled years and during high flow years, cottonwood seedling establishment and recruitment will be surveyed via vegetation plots and targeted reaches in Reaches 3 and 4. Density, age, survival, and elevation of seedlings relative to annual peak flow will be recorded and mapped. Recruitment will be tracked and analyzed according to the definition established in BRGMON-11A TOR Revision 1.

Dendrochronology

Dendrochronology will continue to be used to evaluate the effects of flow conditions on relative productivity (measured as growth rate). Standard tree coring techniques are applied to measure growth increment of the trees based on annuli (i.e., tree ring) width. These growth increments will be measured in the laboratory and then analyzed in relation to the flow conditions as the previous study did (Hall et al. 2009).

2.3.3 Task 3 Reporting

This project will require reporting following each year of field work plus a detailed final synthesis report prior to any WUP Order Review:

- Annual technical reports will be submitted in each year of study to describe annual conditions, summarize survey effort, and to report results. Analyses can be included in the annual report but are not a requirement until the interim and final report.
- A detailed interim report and final report will be prepared prior to any WUP Order Review.
- The interim and final reports will analyze all available data, including relevant data collected outside of this WUP program. Any external sources of information, if referenced appropriately with permissions if required, should be used in conjunction with the study's data to address the Management Questions.
- The Final Report will access and/or reference data and/or results from:
 - Other WUP studies (e.g., BRGMON-11A);
 - Other relevant non-WUP studies; and
 - Other relevant sources of local information.

Reports will follow the standard format for WUP monitoring projects (templates to be provided by BC Hydro). All reports will be provided to BC Hydro as Microsoft Word and Adobe Acrobat (*.pdf) format.

2.4 Interpretation of Monitoring Program Results

The data collected in the proposed monitoring program, and conclusions drawn from analyses in the final report will ultimately be used to assess the degree to which management objectives and technical expectations were met by the implementation of various operational conditions.

The data and information collected will ultimately be used to assess the degree to which management objectives and technical expectations were met by the implementation of various operational flow conditions and application of the Guiding Principles. The results of the monitoring program can also be used to better support more inferences of the expected influence of instream flow on riparian vegetation and permit more defensible conjecture about impacts of flow on abundance, distribution and diversity of vegetation.

2.5 Schedule

- The schedule for the annual activities will be phased to accommodate the requirements of the program. The schedule for the proposed program is provided below in Table 1. Intervals of tasks under Revision 2 will consider those already completed under the terms of Revision 1 and will continue at the intervals specified in Table 1.
- The following data collection is also conditional and may be triggered as a condition of the Guiding Principles in high-flow years:
 - Large vegetation plots
 - Broadscale photopoints
 - Cottonwood seedling and seed release surveys

Table 1: Schedule (these activities will also be completed during high flow years)

Tasks	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Aerial photography	X				X					X	
Transect surveys	X				X					X	
Large vegetation plots ²	X				X					X	
Broad-scale photo points ²	X				X					X	
Cottonwood seedling and seed release surveys ²	X				X					X	
Dendrochronology	X				X					X	
Annual report	X				X					X	
Interim report						X					
Final report		X									X

2.6 Budget

Total program cost: \$1,263,769.

² Also conditionally monitored during high-flow years as recommended by the JPF. Other tasks may also be triggered based on recommendations of the JPF in any high-flow year.

3.0 References

Hall, Alexis A., Rood, Stewart B. and Higgins, Paul S. 2009. Resizing a River: A Downscaled, Seasonal Flow Regime Promotes Riparian Restoration. Restoration Ecology – Journal of the Society for Ecological Restoration International.

Appendix A: Key changes to the BRGMON-11A TOR and rationale

Section	Changes	Rationale
Throughout	<ul style="list-style-type: none"> • Shifted focus a focus on flow regime to flow conditions • Introduced the Guiding Principles and a shift in monitoring focus to year-by-year variable flow conditions during freshet • Introduced the role of the Joint Planning Forum and their needs to inform annual decision based on the Guiding Principles • Consolidating scope that was formerly included in high flow and mitigation monitoring within the scope of the WUP Terms of Reference 	<ul style="list-style-type: none"> • Although the flow regime concept will be revisited at the WUP Order review and this monitoring will continue to support that, the monitoring is shifting focus to better support variable freshet flow conditions on a year by year basis that we expect to continue until BC Hydro has substantially completed facility upgrades. • Acknowledge the linkages between data collected under this monitoring program and its value to applying the Guiding Principles to year-by-year recommendations for water management • Identifying that this monitoring program will now be under more direct oversight and recommendations of the Joint Planning Forum in order to support year-by-year recommendations for water management
Background	<ul style="list-style-type: none"> • Introduced Interim Flow Decision and discussed scheduling change of the Long Term Flow Decision • Detailed the history of high flow management in the Lower Bridge River from 2016 to 2022. 	<ul style="list-style-type: none"> • Provides additional context for current water management approach in the Lower Bridge River.
Methods	<ul style="list-style-type: none"> • Core sampling program remains unchanged. • Included opportunistic sampling (e.g. cottonwood seed dispersal) during conditional high flow monitoring years when flows exceed the WUP hydrograph • Included conditional implementation of cottonwood protection measures from damage caused by beaver activity at the discretion of the JPF but budgeted separately from the TOR by BC Hydro as required. 	<ul style="list-style-type: none"> • Clarify core program monitoring as well as conditional monitoring managed adaptively by the JPF.
Reporting	<ul style="list-style-type: none"> • Updated reporting deliverables to include annual reports, interim final reports and final reports 	<ul style="list-style-type: none"> • Align reporting deliverables with requirements of the JPF to foster adaptive management of the study as well as program summary reports to inform WUP order review

Section	Changes	Rationale
		and long term flow decisions.
Budget	<ul style="list-style-type: none">• Detailed budget table includes estimates for conditional high flow monitoring	<ul style="list-style-type: none">• Document full program cost and clarify budget allocation between ONR and BC Hydro funded years.