Campbell River Water Use Plan

Monitoring Program Terms of Reference

- **JHTMON-1 Upper and Lower Campbell Lake Reservoir Digital Elevation Model**

December 2016

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1.0 MONITORING PROGRAM RATIONALE

This Terms of Reference is for the development of a Digital Elevation Model for both Upper Campbell Lake Reservoir and Buttle Lake Reservoir (Upper Reservoir) and Campbell Lake Reservoir (Lower Reservoir). A cost estimate for the work and a schedule are included.

These Terms of Reference are submitted in response to the Water Act Order issued by the Comptroller of Water Rights on November 21, 2012, Schedule C, Clause 1(c) and Schedule D, Clause 1 (b). The Order requires terms of reference to "assess boating related recreation hazards" in the Upper Reservoir, and Lower Reservoir.

1.1 Background

Recreation values in the Campbell River watershed include significant recreational boating and fishing that can be affected by reservoir management activities in the Campbell River watershed. The Campbell River Water Use Plan Consultative Committee (CC), tracked recreational interests through the development of a Recreation Performance Measure tool (BC Hydro 2004), which identified water level preferences in the Upper Reservoir and Lower Reservoir. These preferences and thresholds were developed "using documentation from BC Hydro as well as other agencies, public use surveys, and professional knowledge/judgment" (BC Hydro 2004).

The CC wanted to ensure that boating hazards related primarily to reservoir operations were properly identified and assessed, in the interests of protecting public safety. The JHTMON-1 project will review boating hazards related to reservoir operating levels. Information gathered for this project will be complementary to other spatial information required for fish spawning and productivity studies (JHTMON-3, 4, and 5), recreation facility upgrade (JHTWORKS-2) and re-vegetation trials (JHTWORKS-3). The products of this project will be useful for multiple purposes to complement work already underway for these other Campbell River Water Use Plan projects.

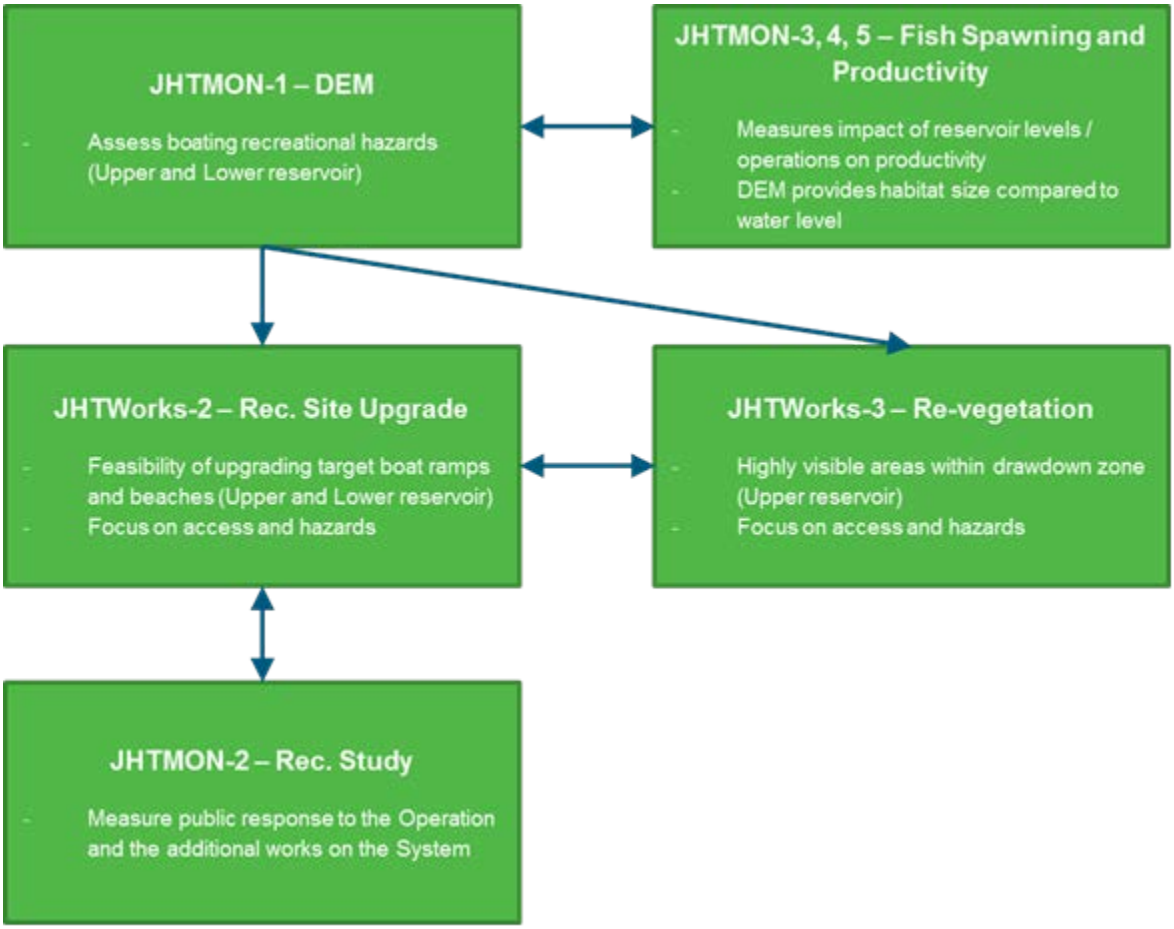

Figure1: Linkages to Other Campbell River Water Use Plan Projects

1.2 Management Questions

This project addresses two questions:

1. What are the locations and elevations of submerged or partially submerged hazards that might affect recreation (particularly boating) in the Upper and Lower Reservoir?

2. What reservoir elevation or range of reservoir elevations are the hazards most exposed to recreational activities (particularly boating)?

1.3 Key Water Use Decision

Upper and Lower Reservoir operating parameters are based on trade-offs of optimizing power production with other values for the system. The extent to which various trade-offs could be evaluated by the CC was directly related to the information available at the time. This meant that there were uncertainties in the recreational impact information and considerations that could be incorporated into the evaluation of reservoir levels – specifically the impact of submerged hazards, including stumps, to recreational boating safety. The CC felt that with better information on the location of submerged recreation hazards, the impact of reservoir

operations on recreational boating could be further evaluated. Having information about submerged hazards will inform the development of options for managing or mitigating public safety risk for boaters.

2.0 Program Proposal

2.1 Objective and Scope

To address the management questions in Section 1.2, the project will be carried out with the following objective in mind:

- To map and collect elevations of recreation hazards (primarily to boating) throughout the operating range of the Upper and Lower Campbell Reservoir.

Scope limitations include:

- The study area is comprised of the Upper Reservoir (including Buttle Lake) and the Lower Reservoir.

- The study will include the collation of both existing and new aerial photography, bathymetry, mapping analysis and digital elevation models.

- New mapping will be provided and updated elevation models will be developed as part of the final deliverables.

2.2 Approach

These terms of reference provide a description of a suggested approach and methodology, but contractors will be encouraged to recommend improvements, provided the changes meet the objectives and limitations stated above. In general, the approach recommended for each study component is as follows:

- *Compilation of Existing Information and Planning*: Conduct a brief overview of data collected to date from BC Hydro's Photogrammetry department and other available data sources. Compile information, including a summary of specifications used and required for project completion and a schedule for additional data collection.

- *Aerial Photography*: Where necessary to fill in data gaps, conduct photo-capture and associated ground surveys during optimal low reservoir operations consistent with the objectives of this study.

- *Connect with BC Hydro and project teams assigned to other Campbell River WUP projects:* There are a number of other Campbell River WUP projects that use spatial information and could benefit from the spatial information generated by this project. These other projects have also gathered spatial information that is available for this project. BC Hydro will coordinate discussion between various project teams to identify potential data gaps that can be filled with spatial information from this project. From these discussions, BC Hydro will define specific requirements and specifications for this project.

- *Hazard Mapping, Digital Elevation Mapping and Analysis*: Once all data are collected and compiled, generate a mapping series identifying hazards for boating and at what reservoir elevation or range of elevations those hazards become exposed. Develop digital elevation models for each reservoir.

2.3 Methods

The following methods are recommended to meet the objectives of the project. BC Hydro anticipates that this work will be implemented through BC Hydro's Photogrammetry department; however, any work performed outside of the department will be managed by BC Hydro's Photogrammetry department and be completed in accordance with BC Hydro's data standards, collection protocols, and analytical requirements.

2.3.1 Project Coordination

Project coordination involves the general administration and technical oversight of the program, which will include, but not be limited to: 1) budget management, 2) study team oversight 3) logistics coordination, and 4) technical oversight in field and analysis components.

2.3.2 Compilation of Existing Information and Planning

Over the years, BC Hydro has acquired numerous collections of aerial photography, bathymetry, and digital elevation models for portions of the Upper and Lower Reservoirs at various operating ranges. This study looks to augment the existing data.

Available data were collected from sources that vary in accuracy and level of detail. Some of these sources include stereo collection of DEM from aerial photography including 1:10,000 and 1:25,000 image scale, bathymetric surveys of portions of both Upper and Lower Reservoirs, including a detailed bathymetric survey in the forebay area of Strathcona Dam, and contour tracing from pre-flood mapping drawings. Digital orthophotography was also produced for the entire Campbell River System and/or specific areas of the watershed for other purposes.

Figures 2 and 3 below illustrate reservoir annual elevation targets. Detailed records of reservoir operations are available from BC Hydro on request.

Once all data have been reviewed and compiled and the data reviewed with BC Hydro's representative on this project, subject matter experts with expertise in boating safety and other project teams requiring data outputs from this project, the data standards and information requirements for this study will be set. An overall work plan including any supplemental photo-capture, mapping and analysis will be developed and reviewed with BC Hydro.

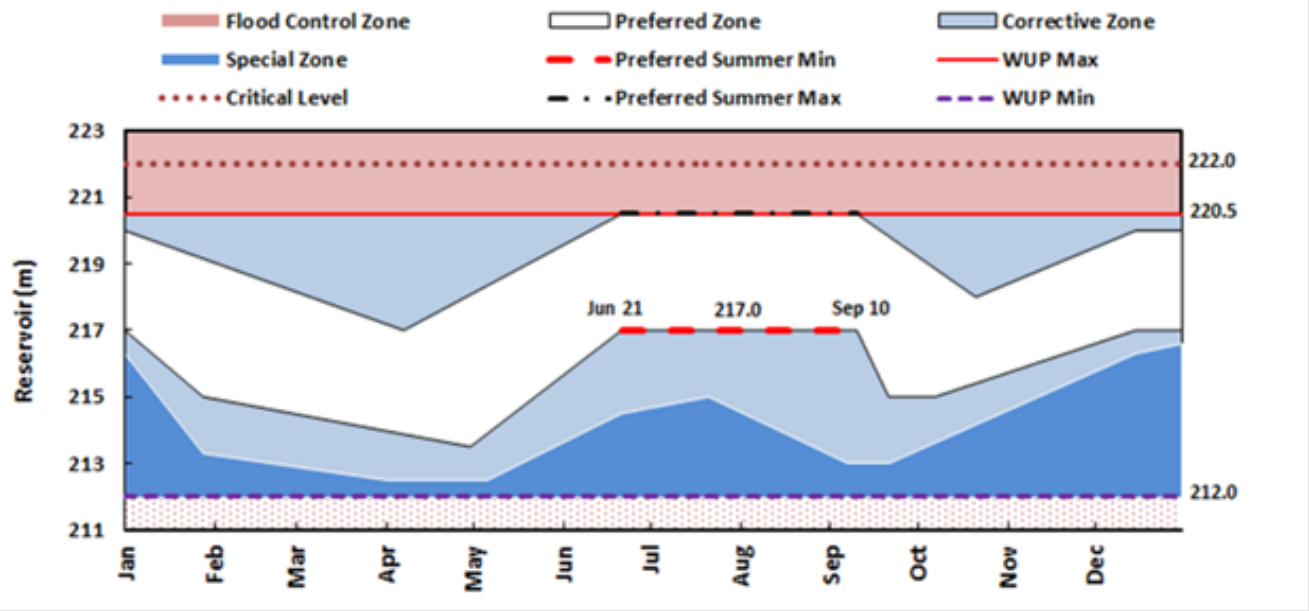

Figure 2 Upper Reservoir Operating Conditions

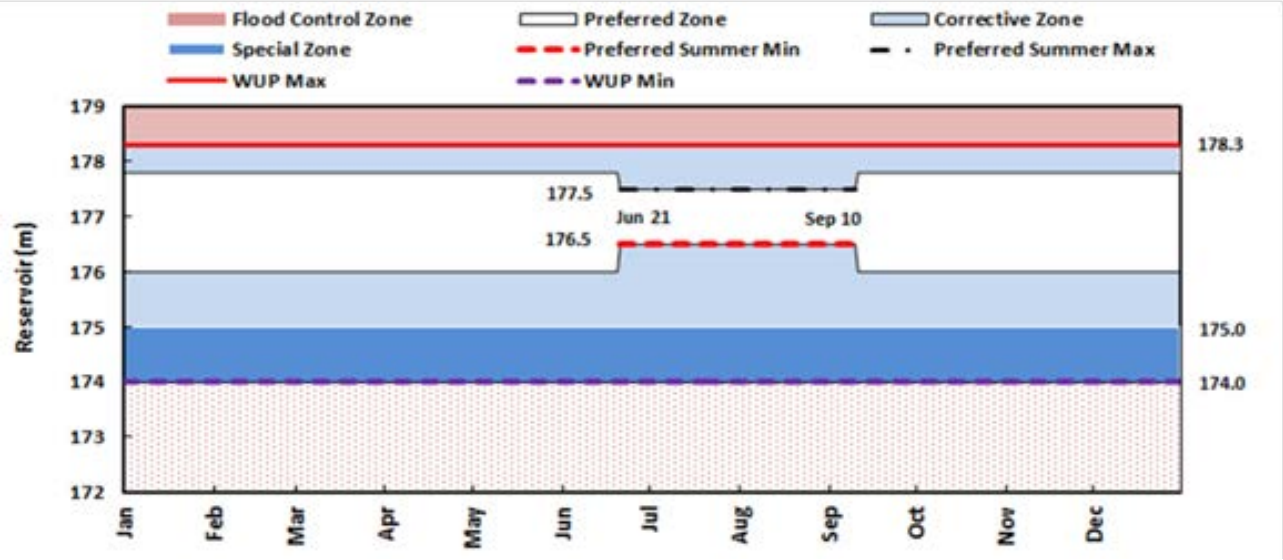

Figure 1 Lower Reservoir Operating Conditions

2.3.3 Aerial Photography

Aerial photography will be scheduled to coincide with low reservoir elevations and optimized sun-angle conditions. These circumstances may mean that the two reservoirs will be flown separately at different times to capture optimal data. Typical low-pool operation for the Upper Reservoir is April to May and September to November. The Lower Reservoir has a relatively small operating range (3.3 m outside of the summer recreation period), and timing of minimum elevations will be driven largely by inflows and generation demand. Typically the Lower Reservoir may be at its lowest levels in the late summer to spring period. Note that reservoir

operations in general are highly driven by inflow from the watershed, which is entirely dependent on weather conditions. Scheduling of aerial photography will be determined by reviewing best available reservoir operation forecasts with BC Hydro's project representative before committing to the photo-capture schedule.

Photos will be flown at a scale appropriate for mapping/digital elevation model interpretation. BC Hydro's Photogrammetry department will confirm the standards for this project during the planning phase of this program.

2.3.4 Bathymetry

Existing bathymetric data available from BC Hydro's Photogrammetry department for the Upper and Lower Reservoirs were obtained by digitizing contour lines from pre-flood mapping drawings with unknown accuracy. A bathymetric survey of both reservoirs will be beneficial for this project.

The work shall be completed according to specifications in a detailed scope of work document to be issued by BC Hydro's Photogrammetry department in consultation with BC Hydro's project representative.

Technologies such as Single beam echo sounders enhanced with the use of side scan sonar may be considered. Due to the presence of stumps in areas closer to the shore, alternative data collection, such as green LIDAR may need to be considered in shallow water. Note that some limited bathymetric data may also be available from the other BC Hydro WLR studies for the Upper and Lower Reservoirs and will be made available for this project.

2.3.5 Hazard Mapping, Digital Elevation Mapping and Analysis

This project will develop a digital elevation model. In addition, shoreline topographic maps delineating and identifying the locations, elevations, and size (where applicable) of contours, landforms, hazards, vegetation, buildings, roads, parks, and all other relevant data will be prepared.

All hazard data will be identified indicating their zones and elevation. The digital elevation model will be analysed to provide:

(a) Elevation relationships: relationships between reservoir elevation and water surface area versus land surface area;

(b) Mapping analysis: the locations of potential hazards (e.g., stumps, rocks, etc. that are within 0.5 m, 1.0 m, 1.5 m and 2.0 m beneath the water surface elevation at the lowest preferred reservoir elevation) and the elevation of those potential hazards; and

(c) Hazard identification plan: based on the water elevation and hazard relationships in (a) and (b) above identify the hazards and at what elevation they become a hazard in each reservoir. Note that actual boating hazards are considered to be within 1.2 m of the water surface, so depending on reservoir elevations, hazard locations will fluctuate with water elevations.

2.4 Deliverables

- A brief report including a summary of the work completed, the mapping and analytical methods used, and the tabulated results of any numerical analysis conducted, will be completed at the end of the project. The exact reporting deliverables will be confirmed with BC Hydro once the initial project plan has been developed.

- Any spatial data collected as part of this project will be provided to BC Hydro's photogrammetry department to be archived in BC Hydro databases.

- A map identifying hazard zones in relation to reservoir levels will be developed to the satisfaction of BC Hydro's project representative.

- Updates to the map identifying hazard zones in relation to reservoir levels will be updated following any physical works to mitigate hazards undertaken in JHTWORKS-2 Upper Campbell Lake Reservoir and Campbell Lake Reservoir Recreation Facility Upgrade within the timeframe of this project.

2.5 Schedule

Based on the operating schedule of both reservoirs, the exact work schedules cannot be determined in advance. This study could take one year with the planning and field/photography phases of the program completed at the start, and the mapping, analysis and reporting filling in the rest of the year. However, if challenges with capturing optimal reservoir elevation are encountered field work may be rescheduled to a more optimal time. BC Hydro will consider adjustments to project schedule to ensure that data requirements met.

2.6 Budget

The total cost estimated for implementing this one-year study is $141,705.

3.0 References

Anon. 2004. Campbell River Water Use Plan: Consultative Committee Report. Prepared on behalf of the Consultative Committee for the Campbell River Water Use Plan. 132 pp. + App.

Hamilton, H. 2000. Airphoto series and compilation photos of Campbell River system flown 22 May 1999. Prepared for BC Hydro Bridge River-Coastal Generation, Burnaby, BC.