

Campbell River Project Water Use Plan

Monitoring Program Terms of Reference

- **JHTMON-11 Upper Campbell Lake Reservoir Erosion Assessment**

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1 Program Rationale

1.1 Background

Erosion of the Upper Campbell and Buttle Lake Reservoir (herein referred to as Upper Campbell Reservoir) is of concern to residents of Cedar Creek and Strathcona Park subdivisions, and the owners of the Strathcona Park Lodge. Shoreline erosion was exacerbated in recent years by the implementation of the 1997 Interim Flow Management Strategy (IFMS, Campbell River Hydro/Fisheries Advisory Committee), which saw an increase in reservoir elevations of approximately 1 m over historical operations. The Campbell River Water Use Plan (JHT WUP) Consultative Committee (CC) incorporated these concerns in the development of the WUP through the evaluation of several alternatives against an erosion performance measure (PM). The PM was developed by the Recreation, Flooding and Erosion Subcommittee, and it assigned impact weighting to various operations as follows:

Table 11.1 Erosion impact weights applied to the Upper Campbell Reservoir Erosion Performance Measure (Anon 2004)

Reservoir Elevation (m)	Impact Weight (0-1)
< 220	0
220-221	0.1
> 221	1

Previous studies on Upper Campbell Reservoir have concluded that shoreline erosion is primarily related to the erosive action of wind-generated waves acting on the upper portion of the existing beach profile (MEP 1995). While this erosive action has stabilized for elevations below 221 m from years of impoundment, beaches above 221 m are still impacted by wave action, and properties above the beach are subject to erosion when the reservoir is surcharged above 221 m.

In consideration of these issues, the JHT WUP CC recommended that the maximum “normal” operating condition be 220.5 m. Although not an operating constraint, the system will be managed below the “normal” maximum except during extreme conditions. The CC also recommended that conditions at the three areas of concern be monitored annually, and rehabilitated using “soft” engineering techniques, until it is concluded that (a) the operations no longer contribute to the erosion at each site, and (b) the recommended physical works stabilize conditions at each site.

1.2 Management Questions

In developing the monitoring proposal on behalf of the Consultative Committee, the Recreation Technical Committee wished to see the following questions addressed:

- 1) What is the relationship between the recommended Upper Campbell Reservoir operating regime and shoreline erosion at three indicator sites?

- 2) How effective are proposed physical works in controlling erosion at the three indicator sites?

1.3 Summary of Impact Hypothesis

To answer the management questions, this study will address the following hypotheses related to erosion at each index site:

- H₀1: Reservoir operations on Upper Campbell Reservoir does not exacerbate shoreline erosion (as represented at three index sites).

Hypothesis H₀1 will be tested for each site condition as approximations of overall shoreline impacts around the reservoir. The test will be independent of erosion control works being proposed for each site, but will be testing operations under the proposed Water Use Plan. Influence of operations on erosion will be evaluated annually using empirically derived indicators of shoreline change and compared with previous year's measurements. Tests of significance will be conducted for each indicator across inter-annual and annual datasets.

- H₀2: Proposed physical works to control erosion are not effective.

Test of this hypothesis will be based annual performance of the erosion control works. Tests of significance will be conducted on each indicator of performance for each site's physical work for the term of the monitoring study. Although tested annually, this hypothesis may not be fully tested until long term data are available.

1.4 Key Water Use Decision

The IFMS operating conditions below John Hart Generating Station (JHT GS) required flexibility in the Upper Campbell Reservoir which resulted in an increase in frequency of reservoir operations exceeding 221 m. Studies have shown that inundation above 221 m can increase erosion rates of upland shorelines. Results from this study will be considered in the next phase of water use planning at the conclusion of the JHT WUP review period, towards optimizing Upper Campbell Reservoir operations in consideration of all affected values.

2 Program Proposal

2.1 Objective and Scope

To answer the management questions, this monitoring proposal has the following objectives:

- To set up monitoring stations at three index sites in the Upper Campbell Reservoir and monitor erosion activity over the review period; and
- To assess the effectiveness of proposed erosion control works for the three index sites.

The study area is limited to three index sites identified in the JHT WUP within a small portion of the Upper Campbell Reservoir (see attached figure):

- Strathcona Park Lodge: several facilities are located within the zone of erosion defined by BC Hydro during the construction of Strathcona Dam and

impoundment of Upper Campbell Reservoir (see MEP 1995 for erosion line setbacks);

- Strathcona Park Lodge Subdivision: Lots 1 to 10 are located just above sloughing till banks and are threatened by continuing erosion from wave action at the foot of the bank; and
- Cedar Creek Subdivision: several lots within and outside of existing erosion setbacks are experiencing erosion at respective shoreline areas.

Monitoring stations will be set at representative locations for each site for continuous and spot measurements and to evaluate erosion control works planned in JHT WUP.

This 10-year monitoring program will be coupled with physical works planned for the Upper Campbell Reservoir, such that the Upper Campbell River erosion physical works program initiatives will be reactive to recommendations from this study. After setting up the study parameters and installing site monitoring stations in Year 1, ongoing monitoring and recommendations will be provided annually to coincide with annual planning for the physical works program (see JHT WUP Physical Works Terms of Reference for program specifics).

2.2 Approach

This terms of reference provides a description of the studies as they are presently conceived, but contractors are encouraged to suggest improvements, provided the changes meet the objectives stated above. In general the approach recommended for each study component is as follows:

- *Study definition and site set-up:* Year 1 will be spent reviewing the terms of the physical works program, outlining monitoring parameter and reporting requirements, and identifying and installing monitoring stations at the three index sites;
- *Annual monitoring and analysis:* the 10-year annual monitoring program will incorporate monitoring methods used historically (BC Hydro 1993) and additional methods for monitoring physical works effectiveness; and
- *Recommendations and physical works planning:* After Year 1, annual reporting from this monitoring program will be incorporated into the physical works planning for the following year, in an effort to improve the effectiveness of the physical works program.

2.3 Methods

The following methods are recommended to meet the objectives of the studies as defined by the consultative committee during the Water Use Plan process, and to assess the hypotheses as stated in these terms of reference. Any changes must meet the objectives and information requirements without increasing the cost or scope of this monitoring program.

2.3.1 Study Definition and Site Set-Up

Upon contract award, the lead geo-scientist will refine the study terms based on the following information review:

- *Study results to date:* several technical investigations, led by BC Hydro's engineering group (MEP 1995) and by the regional facility office in Campbell River (BC Hydro 2002) have been conducted assess and mitigate shoreline erosion in Upper Campbell Reservoir. A review of all available information is required prior to initiating a monitoring program;
- *Physical works terms of reference:* a review of the physical works program will be conducted towards incorporating key monitoring parameters to assess the effectiveness of the program in reducing existing erosion concerns. Efforts will be made to incorporate methods for monitoring both ongoing wave/operationally motivated erosion activity and effectiveness of restoration activities into the annual monitoring design;
- *Alternative monitoring methods review:* methods described herein are a continuation of existing monitoring and assessment techniques employed at Upper Campbell Reservoir since 1993. A review of key erosion monitoring references will be conducted to identify and incorporate additional or alternative study methods for the program; and
- *Site selection and evaluation:* three monitoring locations representing the three sites identified above will be selected and initial site descriptions will be documented based on a field assessment by the lead scientist in this study. The assessment will include a reconnaissance of known erosion sites proximal to the study area, according to the information reviewed above. Photopoints will be established at each site and the photo-record will be initiated at this stage.

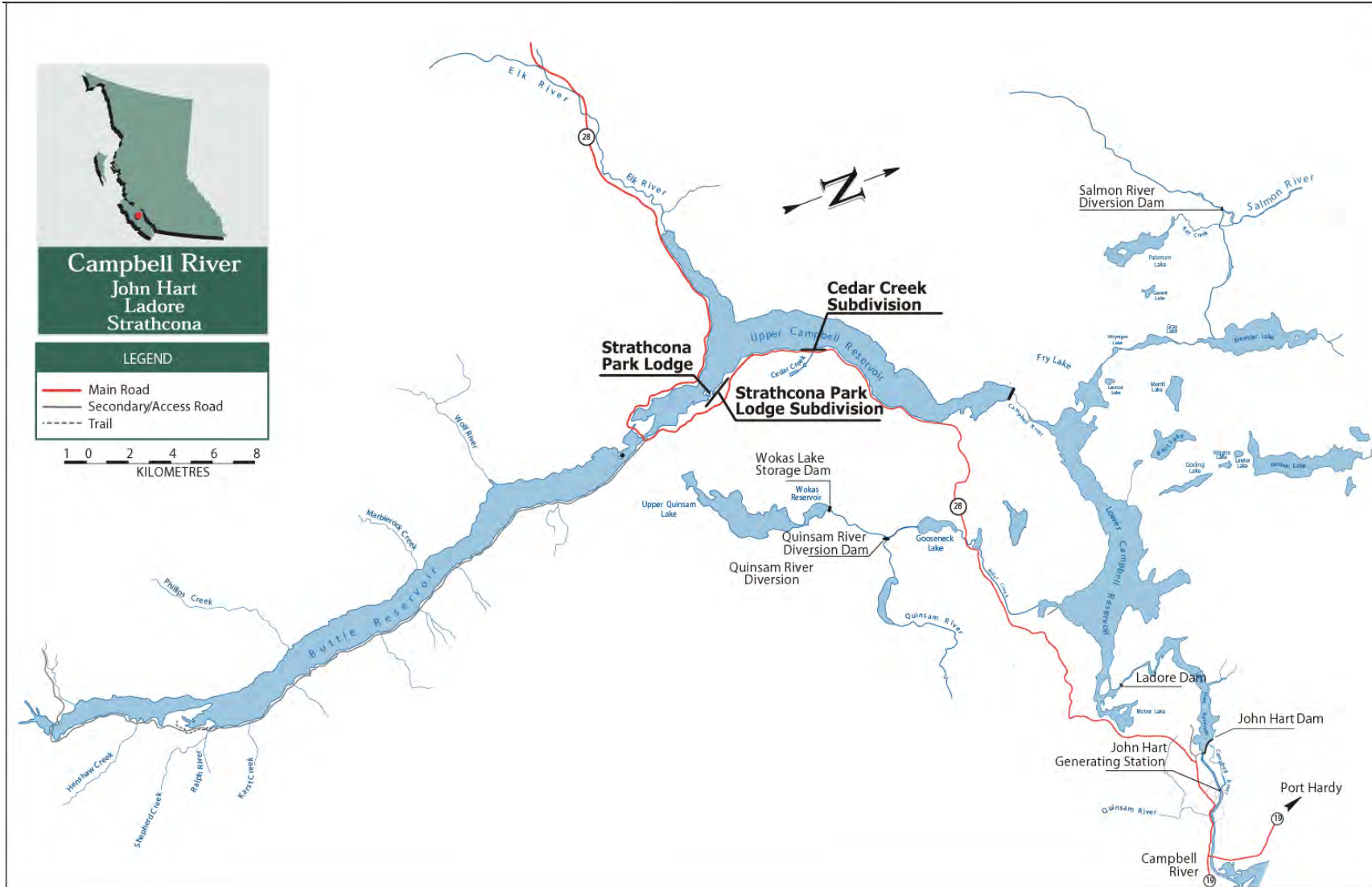


Figure 11.1 Study area noting the locations of the three index sites – Strathcona Park Lodge and Subdivision, and Cedar Creek Subdivision (from MEP 1995).

Once final study terms are developed and submitted to the BC Hydro contract authority for approval and contract implementation, monitoring stations will be assembled at respective sites and site surveys will commence according to the following tasks:

- *Monitoring stations:* Long-term monitoring stations will be installed at each site according to monitoring requirements and budget restrictions. Each station will collect real-time water level and temperature information and be protected from vandalism and weather; the remote platforms will be fitted with a battery of adequate storage and, where necessary, a rechargeable source such as a photo-voltaic cell. It is recommended that the Strathcona Park Lodge site be utilized for wind monitoring, although previous studies have inferred wind speeds from Campbell River Airport (MEP 1995). Contractors may wish to explore the cost-effectiveness cellular and/or satellite data transmission options for water level and temperature measurement along with reduced travel and labour for manual downloads.
- *Initial site survey:* Site surveys should be conducted at low reservoir elevation, typically mid-spring, or mid-fall. Depth and locations of the water level recorders will be surveyed to known elevation. Site extents will range from the stable shoreline area below full pool to stable upland areas above established erosion impact lines. Extents will be surveyed and “permanent” shoreline profile markers will be installed with markers and adjacent ground elevations surveyed. Markers will be set at depths such that surrounding erosion will not compromise their placement. A minimum of 30 markers will be placed in “grid” formation, such that rows of markers are roughly on the same elevation contour. The majority of markers will be placed in the 2-3 m band above 221 m, but will be distributed throughout the site. A representative terrain model of the site will be constructed using GIS software. Photopoints will be established at the upland and shoreline extents, and photographs taken. A comment sheet will be filled out noting
 - Geo-scientist name, date and time
 - Photo-reference IDs and descriptions
 - Predominant weather conditions
 - Professional evaluation of general site stability and recent erosion activities (referenced to nearest marker ID)
 - General comments on site dynamics and issues
- *Shoreline classification:* A minimum of two ground profiles will be surveyed at each site (presumably at the site’s lateral extents), extending perpendicular from shoreline to the stable up-hill zone of the reservoir’s surrounding topography. Permanent profile start and terminal markers will be established and surveyed. At regular intervals along each profile (i.e. where material conditions and/or slope angles change), the surface and sub-surface soils will be classified into dominant and sub-dominant categories according to BC RISC guidelines (2001). All surveys are to be tied to known controls. Upon completion of the site assessment, a brief analysis of slope profiles and erosion potential will be developed based on the slope stability criteria in Table 11.2. The terrain model will integrate the beach material types identified in this survey.

Table 11.2 Beach slopes for various material classifications. Adopted from BC Hydro (1993).

Stable Beach Slope (H:V)	Beach Material	
	Description	D50 (mm)
10:1	Fine Sand	0.2 - 0.4
8:1	Medium Sand	0.4 - 2.0
7:1	Coarse Sand	2.0 - 5.0
6:1	Fine Gravel	5.0 - 20
5:1	Coarse Gravel	20 - 75
4:1	Cobbles	75 - 125
3:1	Large Cobbles	125 - 200

- *Follow-up and restoration site surveys:* According to survey requirements for effectiveness monitoring of restoration sites, each site will be reviewed and survey markers and photopoints will be established OR monitoring requirements for each site be reviewed for consistency with the above approach.

2.3.2 Annual Monitoring and Analysis

The three index sites will be monitored and maintained year-round and for each year in the 10-year WUP review period as follows:

- *Monitoring platform maintenance:* Each site will be visited three times per year to download water level, wind and temperature information from the previous monitoring period. At each visit, stations will be checked for battery levels, accuracy and site integrity. Where instruments are to be replaced, there is contingency in this study program to consider replacing two units over the 10-year period. Photographs will be taken at each photopoint during each tri-annual visit, and ;
- *Site survey monitoring:* Once per year, preferably during mid-spring low reservoir conditions, ground elevations at established survey markers and along both slope profiles will be re-surveyed. Where ground erosion around survey markers has undermined or will undermine markers, the approximate location of the marker will be surveyed and a new marker will be set and surveyed at the location. Where required, the shoreline classification will be re-assessed (e.g., where surface erosion exposes a different soil type). A representative terrain model of the site will be constructed using GIS software, integrating surface material types.

Monitoring data will be analyzed annually after site surveys are complete and data are entered into a formatted database. The following steps will be taken during the analysis to test each hypothesis:

- *Water level analysis:* data from each water level monitoring station will be sorted and reviewed for errors and compiled into a single spreadsheet along with data from the wind monitoring station and BC Hydro operations data. A statistical summary of water levels and correlated wind levels will be provided for consideration in establishing the root causes of erosion.
- *Erosion analysis:* site terrain models will be compared each year, and degrees of material movement will be analyzed using GIS software, both between years and over the entire monitoring period. The analysis will also describe the erosive

tendency of different material types according to the shoreline survey mapping conducted. Erosion rates at some sites have already been defined (see MEP 1995), and these should serve as the basis for comparison to evaluate the effectiveness of the recommended operating regime.

2.3.3 Reporting, Recommendations and Physical Works Planning

Each year the analysis and interpretation of results will be documented in a study report that will describe (a) the effectiveness of the recommended Upper Campbell Reservoir operations, (b) the effectiveness of physical works on erosion control, and (c) recommendations for improving physical works' effectiveness. The recommendations for physical works improvements will include methods and timing and will be considerate of the annual budget available to the program, and the program objectives set out by the JHT WUP CC.

In Year 5 of the monitoring program, an interim data report and overview report will be prepared summarizing recommendations and overall effectiveness of the operating regime and physical works program, and make recommendations for implementation over the next five years of the review period. In Year 10 of the monitoring program, a final report will be prepared to summarize monitoring results over the review period, the status of erosion, and define mechanisms for erosions as they pertain to operations to support decision processes in future planning processes. The report will identify those operations that exacerbate or mitigate erosion at index sites, and suggest physical works improvements, and/or make a strong case for collecting more information, including the types and length of monitoring required.

2.4 Interpretation of Results

The results of this monitoring program will be compared annually to determine the extent and means of shoreline erosion at three sites. Indicators such as duration of reservoir operations above 221 m, rate of erosion, and wind speed (corresponding to wave height) will be compared annually and correlated to erosion measured through spatial analysis. Where strong correlations exist, relationships with operations will be evaluated. Scenarios for operational changes for reduced erosion may result from these interpretations.

2.5 Schedule

Within-year timing of activities will be set once contract terms are implemented. However, the following tentative schedule is recommended for data collection per the study methods proposed above (Table 11.3)

- January-February Year 1 – Information Review
- March-April Years 1-10 – Initial site survey and station setup (Year 1), annual surveys and data download #1
- July-August Years 1-10 – data download #2
- November-December Years 1-10 – data download #3
- January – Draft annual report (Years 1-4, 6-9)
- February – Draft interim report (Year 5) or final review period report (Year 10), final report (Years 1-4)

- March-April – Final Report and Recommendations (Interim: Year 5, Review Period: Year 10)

2.6 Budget

Total cost for the program presented here is roughly \$268,471 based on a 2014 start.

3 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. technical guidelines for determining slope stability and groundwater impacts on reservoir

BC Hydro. 2002. Strathcona Park Lodge and Cedar Creek subdivision shoreline impact (file folder). Prepared for Vancouver Island Generation, Campbell River, BC.

Campbell River Hydro/Fisheries Advisory Committee. 1997. Campbell River Interim Flow Management Strategy (IFMS). 51 pp.

MEP (Maintenance, Engineering and Projects). 1995. Upper Campbell Lake shoreline impact study. Prepared for BC Hydro, Burnaby, BC.

RISC (Resource Inventory Standards Committee). 2001. Reconnaissance (1:20,000) fish and fish habitat inventory standards and procedures. Prepared by BC Fisheries Information Services Branch, Victoria, BC.