Duncan Dam Project Water Use Plan
Monitoring Program Terms of Reference

- DDMMON-16 Lower Duncan River Fish Stranding Impact Monitoring

April 24, 2008
1.0 OVERVIEW

This document presents Terms of Reference for monitoring program and physical works for the Duncan Dam Water Use Plan (Table 1). The monitoring programs will address key questions that affected decision making throughout the consultative process. They will assess expected outcomes of operational changes recommended in the Water Use Plan and will provide improved information for future operating decisions. The physical works programs will reduce ongoing erosion to a valuable wetland area, install a boat ramp, develop an action plan to minimize stranding of kokanee spawning in Duncan River side channels, and compensate for nutrient loss to Kootenay Lake.

This document provides detailed Terms of Reference for the following program:

1) DDMMON-16 Lower Duncan River Fish Stranding Impact Monitoring: This 10 year monitoring program will provide annual indices of the effectiveness of measures taken in the Adaptive Stranding Protocol Development programme, including fish stranding rates and stock abundance.

Table 1  Duncan Dam Water Use Plan Physical Works and Monitoring Program Terms of Reference Submission Information

<table>
<thead>
<tr>
<th>Name of Monitoring Program or Physical Works</th>
<th>Order Clause Fulfilled</th>
<th>Submitted with this Package</th>
<th>Previously Submitted To CWR</th>
<th>Submission Date</th>
<th>Leave to Commence</th>
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<tr>
<td>DDMMON-1 Lower Duncan River Ramping Rate Monitoring</td>
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<td>DDMMON-6 Lower Duncan Dam Bull Trout Passage Monitoring</td>
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16.0 DDMMON#16 – Lower Duncan River Fish Stranding Impact Monitoring

16.1 MONITORING PROGRAM RATIONALE

16.1.1 Background

A key objective of the Duncan Dam Water Use Planning decision process was to maximize fish abundance and diversity in the Duncan River Watershed, and specifically to reduce fish stranding risk and maximize habitat suitability in the Lower Duncan River. Several Duncan Dam operations were modified towards reaching these objectives, but there remained uncertainties on how gate operations could best be managed, particularly for discharge reductions. It was recommended that these uncertainties be addressed in an adaptively managed program to be implemented over the WUP review period, as a group of monitoring studies collectively referred to as the Adaptive Stranding Protocol Development (ASPD) program. This suite of monitoring programs will provide the rationale for the implementation of a final operating protocol for Duncan Dam release changes:

- DDMMON#1 – Lower Duncan River Ramping Rate Monitoring: experimental flow reductions conducted during the fall period to determine the variables that affect fish stranding risk.
- DDMMON#2 – Lower Duncan River Habitat Use Monitoring: identifying the timing and habitat use preferences of Duncan River fish populations;
- DDMMON#3 – Lower Duncan River Hydraulic Model Development: development of predictive tools to integrate habitat use with water flows at a range of operations to quantify operating impacts on habitat displacement;
- DDMMON#15 – Lower Duncan River Stranding Protocol Development and Finalization: a review and integration of the previous three studies towards finalizing an operating strategy to minimize stranding; and
- DDMMON#16 – Lower Duncan River Fish Stranding Impact Monitoring: a regular assessment of population response to operations.

A key component of the ASPD is the ongoing assessment of fisheries impacts associated with recommended changes. This monitoring program will determine, in conjunction with other stock assessment tools being developed over the monitoring period, the population level impacts of key operations throughout the review period. While stock assessments are not mandated in the WUP monitoring program, there are several habitat use studies that will drive the development of theoretical density estimates against which index stranding assessments will be compared, and used to assess the potential impact of a stranding event on respective fish populations in the Lower Duncan River. These ongoing indexed assessments will be the basis for evaluating the performance of fish stranding mitigation measures implemented as part of the ASPD.

Completing this study will result in partial fulfillment of requirements ordered by British Columbia’s Comptroller of Water Rights, and, in conjunction with the other studies in the ASPD programme, will specifically address clause 5(e) of BC Hydro’s Duncan Dam Conditional Water Licence 27027.
16.1.2 Management Questions

The overall management question to be addressed within the ASPD program is:

What are the best operating strategies at Duncan Dam to reduce fish stranding in the Lower Duncan River?

The specific management questions associated with this monitoring program are:

1. How effective are the operating measures implemented as part of the Adaptive Stranding Protocol Development programme?

2. What are the levels of impact to resident fish populations associated with fish stranding events on the Lower Duncan River?

These questions directly reflect the uncertainties facing the Consultative Committee when making decisions regarding BC Hydro operations on the Lower Duncan River. It is anticipated that by addressing these questions, improvements can be made to the operations at Duncan Dam, and more informed decision making will be applied in future water use planning processes at this project.

16.1.3 Summary of Alternate Hypotheses

To address the management questions above, the monitoring program must test several hypotheses related to the assumptions to be used in the monitoring program, and the effectiveness of the ASPD programme’s recommendations:

H01: Fish stranding observed at index sites along the Lower Duncan River floodplain are representative of overall stranding.

For the fish stranding index to be an effective metric for the river, the overall stranding rate will have to be assessed at regular intervals to define appropriate factors for extrapolating index assessments.

H02: Fish populations in the Lower Duncan River are not significantly impacted by fish stranding events.

This hypothesis assumes that fish population levels and recruitment processes are known in the Lower Duncan River. Standing stock estimates will be obtained at regular intervals throughout the review period, and assumptions about juvenile to adult recruitment in the area for each target species will be researched and documented. Where recruitment rates are unknown or uncertain, ranges will be provided to define appropriate limits of survival. Finally, a recruitment model will be developed that will integrate stranding rates (both observed and derived from known operations) with population levels to estimate whether significant or cumulative population declines are being caused by Lower Duncan River operations. Significant population level declines will be defined as those attributed to operations that keep populations from achieving productive levels thought to be available through the prescribed Water Use Plan flow regimen for Duncan Dam.

This study program will integrate information from other studies related to habitat use (DDMMON#2) and habitat availability (DDMMON#3) at various flows to assess site representation, extrapolate standing stock estimates, and to define target species.
16.1.4 Key Water Use Decision Affected

The ASPD programme will define operating strategies to reduce fish stranding on the Lower Duncan River. This study will assess the effectiveness of those operating measures for consideration in future water planning processes. At any point during the Duncan WUP review period where significant impacts are being observed, and where these impacts can be reasonably mitigated through alternative operating protocols, an inter-agency review may trigger changes to operating orders for the Duncan Dam facility prior to the end of the review period.

16.2 MONITORING PROGRAM PROPOSAL

16.2.1 Objective and Scope

The objective of this monitoring program is to assess the effectiveness of operating measures implemented as part of the ASPD programme. A secondary objective is to empirically assess the influence of stranding events on resident and/or rearing fish population levels in the Lower Duncan River.

The study program will integrate stranding assessments, standing stock assessments, information reviews and recruitment analysis to meet the objectives. It is anticipated that several index stranding assessments will occur each year, with opportunistic standing stock and recruitment analyses occurring throughout the review period.

Study component work will be limited to the Lower Duncan River mainstem and sidechannels, and will be initiated prior to implementation of the ASPD programme recommendations (planned for Year 3 of the 11 year review period). It is worth noting that the index assessment methodology in this TOR follows that utilized prior to WUP implementation, providing several years of “pre-ASPD” stranding results.

Fish species of interest were previously defined by the Consultative Committee as rainbow trout (Oncorhynchus mykiss), emigrating kokanee juveniles (O. nerka) and mountain whitefish (Prosopium williamsoni), although recent flow ramping studies (see Golder 2007, e.g.) have shown other fish species to be susceptible to stranding during operating changes (e.g. longnose dace <Rhinichthys cataractae> and redside shiner <Richardsonius balteatus>). Low numbers of juvenile bull trout (Salvelinus confluentus) have been sampled during historic stranding assessments, while burbot (Lota lota) typically do not reside in the system and have not been observed in previous stranding assessments. The attached life history table describes the current status of knowledge for potential species of interest.
Table 16-1: Life history timing for species of interest in the Lower Duncan River. Rearing phases for all species are assumed to be consistent with the region’s growing season: 1 April to 31 October

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For stranding and stock assessment components, juvenile salmonids and smaller adults of other fish species (<150 mm) will be targeted, and recruitment analyses will be limited to those life stages studied in this program. This cut-off is based on assessment limitations (standing stock assessments cannot target adult salmonids), and empirical stranding observations that are predominantly limited to small fish.

16.2.2 Approach

According to these study terms and the study plan to be recommended under DDMON#15 – Lower Duncan River Stranding Protocol Development and Finalization, there are three components planned for this study program:

- Stranding assessments: index assessments of stranded fish will be conducted up to four times each year to record the impacts of both planned and unplanned operating changes on the Lower Duncan River – specifically decreases in flow release from Duncan Dam. In addition, one assessment each year will include an expanded stranding assessment to calibrate extrapolation factors for the river. A stranding risk measure will be updated and reported for each event.
- Annual stock assessments: in the late summer each year, an indexed stock assessment will be conducted for species of interest. A standing stock estimate for each species life history observed will be calculated for the river.
- Stranding and stock recruitment analysis and reporting: in consideration of stock abundance estimates, assumed natural species life history survival indices and fish stranding estimates for each year of operations, an analysis will be conducted to determine whether fish stranding has a significant impact on fish populations in the Lower Duncan River. Stranding results will be summarized for each assessment and a summary report prepared each year estimating the total number of fish stranded each year and potential stock implications of these operations, with emphasis on evaluating the effectiveness of ASPD measures.

16.2.3 Methods

The following methods describe the approach that was recommended by the DDM WUP CC and approved by regulating agencies. Deviating from the technical design of these terms of reference is not recommended except where explicitly approved by the contract authority and stakeholders committed to ensuring the ASPD plan is approved and implemented. Approval may be given if the design assures improved
understanding, data resolution, and does so in a reasonable time frame and within budget.

Upon the completion of stranding protocol adaptations central to DDMMON#15 – Lower Duncan River Stranding Protocol Development and Finalization, it is anticipated that the methods below may be revised to reflect the mitigation options, revised stranding issues and fisheries concerns. As above, budget and scheduling limitations, Duncan Dam Water Use Planning commitments, and impacts to the effectiveness of this study will be considerations in any program changes.

16.2.3.1 Stranding Assessments

There are two levels of stranding assessments proposed for this study program: index assessments and calibration assessments. Index assessments will be conducted throughout the year to document fish stranding during both planned and unplanned operations. Calibration assessments will be carried out each year to define the variability in stranding rates spatially, temporally and between species, to ensure that the index stranding results can be reasonably extrapolated for the entire Lower Duncan River floodplain.

Index Stranding Assessments

Index stranding assessments will be conducted annually throughout the review period in two phases: before and after ASPD recommendations. In Years 3 and 4 of the review period the ASPD will be revised to incorporate information developed in the ASPD study programme, which will include, but not be limited to:

- Specific operating protocols for Duncan Dam to reduce fish stranding risk in Lower Duncan River;
- Habitat values and distribution corresponding to specific species use and interpreted/observed stranding risk; and
- Guidelines for observing, analyzing and reporting fish stranding incidents on the Lower Duncan River.

Prior to ASPD revisions, fish stranding assessments will be conducted and reported per the current Lower Duncan River Fish Stranding Protocol (BC Hydro 2004) at sites currently considered representative of the river. Several reports have been generated under the protocol (see AMEC 2005 for a description of stranding sites).

Following the ASPD revisions, fish stranding assessments will be repeated according to the specific methodology in the ASPD document (DDMMON#15 – Lower Duncan River Stranding Protocol Development and Finalization defines the schedule and approach to be used for the revisions). It is anticipated that index sites may be different than those monitored prior to ASPD revisions – the study budget will accommodate up to 15 index sites, identified in the information review and planning section.

This monitoring program will accommodate up to five fish stranding assessments (four index assessments and one calibration assessment per year) following either planned or unplanned downward flow changes at Duncan Dam (ramp-downs) that are not otherwise being assessed (e.g. during DDMMON#1 – Lower Duncan River Ramping Rate Monitoring flow trials). Where excessive flow changes are incurred, it will be the BC Hydro contract monitor’s decision to determine which assessments will
be conducted and if more are required. To ensure the study budget will be adequate to cover potential assessment requirements, the assessment frequency suggested in this TOR is higher than that currently warranted by planned operational changes.

In general fish stranding assessments will be confined to pre-defined areas of known extents. Assessments in dewatered areas will enumerate stranded fish by hand, and in isolated pools by electrofishing where required, using the 3-pass depletion methodology (see Anon 1995 for sampling and analysis procedures). Enumeration will include documenting fish condition, species and length. Access will be divided between boat and vehicle depending on the river location.

**Calibration Stranding Assessments**

Annual calibration stranding assessments will be conducted following a Duncan Dam rampdown. The calibration assessment is counted as one of the five assessments budgeted for this study program. The calibration assessment methodology will be similar to that applied in the index sampling section except that during the calibration assessments, 30 sites will be sampled instead of 15.

The additional 15 assessment sites will be defined in the information review section, and will be representative of the diversity of habitat in the Lower Duncan River. Whereas the index sites will be chosen to quantify the majority of fish stranding, the additional calibration sites will be used to extrapolate index results for the Lower Duncan River (expected to be at stranding rates less than those observed in index sites). As noted in the analysis section below (Section 16.2.3.3), reviews of these sites may show increased stranding in calibration sites, necessitating replacement of one or more index sites. Such changes will be carefully documented and retroactively reviewed to document potential ramifications to historic analysis of stranding.

Calibration assessments will be scheduled to ensure that a minimum of two calibrations are conducted per season by the end of the review period. More calibrations will be conducted in the summer and fall than in winter over the review to reflect the relative importance of those seasons for fish populations in the Lower Duncan River.

Calibration stranding data will be extrapolated according to the habitat type areas defined in the information review: average fish stranding densities for each habitat type defined in the calibration surveys will be integrated for each flow change reviewed during both calibration and index surveys to produce a total fish stranding value that is appropriate for the season and flow level.

**16.2.3.2 Annual Stock Assessments**

To determine the potential effect of fish stranding on fish populations in the Lower Duncan River, this study task will attempt to quantify standing stock for fish species of interest in the river at index sites identified in the information review. It is anticipated that the information review from DDMMON#15 will recommend index sites for annual stock assessments.

Starting in Year 3 (2010) (following the preliminary implementation of ASPD recommendations), ten pre-selected index sites will be sampled by electroshocker using established stock assessment techniques (see Anon. 1995). In general, 3-pass electrofishing within approximately 100-150 m² closed net areas will be conducted by three trained fisheries technicians at each site at the critical streamflow period.
(CSFP), between August and mid-October. Site selection and assessment timing will
consider the potential impacts to spawning/incubating kokanee that may be present
during the stock assessment. Fish will be enumerated by species, age class (dictated
by locally developed length-frequency histograms), length and weight. Habitat within
the sites will be characterized by:

- hydraulics: dominant and subdominant substrate class, depth and velocities
  will be taken at a minimum of 10 stations along a representative transect
  within each site;
- site characteristics: location (UTM), wetted area within the site (length and
  width of site);
- instream/overhead cover;
- substrate characteristics: per cent area by substrate class (sand, gravel,
cobble and boulder), degree of substrate embededness, diameter of the 90th
percentile substrate size ($D_{90}$) and the maximum diameter substrate ($D_{max}$);
and
- water quality parameters: temperature, pH, turbidity and total alkalinity taken
  at the time of sampling at each site

The habitat characteristics (hydraulic type, mainstem/sidechannel, mean and
maximum depth within the habitat unit, and stream and channel width at site)
adjacent to fish capture will be noted to consider habitat suitability criteria reliability.

As outlined in the scope of these study terms of reference, species life histories of
interest will be restricted to:

- Juvenile (fry and parr) rainbow trout ($Oncorhynchus mykiss$);
- Emigrating (spring/early summer) kokanee juveniles ($O. nerka$);
- Juvenile mountain whitefish ($Prosopium williamsoni$); and
- Juvenile bull trout ($Salvelinus confluentus$)

Sampling techniques, including representative sample site selection, will focus on
species above, but incidental captures of other non-sport species (e.g., longnose
dace and redside shiner) will be enumerated and a standing stock will be estimated
for those species as well (if sufficient numbers of fish are captured).

After four years of assessment, this task will be reviewed to determine if further
assessment is required, or if reduced effort is warranted. This determination will be
made in consultation with regulatory agencies, and will be based on whether the
standing stock estimates support study objectives.

### 16.2.3.3 Stranding and Stock Recruitment Analysis and Reporting

Analysis and reporting for this study program is comprised of four sub-tasks:

- **Stranding Analysis**: As described above, total fish stranding for each
  assessment will be calculated by extrapolating observed fish stranding
densities over the entire dewatered area. Dewatered areas and areas of each
  habitat type will be defined by the results of DDMMON#3 – Hydraulic Model
  Development. Specific stranding rates will be assigned for each habitat type
  as per index and calibration stranding assessment results for the relevant
season, fish species, flow level and/or hydraulic unit (e.g. mainstem vs. sidechannel). The total fish stranded will be the result of integrating the stranding rates for each habitat type by their respective areas dewatered following each observed operation. At the end of each year, a retrospective summary of observed and unobserved fish stranding estimates will be compiled, with unobserved stranding estimates applying stranding rates from the closest observed stranding assessment integrated over the dewatered area for that operation.

- **Standing stock analysis**: Given the representative standing stock data collected above (either systematically or by habitat type), it is anticipated that fish densities observed at index sites will be extrapolated without need for calibration. A standing stock will thus be derived for each species life history observed for the entire Lower Duncan River.

- **Recruitment analysis**: Given natural recruitment bio-standards (e.g. fry to parr survivals), thresholds of survival between life stages required to sustain fish populations, fish stranding estimates and standing stock estimates for each species life history, an assessment will be made to determine if operational changes result in fish population level impacts. The analysis will incorporate confidence intervals and will identify opportunities in this study design to improve the reliability of these estimates (subject to available budget and review period constraints).

- **Reporting**: There are three levels of reporting required:
  
  o Stranding assessment reporting: for each index stranding assessment, a data summary will be prepared documenting the stranding rate and total stranding estimate for each species life history estimated according to the methods above. Where calibration assessments are conducted, the reporting format will remain the same, with calibration factors integrated into the results, and details of the implications of the calibration data described in an annual report, discussed below;

  o Annual reporting: a formal annual summary will summarize the three levels of analysis provided above, including a review of the results and implications of the stranding calibration studies. Each report will provide recommendations on improving the study design, and, where appropriate, Duncan Dam operations. The annual report will include an update to a stranding database that will summarize by species, timing and flow change the impacts observed and analyzed for each rampdown.

  o Year 3 or 4 study plan: prior to implementing stranding assessment recommendations from ASPD studies, a study plan will be formalized with BC Hydro and regulatory agencies, re-iterating or restating the approach recommended here.

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1 Unobserved stranding will be based on those operations that in retrospective analyses are shown to have resulted in Lower Duncan River dewatering but did not trigger a ramping assessment due either to lack of availability, budget, or predicted impacts. Based on stranding densities observed in adjacent monitored events, the stranding estimates in unobserved stranding events can be estimated using the methods proposed herein.
As above, in Year 7 of the review period (after four years of standing stock assessments), standing stock and recruitment analyses will be reviewed and recommendations provided in the annual report on the requirement for further assessment. This recommendation will consider study requirements, stock assessment techniques and study results to determine whether further study is warranted and, if so, at what frequency. Any recommended changes to study approach must meet budget requirements and management objectives, and will be reviewed by regulatory agencies prior to being finalized.

16.2.4 Interpretation of Monitoring Results

This study and its results will continue BC Hydro’s compliance with local regulatory requirements to monitor Lower Duncan River fish stranding impacts from Duncan Dam operations. This study will also provide context for observed impacts by assessing potential population level influence caused by fish stranding. Whereas the fish stranding assessments will be largely empirically derived, population level influences will rely on available bio-standards and index level population estimates to inform the result. These calculations and their results will be reviewed annually by BC Hydro and local regulators to confirm (a) their derivation was appropriate and (b) the appropriate recourse has been implemented where fish populations are deemed to be influenced by Duncan Dam operations. As above, standing stock and recruitment analyses will be formally reviewed in Year 7 of the review period (after four years of standing stock data collection), to determine whether study objectives are being met.

It is anticipated that any recommendations following ASPD finalization will be considered in the next water planning process for the Duncan Dam project, and therefore, recourse for observed impacts during the review period would not be implemented until that time. However, where impacts are beyond those reasonably anticipated at the time of Water Use Plan implementation, re-opening the WUP will have been triggered and alternative stranding protocol measures will be evaluated.

16.2.5 Schedule

The schedule for within-year fish stranding assessments will be dependant on local plant operating changes, and so data reporting deadlines for those assessments are not summarized here. It is anticipated that much of the field work will be limited to the growing season (March to October) and so annual reporting is recommended as follows:

- February 1 – Draft annual report
- March 1 – Final annual report

As defined above, the implementation of ASPD recommendations and finalization will likely be staggered between Years 3 and 4 of the review period. At that time, this study plan must be revised and finalized in advance of Year 4’s field season. Following ASPD finalization, stock assessment and recruitment assessments will be implemented annually and reported according to the schedule recommended above. In Year 7 of the review period stock assessment and recruitment analyses will be formally reviewed, at which point the tasks may continue as above, be refined, cancelled or scaled back.
16.2.6 Budget

The annual budget for this monitoring program as described above is estimated to cost $85.8K per year with inflation and contingencies for the 11-year review period. The approved amount in consideration of inflation was approximately $55K per year. The cost differences are largely associated with the increased effort required to conduct stranding assessments, the inclusion of stranding assessments in Years 1 and 2 and stock assessment costs. However, these additional costs are more than offset due to anticipated cost savings in other ASPD monitoring programs.

16.3 REFERENCES


