

Duncan Dam Project Water Use Plan

Monitoring Programs and Physical Works Annual Report: 2016

Implementation Period: April 2015 to March 2016

- DDMMON-1 Lower Duncan River Ramping Rate Monitoring
- DDMMON-2 Lower Duncan River Habitat Use Monitoring
- DDMMON-3 Lower Duncan River Hydraulic Model Development
- DDMMON-4 Lower Duncan River Kokanee Spawning Monitoring
- DDMMON-5 Upper Duncan River Bull Trout Migration Monitoring
- DDMMON-6 Lower Duncan Dam Bull Trout Passage Monitoring
- DDMMON-7 Lower Duncan River Water Quality Monitoring
- DDMMON-8 Duncan Watershed Riparian and Cottonwood Monitoring
- DDMMON-9 Lower Duncan River Mosquito Monitoring and Management Plan Development
- DDMMON-10 Duncan Reservoir Fish Habitat Use Monitoring
- DDMMON-11 Duncan Reservoir Burbot Monitoring
- DDMMON-12 Duncan Reservoir Archaeological Overview Assessment
- DDMMON-13 Duncan Reservoir Archaeological Site Erosion Monitoring
- DDMMON-14 Duncan Wildlife Use Monitoring
- DDMMON-15 Lower Duncan River Stranding Protocol Development and Finalization
- DDMMON-16 Lower Duncan River Fish Stranding Impact Monitoring
- DDMMON-17 Duncan Reservoir Kokanee Stock Assessment
- DDMWORKS-1 Lower Duncan River Argenta Slough Erosion Protection
- DDMWORKS-2 Duncan Reservoir Glacier Creek Boat Ramp Extension
- DDMWORKS-3 Plan to Address Nutrient Retention Caused by Duncan Dam Operations
- DDMWORKS-4 Action Plan to Minimize Stranding of Kokanee Spawning in Lower Duncan River Sidechannels

For Conditional Water Licence for Duncan Dam and Reservoir 27027

April 30, 2016

BC Hydro Duncan Dam Project Water Use Plan Monitoring Programs and Physical Works Annual Report: 2016

1 Introduction

This document represents a summary of the status and the results of the Duncan Dam Water Use Plan (WUP) monitoring programs and physical works to March 31, 2016, as per the Duncan Dam Order under the *Water Act*, dated December 21, 2007. There are seventeen monitoring programs and four physical works.

2 Status

The following table outlines the dates that Terms of Reference (TOR) for the Duncan Dam WUP monitoring programs and physical works were submitted to and approved by the CWR.

Table 2-1: Dates of Duncan Dam WUP TOR Submissions and Approvals by the Comptroller of Water Rights

Monitoring Program & Physical Works TOR	Order Clause	Original ToR Submission		Most Recent ToR Resubmission	
		Date Submitted	Date Approved	Date Submitted	Date Approved
DDMMON-1 Lower Duncan River Ramping Rate Monitoring	Clause 5(e)	Apr 03, 2008	Apr 30, 2008		
DDMMON-2 Lower Duncan River Habitat Use Monitoring	Clause 5(e)	Aug 07, 2008	Sep 9, 2008		
DDMMON-3 Lower Duncan River Hydraulic Model Development	Clause 5(e)	Apr 03, 2008	Apr 30, 2008	Mar 31, 2014	Jul 28, 2014
DDMMON-4 Lower Duncan River Kokanee Spawning Monitoring	Clause 6(a)	Apr 03, 2008	Apr 30, 2008	Dec 19, 2008	Mar 17, 2009
DDMMON-5 Upper Duncan River Bull Trout Migration Monitoring	Clause 6(b)	Jan 23, 2008	Mar 05, 2008	Feb 22, 2010	Mar 18, 2010
DDMMON-6 Lower Duncan Dam Bull Trout Passage Monitoring	Clause 6(b)	Jan 23, 2008	Mar 05, 2008		
DDMMON-7 Lower Duncan River Water Quality Monitoring	Clause 6(c)	Dec 16, 2008	Mar 11, 2009		
DDMMON-8 Duncan Riparian Monitoring	Clause 6(d)	Aug 07, 2008	Sep 09, 2008	Nov 01, 2012	Nov 15, 2012
DDMMON-9 Lower Duncan River Mosquito Monitoring and Management Plan Development	Clause 6(e)	Aug 07, 2008	Sep 09, 2008	May 13, 2013	Jun 13, 2013
DDMMON-10 Duncan Reservoir Fish Habitat Use Monitoring	Clause 6(f)	Dec 16, 2008	Mar 11, 2009		
DDMMON-11 Duncan Reservoir Burbot Monitoring	Clause 6(g)	Apr 03, 2008	Apr 30, 2008	May 01, 2013	May 29, 2013
DDMMON-12 Duncan Reservoir Archaeological Overview Assessment	Clause 5(f)	Dec 04, 2009	Feb 05, 2010		
DDMMON-13 Duncan Reservoir Archaeological Site Erosion Monitoring	Clause 5(g)	Dec 04, 2009	Apr 07, 2010		
DDMMON-14 Duncan Wildlife Use Monitoring	Clause 6(h)	Aug 07, 2008	Sep 09, 2008		

Monitoring Program & Physical Works TOR	Order Clause	Original ToR Submission		Most Recent ToR Resubmission	
		Date Submitted	Date Approved	Date Submitted	Date Approved
DDMMON-15 Lower Duncan River Stranding Protocol Development and Finalization	Clause 5(e)	Dec 16, 2008	Mar 11, 2009	Jul 30, 2009	Aug 31, 2009
DDMMON-16 Lower Duncan River Fish stranding impact monitoring	Clause 5(e)	Jul 23, 2008	Sep 08, 2008		
DDMMON-17 Duncan Reservoir Kokanee Stock Assessment	Clause 6(f)	Dec 04, 2009	Apr 08, 2010		
DDMMWORKS-1 Argenta Slough Erosion Protection	Clause 5(a)	Jan 23, 2008	Mar 18, 2008	Jul 30, 2014	Aug 19, 2014
DDMMWORKS-2 Glacier Creek Boat Ramp	Clause 5(b)	Jan 23, 2008	Mar 18, 2008		
DDMMWORKS-3 Plan to Address Nutrient Retention Caused by Duncan Dam Operations	Clause 5(d)	Jan 23, 2008	Mar 18, 2008		
DDMMWORKS-4 Action Plan to Minimize Stranding of Kokanee Spawning in Lower Duncan River Sidechannels	Clause 5(c)	Dec 04, 2009	Apr 08, 2010	Dec 03, 2013	Jan 15, 2014

3 Schedule

The following table outlines the current schedule for the monitoring programs and physical works being delivered for the Duncan Dam WUP.

Table 3-1: Monitoring Programs and Physical Works Schedule as of March 31, 2016

Monitoring Programs	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	WLR YR1	WLR YR2	WLR YR3	WLR YR4	WLR YR5	WLR YR6	WLR YR7	WLR YR8	WLR YR9	WLR YR10	WLR YR11 Final Review
DDMMON-1 Lower Duncan River Ramping Rate Monitoring	✓	✓								■	
DDMMON-2 Lower Duncan River Habitat Use Monitoring	✓	✓	✓	✓	✓						
DDMMON-3 Lower Duncan River Hydraulic Model Development		✓	✓		✓					■	
DDMMON-4 Lower Duncan River Kokanee Spawning Monitoring	✓	✓	✓	✓	✓	✓	✓	✓	■	■	
DDMMON-5 Upper Duncan River Bull Trout Migration Monitoring	✓	✓			✓	✓		✓		■	
DDMMON-6 Lower Duncan Dam Bull Trout Passage Monitoring	✓	✓	✓	×							
DDMMON-7 Lower Duncan River Water Quality Monitoring			✓	✓	✓						
DDMMON-8 Duncan Riparian Monitoring		✓	✓		✓	✓	✓	✓	■	■	■
DDMMON-9 Lower Duncan River Mosquito Monitoring and Management Plan Development		✓	✓	✓	✓		✓		■		■
DDMMON-10 Duncan Reservoir Fish Habitat Use Monitoring		✓	✓	✓	✓		✓		■		■
DDMMON-11 Duncan Reservoir Burbot Monitoring		✓	✓	✓			✓	✓	✓		

Monitoring Programs	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	WLR YR1	WLR YR2	WLR YR3	WLR YR4	WLR YR5	WLR YR6	WLR YR7	WLR YR8	WLR YR9	WLR YR10	WLR YR11 Final Review
DDMMON-12 Duncan Reservoir Archeological Overview Assessment			✓								
DDMMON-13 Duncan Reservoir Archeological Site Erosion Monitoring				✓	✓	✓	✓	✓			
DDMMON-14 Duncan Wildlife Use Monitoring		✓		✓			x			■	
DDMMON-15 Lower Duncan River Stranding Protocol Development and Finalization		✓	✓	✓	✓	✓	✓	✓	■	■	■
DDMMON-16 Lower Duncan River Fish stranding impact monitoring	✓	✓	✓	✓	✓	✓	✓	✓	■	■	
DDMMON-17 Duncan Reservoir Kokanee Stock Assessment									■	■	■
Physical Works											
DDMWORKS-1 Argenta Slough Erosion Protection	✓	✓	x				x			■	
DDMWORKS-2 Glacier Creek Boat Ramp	x	✓									
DDMWORKS-3 Kootenay Lake Nutrient Loading Funding	✓	✓	✓	✓	✓	✓	✓	✓	■	■	
DDMWORKS-4 Action Plan to minimize stranding of kokanee stranding in Lower Duncan River Sidechannels						✓	x	x	■	■	
Legend: ■ = Program to be undertaken/initiated in identified year u/w = Program is underway ✓ = Program completed for the year ■ = Pending x = Program started, but encountered operational or hydrological delays											

4 Monitoring Programs and Physical Works Terms of Reference

The monitoring programs and physical works being implemented under the Duncan Dam WUP are described in Terms of Reference. These Terms of Reference and the reports for work completed to date can be found here:

http://www.bchydro.com/about/sustainability/conservation/water_use_planning/southern_interior/duncan_dam.html

5 Status of Monitoring Programs

5.1 DDMMON-1 Lower Duncan River Ramping Rate Monitoring

The 2012 Annual Report provided a detailed summary of the work that is summarized below for completeness of this Annual Report.

Several ramping experiments were conducted in 2009 to support Clause 5e of the Order which requires the development of an adaptive protocol to minimize stranding of fish in the Lower Duncan River. In a subsequent stakeholder meeting, stakeholders agreed that ramping experiments were not the most effective way of

answering the management questions. In lieu of ramping experiments, the stranding assessments in DDMMON-16 were modified as follows: day time flow reductions (to minimize night time stranding), a flow reduction rate of 10 cm/hr or less, and multiple smaller increment flow reductions.

BC Hydro will conduct a gap analysis in Fiscal 2017 to ensure the management questions from DDMMON-1 were addressed through DDMMON-16 methods.

5.2 DDMMON-2 Lower Duncan River Habitat Use Monitoring

This monitoring project was initiated in 2008 and completed in 2012.

5.3 DDMMON-3 Lower Duncan River Hydraulic Development

This monitoring program was initiated in 2009. The objective of this monitoring program is to provide a comprehensive model of hydraulic and fish habitat values for the Lower Duncan River floodplain for the normal range of flow conditions affected by Duncan Dam operations.

This program includes a two-year development stage at the start of the review period, with model updates scheduled for Years 5 and 10 of the review period. The 2012 Annual Report provides an accurate summary of the project for the first two years of implementation.

The Year 5 (October 2013) model update captured changing conditions in the river; incorporated advancements in the hydraulic model; and reinforced the potential links between other monitoring programs in the Duncan Dam Project Water Use Plan.

The next update to the hydraulic model will occur in 2017.

5.4 DDMMON-4 Lower Duncan River Kokanee Spawning Monitoring

This monitoring program was initiated in 2008 and will be carried out every year over ten years.

Attached is the report for Year 6 (2013) dated February 2016. As described in DDMWORKS-4, BC Hydro modified operations in 2013 in two ways to minimize dewatered redds. First, the fall reduction in Duncan Dam discharge occurred approximately five days earlier than normal in an attempt to avoid dewatering of redds deposited by early spawners. The second modification was to increase minimum flows through the kokanee spawning period from 73 cms to 80 cms.

This program monitored spawning kokanee from September 19 to October 9, 2013. Peak spawning was estimated to have occurred on October 4, 2013; however, results were inconclusive about the benefits from the experimental flows due to changes in methodology and difficulties in conducting field studies during the brief peak spawning period.

The reports for Year 7 (2014) and Year 8 (2015) are in draft and will be submitted with next year's annual report.

5.5 DDMMON-5 Upper Duncan River Bull Trout Migration Monitoring

This monitoring program was initiated in 2008 and will be carried out periodically over ten years. Implementation occurred in 2015, and the study will implement again in 2017. Attached is the Year 4 report (2013 data) dated July 2, 2014.

The Year 5 report (2015 data) will be submitted in next year's annual report.

5.6 DDMMON-6 Lower Duncan Dam Bull Trout Passage Monitoring

This monitoring program was initiated in 2008 for three years.

The operation of the bull trout transfer program at Duncan Dam May to September each year allows the migration of bull trout from the Lower Duncan River to spawning locations in the Upper Duncan River system (upstream of Duncan Dam). Fish passage at Duncan Dam is facilitated through the installation of a weir immediately downstream of the flip bucket of the Low Level Operating Gate. In 2012, we concluded that the existing weir is an effective system for ensuring bull trout has passage through the dam.

The second objective of this study was to evaluate alternative passage methods. In 2011, redesign and automation of the weir was proposed primarily for operational flexibility and safety reasons. As implementation of the improvements to update the weir is outside of the scope of the Duncan Dam Project WUP, BC Hydro is proceeding with design phases of the project under the regular capital planning process. Construction would occur in 2018 at the earliest and post-monitoring would be part of the capital project's scope.

5.7 DDMMON-7 Lower Duncan River Water Quality Monitoring

This monitoring program was initiated in 2010 and was completed in 2012.

The objective of this monitoring program is to determine if a relationship exists between water quality parameters (TGP levels and water temperature) and Duncan Dam operations and decide how each of the water quality parameters affect fish species downstream of Duncan Dam using the total gas pressure as a performance measure (there is no performance measure for water temperature).

From the conclusions in the final report in September 2012, the Lower Duncan River (LDR) generally supports the productivity of fish species of interest (kokanee, rainbow trout and mountain whitefish). Some critical life history periods may be negatively influenced by water temperature within the LDR as follows:

- The influence of the LDR water temperature regime on kokanee may affect the abundance of spawners present, spawning distribution, timing of peak spawn, and fry emergence.
- Water temperature was one environmental variable that potentially decreased rainbow trout egg survival during periods of dewatering in the DDM tailout spawning area, but observed temperatures were not outside optimal preferences for other life history stages of this species.

- The influence of DDM operations on water temperatures in the LDR may affect mountain whitefish spawn and emergence timing, since water temperatures were observed to be higher than optimal at the commencement of the observed spawning and incubation period.

5.8 DDMMON-8 Duncan Watershed Riparian and Cottonwood Monitoring

This project has been divided into two discrete monitoring components based on their locations in the Duncan River watershed.

5.8.1 DDMMON-8-1 Lower Duncan River Riparian Cottonwood Monitoring

The aim of the study is to provide site-specific data to guide the flow management regime and to improve the understanding of the relationships between flow regime, physical environmental conditions, and riparian vegetation.

This monitoring program was initiated in 2009 and, with the exception of 2011, will be carried out every year over ten years. Attached is the report for Year 6 dated March 2016.

Results to date suggest that cottonwood establishment and survival are linked to water inundation, river stage during the growing season, deposition and erosion, establishment elevation, and the growing-season weather. All of these factors, excluding weather, are influenced by river regulation. The past six years of results show a strong trend suggesting that river flow regime does affect establishment and survival along the Lower Duncan River. Hypothesis testing will occur in 2018.

5.8.2 DDMMON-8-2 Duncan Reservoir Riparian Monitoring

This long-term monitoring program is being implemented to assess the effects of Alternative S73 through observation of riparian distribution and abundance and testing of hypotheses underlying the approach taken in the WUP.

This monitoring program was initiated in 2009, implemented in 2012 and 2015, and will next be carried out in 2018. Attached is the Year 3 report (2015) dated March 2016.

A summary of 2015 results showed a significant decrease in vegetation cover by area and an increase in bare ground area. Weather may be an important factor but there were no two sampling years with similar spring weather. Future sampling may indicate the level of spring weather effects on vegetation communities, and especially annual plant communities. Hypotheses testing results in 2018 will define how much each factor tested contributes to the change in vegetation cover.

5.9 DDMMON-9 Lower Duncan River Mosquito Monitoring and Management Plan Development

This monitoring program was initiated in 2009 and will be carried out periodically over ten years. Attached is the Year 5 report (2014) dated September 8, 2015.

Some results to date include:

- Twenty-two species of mosquitoes have been observed throughout the spring and summer period in the lower Duncan River floodplain. Two species are defined as nuisance mosquitoes that emerge in large numbers and are aggressive human biters.
- Initial Duncan Floodplain flooding during the spring (largely driven by unregulated inflows) represents the largest opportunity for nuisance mosquito production, and reflooding later in the summer (largely driven by regulated discharges from Duncan Dam) can increase production, depending on the difference between summer and spring peak river flows (regulated + unregulated).
- Different vegetation support different levels of nuisance mosquito breeding; regulation of summer flows can influence the flooding of key vegetation types like grasslands. Other factors outside of BC Hydro control, such as precipitation and warmer temperatures, will increase the productivity of nuisance mosquito populations in any given period of the spring and summer.

5.10 DDMMON-10 Duncan Reservoir Fish Habitat Use Monitoring

This monitoring program was initiated in 2009 and will be carried out periodically over ten years. Attached is the report for Year 6-7 (2014) dated November 24, 2015.

In 2010 Rainbow Trout were considered to have been adequately addressed and were dropped from the monitoring program. This was based on the lack of available habitat, low water temperatures, and limited Rainbow Trout presence. It was determined that it was unlikely that Duncan Lake and its tributaries supported large numbers of Rainbow Trout prior to dam construction, and therefore rainbow trout are no longer considered a key species with respect to reservoir management.

In 2011, the program focused on spawning activities of kokanee and bull trout with the intention to provide a solid spawning escapement and location dataset for use in future programs. The results gained will be used as an index where reservoir operation impacts can be investigated.

5.11 DDMMON-11 Duncan Reservoir Burbot Monitoring

This monitoring program was initiated in 2009. In 2013, after three years of attempting to monitor adult Burbot spawning with little success and to capture juvenile Burbot with no success, this program changed its methods from direct biological monitoring to a physical modelling approach.

This program will map potential Burbot habitat and monitor temperature in the upper Duncan Reservoir drawdown zone. The Burbot habitat mapping and modelling occurred in August 2015 and associated temperature monitoring will be complete in 2016. The final report will be submitted with next year's annual report.

5.12 DDMMON-12 Duncan Reservoir Archaeological Overview Assessment

The key objective addressed by this monitoring program is to collect information on cultural resource potential or sensitivity within portions of the drawdown zone of the Duncan reservoir and, based on this research, identify cultural site locations suitable for long-term erosion monitoring under DDMMON-13.

This study was initiated in 2010 and was completed in 2011.

5.13 DDMMON-13 Duncan Reservoir Archaeological Site Erosion Monitoring

The purpose of this study was to monitor the rate of erosion at two archaeological sites on Duncan Reservoir. This study was initiated in 2011, carried out every year for five years, and concluded last year (2015). Attached is the report for Year 5 dated October 22, 2015.

Based on the data collected over five years, it appears that the two archaeological sites are subject to both erosion and deposition, with erosion being the dominant process. Deposition appears to occur during years with relatively quiet or calm weather, while erosion appears to occur under stormy weather. The ground surfaces at both sites have, over the five years of monitoring, lowered in average elevation by approximately 1 cm. Artifacts observed within the monitoring areas have generally lowered, in keeping with this drop in the ground surface elevation, and shifted away laterally, from their original recorded location by typically less than 10 cm.

The information from this study will be used by BC Hydro's Reservoir Archaeology Program to assess the impacts of normal reservoir operations on these two archaeological sites and to better understand erosion within the Duncan drawdown zone as a whole. The study information is also expected to assist future decision makers and the development of an Archaeological Management Plan.

5.14 DDMMON-14 Duncan Wildlife Use Monitoring

This monitoring program was initiated in 2009 and implemented in 2011. The 2014 field season was cancelled because, based on an external review of this study, the Terms of Reference (TOR) needed revision to incorporate the latest findings from DDMMON-8.

Since 2014, we have involved subject matter experts in a further review of the study design. Three main issues are preventing the successful implementation of this study:

- sample sizes are too small;
- the areas around the reservoir and lower Duncan River that are affected by BC Hydro operations are too narrow to enable the sampling that could detect a meaningful impact on wildlife and wildlife habitat; and
- the 11-year WUP period (i.e., 2008-2018 inclusive) is too short of a time frame to assess how BC Hydro operations are affecting wildlife habitat (i.e., to measure the effects of cottonwood tree regeneration on wildlife).

We are continuing to conduct external reviews and will further convene with regulatory agencies (Ministry of Forests, Lands and Natural Resource Operations, and Canadian Wildlife Service) and First Nations to determine how best to reduce our uncertainty on wildlife use next to the Duncan Reservoir and lower Duncan River. Based on the outcome of that meeting, we are planning to resubmit the Terms of Reference by March 2017.

5.15 DDMMON-15 Lower Duncan River Stranding Protocol Development and Finalization

This monitoring program was initiated in 2009 and will be carried out every year for ten years.

In January 2016, we updated the regulatory agencies (Department of Fisheries and Oceans and the Ministry of Forests, Lands and Natural Resource Operations) on the Adaptive Stranding Protocol (ASP), the monitoring programs that inform the protocol and the recommended next steps in protocol development. It is anticipated that the ASP will be refined once more before the end of the WUP.

Attached is the report for Year 4 (2012-2013) dated September 9, 2015.

5.16 DDMMON-16 Lower Duncan River Fish Stranding Impact Monitoring

The end objective of this monitoring program is to finalize a flow reduction protocol, including stranding response procedures (e.g., fish salvaging), flow reduction procedures at Duncan Dam, internal and external correspondence procedures, stranding assessment methodology, and reporting requirements.

This monitoring program was initiated in 2008 and will be carried out every year for ten years. Attached is the report for Year 6 (April 2013 to April 2014) dated July 3, 2015.

Based on collected data and the life history of species present in the system, Duncan Dam operations increase the risk of stranding in certain seasons and during periods of longer wetted histories. To date, low stranding rates of juvenile Mountain Whitefish are not believed to result in population level effects. The current interstitial stranding estimation for juvenile Rainbow Trout is too uncertain to inform a confident total stranding estimate. The uncertainty surrounding these conclusions is currently high because of the high degree of variation in stranding rates, high uncertainty of abundance and interstitial stranding estimates, and the many variables that contribute to stranding. The uncertainty should be reduced as the study is undertaken for the remaining four years.

5.17 DDMMON-17 Duncan Reservoir Kokanee Stock Assessment

The program will improve understanding of the effects of reservoir operation on kokanee populations, and will lead to a better understanding of the implications of entrainment on kokanee populations to assist in future decisions regarding the operation of Duncan Reservoir.

This monitoring program will be carried out every year for three years commencing in summer 2016.

6 Status of Physical Works

6.1 DDMWORKS-1 Argenta Slough Erosion Protection

The regulatory agencies (Department of Fisheries and Oceans and Ministry of Forests, Lands and Natural Resources) do not support proceeding with any proposed physical works. For Works 1, the regulators agreed to continue erosion monitoring and the creation of an ecological inventory of the areas of the slough that are threatened by a breach.

We had planned to submit the ecological inventory with this year's annual report; however, more work was required with regards to describing and evaluating wetland function as defined by the Federal Policy on Wetland Conservation, and determining the likelihood of plant and wildlife presence based on species occurrence records, range distribution, and habitat requirements. The Ecological Inventory will be submitted with next year's annual report.

6.2 DDMWORKS-2 Glacier Creek Boat Ramp Extension

The ramp was completed in May 2009. The Regional District of Central Kootenay is maintaining the ramp. BC Hydro is planning an inspection of the ramp this summer (2016).

6.3 DDMWORKS-3 Plan to Address Nutrient Retention Caused by Duncan Dam Operations

Payments are made annually to the amount of 17.5% of the previous years fertilization cost as per the letter of agreement between BC Hydro and the Fish and Wildlife Compensation Program (FWCP). In 2015, the payment was \$144,993.80.

6.4 DDMWORKS-4 Action Plan to Minimize Stranding of Kokanee Spawning in Lower Duncan River Sidechannels

The regulatory agencies (Department of Fisheries and Oceans and Ministry of Forests, Lands and Natural Resources) rejected physical works given issues with logistics, annual maintenance and potential secondary effects on other resources in the area. As an alternate method to mitigate kokanee stranding, an opportunistic alteration to the flow regime was realized from September 2013 to February 2014. The evaluation of this modified flow regime was conducted in Year 6 of DDMMON-4.

The results from DDMMON-4 2013 report were inconclusive about the benefits from the experimental flows because of changes in methodology and difficulties in conducting field studies during the brief peak spawning period. During the beginning of the WUP, the Lower Duncan River Kokanee spawners represented a very small proportion of the regional spawners (those that spawn in Meadow Creek and Lardeau River); however, in the past few years this relative proportion is shifting as the Meadow Creek and Lardeau River spawner populations have been on a

downward trend which has resulted in higher regulatory concern for regional population.

Moving forward, the regulatory agencies supported the idea of BC Hydro modelling and evaluating various hypothetical discharge scenarios of Duncan Dam operations to determine how both timing and the volume of discharges may affect spawning kokanee. Any effect of operations on kokanee will be expressed in terms of proportion of available spawning area dewatered, potential egg loss, and any other variables important in evaluating how different Duncan Dam operations affect spawning kokanee.

BC Hydro will utilize the results of this analysis to evaluate the opportunity to change operations within the Columbia Treaty, International Joint Commission and WUP constraints. We plan to meet again with regulators and First Nations prior to implementation of any modification to operational flows.

7 Monitoring Programs and Physical Works Costs

The following table summarizes the Duncan Dam WUP monitoring programs and physical works costs approved by the Comptroller and the Actual Costs to March 31, 2016.

Table 7-1: Duncan Dam WUP Monitoring Programs and Physical Works Costs

Monitoring Programs	Costs approved by CWR	Life to Date Actuals (LTD)	Estimated to Complete (Forecast)	Total Forecast (LTD and Forecast)	Variance Total to Approved	Explanation	Corrective Action
DDMM01A Ramping Rate	\$247,883	\$125,967	\$116,847	\$242,813	\$5,070	Efficiencies found during project implementation	
DDMM01A Ramping Rate - ONR DM	\$34,639	\$17,643	\$12,847	\$30,489	\$4,150		
DDMM01A Ramping Rate - ONR Imp	\$213,244	\$108,324	\$104,000	\$212,324	\$920		
DDMM02A Low Duncan HabitatUse	\$566,815	\$502,057	\$502,057	\$502,057	\$64,758	Project complete	
DDMM02A Low Duncan HabitatUse - ONR DM	\$84,707	\$40,585	\$40,585	\$40,585	\$44,122		
DDMM02A Low Duncan HabitatUse - ONR Imp	\$482,108	\$461,472	\$461,472	\$461,472	\$20,636		
DDMM03A Low Duncan Hydraulic	\$674,088	\$567,054	\$91,506	\$658,560	\$15,528	Efficiencies found during project implementation	
DDMM03A Low Duncan Hydraulic - ONR DM	\$88,037	\$76,844	\$10,711	\$87,555	\$482		
DDMM03A Low Duncan Hydraulic - ONR Imp	\$586,051	\$490,210	\$80,795	\$571,005	\$15,046		
DDMM04A Low Duncan Kokanee Sp	\$1,462,700	\$738,939	\$289,784	\$1,028,723	\$433,977	Efficiencies found during project implementation	
DDMM04A Low Duncan Kokanee Sp - ONR DM	\$148,850	\$55,482	\$24,491	\$79,973	\$68,877		
DDMM04A Low Duncan Kokanee Sp - ONR Imp	\$1,313,850	\$683,457	\$265,293	\$948,750	\$365,100		
DDMM05A Up Duncan Bull Study	\$436,738	\$273,111	\$103,445	\$376,555	\$60,183	Efficiencies found during project implementation	
DDMM05A Up Duncan Bull Study - ONR DM	\$88,738	\$47,894	\$21,908	\$69,802	\$18,936		
DDMM05A Up Duncan Bull Study - ONR Imp	\$348,000	\$225,217	\$81,537	\$306,753	\$41,247		
DDMM06A Low Duncan Bull Pass	\$280,970	\$93,135	\$93,135	\$93,135	\$187,835	Project complete	
DDMM06A Low Duncan Bull Pass - ONR DM	\$78,970	\$27,205	\$27,205	\$27,205	\$51,765		
DDMM06A Low Duncan Bull Pass - ONR Imp	\$202,000	\$65,930	\$65,930	\$65,930	\$136,070		
DDMM07A Low Duncan Water Qual	\$154,827	\$106,114	\$2,457	\$108,570	\$46,257	Project complete	
DDMM07A Low Duncan Water Qual - ONR DM	\$43,003	\$22,077	\$2,457	\$24,534	\$18,469		
DDMM07A Low Duncan Water Qual - ONR Imp	\$111,824	\$84,037	\$84,037	\$84,037	\$27,787		
DDMM08A Low Duncan Riparian	\$1,457,738	\$815,084	\$500,816	\$1,315,900	\$141,838	Efficiencies found during project implementation	
DDMM08A Low Duncan Riparian - ONR DM	\$192,758	\$90,924	\$46,799	\$137,724	\$55,034		
DDMM08A Low Duncan Riparian - ONR Imp	\$1,264,980	\$724,159	\$454,017	\$1,178,176	\$86,804		
DDMM09A LDR Mosquito Mon	\$730,574	\$461,255	\$216,688	\$677,942	\$52,632	Efficiencies found during project implementation	
DDMM09A LDR Mosquito Mon - ONR DM	\$122,310	\$95,794	\$26,349	\$122,142	\$168		
DDMM09A LDR Mosquito Mon - ONR Imp	\$608,264	\$365,461	\$190,339	\$555,800	\$52,464		
DDMM10A Res Seasonal Habitat	\$791,362	\$589,305	\$139,017	\$728,322	\$63,040	Efficiencies found during project implementation	
DDMM10A Res Seasonal Habitat - ONR DM	\$117,205	\$61,057	\$19,979	\$81,036	\$36,169		
DDMM10A Res Seasonal Habitat - ONR Imp	\$674,157	\$528,248	\$119,038	\$647,286	\$26,871		
DDMM11A Duncan Burbot	\$829,768	\$637,851	\$36,485	\$674,336	\$155,432	Efficiencies found during project implementation	
DDMM11A Duncan Burbot - ONR DM	\$173,632	\$59,378	\$2,457	\$61,835	\$111,797		
DDMM11A Duncan Burbot - ONR Imp	\$656,136	\$578,473	\$34,029	\$612,501	\$43,635		
DDMM12A Duncan Arch Assess	\$68,632	\$71,521	\$71,521	\$71,521	(\$2,889)	Project complete	
DDMM12A Duncan Arch Assess - ONR DM	\$21,870	\$26,992	\$26,992	\$26,992	(\$5,122)		
DDMM12A Duncan Arch Assess - ONR Imp	\$46,762	\$44,529	\$44,529	\$44,529	\$2,233		
DDMM13A Duncan Arch Monitor	\$306,185	\$245,646	\$1,117	\$246,763	\$59,422	Project complete. Final reporting outstanding.	
DDMM13A Duncan Arch Monitor - ONR DM	\$79,579	\$66,740	\$1,117	\$67,857	\$11,722		
DDMM13A Duncan Arch Monitor - ONR Imp	\$226,606	\$178,906	\$178,906	\$178,906	\$47,700		
DDMM14A DuncanResRiparianWLD	\$450,955	\$234,392	\$214,267	\$448,658	\$2,297	New study design to be determined.	Terms of Reference revision to be submitted by Mar 31, 2017.
DDMM14A DuncanResRiparianWLD - ONR DM	\$97,167	\$76,654	\$18,216	\$94,870	\$2,297		
DDMM14A DuncanResRiparianWLD - ONR Imp	\$353,788	\$157,738	\$196,050	\$353,788			
DDMM15A LDR Stranding Protocol	\$257,049	\$137,719	\$85,017	\$222,736	\$34,313	Efficiencies found during project implementation	
DDMM15A LDR Stranding Protocol - ONR DM	\$71,421	\$36,154	\$32,372	\$68,526	\$2,895		
DDMM15A LDR Stranding Protocol - ONR Imp	\$185,628	\$101,565	\$52,645	\$154,210	\$31,418		
DDMM16A LDR Stranding Assess	\$1,002,995	\$650,083	\$260,869	\$910,952	\$92,043	Efficiencies found during project implementation	
DDMM16A LDR Stranding Assess - ONR DM	\$144,330	\$51,558	\$42,833	\$94,391	\$49,939		
DDMM16A LDR Stranding Assess - ONR Imp	\$858,665	\$598,525	\$218,036	\$816,561	\$42,104		
DDMM17A Duncan Res KoK Mon	\$248,583	\$2,047	\$224,733	\$226,781	\$21,802	Study to commence in 2016.	
DDMM17A Duncan Res KoK Mon - ONR DM	\$49,281	\$2,047	\$25,431	\$27,479	\$21,802		
DDMM17A Duncan Res KoK Mon - ONR Imp	\$199,302	\$199,302	\$199,302	\$199,302			
DDMW01A Argenta Slough Eros	\$270,861	\$173,108	\$97,753	\$270,861	\$0		
DDMW01A Argenta Slough Eros - ONR DM	\$47,561	\$44,771	\$8,178	\$52,950	(\$5,389)		
DDMW01A Argenta Slough Eros - ONR Imp	\$223,300	\$128,336	\$89,575	\$217,911	\$5,389		
DDMW02A Glacier Creek Boat	\$197,339	\$123,951	\$1,117	\$125,068	\$72,271	Project complete. Final reporting outstanding.	
DDMW02A Glacier Creek Boat - ONR DM	\$71,139	\$37,375	\$1,117	\$38,492	\$32,647		
DDMW02A Glacier Creek Boat - ONR Imp	\$126,200	\$86,576	\$86,576	\$86,576	\$39,624		
DDMW03A Plan Nutrient Reten	\$1,496,979	\$1,054,299	\$292,517	\$1,346,816	\$150,163	Efficiencies found during project implementation	
DDMW03A Plan Nutrient Reten - ONR DM	\$40,979	\$3,012	\$1,117	\$4,129	\$36,850		
DDMW03A Plan Nutrient Reten - ONR Imp	\$1,456,000	\$1,051,287	\$291,400	\$1,342,687	\$113,313		
DDMW04A Action Plan Kokanee	\$241,650	\$15,866	\$103,632	\$119,498	\$122,152	Efficiencies found during project implementation	
DDMW04A Action Plan Kokanee - ONR DM	\$90,342	\$15,711	\$11,050	\$26,761	\$63,581		
DDMW04A Action Plan Kokanee - ONR Imp	\$151,308	\$155	\$92,582	\$92,737	\$58,571		

OR - Ordered Remissible
ONR - Ordered Non-Remissible

* Red values in parentheses denote overage.