Wahleach Project Water Use Plan

Monitoring Programs and Physical Works

Annual Report: 2011

Implementation Period: February 2010 to January 2011

- WAHMON-1 Lower Jones Creek Fish Productivity Indices (Schedule B 1.a)
- WAHMON-2 Channel Stability Assessment (Schedule B 1.a)
- WAHMON-3 Herrling Island Sidechannel Chum Spawning Success Monitoring (Schedule B 1.b)
- WAHWORKS-1 Boulder Creek Diversion Bypass (Schedule A 2.a. ii)
- WAHWORKS-2 Wahleach Reservoir Fertilization Program (Schedule C)
- WAHWORKS-3 Lower Wahleach (Jones) Creek Channel Enhancement Project (Schedule D)

For Water Licenses 119711, 119709 and 119710
1 Introduction

This document represents a summary of the status and the results of the Wahleach Project Water Use Plan (WUP) monitoring programs and physical work to 31 January 2011, as per the Wahleach Project Order under the Water Act, dated 19 January 2005. There are three monitoring programs and three physical work projects:

a) Lower Jones Creek Fish Productivity Indices
b) Channel Stability Assessment
c) Herrling Island Sidechannel Chum Spawning Success Monitoring
d) Boulder Creek Diversion Bypass
e) Wahleach Reservoir Fertilization Program
f) Lower Wahleach (Jones) Creek Channel Enhancement Project

2 Background

The water use planning process for BC Hydro’s Wahleach hydroelectric facility was initiated in September 2000 and completed in October 2002. The conditions proposed in the Wahleach WUP for operation of BC Hydro’s Wahleach hydroelectric facilities reflect the October 2002 recommendations of the Wahleach WUP Consultative Committee (CC).

In December 2004, the Wahleach WUP was submitted to the provincial Comptroller of Water Rights.

On 19 January 2005, BC Hydro was Ordered to implement the conditions proposed in the Wahleach WUP and prepare monitoring program and physical works Terms of Reference (TOR).

On 24 August 2005, the Wahleach WUP monitoring program and physical works TOR were submitted to the Comptroller for review and approval.

On 27 September 2005, the Comptroller accepted the TOR for the Lower Jones Creek Fish Productivity Indices, the Channel Stability Assessment, and the Herrling Island Sidechannel Chum Spawning Success.

On 28 October 2005, the Comptroller accepted the TOR for the Boulder Creek Diversion Bypass, Wahleach Reservoir Fertilization program and the deferral of TOR for the Lower Wahleach Creek Channel Enhancement project to 15 June 2006. The revised Terms of Reference for the Lower Wahleach Creek Channel Enhancement project were given leave to commence by the Comptroller 2 August 2006.

On 27 June 2006, the Comptroller accepted the TOR addendum for the Wahleach Reservoir Fertilization Program and the revised implementation budget accounting for increases in both labour and fertilizer costs.
On 26 July 2007, the Comptroller accepted the TOR addendum for the Boulder Creek Diversion Bypass and the revised implementation budget for restoration of the temporary diversion structure.

On 20 November 2008, the Comptroller accepted the TOR addendum for the Wahleach Reservoir Fertilization Program including a further increase in labour and fertilizer costs as well expanded sampling program through program year 5. Year 6 – 10 program costs were to be confirmed during the five year interim review scheduled for the summer of 2010.

In August 2010 a Wahleach WUP five year interim review was completed to evaluate the results of the monitoring and physical works programs with specific focus on the availability of Boulder Creek inflows, fish productivity in Lower Jones Creek and productivity benefits of the Wahleach Reservoir Fertilization program. The program specific outcomes of the interim review are discussed in the following program specific status and interpretation of data sections, however, the general outcome of the review was Monitoring Committee agreement to continue WUP implementation for a further 5 years to allow continued evaluation of WUP effectiveness.

On 27 September 2010, the Comptroller accepted the TOR addendum for the Wahleach Reservoir Fertilization Program confirming increased labour and expanded sampling program for the remaining 5 years of program implementation.

3 Status

The following table outlines the status and schedule for the Wahleach Project WUP monitoring programs and physical works.
Table 3-1: Status and Schedule of Wahleach Project WUP Monitoring Programs and Physical Work Implementation

<table>
<thead>
<tr>
<th>Study/Physical Work</th>
<th>Component</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
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<tr>
<td></td>
<td></td>
<td>WLR YR1</td>
<td>WLR YR2</td>
<td>WLR YR3</td>
<td>WLR YR4</td>
<td>WLR YR5</td>
<td>WLR YR6 Interim Review</td>
<td>WLR YR7</td>
<td>WLR YR8</td>
<td>WLR YR9</td>
<td>WLR YR10 Final Review</td>
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<td>Fry Outmigration Assessment</td>
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<td>✓</td>
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<td></td>
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<td>✓</td>
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<td></td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
<td>■</td>
<td>X</td>
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</tr>
<tr>
<td></td>
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<td>✓</td>
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<td>X</td>
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<td>Behaviour Assessments</td>
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<td>Stranding Assessments</td>
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<td>✓</td>
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<td>Final Upgrade</td>
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<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Wahleach Reservoir Fertilization Program</td>
<td>Fertilization and Basic Monitoring</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
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<td>■</td>
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<td>Lower Wahleach Creek Channel Enhancement Project</td>
<td>DEL 3</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>□</td>
<td>□</td>
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</table>

1. Per the terms of reference for these study components, no steelhead or smolt studies will be conducted until confirmation of either populations in Lower Jones Creek is provided through fry and salmon study components.
2. The works completed in September 2005 were undermined during a storm event November 2006; replacement complete in September 2007.
3. The enhancement project delay to 2006 was approved by the Water Comptroller 28 October 2005. The enhancement works terms of reference was given leave to commence 2 August 2006.
4. Interim 5 year review occurs in year 6 given requirement to consider results of a full 5 years of monitoring with sufficient reporting period.

Legend: □ = Project timing subject to change according to maintenance schedule
■ = Project to be undertaken/initiated in identified year
u/W = Project is underway
✓ = Project is complete for the year
X = Project implementation discontinued based on outcome of interim review
## Wahleach Project WUP Monitoring Programs

This section outlines the status of the Wahleach Project WUP monitoring programs as per the Order under the *Water Act*, dated 19 January 2005. The following table summarizes the monitoring indicator values of interest for each study.

### Figure 4.1: Summary of Wahleach Project WUP Monitoring Program Results

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<thead>
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</thead>
<tbody>
<tr>
<td>Lower Jones Creek Fish Productivity Indices</td>
<td>Chum Salmon Egg to Fry Survival (%)</td>
<td>9%</td>
<td>0.37%</td>
<td>0.30%</td>
<td>0.39%</td>
<td>1.17%</td>
<td>1.07%</td>
<td>N/A</td>
<td>0.97%</td>
<td>3.13%</td>
<td>Not Studied</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Pink Salmon Egg to Fry Survival (%)</td>
<td>13%³</td>
<td>0.36%</td>
<td>0.32%</td>
<td>N/A</td>
<td>2.56%</td>
<td>3.54%</td>
<td>N/A</td>
<td>0.66%</td>
<td>Not Studied</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steelhead Smolt Production (100m²)</td>
<td>2</td>
<td>No smolts observed</td>
<td>No smolts observed</td>
<td>No smolts observed</td>
<td>No smolts observed</td>
<td>No smolts observed</td>
<td>No smolts observed</td>
<td>No smolts observed</td>
<td>No smolts observed</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coho Smolt Production (m²)</td>
<td>0.67³</td>
<td>No smolts observed</td>
<td>0.0004</td>
<td>0.0019</td>
<td>0.0003</td>
<td>0.0001</td>
<td>0.0005</td>
<td>No smolts observed</td>
<td>0.0003</td>
<td>Not Studied</td>
<td></td>
<td></td>
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<tr>
<td>Channel Stability Assessment</td>
<td>Substrate Quality (% Fraction Fines &lt; 10 mm)</td>
<td>10%</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>32%</td>
<td>Not Studied</td>
<td>45%</td>
<td>Not Studied</td>
<td>55%</td>
<td>Not Studied</td>
<td></td>
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<tr>
<td></td>
<td>Cross sectional area changes (m²)</td>
<td>0</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>0.72m²</td>
<td>Not Studied</td>
<td>22.12m²</td>
<td>Not Studied</td>
<td>11.48m²</td>
<td>Not Studied</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Herrling Island Sidechannel Chum Spawning Success Monitoring</td>
<td>Chum egg to fry survival (%)</td>
<td>9%</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>4.90%</td>
<td>3.10%</td>
<td>N/A²</td>
<td>5.63%</td>
<td>N/A²</td>
<td>Not Studied</td>
<td></td>
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<tr>
<td></td>
<td>Chum Adult stranding risk (# stranded)</td>
<td>0</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>12 adults</td>
<td>2 adults</td>
<td>0 adults</td>
<td>0 adults</td>
<td>15 adults</td>
<td>Not Studied</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pink egg to fry survival (%)</td>
<td>13%³</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>N/A</td>
<td>2.34%</td>
<td>N/A</td>
<td>N/A²</td>
<td>Not Studied</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pink Adult stranding risk (# stranded)</td>
<td>0</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>Not Studied</td>
<td>N/A</td>
<td>15 adults</td>
<td>N/A</td>
<td>500 adults</td>
<td>Not Studied</td>
<td></td>
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<tr>
<td>Wahleach Reservoir Fertilization Program</td>
<td>Kokane Spawners in Index Streams</td>
<td>0</td>
<td>Not Studied</td>
<td>1000</td>
<td>1800</td>
<td>4000</td>
<td>8050</td>
<td>3900</td>
<td>3000</td>
<td>4030</td>
<td>10500</td>
<td></td>
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</table>

1. Salmonid Enhancement Program biostandards for Lower Fraser River natural egg-fry survival of chum and pink salmon - March 1997
3. Provincial biostandard - Coho smolt density of constructed side-channels in Pacific Northwest, Koning and Keely. 1997 (Based on total habitat area of 8000 m²)
6. Interim 5 year review occurs in year 6 given requirement to consider results of a full 5 years of monitoring with sufficient reporting period.
7. High flows during chum spawning prevented redd identification and subsequent dewatering assessment.
8. Monitoring of individual redds and subsequent determination of egg to fry survival rates not feasible given redd superimposition and installation of exclusion fences to mitigate adult and redd stranding.
4.1 WAHMON-1 Lower Jones Creek Fish Productivity Indices

4.1.1 Management Questions

The key management question addressed by this monitoring program is:

1) Will the operational changes recommended in the Wahleach Water Use Plan result in increased productivity for anadromous and resident populations in lower Jones Creek as predicted from the flow-habitat relationships?

4.1.2 Overview

The objective of this monitoring program is to determine the fisheries benefits associated with the flow provisions outlined in the Wahleach WUP.

Monitoring Indicator (a): Egg to fry survival for chum and pink salmon (percent)

Monitoring Indicator (b): Smolt production for steelhead and coho (number of smolts)

There are three studies in this program, as described in the TOR:

- Fry and smolt out migration assessment: annual monitoring of chum fry, pink fry (after odd-year runs) and steelhead/coho smolts (where observed) out migration;

- Adult salmon escapement: annual monitoring of chum, pink (in odd-years), and coho (where observed) spawning.

- Adult steelhead escapement: when observed during fry outmigration monitoring, steelhead adults will be enumerated during the spring spawning period.

4.1.3 Status

The fifth year of this study was initiated in September 2009, and a final report was prepared September 2010 covering the salmon spawning escapement and salmon fry outmigration assessments for the 2009/2010 brood year. As per the Terms of Reference for this study, both the steelhead spawning survey and smolt outmigration assessments were not completed due to lack of evidence of either steelhead or coho salmon runs in the creek.

The five year Wahleach WUP program review was initiated in August 2010 with Monitoring committee consideration of the fish productivity benefits associated with the Lower Jones Creek minimum flow provisions. Through Terms of Reference addendum, the Monitoring Committee confirmed the need to continue fish productivity monitoring through the remaining five years of the WUP review period, however, recommended monitoring during odd pink spawning years only. This recommendation resulted from too few chum, steelhead, and coho returns during non pink years to justify further annual monitoring. The remaining 2011/2012 and 2013/2014 monitoring years will provide additional data to allow further consideration of study specific management questions in light for the WUP review.
An additional outcome of the five year interim review was the recommended expansion of monitoring program to include egg incubation monitoring. The methodology, involving a standardized incubator approach, was confirmed in the August 2010 Terms of Reference addendum and results in no cost increases given reduction in monitoring to odd pink spawning years only.

The 2011/2012 monitoring program will be initiated in September 2011 with the salmon spawning escapement component. A final report for this study is expected 31 August 2012.

4.1.4 Interpretation of Data

Results of the 2009/2010 study program are summarized alongside results from studies initiated in 1999, 2003, 2004, 2005, 2006, 2007 and 2008 in Table 4.1. The 2009/2010 chum salmon egg to fry survival of 3.13% was highest of all monitoring years. Notwithstanding 2007 fry survival results, recent studies have indicated a general increase in egg to fry survival for chum salmon over those observed during pre WUP flow provisions, although all results have been well below the 9% bio-standard for Fraser River chum spawning success. Statistical analysis of pre- and post-WUP egg-to-fry survival for chum salmon indicated that the post WUP survival is not significantly higher then the pre WUP survival rates.

The 2010 pink salmon egg to fry survival of 0.66%, resulting from the largest observed adult escapement of 7823, was the lowest recorded since initiation of the WUP min flow provisions in 2005. The mean post-WUP egg-to-fry survival rate was over 6 times higher for pink salmon (0.34% to 2.25%) compared to pre-WUP mean survival rates, however, statistical comparison is not possible since the pre-WUP sample size (n=2) does not meet the minimum sample size criteria (n=3). The average post WUP pink salmon egg to fry survival of 2.25% is still well below the bio-standard of 10 – 20 % for other coastal systems.

Observations indicate that limited numbers of coho and steelhead use Jones Creek for spawning and rearing. Although their presence is confirmed on an almost annual basis, the numbers are too low to infer any conclusions with respect to the influence of the new flow regime on productivity.

Despite the perceived benefit of the post-WUP flow regime, egg-to-fry survival in Lower Jones Creek remains low and may be limited by factors other than minimum flows. There is evidence that large flow events causing creek realignment, scour and deposition are a factor in low egg-to-fry survival in Lower Jones Creek. The process of scour and deposition often culminates in channel shifting or changes in total wetted area in the lower areas of Jones Creek. Channel shifting has the potential to dewater redds while deposition of fine substrates can limit interstitial flow and reduce oxygen delivery to eggs.

As confirmed in the Interpretation of Data section of WAHMON-2 Channel Stability Assessment and Table 4.1-1, fine sediment concentrations exceeding the 10% fines < 10mm biostandard have been realized in all monitoring years since 2005. This is likely the most significant contributor to impaired egg-to-fry survival rates given the impacts of fine sediment on salmon embryo development.
4.2 WAHMON-2 Channel Stability Assessment

4.2.1 Management Questions

The key management questions addressed by this monitoring program are:

1) Is channel instability in Lower Jones Creek limiting fish productivity?
2) Is substrate quality in Lower Jones Creek limiting fish productivity?

4.2.2 Overview

The objective of this monitoring program is to assess channel change and infer its effects on fish productivity in the anadromous reach of Lower Jones Creek, in consideration of results from the Lower Jones Creek Fish Productivity program.

Monitoring Indicator (a): Substrate quality (fraction fine sand);

Monitoring Indicator (b): Channel migration in spawning areas (Average cross sectional area change)

There are two studies in this program, as described in the TOR:

- Channel stability monitoring: assessment of channel movement between field surveys in each study year;
- Substrate quality monitoring: assessment of the size fraction distribution within sample sites of the Lower Jones Creek channel over the spawning and incubation season.

4.2.3 Status

The third year of this study was initiated in September 2009, and a final report for the 2009/2010 field work was submitted July 2010. Per the Terms of Reference for this study, field work will be conducted during odd pink spawning years only. Therefore, year four of this study will be initiated in fall 2011 with a final report expected 31 August 2012.

A third year report recommendation included the establishment of an additional sixth cross section to more accurately quantify sediment movement in a high density spawning area. A Terms of Reference addendum was endorsed by the Monitoring Committee in August 2010 to include the new cross section with confirmation that no additional study funds would be required.

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1 This indicator has changed as a result of limitations of extrapolating channel area changes observed in channel cross sections. The methodology does not change; the analysis will simply average the total channel area change observed during the field season across all cross sections.
4.2.4 Interpretation of Data

The study showed that the maximum fine content observed in the channel between three assessments conducted through the October to March field seasons averaged 55% across five sites in the study reach. This is higher than the 32% and 45% confirmed during the previous study periods and the fine sediment bio-standard of 10%.

The cross sectional area changes in year 3 were modest compared to the large changes noted in year 2 when an estimated 7500 m$^3$ of sand and gravel was deposited on the fan between April 2006 and November 2007. It is believed that this material derived from a large landslide on a small un-named tributary several kilometres upstream. Similar large sediments inputs have been documented in the past and are likely in the future, reflecting the dynamic nature of alluvial fan development.

A combination of channel shifting, infilling, degradation and fine sediment accumulation throughout the Lower Jones Creek Channel are confirmed as key drivers in impaired Jones Creek fish productivity.

4.3 WAHMON-3 Herrling Island Sidechannel Chum Spawning Success Monitoring

4.3.1 Management Questions

The key management questions addressed by this monitoring program are:

1) Will the recommended operational measures keep spawning away from marginal areas?

2) Do the operational measures in the fall result in minimal fry stranding in the spring?

3) Will the operational measures in the fall result in stranding of adult spawners?

4.3.2 Overview

The objective of this monitoring program is to assess the effectiveness of the Wahleach WUP operational measures recommended by the CC to minimize chum and pink spawning in marginal areas of the Herrling Island sidechannel. A secondary objective is to assess the risk of stranding of adult spawners associated with the recommended operations.

Monitoring Indicator (a): Chum/pink spawning success (egg to fry survival)

Monitoring Indicator (b): Adult stranding risk (spawners per area stranded)

There are three studies in this program, as described in the TOR:

- Adult spawning behavior observations: assessment of behavioural response of spawning chum and pink to Wahleach Generating Station (GS) shutdowns;
Adult stranding risk assessment: direct assessment of stranding risk to chum and pink spawners through measurement of dewatered spawning area and observation of stranded spawners.

Hydrologic Monitoring: in consideration of the behavioural monitoring, an assessment of redd/fry stranding risk will be conducted by monitoring water level stages at key index sites.

4.3.3 Status

The fifth year of this study program was initiated in September 2009, and a final report was submitted 30 June 2010 summarizing the 2009/2010 field season and providing a detailed synthesis of the past five years of data collection.

A program Terms of Reference addendum was endorsed by the Monitoring Committee during the August 2010 five year interim review. The Terms of Reference addendum includes a reduction in monitoring intensity as a result of the review of five years of program results. Given confirmed resolution of study specific management questions relating to assessing the effectiveness of fall Wahleach GS shutdowns in reducing marginal spawning, no further adult spawning or redd field observations will occur during the final five years of program implementation. Field monitoring of Herrling Sidechannel water level fluctuation in response to both GS and Fraser River discharge will continue through the end of the proposed WUP review period in 2015.

A program scope change recommended in the five year program synthesis report and discussed during the interim review involves pilot channel re-contouring and associated monitoring at confirmed high risk chum and pink stranding sites to assess suitability as a future mitigation strategy to prevent both adult and redd stranding.

The pilot channel contouring approach was supported by the monitoring committee, however, Ministry of Environment’s (MOE) summer 2010 confirmation of white sturgeon spawning in Herrling Sidechannel has resulted in MOE resistance to a re-contouring strategy given associated uncertain risk to white sturgeon spawning habitat. Based on further MOE investigation in to white sturgeon critical habitat requirements, due for completion in the upcoming years, there may be opportunities to reassess the pilot contouring initiative through a follow up Terms of Reference addendum.

In efforts to mitigate incidence of adult and redd stranding within the Herrling Sidechannel BC Hydro will install exclusion fences at all confirmed high risk stranding sites on an annual basis until other WUP related operational or physical work strategies are confirmed during a WUP review. Interim funding for stranding mitigation is provided outside of the WUP funding process.

4.3.4 Interpretation of Data

Through completion of five years of Herrling Sidechannel chum and pink spawning monitoring the objectives of this study have been met with the support of the approved Terms of Reference. The five years of monitoring confirmed Wahleach GS shutdowns: 1) did not prevent pink or chum from spawning in marginal habitat and 2)
resulted in the stranding of spawning adult pink and chum during the fall spawning period.

After five years of data collection several conclusions can be made regarding impacts of Wahleach GS operations:

- Since fish can begin the spawning process in a relatively short time period (i.e., less than a day), and new fish may arrive daily on the spawning grounds over most of the run, it has been confirmed that daily short duration Wahleach GS shutdowns do not prevent the development of redds in marginal areas.
- Flow fluctuations may act to reduce spawning density in marginal areas, which may have associated benefits to fish production.
- Adult stranding post Wahleach GS shutdowns can be significant for both adult and pink spawners during years when Fraser River surface flow augmentation is low.
- Pink adult and redd stranding risk appears higher than chum given propensity to spawn in shallow marginal channel locations.
- Impacts of flow fluctuations on the developmental phases of salmon will vary with the timing, magnitude, and duration of the fluctuations as well as with characteristics of the affected site.
- Wahleach GS shutdowns during the spawning period did not eliminate redd or fry stranding in the spring.

5 Wahleach Project WUP Physical Works

This section outlines the status of the Wahleach Project WUP physical works as per the Order under the Water Act, dated 19 January 2005.

5.1 WAHWORKS-1 Boulder Creek Diversion Bypass

5.1.1 Overview

The objective of this physical works is to install and maintain a temporary weir below the Boulder Creek diversion that will ensure supplemental flows are provided when needed and when available. The temporary upgrade involves re-establishment of a headpond and weir structure allowing for the continued access of Wahleach Reservoir kokanee through a \(0.14\text{m}^3\text{s}^{-1}\) minimum flow provision as well as providing augmented flow for Lower Jones Creek.

There are two components for this physical works, as described in the TOR:

- Temporary upgrade of Boulder Creek diversion bypass: To allow supplementation of Lower Jones Creek flows, there are provisions in the Water Use Plan to redevelop the bypass works as required on an annual basis until the five-year review provides further direction; and
- Permanent upgrade of the Boulder Creek diversion bypass: A preliminary design for permanent bypass works was recommended in the Water Use Plan. At the
five year review, upon consideration of the effectiveness of the temporary upgrades and the necessity of flow augmentation to Lower Jones Creek, the design will be finalized and implemented upon approval.

Reporting for the design and implementation of the physical works will be conducted as part of BC Hydro’s Water License Requirements Annual Reporting. Compliance reporting (i.e. how operations are meeting flow targets to Jones Creek, and compliance for Boulder Creek passage flows) will be conducted through BC Hydro’s Generation Operations reporting protocols to the Comptroller.

5.1.2 Status

The temporary upgrade of the Boulder Creek diversion bypass was initiated in August 2005 and completed in September 2005. A final construction report was completed in March 2006 and submitted as part of the 2006 Annual Report submission.

In November, 2006, an extreme inflow event rendered the bypass and kokanee passage works ineffective, as described in the assessment by Sakamoto (2006²). Re-design of the temporary diversion resulted in a revised Terms of Reference submission to the Comptroller. Based on a leave to commence provided on 26 July 2007, construction was completed in September 2007 during the prescribed instream work window. A final construction report was completed in November 2007 and was included with the 2008 Annual Report submission.

No diversion bypass maintenance was required in 2008, 2009, 2009 or 2010 based on confirmation of reliable operation with regional BC Hydro field staff.

Based on the robust nature and confirmed reliable operation of the existing temporary Boulder bypass structure it was confirmed during the August 2010 five year interim review and Terms of reference addendum that upgrade to a more permanent structure would not be considered until the next WUP review. A summer 2010 BCH Engineering bypass structure condition assessment further confirmed bypass operational condition (2010³).

The deferred WUP decision for a permanent bypass fix to will be based on further evaluation of the integrity and bypass flow availability of the temporary structure as well as confirmed fish productivity benefits associated with Lower Jones Creek minimum flow provisions.

5.1.3 Interpretation of Results

The effectiveness of the Boulder Creek diversion bypass works will be evaluated in two ways:

² Sakamoto, Derek, 2006. Boulder Creek Temporary Diversion Weir Breach Assessment. BC Hydro Inter-office memo prepared for BC Hydro Water License Requirements, Burnaby, BC.

³ Sakamoto, Derek, 2010. Boulder Creek Diversion Condition Assessment. BC Hydro Inter-office memo prepared for BC Hydro Water License Requirements, Burnaby, BC.
• Availability and effectiveness to meet Water License constraints: the physical ability of the works to deliver flows both for Boulder Creek kokanee fish passage upstream of the weir, and for the augmentation of Lower Jones Creek flows to meet downstream targets will be assessed in consideration of available upstream Boulder Creek flows, channel instability and operating logistics.

• Performance of fish productivity in Lower Jones Creek: it was anticipated that operating to the constraints specified in the Water License would result in improved productivity for salmon species utilizing the anadromous reach of Lower Jones Creek.

The Boulder Creek temporary bypass has been available to provide supplemental flow to Jones Creek since initial upgrade in September 2005 except during the November 2006 – September 2007 period when the bypass was disabled due to wash out. The available Boulder Creek bypass flows have been critical during both the Lower Jones Creek fall spawner and winter incubation periods to ensure compliance with minimum flow targets.

Kokanee upstream passage over the Boulder Creek bypass structure has been confirmed during the September through October adult spawning window except for a brief period in September 2006 when low flows appeared to impair upstream passage. The upgraded bypass structure completed in September 2007 was confirmed to provide adequate upstream passage during the low flow periods typical of the early fall kokanee spawning period.

The fisheries productivity benefits realized in Lower Jones Creek from minimum flow provisions and associated Boulder Creek bypass augmentation flows are discussed in the Lower Jones Creek Fish Productivity Indices – Interpretation of Results section of this report.

5.2 WAHWORKS-2 Wahleach Reservoir Fertilization Program

5.2.1 Overview

The objective of this physical works is to restore kokanee abundance in Wahleach Reservoir to mitigate impacts of reservoir fluctuations.

There are two annual components for this physical works, as described in the TOR:

• Application of nutrient fertilizer from June through October.

• Effectiveness monitoring including assessments of the below noted performance measure.

Performance Measure (a): Kokanee spawner abundance in index tributaries to Wahleach Reservoir

3 This indicator has been modified to account for differences in monitoring approaches between historic assessments conducted by Limnotek (1995-2000) and Ministry of Environment (2004-current). This change does not affect the study design outlined in the physical works Terms of Reference.
Monitoring results for this project are summarized in Table 4-1.

5.2.2 Status

Since initiation in 2005, fertilizer additions and infrastructure improvements (i.e. boat and storage facility upgrades) outlined in the program Terms of Reference have been implemented as planned. Hydro acoustic monitoring of fish populations in 2005 were delayed due to boat upgrade issues. In 2006, 2007, 2008, 2009 and 2010 all components of the physical works program were implemented as planned.


The responsible program deliver agency, Ministry of Environment, has struggled with both staffing issues and institutional reorganizations causing delays in annual summary report submission. Accordingly, both the 2009 and 2010 annual summary program reporting will be merged with anticipated submission in May 2011. Although summary reports were not submitted the timely consideration of program data did allow for program evaluation and associated method adjustments to ensure efficient program delivery.

The interim five year review completed in August 2010 confirmed program objectives, effectiveness monitoring program methods and associated program spending for the remainder of the ten year implementation period. A Terms of Reference for the reservoir fertilization was endorsed by the Monitoring Committee and approved by the Comptroller’s office in September 2010.

The seventh program year is due to commence in June 2011, however, the Ministry of Environment is considering not fertilizing in 2011 given concerns regarding nutrient carry over from previously fertilization years. If a decision to not fertilize is made, the regular limnology and fish sampling program would continue to allow evaluation of associated environment response.

5.2.3 Interpretation of Results

Results in Table 4.1 are summarized as kokanee spawner abundance in index reservoir tributaries, which provides an index of the fish productivity derived from fertilization. Based on this index, kokanee production has responded positively to fertilizer loading rates with an historic high of 10500 spawners observed in 2010.

Given the lack of juvenile kokanee hatchery supplementation after 2004 all 2009 and 2010 kokanee spawners would be a result of natural reservoir recruitment. This is considered a positive result with the nutrient enriched reservoir and reservoir tributaries providing habitats adequate to support a self sustaining kokanee population. The health of the kokanee population is further supported by 2009 and 2010 results from zooplankton monitoring showing a strong contribution by Daphnia, the preferred food source for kokanee.
Water Quality sampling completed during the May – September fertilization period have indicated recent extreme summer water temperatures are impacting nutrient enrichment benefits. The warm water temperatures are causing algal blooms and impaired habitat conditions not favourable for maximizing kokanee production. Fertilizer loading rates have been adjusted in an attempt to mitigate the impacts of warm temperatures on phytoplankton and zooplankton assemblages.

As described in the above program status section, the Ministry of Environment has confirmed increasing high nutrient levels during recent summer limnology sampling. The carry over and periodic re-suspension of nutrients from past fertilization years has been proposed as a possible cause. A currently proposed 2011 non-fertilization year may assist in confirming the nutrient carry over phenomena.

5.3 WAHWORKS-3 Lower Wahleach Creek Enhancement Channel

5.3.1 Overview

The objective of this physical works is to address the poor productivity issues in Lower Jones Creek. Due to channel stability a recommendation was been made by the Wahleach Monitoring Committee to reconsider the WUP proposed Jones Creek spawning channel and assess alternative enhancement options within the Lower Jones Creek floodplain.

Fish use and habitat stability of this physical works will be monitored as part of the Lower Jones Creek Productivity Indices program.

5.3.2 Status

Based on Wahleach Monitoring Committee recommendation, the Comptroller authorized the delay of submission of Terms of Reference for the Lower Wahleach (Jones) Creek Enhancement Channel to 15 June 2006. After monitoring committee deliberations, these Terms of Reference were finalized and submitted to the Comptroller with leave to commence granted 2 August 2006.

Construction on the works, described as a backwater rearing and spawning channel adjacent to the Jones Creek mainstem channel in Lorenzetta Creek, was completed September 2006 according to plan (with minor exceptions to pool and large woody debris placement). An as-built report was prepared, which included an environmental summary report, and was forwarded to the Comptroller’s office as a component of the 2007 Annual Report submission.

Maintenance of the backwater rearing habitat was completed in August 2008 to maximize rearing potential during low flow periods. Work involved placement of an infiltration gallery to allow supplementation with flows from the Jones Creek mainstem. Infiltration gallery function was initially confirmed, however, constant channel shifting has resulted in variable supplementation capacity. Further infiltration gallery adjustment and expansion was considered, but ultimately discounted based on the considerable instability of the local channel area.

To further improve bank stability and cover adjacent to the backwater rearing channel a vegetation planting program was initiated in spring 2008 and fall 2009.
A condition assessment of the Lower Jones Creek enhancement works was completed in summer 2010 by a Department of Fisheries and Oceans (DFO) habitat biologist. DFO reported that the enhancements were operating as designed with no maintenance or upgrades required. Future maintenance will be confirmed on an annual basis based on condition assessment and work planned for the upcoming summer in stream work window.

5.3.3 Interpretation of Results

Ongoing monitoring of fish use and habitat stability of the off-channel works is conducted as part of the Lower Jones Creek Fish Productivity Indices study program. The 2010 results indicate that flows in the rearing channel are sufficient throughout the year with trapping confirmation of both juvenile coho and rainbow trout utilization. Riparian vegetation growth along the off-channel margins are improving channel integrity and further enhancing habitat quality.

The spawning platforms constructed adjacent to Jones Creek are functioning and being used by pink and chum salmon. Coho salmon spawning has been confirmed further up the Lorenzetta Creek system where habitat characteristics are more suited to coho than the low gradient lower reaches were the spawning platforms are located.

6 Wahleach Project WUP Monitoring Programs and Physical Work Costs

The following table summarizes the Wahleach Project WUP monitoring programs and physical work costs approved by the Comptroller and the actual costs to 31 January 2011.
## Wahleach Project WUP Monitoring Programs and Physical Work Costs

<table>
<thead>
<tr>
<th>Monitoring Programs</th>
<th>Activity</th>
<th>Costs approved by CWR</th>
<th>Total Forecast (Life to Date Actuals and Forecast)</th>
<th>Variance Total to Approved</th>
<th>Explanation</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wahleach Annual Report</td>
<td></td>
<td>$13,140</td>
<td>$13,150</td>
<td>($10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAHMON#1 LOWER JONES CREEK FISH PRODUCTIVITY INDEX</td>
<td></td>
<td>$1,335,486</td>
<td>$543,004</td>
<td>$792,482</td>
<td>Direct management underspending given: 1) Realignment and streamlining of direct management task priorities and 2) TOR addendum confirming reduction in monitoring intensity from annual to odd pink spawning years only.</td>
<td></td>
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<tr>
<td></td>
<td>Non-Remissible Direct Management</td>
<td>$147,986</td>
<td>$43,989</td>
<td>$103,997</td>
<td>Implementation amount overestimated given: 1) Opportunistic study components were not initiated in study years 1 - 5 given lack of fish presence, 2) Opportunistic study components removed from years 6 - 10 given confirmed fish absence in previous monitoring years, 3) Contractor efficiencies in work delivery and 4) August 2010 TOR addendum confirming reduction in monitoring intensity form annual to odd pink spawning years only.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-Remissible Implementation</td>
<td>$1,187,500</td>
<td>$499,015</td>
<td>$688,485</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAHMON#2 CHANNEL STABILITY ASSESSMENT</td>
<td></td>
<td>$227,278</td>
<td>$164,015</td>
<td>$63,263</td>
<td>Direct management underspending based on realignment and streamlining of direct management task priorities.</td>
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<tr>
<td></td>
<td>Non-Remissible Direct Management</td>
<td>$74,678</td>
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<tr>
<td></td>
<td>Non-Remissible Implementation</td>
<td>$152,600</td>
<td>$140,363</td>
<td>$12,237</td>
<td>Implementation amount overestimated given contractor efficiencies in work delivery.</td>
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<tr>
<td>WAHMON#3 HERRLING ISLAND SIDECHANNEL CHUM SPAWNING SUCCESS MONITORING</td>
<td></td>
<td>$479,514</td>
<td>$308,442</td>
<td>$171,072</td>
<td>Direct management underspending given: 1) Realignment and streamlining of direct management task priorities and 2) TOR addendum confirming reduction in annual monitoring intensity.</td>
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</tr>
<tr>
<td></td>
<td>Non-Remissible Direct Management</td>
<td>$141,814</td>
<td>$41,260</td>
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<tr>
<td></td>
<td>Non-Remissible Implementation</td>
<td>$337,700</td>
<td>$267,182</td>
<td>$70,518</td>
<td>Implementation amount overestimated given August 2010 TOR addendum confirming reduction in annual monitoring intensity.</td>
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<tr>
<td>WAHWORKS#1 BOULDER CREEK FLOW BYPASS FACILITY REHABILITATION</td>
<td></td>
<td>$1,330,034</td>
<td>$220,266</td>
<td>$1,109,768</td>
<td>Direct Management overestimate based on August 2010 TOR addendum confirming deferral of bypass capital upgrade implementation decision to next WUP review.</td>
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<tr>
<td></td>
<td>Non-Remissible Direct Management</td>
<td>$265,918</td>
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<td></td>
<td>Non-Remissible Implementation</td>
<td>$1,064,116</td>
<td>$179,728</td>
<td>$884,388</td>
<td>Implementation amount overestimated based on August 2010 TOR addendum confirming deferral bypass capital upgrade implementation decision to next WUP review.</td>
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<td>WAHWORKS#2 WAHLEACH RESERVOIR FERTILIZATION PROGRAM</td>
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<td>$1,145,052</td>
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<td>$12,381</td>
<td>Decrease in implementation costs due to underspending of fertilizer costs in 2009 and 2010.</td>
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<tr>
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<td>Non-Remissible Direct Management</td>
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<td>Non-Remissible Implementation</td>
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<td>WAHWORKS#3 LOWER WAHLEACH CREEK CHANNEL ENHANCEMENT PROJECT</td>
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<td>$241,609</td>
<td>$186,768</td>
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<td>Direct management underspending based on deferral of annual maintenance requirements and efficiencies realized in project management during initial construction phase.</td>
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<tr>
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<td>Non-Remissible Direct Management</td>
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<td>Non-Remissible Implementation</td>
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<td>$33,994</td>
<td>Decrease in implementation costs due to underspending of annual $15K in enhancement maintenance funds.</td>
<td></td>
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</tbody>
</table>

* Red values in parentheses denote overage.