Puntledge River Habitat Restoration:
Bull Island Side-Channel
Post-Construction Monitoring 2005

05.Pu.03

Prepared by:

E. Guimond
473 Leighton Ave.
Courtenay, BC V9N 2Z5
guimonde@telus.net

Prepared for:

Fisheries and Oceans Canada
4166 Departure Bay Rd.
Nanaimo, BC V9T 4B7

Prepared with financial support of:

BC Hydro Bridge Coastal Fish and Wildlife Restoration Program

April 2006

EXECUTIVE SUMMARY

In 2002 and 2003, over 3700 cubic metres of spawning gravel was added to the Bull Island side-channel in the Puntledge River, creating 2165 square metres of critical spawning habitat for chinook, coho and steelhead. A post-construction monitoring program was implemented in the side-channel in 2005/06 to evaluate the physical and biological performance of the spawning gravel placement, and other physical structures in the channel, for providing the required conditions throughout the chinook spawning and incubation period.

Discharge was measured periodically in the side-channel to develop a rating curve that was used to correct continuous water level data recorded with a Soinst Levelogger. Flows in the side-channel were compared to Puntledge mainstem flows for the period October to December 2005. Flows in the side-channel ranged from 1.37 cms to 21.74 cms (44 – 761 cfs) while mainstem flows in Reach C ranged from 5.19 cms to 179.33 cms (182 – 6276 cfs). This demonstrates the function of the rock groyne constructed at the upstream entrance of the side-channel to divert a greater proportion of mainstem flow during low flow periods and a smaller proportion during flood events (range: 17.8% to 48.2% of mainstem (Reach C) flow). The rock groyne reduces potential scouring of spawning gravel during flood events while maintaining adequate discharges through the channel during low flow periods.

Incubation assessments conducted in the side-channel using Jordan cassette incubators indicated a high egg-to-fry survival at all 3 spawning platforms (average = 98.6 %; range: 97.0 % - 100 %). Survival in pipe incubators was significantly lower based strictly on the number of live fry remaining at the time of removal. However, it is believed that some alevins may have escaped through the 3 mm (1/8 inch) diameter holes in the incubators. Therefore percent survival is likely much higher in these incubators. Hydraulic sampling of natural spawn redds was inconclusive due to the difficulty in obtaining adequate numbers of displaced eggs/larvae from the gravel. This problem has been experienced in other channels where screened gravel has been used and may be explained by the larger area of crevices where eggs and alevins can be dispersed compared to native gravel.

On October 13, 2005, over 200 adult chinook were observed on the lower platform (Site 3) and 179 live plus dead chinook were counted at all three spawning platforms 4 days later on October 17, 2005. Adult utilization of the Bull Island side-channel in 2005 was significantly less than the previous 2 years when between 1000 and 2000 adults were observed during the peak spawning period (mid-October). This lower escapement may be indicative of variations in environmental conditions in the side-channel, the mainstem or a combination.

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

The Bull Island side-channel was the main focus of a two-year fish habitat restoration project in 2002-2003, funded by BC Hydro's Bridge Coastal Fish and Wildlife Restoration Program (BCRP). This was the first major spawning gravel infusion project completed in the Puntledge River watershed, as part of a larger long term strategy by Fisheries and Oceans Canada to rebuild the summer run chinook stock to historical (pre-hydro expansion) production levels. Following expansion of the hydro facilities on the Puntledge River in the 1950s, summer runs of chinook and steelhead salmon declined significantly. DFO considers the Puntledge summer run chinook a unique endangered stock and has listed it as a priority for recovery under the Wild Salmon Policy.

Monitoring of completed habitat restoration projects in the watershed is an integral and important component of the DFO recovery plan and the BCRP. A rigorous monitoring plan was implemented in the Bull Island side-channel in 2005. Results from the monitoring surveys in Bull Island provide valuable information for restoring summer chinook spawning habitat in the Puntledge watershed and will be used when designing additional spawning habitat restoration projects in this system. This type of monitoring is critical in determining potential future maintenance requirements such as gravel recruitment.

1.1 Background

The Bull Island side-channel was known to be used historically by summer-run chinook salmon, but has degraded due to loss of gravel recruitment following the construction of the diversion dam. During this 2 year restoration project, 2,165 square metres of spawning habitat were added to this side-channel (Figure 1; Guimond and Norgan 2003). The project included the construction of three Newbury-style rock weirs; two were built below the log jam and one above (Figure 2). Screened spawning gravel (15% ¼" to 1" dia., 50% 1" to 2" dia., and 35% 2" to 3" dia.) was placed upstream of each weir. In addition, a large rock deflector or groyne was constructed at the upstream entrance to the Bull Island side-channel to reduce high river flows into the channel during floods (Figure 2). A low elevation rock weir was added upstream of the rock groyne and adjacent to the channel entrance to increase the proportion of flow diverted into the channel from the mainstem during low river flows (5.7 m^3/s fisheries maintenance flow). These groynes and Newbury weirs improve conditions for spawning, particularly at the lower spawning platform, while maintaining stability of the platforms at high flows. This project has provided spawning habitat for over 200 pairs of salmon – a tenfold increase in the number that could spawn in this channel previously.

1.2 Goals and Objectives

The main objective of the post-construction monitoring assessment in the Bull Island side-channel is to evaluate the physical and biological performance of the spawning gravel placement, the control invert weirs and the rock groyne intake structure that regulates discharge into the channel.

2 STUDY AREA

Bull Island is located in diversion reach (Reach C) of the Puntledge River, downstream of Nib falls and about 300 m upstream of the Comox logging bridge (Figure 1). The side-channel is approximately 640 m in length and between 10 and 20 m wide. Discharge from the river enters the side channel after flowing by a small upstream islet, then drops over a bedrock chute and down a 140 m long steep boulder substrate section before flattening out in a straight section composed of coarse gravel and cobble substrate. There is an accumulation of logs and wood debris in a narrow bend in the channel located between 250 and 440 m below the channel entrance. This deeper section provides excellent cover for juveniles and adults that hold in the river for several weeks. Downstream of the bend is a low gradient section 200 m long, leading back to the mainstem.

3 METHODS

3.1 Ambient Temperature

Water temperature was monitored throughout the incubation period using a built-in temperature sensor on the Solinst water level logger installed at the side-channel (see Section 3.3 Water Level). The instrument was periodically downloaded in order to calculate the Accumulated Thermal Units (ATU - daily mean temperature times the number of days) to estimate the rate of development of eggs for the incubation study. This temperature was compared to the development stage of the control group incubated at Puntledge Hatchery since temperatures at the two sites are very similar. Incubation temperature at Puntledge Hatchery was recorded using a TidbiT temperature logger.

3.2 Intergravel Water Quality

The initial study design called for the collection of intergravel water samples from the three gravel platforms (Sites 1-3) in Bull Island for analysis of in-situ dissolved oxygen, turbidity, and total suspended solids (TSS). However, during a similar incubation study on the Cowichan River in 2004 (Burt et al. 2005), it was found that these measured physical factors produced inconclusive results, and could not be used to evaluate incubation conditions. For example there were higher levels of TSS in intergravel samples collected at the control site compared to those downstream of a known sediment input source (the reverse was expected) and intergravel dissolved oxygen measurements were also inconsistent.

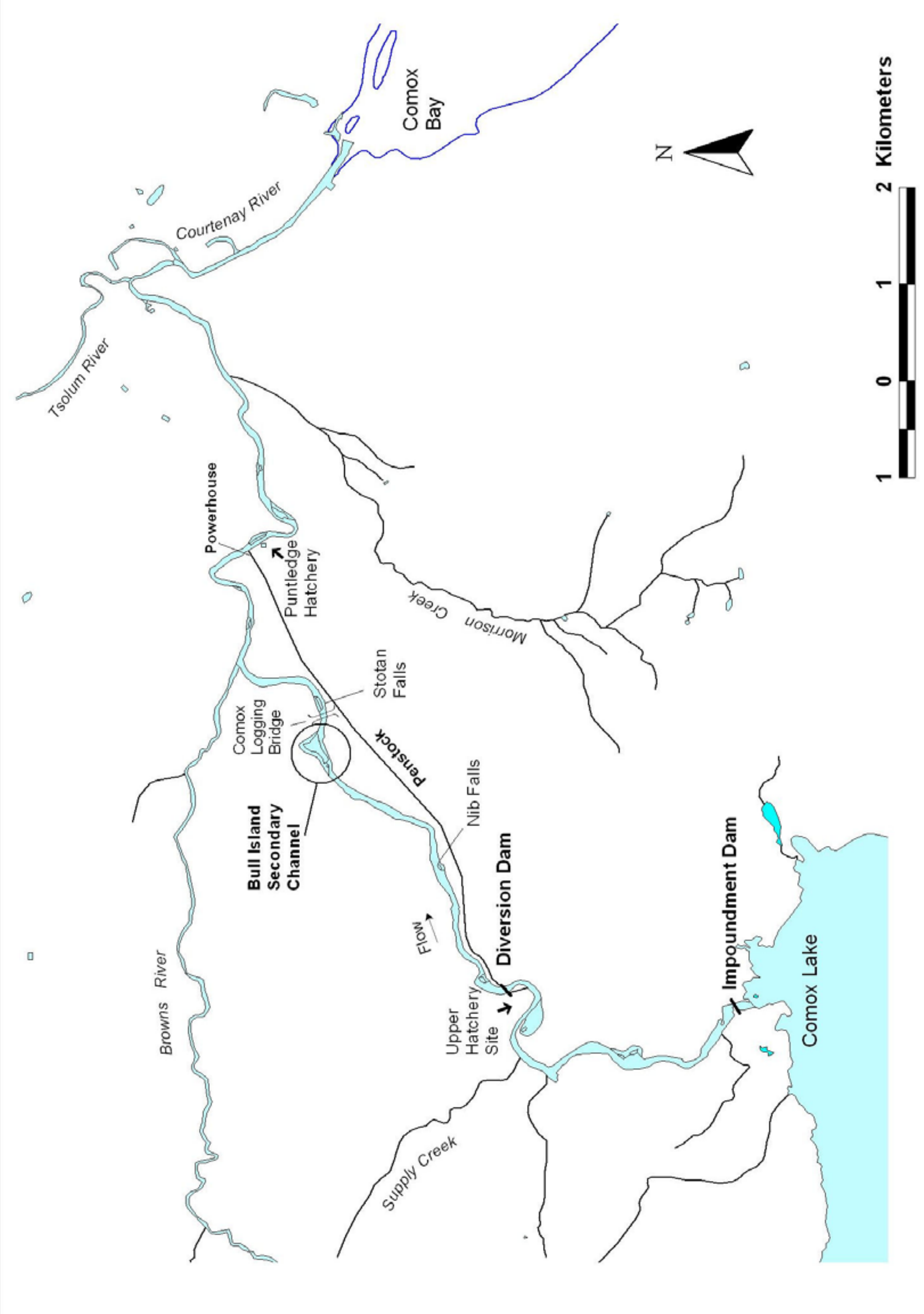

Figure 1. Location of the Bull Island Side-Channel in the lower Puntledge River.

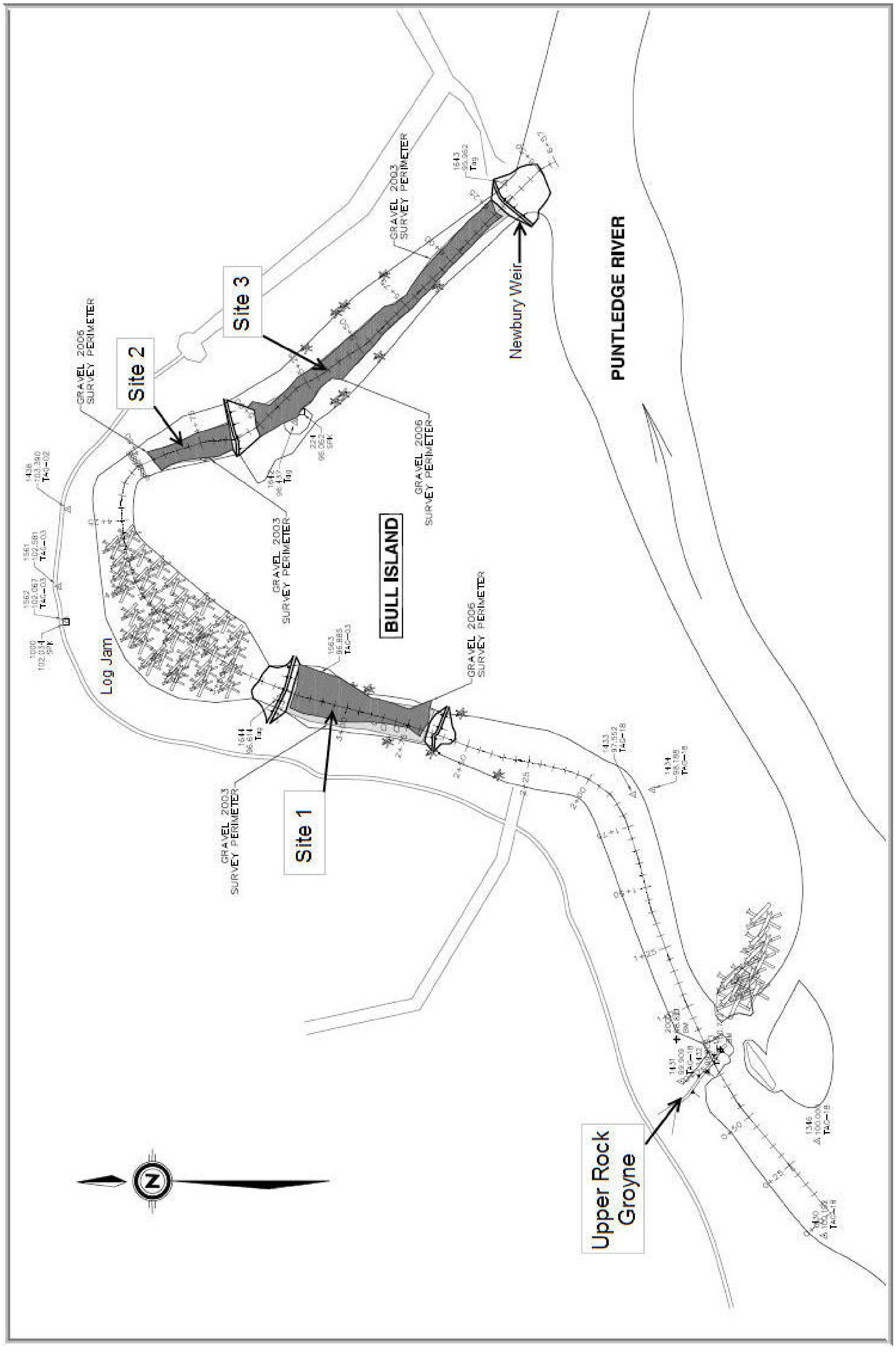

Figure 2. Bull Island side-channel (from DFO drawing 31-103-03) showing constructed features (groynes, weirs and spawning platforms).

Therefore these water quality variables were not monitored during the Bull Island post-construction monitoring project due to the poor relationship between oxygen, TSS and incubation survival. Due to the variability in fine sediment amongst samples and the effects of discharge on intergravel oxygen, it is estimated that several hundred samples would have to be taken at various discharges in order to develop a relationship between incubation quality, TSS and oxygen.

3.3 Water Levels

A Solinst water level data logger was installed at Bull Island on October 4, 2005. The instrument is suspended from stainless steel cable within a 2 inch perforated metal pipe driven into the stream bed. A second recorder located nearby was collected barometric pressure data used to compensate total pressure data collected in the side-channel. A staff gauge was installed at Bull Island using angle iron embedded into the substrate.

3.4 Discharge

Discharge was measured on 5 dates in the Bull Island side-channel at Site 1 (upstream of the logjam) using a Swoffer current meter with a 1.4 m top setting wading rod. Velocities were taken at 1.0 m intervals along a transect perpendicular to the channel, from the left bank to the right bank. Discharge data was obtained for Water Survey of Canada Gauge 08HB084 below the diversion dam (also known as Gauge 6) from Environment Canada, to be used to compare with flows in the side-channel.

3.5 Substrate Composition

An analysis of changes in substrate composition was not conducted during this assessment. Research has shown that surface composition of gravels is inadequate and is often a misleading indicator of gravel quality for salmonid incubation. The gravel quality at a depth of 20 to 30 cm where spawning salmonids usually deposit their eggs can be significantly different from the surface (Everest et al 1981). Gravel quality data collected at Carnation Creek demonstrated that there are significant differences in substrate composition between the surface, middle and bottom layers of a frozen core sample (Scrivener and Brownlee, 1982). The bottom layer has the highest composition of finer material and the top layer having the lowest percentage of fine material (<9.55 mm). This has been observed at all of the DFO SEP spawning channels (M. Sheng, pers. comm.).

Future monitoring studies in this side-channel will assess the need to conduct a more detailed substrate analysis using freeze core or standard core sampling (i.e. McNeil). These results will be compared to initial substrate composition which is based on the screened gravel mix purchased and placed in the side-channel during construction (Guimond and Norgan 2003).

3.6 Spawning Assessment

The side-channel was visually assessed for spawning activity by walking the channel from the outlet to the upstream limit of spawning gravel availability (just upstream of Site 1) on three events during the chinook spawning period. The estimate of chinook spawning escapement for the side-channel was calculated as the maximum sum of live plus dead fish counted during one of the spawning assessment surveys. During one survey, metal "redd markers" painted orange were placed at locations of observed spawning activity to be used to identify sites for hydraulic sampling later in the season.

3.7 Incubation Success

On November 18, 2005, approximately 4500 eggs from fall run chinook salmon at the eyed stage from Puntledge Hatchery (353 ATUs) were loaded into incubators and transported to the side-channel. The eggs were placed in Jordan-Scotty incubation cassettes, 200 eggs per cassette and buried in the three gravel platforms in Bull Island Side-Channel (7 cassettes above the log jam - Site 1, 7 below the log jam – Site 2, and 7 in the platform upstream of the outlet – Site 3; Fig 2). In addition to Jordan cassettes, pipe incubators were also used in Sites 2 and 3 to provide a comparison of incubation survival between the two apparatus (Appendix III, Photo 1). The pipe incubators are 1.9 cm (3/4 inch) metal perforated pipes, 38 cm in length and equipped with masonry drill bits at their tips such that they could be screwed into the substrate using a rechargeable drill. They were fabricated specifically for applications in deep water (Cowichan River) since they can easily be drilled into the substrate from the side of a boat.

Each pipe incubator was loaded with eggs (24 eggs per incubator mixed with small beads as a substrate) and buried beside a Jordan cassette (Appendix III, Photos 2 and 3). Three of these incubators were buried in Site 2 and seven in Site 3. Each incubator (cassette and pipe) was marked with a piece of yellow poly rope for easier recovery at the end of the study. By monitoring the accumulated thermal units (ATU's) and development of the control group at Puntledge Hatchery, we determined the timing of hatch for the study group.

On December 9, 2005, two cassette incubators and one pipe incubator (from Site 2 and Site 3) were removed to check survival to hatch. Cassettes were reburied in the gravel. All cassettes and pipe incubators were removed on February 21, 2005 and contents were inspected to calculate percent survival to swim-up stage before fry were released in the side-channel.

3.8 Hydraulic Sampling

On December 9, 2005, redds in Sites 2 and 3 were hydraulic sampled to assess natural spawn incubation survival to hatch. This included redds previously identified and flagged with orange metal markers during the spawning season as well as additional redds identified on the sampling date.

A redd was hydraulic sampled by inserting a long 40 mm diameter stainless steel probe into the gravel to a depth of 20-45 cm and injecting a pressurized mixture of air and water. The expelled eggs/alevins were captured in a cylindrical catch net, which surrounds the probe (Appendix III, Photos 4 and 5). The contents of the net were emptied into shallow tubs and sand/gravel was separated out. All live and dead alevins and eggs were counted to determine percent survival of embryos for each redd. This is calculated by dividing the total live eggs and alevins by the total eggs/alevins in the sample (live and dead). Sample contents were re-buried in the gravel after counting.

4 RESULTS

4.1 Ambient Temperature

During the Chinook spawning and incubation period water temperatures at the side-channel ranged from a maximum of 14.81 ^{o}C to a minimum of 3.18 ^{o}C between Oct 4, 2005 and Feb 21, 2006. Daily average incubation temperature at Puntledge Hatchery appears to be slightly warmer than temperature measured in Bull Island (Figure 3).

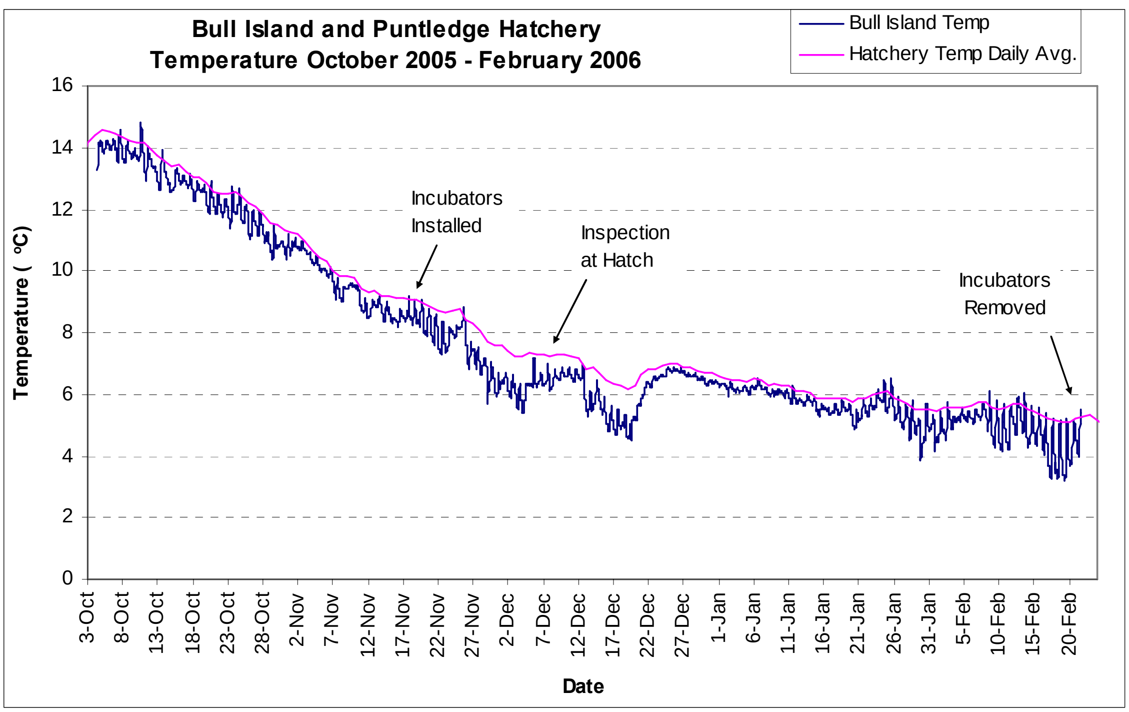

Figure 3. Ambient water temperature recorded in the Bull Island side-channel and Puntledge Hatchery incubation temperature, October 2005 to February 2006.

4.2 Water Level and Discharge

Water level was measured in Bull Island side-channel using a Solinst pressure transducer so that continuous discharge in the channel could be calculated. A stage/discharge curve for the channel was developed using the water level data and the discharge measured on 6 events between October 2005 and April 2006. Using this rating curve, water level data for the entire recording period was calculated to provide a hydrograph for the side-channel (Figure 4). Discharge data for WSC 08HB084 (diversion reach) is included for a portion of the incubation period to compare the proportion of mainstem flow (Reach C) that is diverted into the side-channel under range of flows. Based on the water level recorder data, high flows through the side-channel appear to be significantly moderated by the upstream deflector groyne. Flows through Bull Island side-channel ranged from 17.8% to 48.2% of mainstem (Reach C) flow measured at WSC gauge 08HB084 below the diversion dam (Figure 5). Figure 6 exhibits the relationships between mainstem and side-channel discharge and percentage of flow diverted.

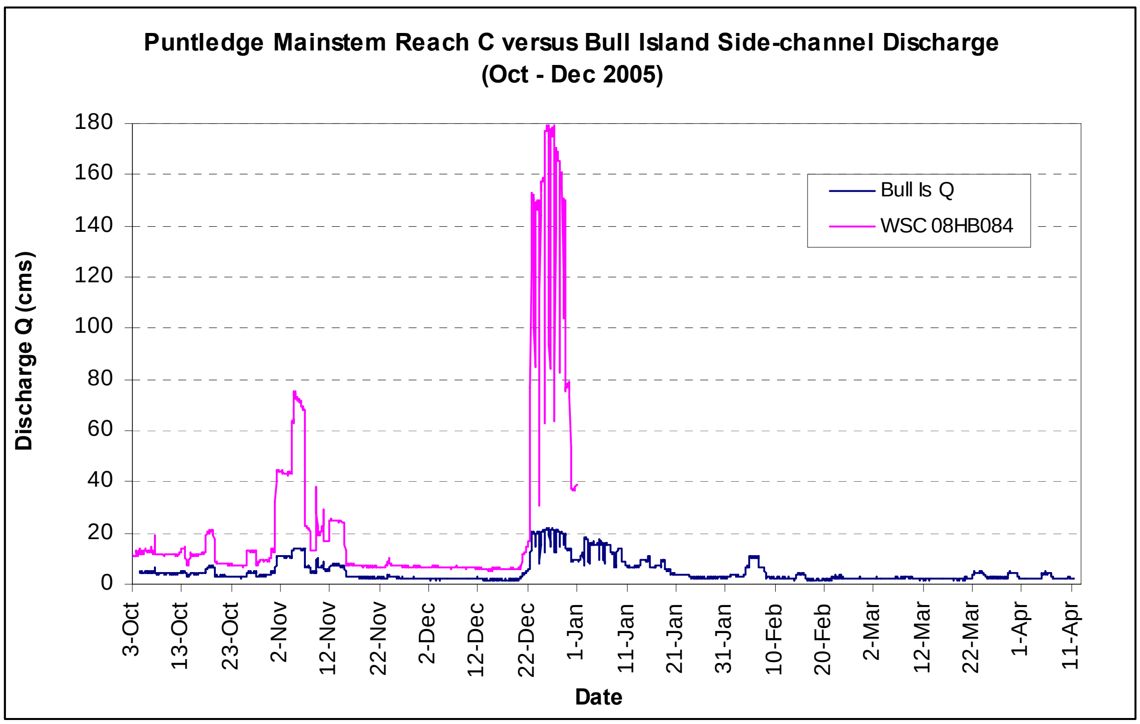

Figure 4. Comparison of discharge in Bull Island side-channel with Puntledge River mainstem discharge (Reach C) for October – December 2005.

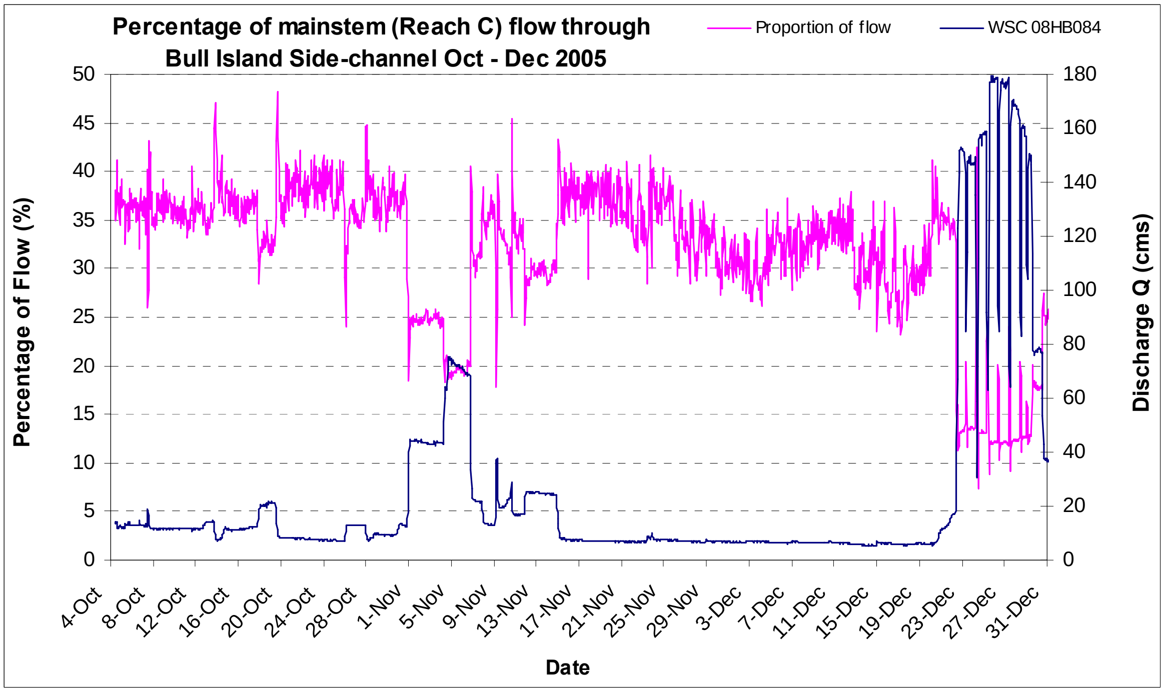

Figure 5. Percentage of Puntledge River mainstem flow (Reach C) diverted into Bull Island side-channel for the period October – December 2005.

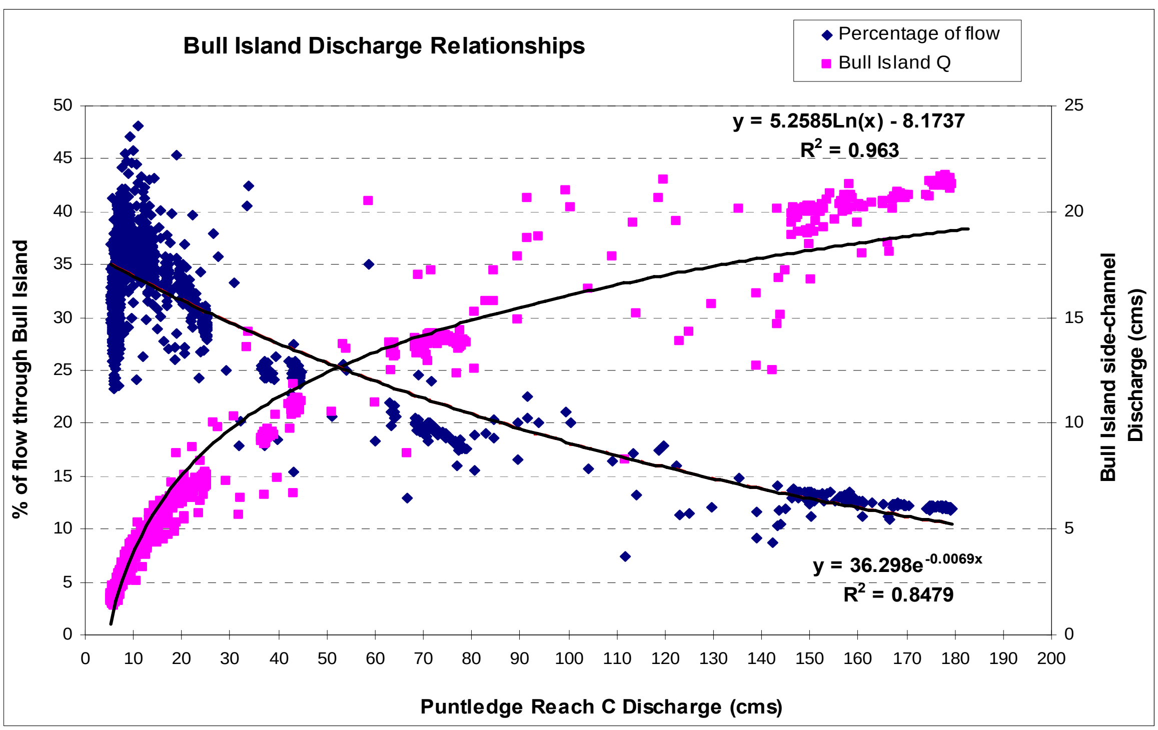

Figure 6. Relationship between Puntledge River (Reach C) and Bull Island side-channel discharges displayed as cubic metres/sec and a percentage of flow, Oct – Dec 2005.

A comparison of water depths and velocities measured over the Jordan incubation cassettes measured during incubation (Dec 19, 2005) and before removal (Feb 21, 2006) is provided in Table 1. The depth of water over the cassette locations in the gravel was greater at all Sites on February 21st, ranging from 4 cm to 18 cm difference, although discharge was similar on both dates.

4.3 As-built (2003) versus Post-construction (2006) Survey

DFO Resource Restoration conducted a total station survey of the spawning platforms in Bull Island side-channel in April 2006 to compare with gravel bed elevations measured immediately following construction completion of the project in 2003. Both surveys are located on DFO drawing 31-103-04 (Appendix IV) and show little change in gravel elevations on all 3 platforms in 3 years.

Table 1. Depth and velocity measurements at Jordan cassette incubator locations in Sites 1 – 3 at Bull Island side-channel, Dec 19, 2005 and Feb 21, 2006.

Date		19-Dec-05		21-Feb-06			
Time		12:30 hrs		13:00 hrs			
Staff Gauge		0.64 m		0.64 m			
Discharge		1.80 cms		1.88 cms			
Site	**Jordan #**	**Depth (m)**	**Velocity (m/sec)**	**Depth (m)**	**Velocity (m/sec)**	**Δ Depth (cm)**	**Δ Velocity (m/sec)**
Site 1 – top platform	J1	0.11	0.605	0.175	0.543	6.5	-0.062
	J10	0.1	0.557	0.18	0.47	8.0	-0.087
	J15	0.11	0.486	0.20	0.473	9.0	-0.013
	J13	0.11	0.486	0.17	0.384	6.0	-0.102
	J7	0.09	0.419	0.14	0.444	5.0	0.025
	J2	0.09	0.476	0.27	0.394	18.0	-0.082
	J16	0.09	0.487	0.20	0.385	11.0	-0.102
Site 2 – middle platform	J14	0.13	0.451	0.23	0.471	10.0	0.02
	J18	0.14	0.263	0.23	0.298	9.0	0.035
	J5	0.16	0.389	0.25	0.438	9.0	0.049
	J10	0.13	0.413	0.22	0.474	9.0	0.061
	J1	0.09	0.434	0.22	0.442	13.0	0.008
	J2	0.1	0.413	0.14	0.529	4.0	0.116
	J4	0.07	0.513	0.15	0.484	8.0	-0.029
Site 3 – bottom platform	J1	0.04	0.25	0.1	0.369	6.0	0.119
	J2	0.05	0.346	0.1	0.403	5.0	0.057
	J3	0.05	0.502	0.115	0.495	6.5	-0.007
	J4	0.07	0.206	0.13	0.18	6.0	-0.026
	J5	0.11	0.156	0.16	0.145	5.0	-0.011
	J6	0.1	0.152	0.15	0.17	5.0	0.018
	J7	0.1	0.334	0.14	0.295	4.0	-0.039

4.4 Spawning Success

Spawning assessment surveys were conducted on October 4, 13, 17, and 27, 2005. Results from the surveys are summarized in Table 2. Highest numbers of spawners were observed on October 13th with over 200 on the lower platform alone (Site 3).

Table 2. Summary of spawning surveys conducted in Bull Island Side-channel Sites 1 – 3 October 2005.

Survey Date	Site 1 Top Platform		Site 2 Middle Platform		Site 3 Lower Platform		Sum Live plus Dead
	Live	Dead	Live	Dead	Live	Dead	
4-Oct-05	0	0	**n/i**	**-**	**n/i**	-	**0**
13-Oct-05	**n/i**	**-**	**n/i**	**-**	>200	-	**>200**
17-Oct-05	32	0	31	1	112	3	**179**
27-Oct-05	2	4	4	3	22	11	**46**

n/I – not inspected

4.5 Incubation Success

On December 9, 2005 one pipe incubator and 2 Jordan cassette incubators were removed from Site 2 and 3 to assess the stage of development and survival at ~500 ATUs. The eggs were just beginning to hatch in the Jordan cassettes and only one dead alevin was observed in each. Survival to this stage was estimated at 99.5%. The eggs in the pipe incubator were more difficult to estimate survival because they were not opened to view the contents. It was only visually inspected from the exterior, however, they appeared to have no dead (white) eggs. All incubators were removed from Bull Island on February 21, 2005 at ~911 ATUs (Appendix III, Photos 6 and 7). Survival to the fry stage in Jordan cassette incubators was high at all three sites (Table 3).

Overall survival in Bull Island side-channel was 98.6 % (range: 97.0 % - 100 %). For the pipe incubators, overall survival was 50.4 % (range: 29.2 % – 79.2 %) calculated as the number of remaining live fry divided by 24 (total number of eyed eggs in the pipe) multiplied by 100. Egg-to-fry survival for the control group at Puntledge Hatchery was 97.7 % (L. Frisson, pers. comm.).

Table 3. Summary of egg-to-fry survival for chinook eggs in Bull Island Side-channel Nov 2005 - Feb 2006 using Jordan and pipe incubators.

Installation Date: November 18, 2005 **Removal Date:** February 21, 2006

Site	Jordan #	Dead Eggs	Dead Alevins	Live Fry	% Survival	Pipe #	Live Fry	Missing[1]	% Survival[2]	Comments
1 - top platform	1	0	0	200	100					All fry healthy; some bent tails;~95% yolk absorbed
	10	2	0	198	99					
	15	1	2	197	98.5					
	13	1	1	198	99					
	7	2	1	197	98.5					
	2	2	3	195	97.5					
	16	3	0	197	98.5					
Mean					**98.7**					
2 - middle platform	14	0	1	199	99.5	6	14	10	58.3	Alevins look good; ~95% yolk absorbed;
	18	0	2	198	99	9	12	12	50.0	some dead on bottom
	5	2	3	195	97.5	5	7	17	29.2	some dead on bottom
	10	0	6	194	97					
	1	1	0	199	99.5					
	2	1	3	196	98					
	4	2	0	198	99					
Mean					**98.5**				**45.8**	
3 - bottom platform	1	2	1	197	98.5	8	6	18	25.0	some dead on bottom
	2	0	4	196	98	10	14	10	58.3	
	3	2	1	197	98.5	1	19	6	79.2	some dead on bottom
	4	0	1	199	99.5	7	8	16	33.3	some dead on bottom
	5	3	3	194	97	2	11	13	45.8	
	6	2	0	198	99	4	16	8	66.7	
	7	2	0	198	99	3	14	10	58.3	some dead on bottom
Mean					**98.5**				**52.4**	

Notes: [1] Estimate of fry missing or dead. It was impossible to estimate the number of dead eggs/alevins and in some cases there was no dead material remaining in the pipe incubator.
[2] For simplicity in this table, % survival is the number of live fry ÷ 24 x 100. See Discussion.

Overall survival in Bull Island side-channel was 98.6 % (range: 97.0 % - 100 %). For the pipe incubators, overall survival was 50.4 % (range: 29.2 % – 79.2 %) calculated as the number of remaining live fry divided by 24 (total number of eyed eggs in the pipe) multiplied by 100. Egg-to-fry survival for the control group at Puntledge Hatchery was 97.7 % (L. Frisson, pers. comm.).

4.6 Hydraulic Sampling

Hydraulic sampling was conducted at Sites 2 and 3 in Bull Island Dec 9, 2005, and results are presented in Table 4. Sampling of all marked redds yielded very few eggs/larvae with the exception of one coho salmon redd. Of the 8 marked redds and over

25 unmarked redds that were sampled, only 5 sites displaced eggs/larvae. A minimum sample size of 100 is needed to calculate percent survival.

Table 4. Summary of hydraulic sampling results at Sites 2 and 3 in the Bull Island Side-channel December 9, 2005.

Location	ID#	Live Alevins	Live Eggs	Dead Eggs	% Survival[1]	Comments
Site 2 - Middle platform	HS1	3	5	1	n/a	CN
Site 2 - Middle platform	HS2	2	0	1	n/a	CN
Site 3 - Lower platform	HS3	0	162	2	98.8	CO
Site 3 - Lower platform	HS4	16	0	0	n/a	CN
Site 3 - Lower platform	HS5	1	40	2	n/a	CN

Notes: [1] percent survival calculated only for sample sizes of 100 or greater.

5 DISCUSSION

The objective of this study was to evaluate the physical and biological performance of the spawning gravel placement, weirs and upper rock groyne for providing the required conditions throughout the chinook spawning and incubation period.

5.1 Physical Performance

The comparison of flows in the side-channel to mainstem flows demonstrates how the function of the rock groyne constructed at the upstream entrance of the side-channel prevents the potential scouring of spawning gravel during flood events while maintaining adequate discharges through the channel during low flow periods. Flows in the side channel ranged from 1.37 cms to 21.74 cms (44 – 761 cfs) while mainstem flows in reach C ranged from 5.19 cms to 179.33 cms (182 – 6276 cfs) during the same period (i.e. October to December 2005). The moderated flows in the side-channel during flood events was also observed during a site visit 3 days following a peak flow of 425 cms (14,875 cfs) in Reach C on October 19, 2003. Flows in the mainstem were still very high (~200 cms) yet in the side-channel, chinook did not appear to have any difficulty spawning during this period.

The 2006 survey of the spawning platforms indicates that for the most part gravel elevations have remained the same since construction at all 3 sites. At Site 3 there is prevalence of greater spawning activity as evidenced by the numerous “ridges and valleys” that have been created in the gravel by chinook during redd construction. This is a common observation in chinook spawning areas whereby chinook salmon deliberately create “windrows” in the gravel to enhance sub-surface flows and oxygen transfer to the eggs (M. Sheng, pers. comm). The survey is further evidence that scouring flows through the side-channel have been eliminated by the rock groyne at the entrance of the channel.

The variation in water depth measured over the incubation cassettes at the 3 sites may also be explained by the subtle changes in gravel depths during redd construction. However, it was also observed that some erosion along the right and left banks both upstream and downstream respectively of the rock weir at Site 2 are diverting a greater proportion of flow from the channel to the margins. There is some concern that if not addressed immediately, velocities and water depth through Site 3 may not be adequate for spawning, or areas that are adequate at higher flows could become dewatered during low flow periods. Both problem areas can be easily repaired by the addition of some larger rock to concentrate flows down the center of the channel.

5.2 Biological Performance

5.2.1 Spawning

Adult utilization of the Bull Island side-channel in 2005 was less than the previous 2 years. Spawning surveys conducted in Bull Island in October of 2003 and 2004 produced counts in the range of 1000 – 2000 chinook. Although the overall escapement of fall-run chinook was strong in 2005 as it was in the previous 2 years, the lower adult utilization in Bull Island may be indicative of the reduced spawning velocities and water depths in the channel, or access difficulties for fall chinook in the mainstem. In 2005, BC Hydro maintained a flow of 12 cms or 420 cfs (range 11.5 - 16 cms) in Reach C from August 2nd until October 14th, for maintenance operations to the powerplant. The elevated flows may have impeded access for fall chinook through Stotan Falls. Other physical obstructions at Stotan Falls may also be influencing fish access through the ladders. Taylor and Guimond (2006) reported that radio-tagged summer chinook experienced a higher failure rate of progressing above Stotan Falls in 2005 than in previous years (17% of the first release group and 33% of the second reaching failing to progress further upstream). During a river swim, technicians noted a log in one of the fish ladders that appeared to be altering the flow pattern through the ladder (D. Fetzner, pers. comm.). Further constraints to migration at this location would likely be even more challenging for fall chinook since this stock historically did not migrate above these physical barriers and are less agile than the summer stock.

5.2.2 Incubation

Following completion of the first phase of gravel placement in Bull Island side-channel in 2002, an incubation study using Jordan incubation cassettes determined an egg-to-fry survival at Sites 1 and 2 of 98% (Wright and Guimond 2003). This was not an unexpected result considering the recent placement of screened gravel and other high-quality results of other physical variables measured during the study.

The spawning platforms continue to provide excellent conditions for incubation, producing high egg-to-fry (98.6 %) survival at all sites in Jordan incubation cassettes. For the pipe incubators percent survival to the fry stage was much less (50.4 %) under the assumption that missing fry are dead. The pipe incubators were perforated with 3 mm (1/8 inch) diameter holes. It was thought that this size would prevent the escape of chinook alevins. However, during inspection of pipe incubators in the Cowichan River incubation study, one pipe was found to contain a coho alevin amongst the chinook that were loaded into it (M. Sheng pers. comm). The only explanation was that the coho alevin was able to gain entry into the pipe through the holes. Therefore, it may be conceivable that chinook alevins, although slightly larger than coho, may also be able to escape through the holes. The amount of dead material that was removed from the pipes during recovery of the incubators did not seem to correlate with the number of missing fry. We estimated anywhere from 3to 5 dead eggs/larvae per pipe based on the quantity of dead material removed. Therefore assuming the remaining are missing live fry the average survival in the pipe incubators would average around 83% (20 live ÷ 24 total).

Pipe incubators may be more appropriate for obtaining information on incubation conditions in the gravel compared to Jordan cassette incubators. Jordan incubators were specifically designed for enhancement purposes and therefore provide ideal conditions for incubation. In Jordan cassettes, each egg is located in a separate cell, thus minimizing the potential for fungus infection and protecting eggs from predators and silt suffocation. The cassettes are placed in the gravel in such a way as to receive the best delivery of dissolved oxygen. The action of digging a hole in the gravel for the cassette essentially cleans the gravel thereby improving conditions further. They likely overestimate survival compared to natural spawn but if they are used to assess incubation year after year they may detect changes in intergravel conditions over time. On the other hand, pipe incubators have all eggs (and beads) in one compartment and because the units are simply drilled into the stream bed, the surrounding gravel is not disturbed. Furthermore, the top plate of the incubator (Appendix IV, Photo 1) acts as a benchmark to assess gravel movement around the incubator. One can more easily measure depth of scour or deposition over the incubators.

Results from hydraulic sampling for natural spawn are inconclusive since only one of the more than 30 redds sampled yielded an adequate sample size to determine survival to the hatching stage (CO – 98.8% survival). The difficulty in obtaining results from this sampling procedure is puzzling, even though redds are marked and/or are often easily identifiable. Hydraulic sampling conducted in Bull Island in previous years, as well as in other channels where screened gravel has been used, have shown similar results. One theory is that the screened gravel size is so porous that the alevins disperse after hatching. Also, the process of injecting pressurized water into the gravel may force the eggs/alevins further into the open crevices of the gravel rather than up to the surface compared to sites with native gravel (M. Sheng, pers. comm.).

6 CONCLUSIONS AND RECOMMENDATIONS

Results of the monitoring study indicate that overall, the Bull Island side-channel is providing high quality spawning and incubation habitat. The physical components constructed in this side-channel (Newbury weirs and rock deflector groyne) are maintaining gravel platforms and regulating flood flows through the channel as designed. An on-going monitoring program to inspect channel features including bank integrity and potential redd dewatering, as well as spawner counts each fall/winter should be implemented in addition to the following recommendations:

1. Repair the two locations in the side-channel identified in 2005 (Site 2 left bank at weir and right bank below weir) where flow is by-passing the centre spawning channel through Site 3.

2. Conduct an in-situ incubation study using the pipe incubators to determine if chinook alevins can escape through the 1/8 inch (3 mm) diameter holes. Half of the pipe incubators could be enveloped in a stainless steel fine mesh screen sleeve while the others remain unaltered.

3. Examine the Stotan Falls fish ladders for potential physical obstructions to migration.

7 ACKNOWLEDGEMENTS

We are grateful for the financial support for this study from BC Hydro Bridge Coastal Fish and Wildlife Restoration Program (BCRP), and Fisheries and Oceans Canada Resource Restoration Division. Special thanks go out to the volunteers involved with data collection throughout this project – Malaspina University-College students Chris Presslauer and Tony Galesloot; and two students in the Youth and Ecological Restoration Project (Wendy Kotilla, Co-ordinator). We are also grateful to DFO Puntledge Hatchery for providing chinook eggs and staff time towards the project.

8 REFERENCES

Burt, D.W., M. Wright and M. Sheng. 2005. Cowichan River Chinook Salmon Incubation Assessment, 2004–2005. Prepared for the Pacific Salmon Commission, Vancouver, BC. 42 p.

Everest, F.H., F.B. Lotspeich and W. R. Meehan. 1981. New Perspectives on Sampling, Analysis and Interpretation of Spawning Gravel Quality. In: N. B. Armantrout (ed.) Acquisition and Utilization of Aquatic Habitat Inventory Information, p. 325 – 333. Western Division, American Fisheries Society, Portland, Oregon.

Guimond, E. and R. Norgan. 2003. Puntledge River Spawning Habitat Restoration: Bull Island Side-Channel Gravel Placement Project 2002 – 2004 Final Report. Project # 02Pu.71. Prepared for BC Hydro Bridge Coastal Fish and Wildlife Restoration Program, Burnaby, BC.

Scrivener, J.C. and M. J. Brownlee. 1982. An analysis of Carnation Creek gravel quality data, 1973 – 1981. In G.F. Hartman (ed.) Proceedings of the Carnation Creek Workshop: A ten year review, p. 154 – 176. Pacific Biological Station, Nanaimo, B.C.

Taylor, J.A. and E. Guimond. 2006. Puntledge River 2005 Summer Run Chinook Radio Telemetry Study. Prepared for Fisheries and Oceans Canada, Nanaimo, BC and BC Hydro, Burnaby, BC.

Wright, M.C. and E. Guimond. 2003. Assessment of incubation survival of summer-run chinook salmon in the Puntledge River headpond and the Bull Island restoration sites. BC Hydro Bridge Coastal Fish and Wildlife Restoration Program, Burnaby, BC.

Personal Communication

Dale Fetzner	Fisheries and Oceans Canada, Puntledge Hatchery
Laurent Frisson	Fisheries and Oceans Canada, Puntledge Hatchery
Mel Sheng	Fisheries and Oceans Canada, Resource Restoration

Project # 05.Pu.03

Appendix I - Financial Statement Form

	BUDGET		ACTUAL	
	BCRP	Other	BCRP	Other
INCOME				
Total Income by Source	14,869.00	5,314.00	14,869.00	5,733.00
Grand Total Income **(BCRP + other)**	20,183.00		20,602.00	
EXPENSES				
Project Personnel				
Wages		4,400.00		3,750.00
Consultant Fees				
(List others as required)				
Biologist	7,200.00		6,900.00	
Technician	3,600.00		640.00	
Materials & Equipment				
Equipment Rental	400.00	914.00		618.00
Materials Purchased	1,570.00		3,917.51	
Travel Expenses	405.00		150.92	540.00
Permits				
(List others as required)				
Lab Analysis	1,000.00			
Administration				
Office Supplies	200.00			
Photocopies & printing	70.00			
Postage				
(List others as required)				
insurance	200.00			
telecommunications	224.00			
5% Admin (Wages and Materials)				825.00
Total Expenses	14,869.00	5,314.00	11,608.43	5,733.00
Grand Total Expenses **(BCRP + other)**	20,183.00		17,341.43	
BALANCE **(Grand Total Income – Grand Total Expenses)**	*The budget balance should equal $0* 0.00		*The actual balance might not equal $0** 3,260.57	

* Any unspent BCRP financial contribution to be returned to: BC Hydro, BCRP
6911 Southpoint Drive (E14)
Burnaby, B.C. V3N 4X8
ATTENTION: JANICE DOANE

Project # 05.Pu.03

Appendix II - Performance Measures

Using the performance measures applicable to your project, please indicate the amount of habitat actually restored/enhanced for each of the specified areas (e.g. riparian, tributary, mainstream).

Performance Measures – Target Outcomes												
			Habitat (m^2)									
Project Type	**Primary Habitat Benefit Targeted of Project (m^2)**	**Primary Target Species**	Estuarine	In-Stream Habitat – Mainstream	In-stream Habitat – Tributary	Riparian	Reservoir Shoreline Complexes	Riverine	Lowland Deciduous	Lowland Coniferous	Upland	Wetland
Impact Mitigation												
Fish passage technologies	Area of habitat made available to target species											
Drawdown zone revegetation/stabilization	Area turned into productive habitat											
Wildlife migration improvement	Area of habitat made available to target species											
Prevention of drowning of nests, nestlings	Area of wetland habitat created outside expected flood level (1:10 year)											
Habitat Conservation												
Habitat conserved – general	Functional habitat conserved/replaced through acquisition and mgmt											
	Functional habitat conserved by other measures (e.g. riprapping)											
Designated rare/special habitat	Rare/special habitat protected											
Maintain or Restore Habitat forming process												
Artificial gravel recruitment	Area of stream habitat improved by gravel plmt.	CN, CO, ST		2165								
Artificial wood debris recruitment	Area of stream habitat improved by LWD plcmt											
Small-scale complexing in existing habitats	Area increase in functional habitat through complexing											
Prescribed burns or other upland habitat enhancement for wildlife	Functional area of habitat improved											
Habitat Development												
New Habitat created	Functional area created											

Appendix III - Photos

Photo 1. Pipe incubator used in Bull Island side-channel to test incubation success**.** Top plate indicates depth at which incubator is buried.

Photo 2. Beads were used as a substrate in the pipe incubators to reduce clumping and fungus spread of any dead eggs or larvae

Photo 3. Paired Jordan and pipe incubators (showing top plate) after burying in the gravel.

Photo 4. Hydraulic sampling equipment used to assess embryo survival of natural spawn in Bull Island side-channel, December 9, 2005.

Photo 5. Hydraulic sampling - nozzle is inserted into gravel forcing eggs/alevins to surface in catch net.

Photo 6. Contents from a pipe incubator exhumed at Site 3 in Bull Island side-channel, February 21, 2006.

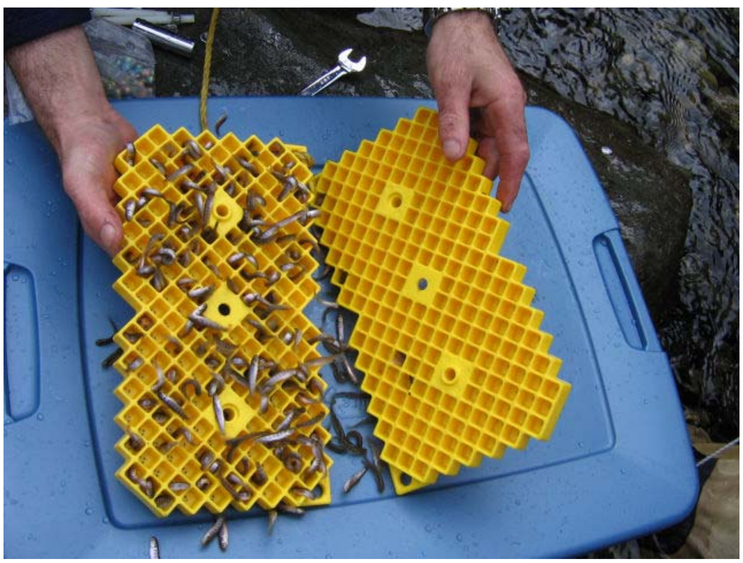

Photo 7. Contents from a Jordan cassette incubator exhumed at Site 3 in Bull Island side-channel, February 21, 2006.

Appendix IV - Profile of the Bull Island side-channel comparing 2003 and 2006 gravel bed elevations.