Puntledge River Stotan Falls - Improvement for Adult Summer Chinook Migration

07.Pun.03

Photo by John Harvey

Prepared by:

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Prepared with financial support of:

BC Hydro Bridge Coastal Fish and Wildlife Restoration Program

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EXECUTIVE SUMMARY

Stotan and Nib Falls are located on the Puntledge River below the BC Hydro diversion dam in Reach C. Summer chinook ascend both of these falls to reach their historical holding and spawning area in Comox Lake and the headpond. Since the expansion of the BC Hydro facility in the 1950s, river discharge in Reach C has changed from a more natural flow regime to a constant regulated flow throughout most of the year. A decrease in both the average flow and in the variability of flow below the diversion dam, as well as an increase in the rate of flow changes during the summer period has affected the ability of summer chinook to acend these falls. Despite remedial work to improve access at the falls between 1923 and 1977, these areas continue to limit the number of summer chinooks that successfully migrate to the upper watershed. Under current ecological conditions, Fisheries and Oceans Canada (DFO) maintains that the survival and sustainability of a natural spawning population of summer chinook in the Puntledge River is dependent on their ability to successfully migrate into Comox Lake.

In 2005, BC Hydro initiated the Puntledge River Water Use Plan. One of the key recommendations was the release of 5 pulse flows in Reach C during the months of July and August to improve chinook and steelhead migration. During these pulse flows, discharge through Reach C is increased from 5.7 m^3/s to 12 m^3/s for a period of 48 hours to stimulate summer chinook and steelhead and facilitate migration upstream. Following a pulse flow event, BC Hydro staff observed several adult chinook stranded at the Stotan Falls area in potholes and on the bedrock shelf on the right side of the river below the Duncan Bay Mainline bridge. Staff later observed that adult summer chinook swimming up the middle Stotan Falls fishway were being attracted to a side-channel that flowed into the fishway half-way up the ladder. During a pulse flow, flow from the side-channel increased and attracted adults into the side-channel which opened to the right side of the river. This side of the river, which is composed of a wide bedrock shelf, only normally has a thin .05-.07 m veneer of water flowing over it and shallow pockets (potholes) are scattered throughout the shelf. When the pulse flow recedes, fish migrating up this side of the river often become stranded.

To mitigate the stranding risk during the summer migration period, a diversion channel was designed to intercept the side-channel flow and direct it away from the fish ladder. Construction of the diversion channel was completed over a 2-day period in early June as per an engineered design prepared by DFO Resource Restoration Division (RRD). An existing access ramp to the Puntledge River, located on the upstream side of the Duncan

Bay Mainline Bridge, was used by equipment to access the river and work site. Once at the river, equipment could access the work site by traveling downstream for 200 m on smooth bedrock along the right side of the river. The right side of the river was dewatered from the Duncan Bay Mainline Bridge to the work site by constructing a coffer dam using 1 cubic metre pre-filled mega bags with gravel, 6 ml polyethylene film and sand bags. While the right side of the river slowly dewatered, the effected downstream area was fry salvaged.

A Hitachi EX200 with a hydraulic hammer constructed the diversion channel by breaking out a rock trench in the streambed while a Deere EX225C LC cleared the broken material and stockpiled it for loading into a Volvo 6WD off-road truck. Approximately 19 truck loads of broken rock (~15 m^3/load) were removed from the river and hauled to a spoil site on the south west side of the river approximately 0.5 km from the work site. Due to the predominance of shale at the site, equipment was able to easily break the rock, allowing the work to be completed in less than half the estimated time. This resulted in significant time and cost savings to the project.

Monitoring of the completed diversion channel and surrounding area was conducted during summer (July/August) pulse flows and again during October pulse flows. Flows entering the fish ladder were intercepted during typical pulse events (12 m^3/s) and no adults were observed being stranded on the right side of the river.

TABLE OF CONTENTS

Executive Summary ..... **ii**
Table of Contents ..... **iv**
List of Figures ..... **v**
List of Tables ..... **v**

1 INTRODUCTION **1**
1.1 Background *2*
1.2 Goals and Objectives *2*
2 Study Area **3**
3 Methods **3**
3.1 Project Design *3*
3.2 Site Access *3*
3.3 Site Isolation and Fry Salvage *5*
3.4 Channel construction *6*
3.5 Post-construction site rehabilitation and monitoring *7*
3.6 Communications *8*
4 Results and Discussion **8**
4.1 Construction *8*
4.2 Monitoring *9*
5 Recommendations **11**
6 Acknowledgements **11**
7 References **12**

Appendices

A BCRP Financial Statement
B Performance Measures – Actual Outcomes
C Confirmation of BCRP Recognition
D Photos
E DFO 2006 Drawing SF-100. Puntledge River Stotan Falls Fishway Diversion Channel - Plan, Profile and Typical Section
F DFO 2008 As-built Drawing SF-100 Rev 1. Puntledge River Stotan Falls Fishway Diversion Channel - Plan, Profile and Typical Section

LIST OF FIGURES

Figure 1. Puntledge River showing location of Stotan Falls and other major features 4

Figure 2. Location of the Stotan Falls area showing fish ladders and location of attraction flow into middle fish ladder.....5

Figure 3. Hourly discharge for the Puntledge River at Gauge 6 below the diversion dam (WSC Gauge No. 08HB084). 9

LIST OF TABLES

Table 1. Summary of equipment used and material removed for the Stotan Falls channel construction and migration improvement project in the Puntledge River, June 2007.....7

Table 2. Results from post-construction monitoring at Stotan Falls, July and October 2007 10

1 INTRODUCTION

Stotan and Nib Falls are located on the Puntledge River below the BC Hydro diversion dam in Reach C (Figure 1). Summer chinook ascend both of these falls to reach their historical holding and spawning area in Comox Lake and the headpond. Based on historic migration timing record, successful migration above the falls occurred during the spring freshet period when discharge slowly increased and decreased before and after peak snow melt. In contrast, these falls appear to have historically acted as a physical and biological barrier to migrating Fall chinook which normally entered the river in October. River discharge would normally be higher during this period and consequently inaccessible above the falls.

Since the expansion of the BC Hydro facility in the 1950s, river discharge in Reach C has changed from a more natural flow regime to a constant regulated flow throughout most of the year (BC Hydro 2003). A decrease in both the average flow and in the variability of flow below the diversion dam, as well as an increase in the rate of flow changes during the summer period has affected the ability of summer chinook to acend these falls. A historic review of activities on the Puntledge River found that remedial work on these falls began in 1923 and continued sporadically until 1977 (Bengeyfield and McLaren, 1994). The intention of the work was to improve access for summer chinook. These works inadvertently benefited other species previously not capable of ascending these falls. Radio-telemetry studies conducted in the last 5 years indicate that Stotan Falls and to a lesser degree, Nibs Falls, may account for as much as 30 % in the failure of tagged fish to progress upsteram (Taylor and Guimond, 2006). In addition to the Stotan and Nib Falls reaches, the Powerhouse tailrace pool, diversion dam and impoundment dam further delay migration and further limit the number of summer chinooks successfully migrating to the upper watershed.

Under current ecological conditions, Fisheries and Oceans Canada (DFO) maintains that the survival and sustainability of a natural spawning population of summer chinook in Puntledge River is dependent on their ability to successfully migrate into Comox Lake. Adults that are able to hold in Comox Lake during the summer months experience an increased spawning survival rate by taking refuge in the cooler water below the lake thermocline. In 2007, 10 radio-tagged adults fitted with temperature loggers were released into Comox Lake in mid July. All of these fish survived to spawn in October, and data from a temperature logger recovered from one of these fish indicates that the adults spent most of the summer period at a mean temperature of 15-

16 degrees Celsius[1]. In contrast, adults that hold all summer in the river are subjected to seal, otter, mink and bear predation, illegal fishing and water temperatures above 20 degrees Celsius. It is estimated that at least half of these adults die before spawning during warm summers (M. Sheng, pers. comm.).

1.1 Background

In 2005, BC Hydro initiated the Puntledge River Water Use Plan. One of the key recommendations was the release of 5 pulse flows in Reach C during the months of July and August to improve chinook and steelhead migration. During these pulse flows, discharge through Reach C is increased from 5.7 m^3/s to 12 m^3/s for a period of 48 hours to stimulate summer chinook and steelhead and facilitate migration upstream. Following a pulse flow event, BC Hydro staff observed several adult chinook stranded at the Stotan Falls area in potholes and on the bedrock shelf on the right side of the river below the Duncan Bay Mainline bridge. Staff later observed that adult summer chinook swimming up the middle Stotan Falls fishway were being attracted to a side-channel that flowed into the fishway half-way up the ladder (Figure 2; Appendix D: Photo 1). During a pulse flow, flow from the side-channel increased and attracted adults into the side-channel which opened to the right side of the river. This side of the river, which is composed of a wide bedrock shelf, only normally has a thin .05-.07 m veneer of water flowing over it and shallow pockets (potholes) are scattered throughout the shelf. When the pulse flow recedes, fish migrating up this side of the river often become stranded.

1.2 Goals and Objectives

The objective of the Stotan Falls Improvement for Adult Summer Chinook Migration Project is to reduce the risk of summer chinook adult stranding during pulse flow events in July and August. The overall goal is to increase the survival of summer-run chinook to the spawning stage and increase natural escapement to the spawning grounds by improving migration into Comox Lake.

[1] Data currently being compiled for the BCRP Summer Chinook Radio Telemetry Study report by Guimond and Taylor.

2 STUDY AREA

Stotan Falls is located 9.3 km upstream of the estuary in Reach C of the Puntledge River which encompasses the section from the BC Hydro diversion dam downstream to the Powerhouse (Figure 1). Reach C is typically a bedrock/boulder reach dominated by two sets of waterfalls, Stotan Falls and Nib Falls located 2 km further upstream. Historically, these falls were barriers to most anadromous fish except summer runs of chinook and steelhead salmon. However, since modifications to the falls and installation of blasted fishways constructed between 1923 and 1977 (see Figure 2) the area is now accessible by a variety of salmonids (Bengyfield and McLaren, 1994).

3 METHODS

3.1 Project Design

Fisheries and Oceans Canada Resource Restoration Division (DFO RRD) conducted a site reconnaissance of the area in November 2006. A survey was completed and a diversion channel was designed to address the stranding issue. The design took into consideration depth, width and length of a channel capable of transporting typical pulse flows away from the fish ladder and into an area of the river that would not create additional attraction flow issues (Appendix E). The construction plan minimized impacts to the river and riparian area. An as-built design was completed in January 2008 (Appendix F).

3.2 Site Access

An existing access ramp to the Puntledge River, located on the upstream side of the Duncan Bay Mainline Bridge and adjacent to the Bevan Creek confluence, was used to access the river and work site. This site was chosen over a second undeveloped opportunity located on the downstream side of the logging bridge, because there was no disturbance to the riparian zone and it did not require any additional clearing or ballasting. A hydro pole anchor cable near the ramp entrance was temporarily removed by BC Hydro to safely allow equipment to access a road ramp to the river. Once at the river, equipment could access the work site by traveling downstream for 200 m on smooth bedrock along the right side of the river. Traffic control was setup at the ramp entrance on the Duncan Bay Mainline for the duration of the project.

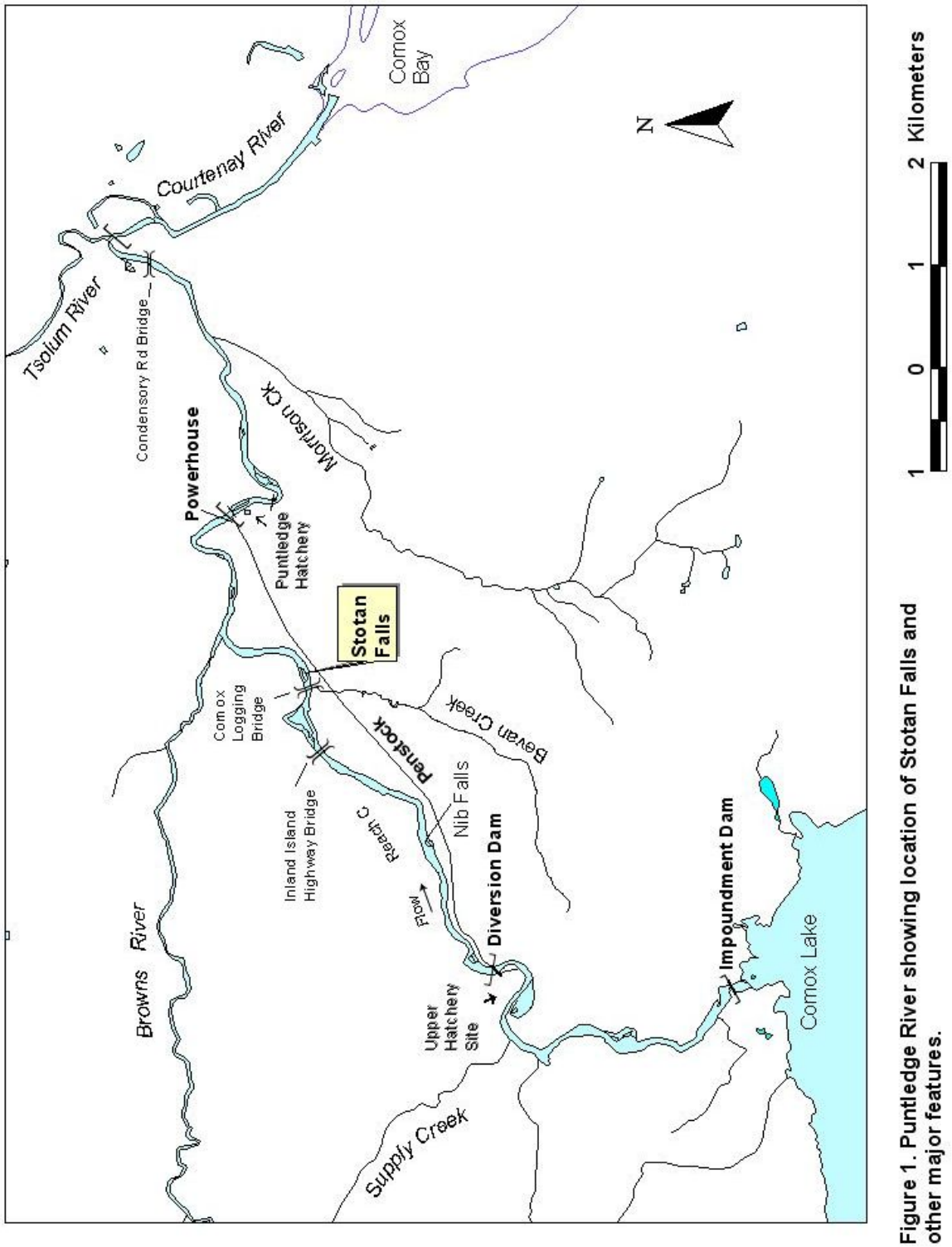

Figure 1. Puntledge River showing location of Stotan Falls and other major features.

Figure 2. Location of the Stotan Falls area showing fish ladders and location of attraction flow into middle fish ladder.

3.3 Site Isolation and Fry Salvage

The right side of the river was dewatered from the Duncan Bay Mainline Bridge to the work site 200 m downstream in order to allow machinery and trucks to access the site and minimize silt production. This was accomplished by constructing a coffer dam using 1 cubic metre pre-filled mega bags with gravel, 6 ml polyethylene film and sand bags. The mega bags were donated by DFO from a previous construction project and delivered to the Puntledge River, saving time and money for the project.

The coffer dam was constructed from the right bank just upstream of the ramp access, and downstream of the Bevan Creek confluence, and extended into the river to the first

instream bridge abutment. It continued further across the river from the opposite side of the abutment, for a total length of approximately 30 m. In addition, flow from a small channel cutting through the island adjacent the work site was pumped around the work zone using a 3 inch trash pump. While the right side of the river slowly dewatered, the effected downstream area was fry salvaged. Potholes that remained wetted were fished with dipnets and pole seines. Access for machinery was on solid bedrock. Potholes around the work site were easily avoided. Although the area dewatered covered a large area (~7000 m^2), only 2 dozen salmonids were removed from the area. This was indicative of the very poor rearing habitat in this reach. Many of the fish salvaged were recent Upper Puntledge Hatchery chinook smolt releases.

3.4 Channel construction

A Hitachi EX200 with a hydraulic hammer built the diversion channel by breaking out a rock trench in the streambed as per the engineered design (DFO) while a Deere EX225C LC cleared the broken material and stockpiled it for loading into a Volvo 6WD off-road truck. The streambed at the work site was predominantly shale with some sandstone, and was easily broken. The rock was removed from the river and hauled to a spoil site at Comox Timber Ltd.'s property (Hancock Forest Management) on the south west side of the river (location of the BCRP 2006/07 Forbidden Side-channel project) only 0.5 km from the work site. Approximately 19 truck loads of broken rock (~15 m^3/load) were removed from the river. Rock breaking and removal was completed by late afternoon on the second day of the project. The coffer dam was then dismantled, bulk bags were loaded into the Volvo and delivered to a disposal site on Duncan Bay Mainline. A summary of equipment used, duration and quantity of material removed form the river is outlined in Table 1.

All equipment working in the river was equipped with environmentally friendly Bio-Hy-Gard transmission and hydraulic oil, which is formulated with a canola oil base and is recommended for use in environmentally sensitive areas.

Table 1. Summary of equipment used and material removed for the Stotan Falls channel construction and migration improvement project in the Puntledge River, June 2007.

Equipment	Description	Quantity
Hitachi EX200 with Rock Breaker	Channel excavation	9 hours
Deere Excavator EX225C LC	Removal of rock and loading truck	19 hours
Off-Road Gravel Truck	Transport rock to storage site	10.5 hours
Flat Bed	Equipment mobilization and delivery mega bags	6.5 hours
Crane Truck and tri-axle trailer	Delivery mega bags	4.5 hours
Rock	Amount of excavated material removed from the river	285 m^3

3.5 Post-construction site rehabilitation and monitoring

Following completion of the project, the access ramp was re-graded to remove equipment tracks and blockaded with large boulders to prevent unauthorized access by off-road or all-terrain vehicles (ATVs).

Monitoring of the channel was carried out during and following pulse flows in July/August and October. The objectives of this monitoring program were to:

i. identify any stranding of adult fish on the right side of the river,
ii. determine whether the new diversion channel eliminated the flow from entering the middle fish ladder during typical pulse flows, and
iii. determine whether the redirected flow attracted adult fish to other areas of the falls.

Technicians observed the middle fish ladder and at the base of the falls during the pulse flows for migrating salmon. Technicians also thoroughly examined the shallow area, including potholes and pools, on the river right, between the new diversion channel and the Duncan Bay Mainline Bridge, for stranded fish during and immediately following a pulse flow.

3.6 Communications

A Communications Plan was implemented by staff of Comox Valley Project Watershed Society to notify the public and immediate community of the project. This included press releases in local newspapers, temporary signage during the project construction, and an article in the *Watershed News* (Appendix C). A more detailed Community Outreach Program associated with this and three other BCRP projects in the Puntledge River watershed is summarized in a separate report.

4 RESULTS AND DISCUSSION

4.1 Construction

The project was completed over a two day period (June 4-5, 2007). Site isolation, dewatering and fry salvaging was completed on day one of the project, while channel excavation, removal of broken rock and dismantling of the coffer dam was completed on day 2. The project was conducted in early June in order to be completed for the July/August pulse flows for summer chinook and steelhead migration. This work window also mitigated the risk to public safety. The Stotan Falls area is a very popular recreation destination in the Comox Valley. The area may attract > 200 swimmers and sunbathers on a typical hot summer day. Therefore the potential for public and heavy equipment encounters both in the river and on the road/access ramp area would have been high during the busy recreation period. Scheduling the work prior to the warm weather and warm water temperatures and prior to the end of the school year reduced this safety risk. This required the approval from federal and provincial agencies because it was outside of the general instream work window (July 1 – Sept 15).

The project was estimated to take approximately 4 to 5 days to complete based on rock breaking time estimates, channel size, etc. However, the work was completed in half the allotted time as a result of the predominance of shale at the site which broke easily. This resulted in significant time and cost savings to the project. It should also be noted that the high snowpack coupled with a full reservoir required BC Hydro to begin spilling immediately following completion of the project. Had the work required the 4-5 days as predicted, the project would have been temporarily suspended. This would have required dismantling and reassembly of the coffer dam, and repeating site isolation,

dewatering and fry salvaging. Fortunately, the work was completed during a two day window between spill events (Figure 3).

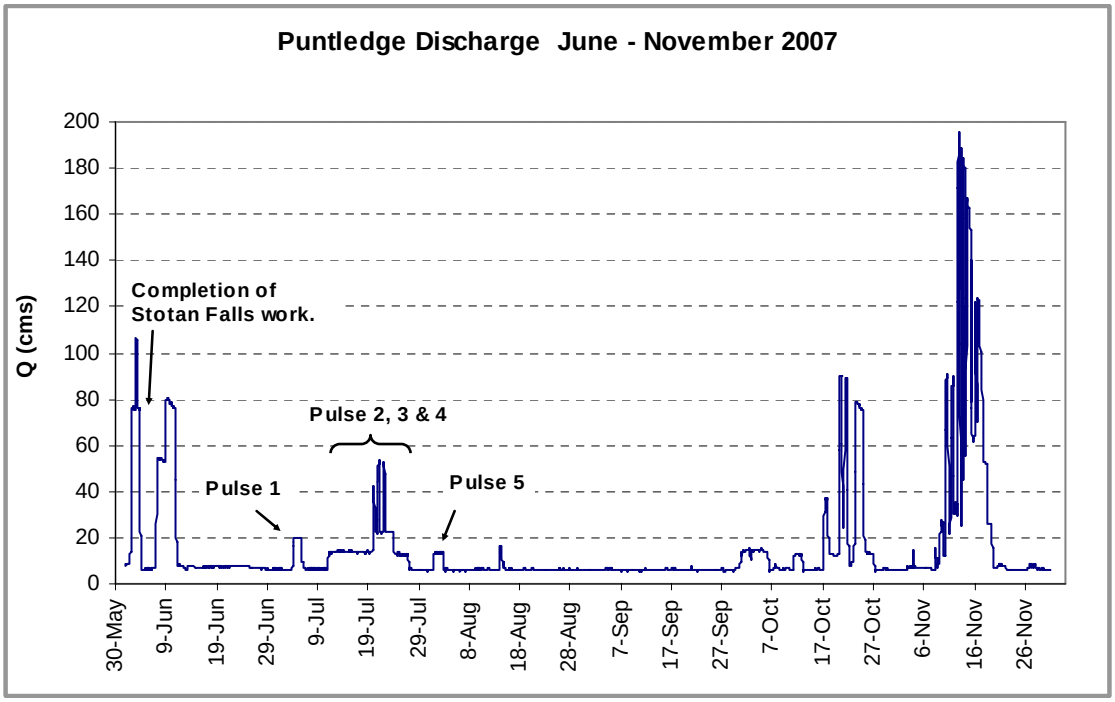

Figure 3. Hourly discharge for the Puntledge River at Gauge 6 below the diversion dam (WSC Gauge No. 08HB084).

4.2 Monitoring

Summer pulse flows for summer chinook and steelhead migration were scheduled for July 4-5, 11-12, 18-19, 25-26 and August 1-2. Figure 3 illustrates discharge in Reach C (measured at Gauge 6 below the diversion dam). During a typical pulse flow, discharge through the reach is increased from 5.7 m^3/s to 12 m^3/s for a period of 48 hours. However, the first pulse flow was higher (20 m^3/s versus 12 m^3/s) while the second, third and fourth pulse flows merged into one pulse extending over a 16 day period with a magnitude ranging from 12 – 53 m^3/s. The last pulse flow in August was a normal pulse flow (12 m^3/s, 48 hrs). No fish were observed in any of the 3 key areas (fish ladder, base of falls, shallow area on river right) monitored during 3 events in July (Table 2). Snorkel swims conducted in the pool below the middle Stotan Falls fish ladder yielded a count of only 2 chinook on July 10 (prior to pulse flows 2, 3 and 4), while 3 subsequent swims did not find any chinook in this pool (Ecodynamic Solutions

Inc, unpublished data). It is not conclusive whether the channel diversion work fully accounted for the lack of fish observed during these monitoring events. The extended pulse flow period and higher discharges in addition to spill events in June may have facilitated chinook though this area of the river without incident. At least 245 summer chinook had passed the lower hatchery fence and were migrating through Reach C prior to June 18th (as evidenced through video surveillance at the lower hatchery and diversion dam fishways). Over 70% of these fish migrated into the headpond through the diversion dam fishway before August 3rd, suggesting that a large number of summer chinook present in Reach C during the pulse flows likely took advantage of the higher pulse durations and discharges to migrate through Stotan Falls. The lack of chinook below Stotan Falls from snorkel surveys also supports this likelihood.

Fall chinooks were also monitored in October during pulse flows and similar results were observed. On one visit, two carcasses were rercorded, one of which was very decomposed. It is probable that both of these carcasses originated from upstream and were carried downstream during the pulse flow.

Flow from the side-channel has been completely diverted from the middle fish ladder during typical pulse flow discharges (12-13 m^3/s). At higher river discharges, some side-channel flow may enter the ladder but it is unlikely to attract fish, compared to flows in the ladder at high river discharges.

Table 2. Results from post-construction monitoring at Stotan Falls, July and October 2007.

Date	Start Time	Finish Time	Discharge m3/s	Crew	Comment
4-Jul	9:45	11:45	19.7	DC/JE	no fish observed in fish ladder or on river right (high than typical pulse flow)
6-Jul	10:15	10:50	6.6	DC/EG	pulse ramp down at 0:01 July 6; no fish observed on river right
26-Jul	9:30	10:30	12.5	DC/JE	pulse flow following 4 day spill; no fish observed
19-Oct	10:00	11:00	12.075	DC/EG	pulse flow following 24 hour spill; one decomposed and one fresh carcass observed on river right; one fish observed in fish ladder
22-Oct	12:15	13:20	7.8	DC/EG	following 48 hr spill; no fish observed
26-Oct	10:00	11:00	13	DC/EG	pulse flow following 3 day spill; no fish observed
27-Oct	9:30	10:30	6	DC/EG	pulse ramp down at 0:01 Oct 27; no fish observed on river right

5 RECOMMENDATIONS

The extended pulse flow period and higher discharges during the peak summer chinook migration period in July 2007 prevented a proper post-construction risk assessment of stranding under typical pulse flow discharges. Although the problem side-channel flow has been diverted away from the middle fish ladder at Stotan Falls during these pulse discharges, it is recommended that monitoring of the area be continued in July 2008 to ensure the diverted flow has not created attraction issues in other areas of the falls.

6 ACKNOWLEDGEMENTS

This project was made possible through the financial support of the B.C. Hydro Bridge Coastal Fish and Wildlife Restoration Program (BCRP). We also extend our gratitude to Fisheries and Oceans Canada Resource Restoration Division (Nanaimo) for in-kind assistance and technical support, Emcon Services Ltd. For donation of sand bags and sand, and Hancock Forest Management (Comox Timber Ltd.) for permission to store excavated material.

7 REFERENCES

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Personal Communication

Mel Sheng Fisheries and Oceans Canada, Resource Restoration

APPENDICES

APPENDIX A: BCRP Financial Statement

Project #: 07.Pun.03

INCOME	BUDGET			ACTUAL			Comment
	BCRP	Other (Cash)	Other (in-kind)	BCRP	Other (cash)	Other (in-kind)	
Total by Source	$42,635.00	$0.00	$5,610.00	$42,634.90	$0.00	$6,799.88	
Grand Total Income (BCRP + Other)	**$48,245.00**			**$49,434.78**			
EXPENSES							
Project Personnel							
Construction Supervision	$2,000.00			$690.00			
Technician	$600.00			$360.00			
Construction Labour (flag person)	$3,000.00			$2,602.73			
Project Coordinator	$6,720.00			$6,895.80			
DFO (Biologist)			$1,600.00			$1,600.00	
DFO (Eng. Tech.)			$3,400.00			$3,400.00	
Communications	$3,150.00			$3,150.00			
Material and Equipment							
Mobilization/Demob	$795.00			$4,934.30			bio hy-guard oil and delivery of bulk bags
Excavator, rock breaker	$11,440.00			$5,003.20			
Off-Road Gravel Truck	$1,904.00			$1,669.50			
Hwy gravel Truck	$1,780.00						
Road ballast (pit run & rock)	$1,395.00					$270.00	for bulk bags
Bulk Bags	$660.00					$660.00	
Equipment Rental	$500.00			$58.76			
Misc field, safety supplies, permits	$100.00		$100.00	$371.00		$100.00	
Site isolation and Landscape materials	$1,100.00			$342.35			
Travel & accommodation	$1,255.00			$335.70			
Stream of Dreams workshop	$2,360.00			$2,360.00			
Adiministration							
Office space, equip, supplies							
Photocopies and printing						$166.88	
Production of As-built Drawings							
Admin Fees (10%)	$3,876.00		$510.00	$2,877.33		$603.00	
Total Expenses	**$42,635.00**	**$0.00**	**$5,610.00**	**$31,650.67**	**$0.00**	**$6,799.88**	
Grand Total Expenses (BCRP + others)	**$48,245.00**			**$38,450.55**			
Balance (Grand Total Income - Grand Total Expenses	**$0.00**			**$10,984.23**			
BCRP Balance (surplus)	**($10,984)**						

APPENDIX B - Performance Measures

Project #_ 07.Pun.03

Performance Measures – Target Outcomes													
Project Type	**Primary Habitat Benefit Targeted of Project (m^2)**	**Primary Target Species**	**Habitat (m^2)**										
			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	Summer chinook and steelhead		**>7 km**	**>8 km**							
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.											
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 C: Confirmation of BCRP Recognition

Article in the Comox Valley Echo announcing the Stotan Falls Improvement Project, May 29, 2007.

B4 Comox Valley Echo Tuesday, May 29, 2007

Time Out

Large fish ladder at Stotan Falls allows migrating salmon to get into he upper river (Photo by John Harvey)

Falls fishway gets facelift

Public asked to stay out of river at Stotan Falls while project underway

Stotan Falls on the Puntledge River is about to get another facelift. A popular place for swimmers and sunbathers in the summer months, Stotan Falls is also the site of a large fish ladder which allows migrating salmon to access the upper river.

June 4th marks the start of a week-long project to modify the fish ladder located just downstream of the Comox Logging Road bridge over the Puntledge River.

The project aims to improve migration of summer chinook salmon during higher spring flows.

"Impacts from industrial, urban and agricultural development in the watershed, as well as over-harvesting and predation has caused the summer chinook population to decline to critically low numbers", says Project Biologist Esther Guimond. "This project is just one step in an overall attempt, by Fisheries and Oceans Canada, to rebuild this once plentiful stock, which historically returned by the thousands", she adds.

The project at Stotan Falls is being undertaken by contractors working for Comox Valley Project Watershed Society, who is coordinating a series of other projects focused on the Puntledge River this year as well. TimberWest and Comox Timber are supporting the project by permitting access to the work site, which is on private property.

For safety reasons the public is being asked to refrain from entering the Puntledge River at Stotan Falls between June 4th and June 8th, while the project is underway.

The project is funded through a $42,635BC Hydro Bridge Coastal Fish and Wildlife Restoration Program (BCRP) grant with support from Fisheries and Oceans Canada. For further information on the project, contact Esther Guimond at 218-7466.

APPENDIX D: Photos

Photo 1. Confluence of problem side-channel with the middle fish ladder in Stotan Falls during a flow of ~8 m^3/s (from BC Hydro website Gauge 6) November 9, 2006.

Photo 2. Location of the side-channel confluence with the middle fish ladder after construction of the diversion channel, at a pulse flow of ~12 m^3/s (from BC Hydro website Gauge 6) February 8, 2008. Note entire area previously wetted is now dry.

Photo 3. Existing access ramp to Puntledge River located on upstream side of Duncan Bay Mainline Bridge, beside Bevan Creek confluence (left of photo).

Photo 4. Placement of pre-filled mega bags, plastic sheeting and sandbags for coffer dam construction at upper end of equipment access route.

Photo 5. Access route for equipment on right side of river between Duncan Bay Mainline Bridge and work site ~200 m downstream. Photo taken during base flow conditions (5.7 m^3/s) looking upstream from proposed work site.

Photo 6. Access route for equipment on right side of river after site isolation measures, June 4, 2007. Coffer dam visible at bridge.

Photo 7. Location of proposed diversion channel looking downstream before excavation work, June 5, 2007.

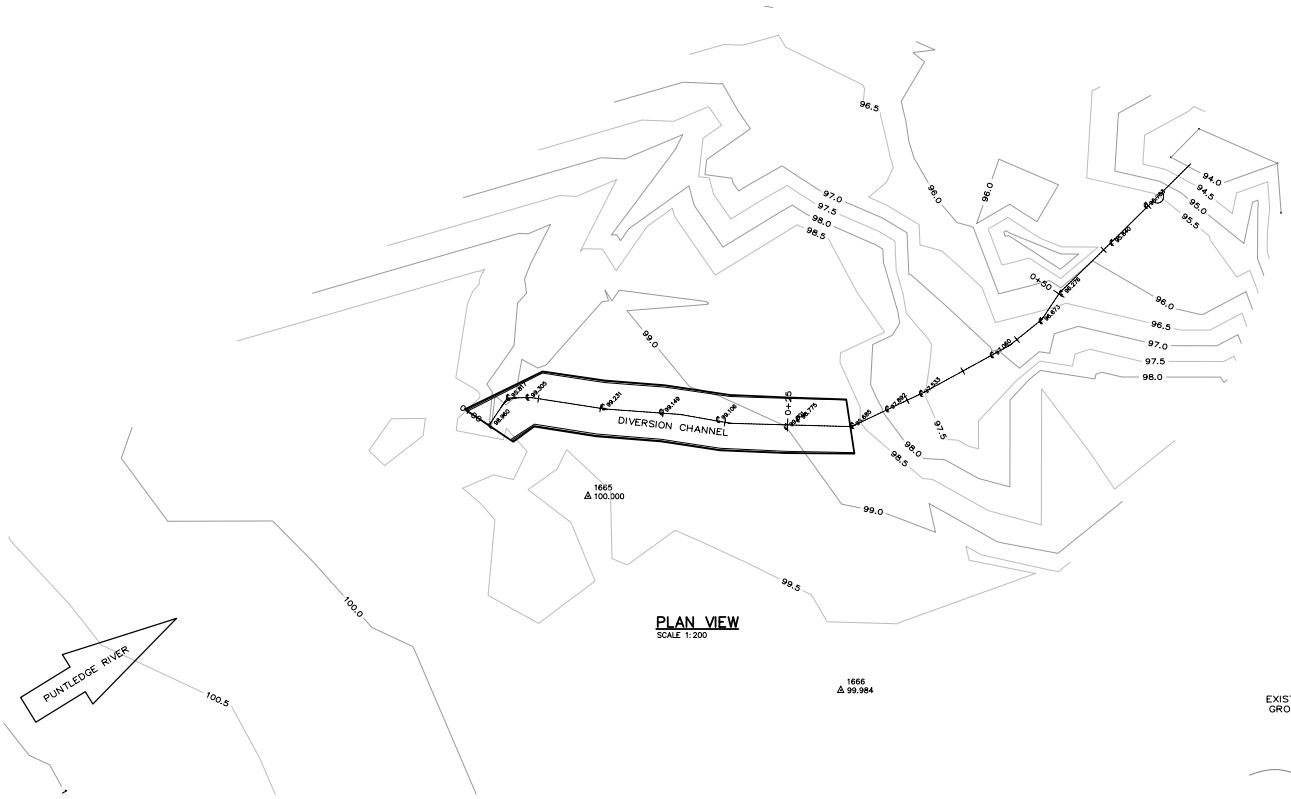
Photo 8. Commencement of channel excavation work looking downstream, June 5, 2007.

Photo 9. Upstream view of the location of the proposed diversion channel before excavation work November 9, 2006. Arrow indicates the upstream end of the channel.

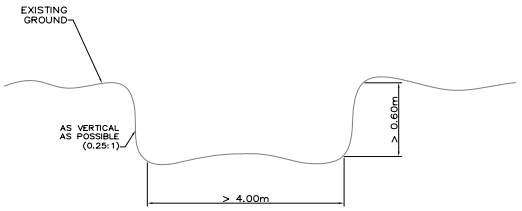
Photo 10. Upstream view of the diversion channel after completion June 19, 2007. Gauge 6 discharge = 7.5 m^3/s.

Photo 11. Stotan Falls looking upstream towards the middle fish ladder (right) and the outlet flow from the new diversion channel (left), June 19, 2007. Gauge 6 discharge = 7.5 m^3/s.

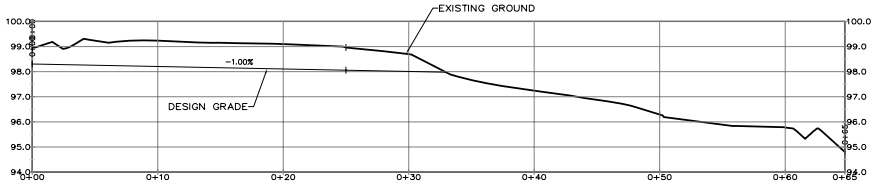
Photo 12. Stotan Falls looking upstream towards the middle fish ladder (far right) and the outlet flow from the new diversion channel (centre), July 4, 2007. Gauge 6 discharge = 19.7 m^3/s.



PLAN VIEW
SCALE 1:200



TYPICAL SECTION
NTS



CENTRELINE PROFILE
HORIZ: 200
VERT: 100

APPENDIX E

FISHERIES AND OCEANS CANADA
OCEANS, HABITAT AND ENHANCEMENT - SCD

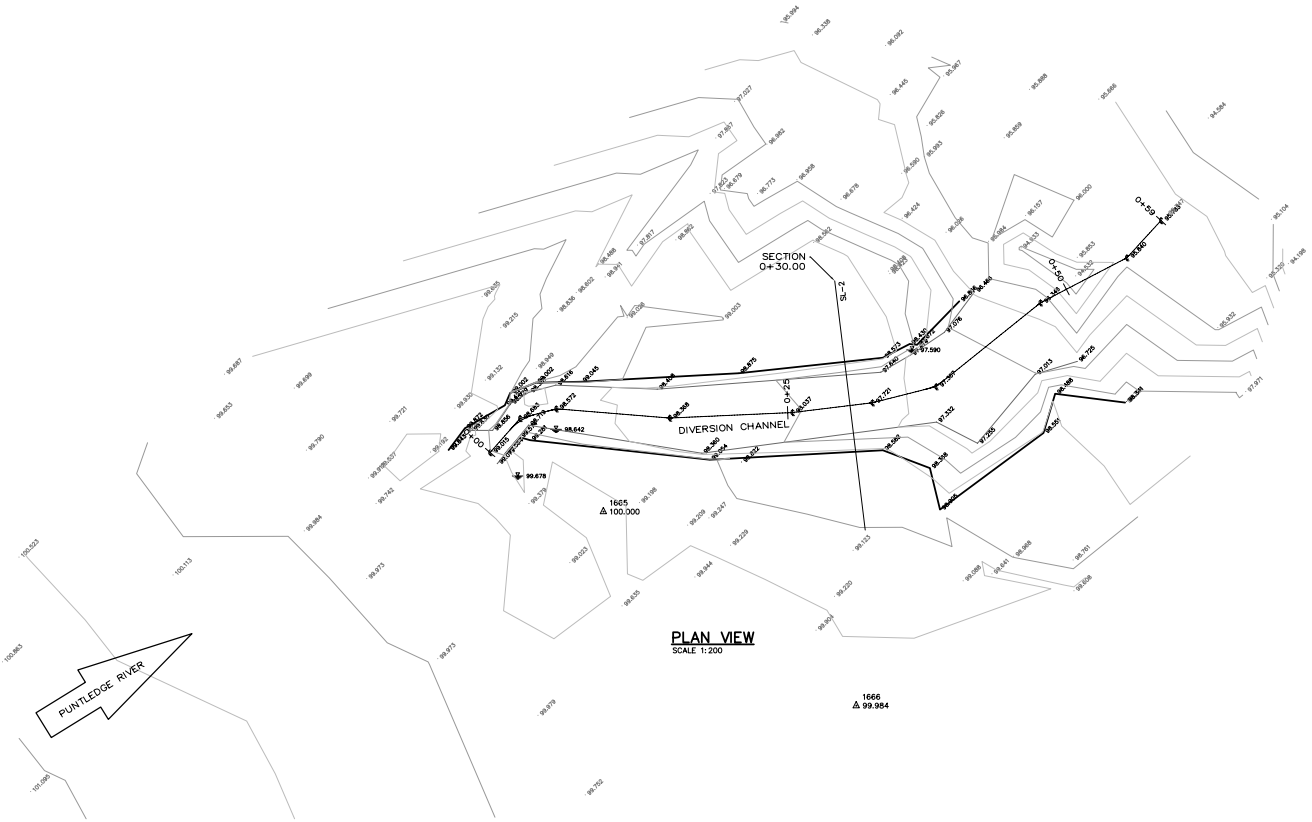
1. ALL DISTANCES STATIONING AND ELEVATIONS ARE IN METRES
2. ALL ELEVATIONS ARE ASSUMED AND BASED ON TRAVERSE HUB 1665 DATUM 100.00 METRES
3. ALL COORDINATES ARE ASSUMED ORIGIN
4. BEARINGS ARE ASTRONOMIC AND ARE DERIVED FROM COMPASS
5. SURVEYED 09 NOV 06 BY RN/DP DFO-RRU SOUTH COAST DIVISION

DESIGNED: RN
DRAWN: RN
CHECKED:
RECOMMENDED:
APPROVED:
APPROVED:

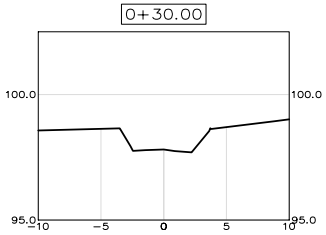
PUNTLEDGE RIVER
STOTAN FALLS
FISHWAY DIVERSION CHANNEL
PLAN, PROFILE, AND TYPICAL SECTION

SCALE: AS SHOWN
DATE: 10 NOV 06
DRAWING NUMBER: SF-100
REVISION:

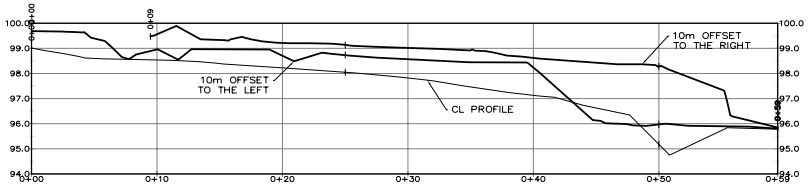
DWG. NO.	REFERENCE DRAWINGS	NOTES	NO.	DATE	REVISIONS



PLAN VIEW
SCALE 1:200



SECTION 0+30
HORIZ: 200
VERT: 100



DIVERSION CHANNEL PROFILE
HORIZ: 200
VERT: 100

APPENDIX F

FISHERIES AND OCEANS CANADA
OCEANS, HABITAT AND ENHANCEMENT - SCD

DWG. NO.	REFERENCE DRAWINGS

NOTES
1. ALL DISTANCES STATIONING AND ELEVATIONS ARE IN METRES
2. ALL ELEVATIONS ARE ASSUMED AND BASED ON TRAVERSE HUB 1665 DATUM 100.00 METRES
3. ALL COORDINATES ARE ASSUMED ORIGIN
4. BEARINGS ARE ASTRONOMIC AND ARE DERIVED FROM COMPASS
5. SURVEYED 09 NOV 06 BY RN/DP DFO–RRU SOUTH COAST DIVISION
6. ASBUILT SURVEY 30 JAN 08 BY RN/DP DFO–RRU SOUTH COAST DIVISION

NO.	DATE	REVISIONS
1	31 JAN 08	REVISED TO REFLECT ASBUILT

DESIGNED RN
DRAWN RN
CHECKED
RECOMMENDED
APPROVED
APPROVED

PUNTLEDGE RIVER
STOTAN FALLS
FISHWAY DIVERSION CHANNEL
PLAN, PROFILE, AND TYPICAL SECTION

SCALE AS SHOWN
DATE 10 NOV 06
DRAWING NUMBER SF-100
REVISION 1