A RESTORATION PLAN FOR FISH AND FISH HABITAT WITHIN ANADROMOUS REACHES OF THE JORDAN RIVER

FWCP SEED PROJECT 14.JOR.01

Prepared For:

Fish and Wildlife Compensation Program

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Prepare with the financial support from:

Fish and Wildlife Compensation Program on behalf of its program partners
BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations, and Public Stakeholders

With in-kind support from:

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June 10, 2015

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EXECUTIVE SUMMARY

In 2014, D. Burt and Associates was awarded funding through the Fish and Wildlife Compensation Program (FWCP) to develop a fish and fish habitat restoration plan for anadromous reaches of the Jordan River. Partners in this project included the Fisheries Section of the Pacheedaht First Nation and Northwest Hydraulic Consultants.

Until 2008, self-sustaining populations of anadromous species were not possible, primarily due to excessive levels of dissolved copper associated with past mine operations, compounded by extremely low summer flows due to extraction of water at Elliott Dam. In addition, fish use in the reach downstream of the generating station, has been impacted by loss of gravel and fluctuating flows associated with operation of the powerhouse as a peaking plant. Initiation of fish flow releases from Elliott Dam in January 2008 has done much to alleviate some of these constraints. In particular, there is substantially more water in the river during base summer flows, which has greatly improved the quantity and quality of fish habitat, and provided sufficient dilution of copper inputs, that rearing stages have recolonized habitats throughout the lower river.

The above changes are a substantial improvement for the lower Jordan River, however, recovery of historic salmon and steelhead runs remains severely limited by shortages of spawning, rearing, and estuarine habitats. Thus, restoration projects that improve the productive capacity of existing habitat, or create new habitat, will be an important component in the recovery process. A logical first step in these efforts was to develop a restoration plan that explored a range of practical options for the creation, augmentation, and enhancement of critical habitats within the anadromous reaches of the Jordan River. The goal of this document was to fulfill these objectives. The scope was to provide feasibility-level biological and engineering considerations for identified projects.

The approach for development of restoration prescriptions involved review available data, analysis of hydrology data, discussions with people knowledgeable about the river, and field investigations to identify specific sites, their options, and limitations. Target species were those that historically occurred in the Jordan River, including pink, chum, and coho salmon, as well as steelhead and searun cutthroat trout.

Eight prescription areas were identified and include 4 sites upstream of the generating station tailrace, and 4 sites downstream of the tailrace. Identified prescriptions range from projects to improve adult fish passage at points of difficult migration, installation of spawning gravel and Large Woody Debris (LWD), bank stabilisation, removal of metal debris, sidechannel development, and restoration of estuarine habitats.

The biological benefits from these projects include placement of about 4,000 m^2 of spawning habitat, capable of supporting around 8,000 pink, 4,000 chum, 310 coho, and 130 steelhead adults. LWD installations in the mainstem, along with creation of a sidechannel are anticipated to increase the rearing capacity of anadromous reaches, providing habitat for an estimated 4,000 coho fry, 720 steelhead parr, and 117 searun cutthroat parr. Potential smolt yield was estimated at 730 coho smolts, 454 steelhead smolts, and 74 searun cutthroat smolts. Additional gains in coho and steelhead production could be achieved by providing fish passage at the current anadromous barrier.

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1. INTRODUCTION

Historically the Jordan River was home stream to healthy runs of coho, chum, and pink salmon, as well as steelhead and searun cutthroat trout (Burt 2012). Coho and chum runs declined suddenly in the early 1950's and became extinct by the late 1950's – early 60's. Pink salmon were last observed in 1970, after which they too became extinct (Figure 1). Six years of monitoring by BC Hydro Water Use Plan (WUP) studies provided insight into the demise of these runs (summarised in Burt 2015). Foremost among factors, was that most of the anadromous portion of the river became contaminated with dissolved copper, which leaches into the river from an 80 m long deposit along the left bank near the top of the anadromous section. The WUP monitoring studies showed that, while copper levels did not deter successful spawning and incubation, they completely prevented the occurrence freshwater rearing. Thus species such as coho and steelhead have been unable to complete their life history and produce outgoing smolts. It seems likely that copper contamination was the main reason for the abrupt decline in salmon runs in the 1950's and 60's. The stragglers that hung on for some time, as well as the pink runs, were likely sustained by the old tailrace channel, which was a 500 m long outflow channel for the original generating station when it was located on the east side of the river. At that time the generating station drew its water directly from Diversion Reservoir, and operated under continuous generation. This supplied the original tailrace channel with a continuous flow of water free of copper contaminants. When BC Hydro moved the plant to the west side of the river in 1971, the 500 m long channel was decommissioned and this last freshwater refuge was lost. Furthermore, the new generating station has been operated as a peaking power plant, which has resulted in extreme fluctuations in flow and scour of historic spawning beds downstream of the new tailrace. These changes effectively sealed the fate of remaining salmon runs.

This grim situation was dramatically improved beginning in January 2008 when BC Hydro initiated fish flow releases from Elliott Dam. The terms of the Jordan WUP called for a minimum release of 0.25 m^3/s, however, due to issues with the control mechanism, the valve has been locked in the full open position, resulting releases ranging from roughly 0.3–0.4 m^3/s, depending on water elevation in Elliott Headpond. These releases have dramatically improved the quantity and quality of aquatic habitat throughout the river downstream of Elliott Dam. In addition, for the anadromous portion of the river, the increased flows have provided sufficient dilution of copper that rearing fish have colonized the previously dead zone. Furthermore, juvenile trout sampled from within this zone were found to have similar condition factor (weight to length ratio) as fish from upstream sites, suggesting an ability to successfully rear in the copper impacted zone (Burt 2013). This turn around in river function has opened the possibility for undertaking habitat restoration and related projects that help to restore salmon and trout runs back to the Jordan River.

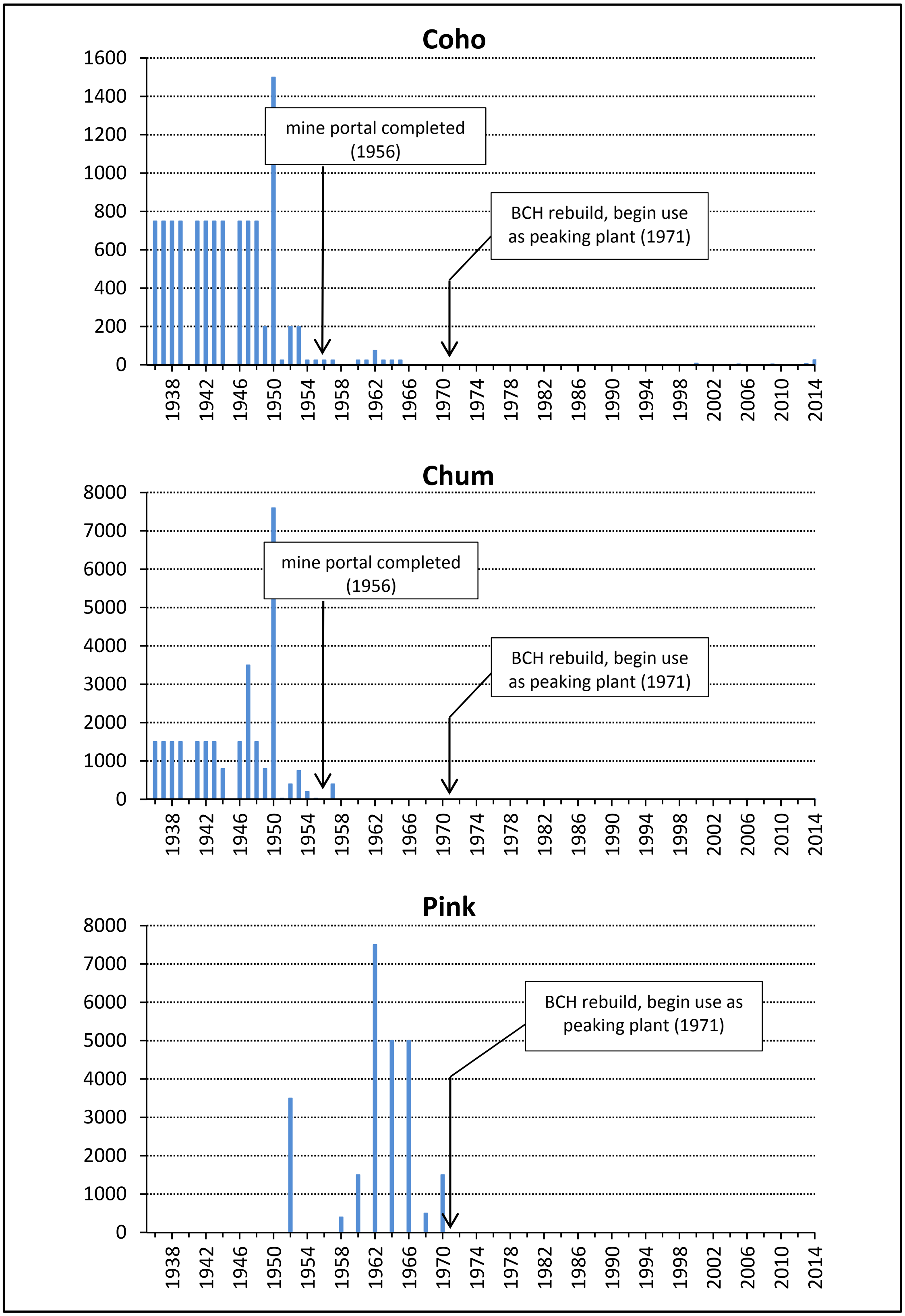


Figure 1. Jordan River salmon escapement estimates, 1936–2014. Sources: 1936–52 (Hirst 1991); 1953–2004 (DFO 2011); 2005–2010 (Cascadia Biological Services 2013); 2013–2014 (Pacheedaht First Nation snorkel surveys). For pink salmon, DFO's first record was 1952, then 1958, then on subsequent even years. No pinks were observed by inspections after 1970, and inspections ceased after 1977.

The purpose of this report was to develop a set of restoration projects that can be undertaken in future years to assist in the recovery of the anadromous runs that once occurred in the lower Jordan River. The report does not provide detailed engineering feasibilities for identified projects as these will be developed as individual projects are addressed. The report does however, provide preliminary feasibly considerations based on field investigations in summer 2014.

2. STATUS AND LIMITATIONS OF EXISTING HABITAT

The anadromous portion of the Jordan River contains 3 distinct reaches (Figure 2). Reach 1 is 970 m in length and extends from the mouth to just upstream of the current tailrace outlet. This reach is influenced by tidal cycles, turbine discharges from the generating station, and upstream discharge from Elliot Dam and tributaries downstream of the dam. Since the Jordan facility is operated as a peaking power plant, discharges downstream of the tailrace can fluctuate from current base flows of roughly 0.3–0.4 m^3/s, to as much as 70 m^3/s at peak generation. Reach 2 extends from the top of Reach 1 upstream for 330 m to a partial barrier rock falls. The copper contamination mentioned in the introduction emanates from a section of mine waste material along the east bank at the top of this reach (see "Mine deposit" in Figure 2). Reach 3 is 225 m in length and terminates at a 4.6 m rock rubble falls, considered to be a complete barrier to anadromous migration. This third reach is steeper gradient and filled with extremely large boulders (4 m +), which results in several sections of difficult fish passage.

One issue affecting all three anadromous reaches is the minimal gravel deposits available for spawning. This imposes limits on the total number of spawners supported by the river. Several compounding factors have contributed to the depleted gravel condition in the lower river: 1) the upper river gravel supply has been cut-off by the inline reservoirs and dams, 2) the channel and banks downstream of Elliot Dam are mainly bedrock and boulder, and thus supply limited, and 3) extreme flow releases at Elliott Dam (e.g. 2,167 m^3/s in 1997) appear to have scoured the streambed down to the glacial lag deposits (boulders and bedrock). The tributaries downstream of Elliot Dam contribute some alluvial sediments, but the overall gravel supply appears insufficient to maintain downstream gravel beds.

The following subsections describe the status of fish habitat in the three anadromous reaches, and factors currently limiting production of anadromous salmonids. These factors will provide direction for the types of prescriptions required on the lower Jordan River.

Reach 1

Historically, Reach 1 was comprised of two main features that were important for salmonid production. The first was a small but viable estuary occupying the lower half of the reach (digitized at ~14.6 hectares in size). Estuarine habitats are typically complex and highly productive ecosystems, where there is mixing of salt and fresh water, and their associated nutrients (Flynn et al. 2006). The salt marsh communities that thrive in these environments, and associated detritus buildup, result in large populations of food organisms. For juvenile salmonids, these sites provide excellent nursery habitats, the abundance of food promotes rapid growth, while the brackish water facilitates the transition from fresh to saltwater. Relevant species with heavy reliance on estuarine habitats during the juvenile phase include coho and chum salmon, and steelhead and searun cutthroat trout.

The main salt marsh in the Jordan River estuary was located on the present day dryland sort (Burt 2012). Creation of the dryland sort in the late 1960's removed this area from production and diminished the estuarine area by roughly 70% (~10.3 hectares). In addition, productivity of remaining estuarine habitat has probably been diminished by periodic dredging to maintain depths required for log booming and barge operations. These activities likely prevent development of flora and fauna within affected zones (e.g., eelgrass bed communities).

Today, some salt marsh habitat occurs in a band that extends up the old tailrace channel (~ 0.5 ha in area). The head of the channel is fed by a small creek. Inflows from this creek drop to a trickle during summer base flow periods (~ 0.5 L/s). Inspection of this area in September 2014 suggested that functionality as a salt marsh channel is limited by an elevated thalweg, mud substrate, and the fact that the channel is blind (no secondary connection).

The other historically important feature of Reach 1 are the expansive riffle and run habitats between the estuarine zone and the Jordan Generating Station tailrace. This is a part of the river where the channel widens, gradient diminishes, and would normally be a depositional zone for gravel substrates. This assessment is consistent with descriptions of the area by T'Sou-ke First Nation elders, who indicated that area just upstream of the mouth was once abundant in gravel and was heavily used by spawning salmon (Recreation Resources Ltd 2001). Species use was most likely pink and chum salmon since these are known tidal spawners (Heard 1991, Salo 1991). Field assessment of the area in 2013, and subsequent GIS measurement of the portion likely to have been conducive for spawning suggests an area of at least 8,000 m^2 (Burt 2014a). In comparison, upstream of the tailrace, the narrower channel and higher gradient results in much smaller individual habitat units, and consequently, potential spawning sites are much smaller in dimension. These pieces of information suggest that the historic gravel beds downstream of the tailrace were likely the main spawning area for Jordan River pink and chum salmon, and appear to have been the only location with sufficient spawning space to support the early escapements shown in Figure 1.[1]

Examination of the region downstream of the tailrace during the 2014 field investigations suggested a channel that has been heavily degraded (perhaps by 1–2 m) such that what remains is an armoured layer of boulders and cobbles. The cause of this degradation may be in part related to interception of gravel recruitment sources by Elliott and Diversion Dams in combination with scour from extreme flow releases from Elliott Dam (e.g., 2,167 m^3/s in 1997). The other contributing factor is likely the turbine flows, which can be up to 70 m^3/s, and are turned on and off repeatedly during fall,

[1] Example: Assuming spawning biostandards of 1.2 m^2/spawning pair for pink salmon, and 2.6 m^2/spawning pair for chum salmon (Burt 2004), the region downstream of the tailrace could have supported 13,000 pinks and 6,200 chums (spawning area ÷ biostandard · 2 based on a 1:1 sex ration).

winter and spring periods. Thus any gravels deposited within Reach 1 during annual freshet events are likely displaced downstream during periods of generation.

The one exception to the paucity of gravel in Reach 1, is a patch that occurs downstream of the tailrace on the inside curvature of turbine outflows. The orientation of the tailrace is such that the turbine flows discharge on a diagonal across to the far left bank (east bank), which directs them downstream some distance before the energy of the discharges disperse across the channel width. This flow pattern results in a protected region where a small accumulation of gravel is allowed to form similar to a natural point bar on the inside of a river bend. Measurement of this site in 2013 found 495 m^2 of continuous gravel and 423 m^2 of patchy gravel, for a total area of 918 m^2 (Burt 2014a).

Reach 2

The features of Reach 2 are shown in Figure 2. This reach has an overall gradient of about 1% and habitat types include riffles, glides, and pools. Cover for juvenile salmonid rearing is primarily from boulders and cobbles, but there are also some deep pool habitats that offer cover. In recent years there has been some large woody debris (LWD) cover opposite Unnamed Creek 3. This cover was introduced to the river during the winter of 2011/12 when the steep right embankment slumped and several trees fell into the river. Field surveys in 2013 found these structures to be well used by rearing juveniles (rainbow/steelhead and coho) in the summer, and adult coho in the fall. However, this LWD was swept downstream and out of the system during high flows in the winter of 2013/14.

In terms of current status, fish habitat in Reach 2 (and all lower river reaches) has been dramatically improved by the fish flow releases initiated from Elliott Dam beginning in January 2008. Reach 2 now offers excellent rearing habitat for rainbow and steelhead trout due to the abundance of boulder and cobble cover, the improved depths, velocities, and wetted area provided by the flow release, and the concurrent benefits of the flow release to aquatic insect production. Though not the preferred cover for juvenile coho, the 6-year Fish Index Study demonstrated that coho fry used these habitats in some years. Favoured coho rearing habitat (quiet water with LWD, overstream vegetation, and LWD cover elements) are lacking in anadromous reaches of the Jordan River, with the best site being the large pool at Unnamed Creek 3.

Other habitats in short supply within Reach 2 are adult holding sites (preferably with cover elements), and spawning habitat. There is only one high quality holding site in Reach 2, and that is the aforementioned large pool at the mouth of Unnamed Creek 3. This pool has a tendency to infill but depth has generally been maintained on the right side due to scour associated with some very large boulders. The pools is also lacking is cover elements such as LWD. There are 3 other small pools upstream of this one, but their size and depth limit function as adult holding sites (≤ 15 m x 15 m x 2 m deep).

Spawning habitat was inventoried as part of the 2014 field program for this project. Results indicated some small but continuous gravel beds between the tailrace and the large pool, in the tailout of the large pool, and in a 20 m section upstream of the large pool. The remaining gravel sites were in pockets where accumulations were encouraged by local boulder formations. Total spawning area for Reach 2 was estimated at only 119 m^2. The quality of most gravel sites was diminished by two common features: 1) the presence of cobbles amongst the gravel, and 2) lack of gravel bed depth. The presence of cobbles can be an issue because they are difficult for fish to move, break up available area, and can encourage substrate compaction. Excessive fines was generally not an issue in Reach 2.

Another potential issue in Reach 2 is predation by a family of river otters that has taken up residence in the Lower Jordan River in recent years. These otters have been observed foraging throughout Reaches 1 and 2. A possible concern is that the otters may be slowing the recovery of salmon runs to the Jordan River. The general scarcity of cover elements, both for adults and coho juveniles, makes them more vulnerable to predation by these mammals. On the positive side, the Ministry of Environment reports that because of their position at the top of the food chain, river otters are often used as bio-indicator for water quality and pollution concerns (Hatler et al. 2003). Thus, the establishment of a family of river otters in the Lower Jordan River lends further evidence that copper issues in the lower river have been at least partially alleviated by the fish flow releases.

Reach 3

Reach 3 is the uppermost anadromous reach, and is notable for having a much steeper gradient (11%), and for its extremely large substrates. Due to the very large boulders, rearing habitat for juvenile rainbow and steelhead trout is excellent. However, as in Reach 2, rearing habitats favoured by coho are lacking. Exceptions include a large pool 30 m up from the bottom of Reach 3 (termed “Rock Face Pool”), and a section of pool habitat at the top of Reach 3. These provide quiet water pool habitat, but are lacking in preferred coho cover elements such as LWD or overstream vegetation. Spawning gravels are generally limited to pockets where boulder formations encourage deposition and retention, but are of good quality where they occur. The one continuous gravel bed found in this reach is located at the tailout of Rock Face Pool, and in this case, the quality is somewhat impaired by a relatively high percentage of fines. One adult coho was observed holding over a redd at this site in fall 2013. During the 2014 field surveys, potential spawning gravel in this reach was surveyed up to the Rock Face Pool and amounted to 228 m^2 with most located at Rock Face Pool tailout.

The main issue in Reach 3 is related to the challenge imposed on adults to ascend this reach. The channel morphology is dominated by boulder controlled step-pools, but the large size of the boulders results in very large steps which may impediments to salmon migration, particularly at low flows. Nevertheless, the finding of an adult coho in the Rock Face Pool in 2013 indicates that some adult coho and steelhead are able to ascend at least part way up this reach under certain flows.

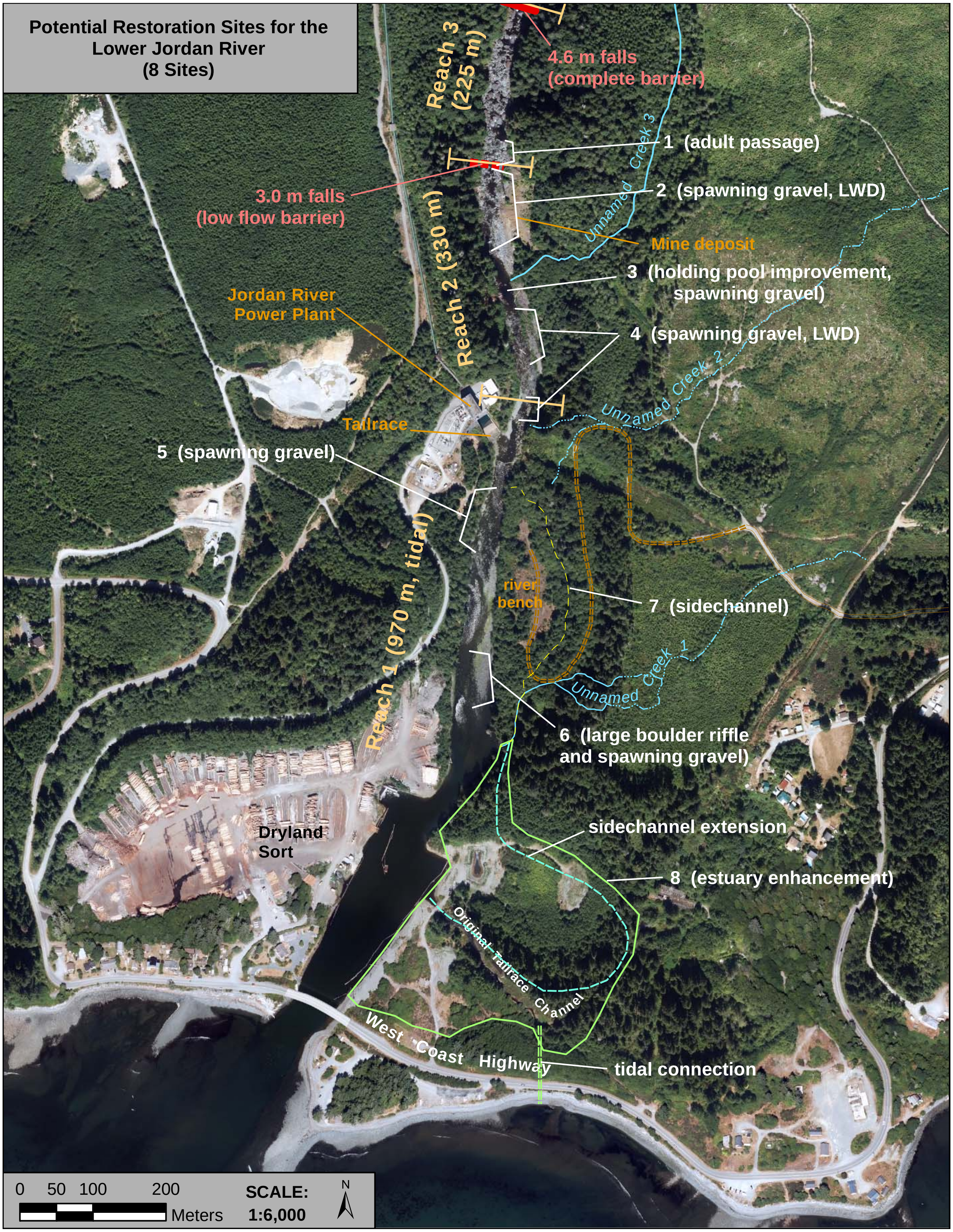


Figure 2. Overview map of the lower Jordan River showing the 3 anadromous reaches and locations of the 8 prescription sites presented in the restoration plan.

Synopsys of Limiting Factors

It is apparent from the above descriptions, that fish habitat in the lower Jordan River has been severely impacted by mining, hydroelectric, and forestry activities, resulting in numerous constraints on fish production and affecting multiple life stages. The following summarises the main limiting factors affecting the production of salmonids from the lower Jordan River:

- The anadromous stream length is very short (920 m tidal, 555 m non-tidal, historically non-tidal length may have been 1.5 km) (most crucial to coho and steelhead).
- There are only a few adult holding pools within the anadromous stream length.
- Spawning habitats are in extreme short supply (most crucial to species with limited or no freshwater rearing, i.e., pink and chum salmon).
- There is a shortage of coho rearing and favoured coho overwintering habitats are non-existent.
- The estuary is much reduced and highly impacted (rearing and staging grounds for coho, chum, steelhead, and searun cutthroat).
- In years with extreme spills at Elliott Dam there could be high mortality of incubating eggs and overwintering juveniles due to habitat scour.
- Peaking flows downstream of the tailrace have the potential to diminish spawning success (e.g., force adults off redds), displace rearing and outmigrant juveniles when generation is turned on, and strand these fish when generation is turned off.

Due to dilution benefits from the flow release, copper toxicity has not been listed as a limiting factor; however it should be noted that potential subtle effects on fish physiology, and whether prolonged exposure affects smolt production, have not been assessed.

3. METHODS

Assessment of potential restoration sites and development of restoration options for each site were developed as a team effort among Dave Burt (D. Burt and Associates, DBA), Graham Hill (Northwest Hydraulic Consultants, NHC), and Helen and Jeff Jones (Pacheedaht First Nation, PFN). Development of the plan was assisted by reconnaissance field trips conducted during July 10–11 and September 3–5, 2015. Activities undertaken during the reconnaissance trips included:

- Collection of site dimensions, GPS coordinates, photographs, and discussion of potential restoration options, approach, and machine access.
- Level and rod survey of the thalweg longitudinal profile from the tailrace upstream to the Rock Face Pool, plus a cross-section profile mid Reach 2 (profiles in Reach 1 were completed in 2013).
- An inventory of potential spawning gravel in Reaches 2 and 3 (Reach 1 was assessed in 2013)

The hydrologic assessment was completed by NHC using flow data for the period 1990 to 2013 obtained from BC Hydro.

Maps and GIS measurements were done by DBA in ArcMap using 20 cm resolution 2013 orthophotos streamed from the Capital Regional District's Web Map Service (WMS) server (http://crdatlas.ca/geospatial-data.aspx).

The plan also drew upon the results from a number of recent reports on the Jordan River including:

- FWCP seed projects 13.JOR.01 (Burt 2014b) and 13.JOR.02 (Burt 2014a)
- Summary of Water Quality and Biological Data for Anadromous Reaches of the Jordan River (Burt 2012)
- Jordan WUP Monitor #1: Inflow Monitoring Program (Burt and Hudson 2013)
- Jordan WUP Monitor 2: Lower Jordan River Fish Index Study (Burt 2013)

Quantification of the biological benefits of the identified restoration projects, relied on a number of biostandards with associated assumptions; these are given in Table 1. As an example, if 100 m^2 of high quality pink spawning habitat were created, the spawning biostandard of 0.6 m^2 per spawning pair suggests this habitat could support 333 adults (100 m^2 ÷ 0.6 · 2 assuming a 1:1 sex ratio). If 200 m^2 of coho rearing habitat were created, it would be predicted to support 92 coho fry and yield 13.8 coho smolts (46 coho fry/100 m^2 · 200 m^2 = 92 fry; 92 fry · 15% survival = 13.8 smolts).

Table 1. Biostandards used in quantifying biological benefits of restoration plan projects.

		Pink	Chum	Coho	Steelhead
1) Spawning biostandard	Natural sites:	1.2	2.6	10	15.5
(m^2 per spawning pair)	Enhanced or installed gravel pads:	0.9	2.0	5	7.6
2) Rearing biostandard	Existing condition: from Burt (2013):			2008–2010	densities
(# of fish/100 m^2)	After enhancement:			46	10
3) Survival to smolt				15% (fry-to-smolt)	63% (parr-to-smolt)
4) Smolt yield from rearing biostandard (smolts/100 m^2)				6.9	6.3

Sources:

1) From Burt (2004), except that for pink and chum spawning, a more conservative enhanced biostandard of 75% of the natural biostandard was used instead of 50%.
2) Based on the Provincial Alkalinity Model (Ptolemy 1993); alkalinity and mean fish weight from Burt (2013). These data resulted in a predicted maximum biomass of 225 g/100 m^2 for high quality trout rearing habitat, and 450 g/100 m^2 for high quality coho rearing habitat. Mean weights for years following the fish flow release were 4.9 g for coho fry, and 23.3 g for rainbow parr (ages 1^+ and 2^+ combined). These were divided into the maximum biomass giving predicted maximum densities of 92 coho fry/100 m^2 and 10 steelhead parr/100 m^2. Since rearing habitat in the lower Jordan River is more conducive to steelhead rearing than coho rearing, the coho rearing biostandard was reduced by 50%, giving a density of 46 coho fry/100 m^2.
3) Coho fry-to-smolt survival: DFO SEP data (Mel Sheng, pers. comm.); steelhead parr-to-smolt survival: Ward and Slaney (1993)
4) Smolt yield (smolts/100 m^2) = rearing biostandard · survival to smolt ÷ 100

4. HYDROLOGIC ANALYSIS

In order to assess the low flow and high flow conditions at the project sites, a hydrologic analysis was conducted using hourly discharge obtained from BC Hydro. These data spanned the years 1990–2013 and included the following:

- Non-Power Release Flows (NPRFs) at the Elliott Dam; this includes weir flow over the dam's spillway, discharge from the Low Level Outlet (LLO), and Fishwater Release Valve (FRV) flows.
- Turbine Flows (TBF) at the Jordan Powerhouse.
- Total System Inflows (TSI) into the Elliot, Diversion, and Bear Creek Reservoirs.

It should be noted that the FRV became operational in January 2008 and reliable data is only available from 2009 to 2013. A separate record of the FRV flows was also provided by BC Hydro. The FRV is not adjusted (Burt and Hudson 2013), thus the discharge only varies slightly depending on reservoir stage.

The maximum hourly peak generating flow (TBF) is 68.3 m^3/s, and mean annual minimum NPRF (2009 – 2013) are 0.287–0.347 m^3/s.

4.1 Low Flow Analysis

A low flow study was conducted using the NPRFs at the Elliott Dam combined with a regional adjustment to account for the watershed contribution downstream of the dam. For the 1990 to 2008 pre-FRV period, the recorded minimum daily discharge from the dam was consistently 0 m^3/s. In 2008 a low flow release valve was installed at Elliot dam, and in 2009 the required target flow release was 0.395 m^3/s (Burt and Hudson 2013).

The impact of the FRV was that the annual minimum 7-day average, daily discharge for the NPRFs ranged from 0.287–0.347 m^3/s for 2009 to 2013, with a mean value of 0.309 m^3/s. The lowest value for the six year period, 0.287 m^3/s, occurred in 2012.

In order to estimate the low flow discharge for the lower river, local inflows below the dam had to be accounted for. In 2005, an inflow monitoring program was implemented on the lower reach of the Jordan River by Burt and Hudson (2013). Prior to the FRV coming online, the lowest measured inflow in the river immediately upstream of the powerhouse tailrace was 0.012 m^3/s (Burt, 1996). This measured flow is the best available base flow data for the catchment area downstream of the reservoir. The downstream discharge contribution was added to the mean annual minimum 7-day average daily discharge (0.309 m^3/s), and lowest 7-day average daily discharge (0.287 m^3/s) from 2009 to 2013, giving low flow design discharges of 0.321 m^3/s and 0.299 m^3/s, respectively, in the anadromous reach.

4.2 High Flow Analysis

Typically, a Flood Frequency Analyse (FFA) would be used to estimate the design discharge using available discharge records, but FFAs assume that the flow records are random and homogenous. These assumptions do not hold for the Lower Jordan River because the system is regulated by multiple dams. FFAs estimated discharges and return periods can be considerably skewed due to reservoir operations. As an alternative, an Exceedance Analyses (EA) approach has been chosen for this project. This analysis shows the average number of days per year that daily discharges are met or exceeded for the period of record.

A high flow analysis was conducted for upstream and downstream of the powerhouse tailrace. No combined discharge record exists for these reaches of the river, so synthesized records extending from 1990 to 2013 were created using the NPRF, TBF, and TSI data sets.

Firstly, the TSI record was used to create a synthesized inflow record for the drainage area between the dam and project reach. The synthesized inflow record was created by scaling the TSI according to drainage area ratios and an averaged Creager Exponent (Watt et al. 1989); the equation below shows the scaling relationship. This synthesized inflow record was then combined with the NPRF record to estimate the discharges above the tailrace. The discharges below the tailrace were estimated by combing the NPRF, TBF, and synthesized inflow records.

$$Q_{inf-synth} = Q_{TSI}(\frac{A_{M1}}{A_{TSI}})^C$$

$Q_{inf\text{-}synth}$, Q_{TSI}, A_{M1}, A_{TSI}, and C, represent the synthesized inflows; the total system inflows; the drainage area for the reach between the dam and the project site; the drainage area for Elliott, Diversion, and Bear Creek Reservoirs; and the averaged Creager Exponent, respectively. A_{M1} was calculated for a mainstem monitoring station immediately upstream of the tailrace, resulting in a value of 16.87 km^2 (Burt and Hudson 2013). A_{TSI} represents the much larger drainage area for the entire upstream reservoir system with a value of 144.1 km^2 (Burt and Hudson 2013). The adopted Creager exponent was 0.78.

Upstream of the Tailrace

Two EAs were conducted on the discharge record upstream of the tailrace; one for the full record (1990 – 2013) and another from 2009 – 2013. The EA results are shown in Figure 3. The differences between the curves could be due to hydrologic variations, change in system operations, and/or effects of FRV.

Downstream of the Tailrace

An exceedance analysis was conducted on both the full record and the 2009 – 2013 record downstream of the tailrace; the results are shown in Figure 4. Again, differences between the two curves could be due to hydrologic variations, change in system operations, and/or effects of FRV.

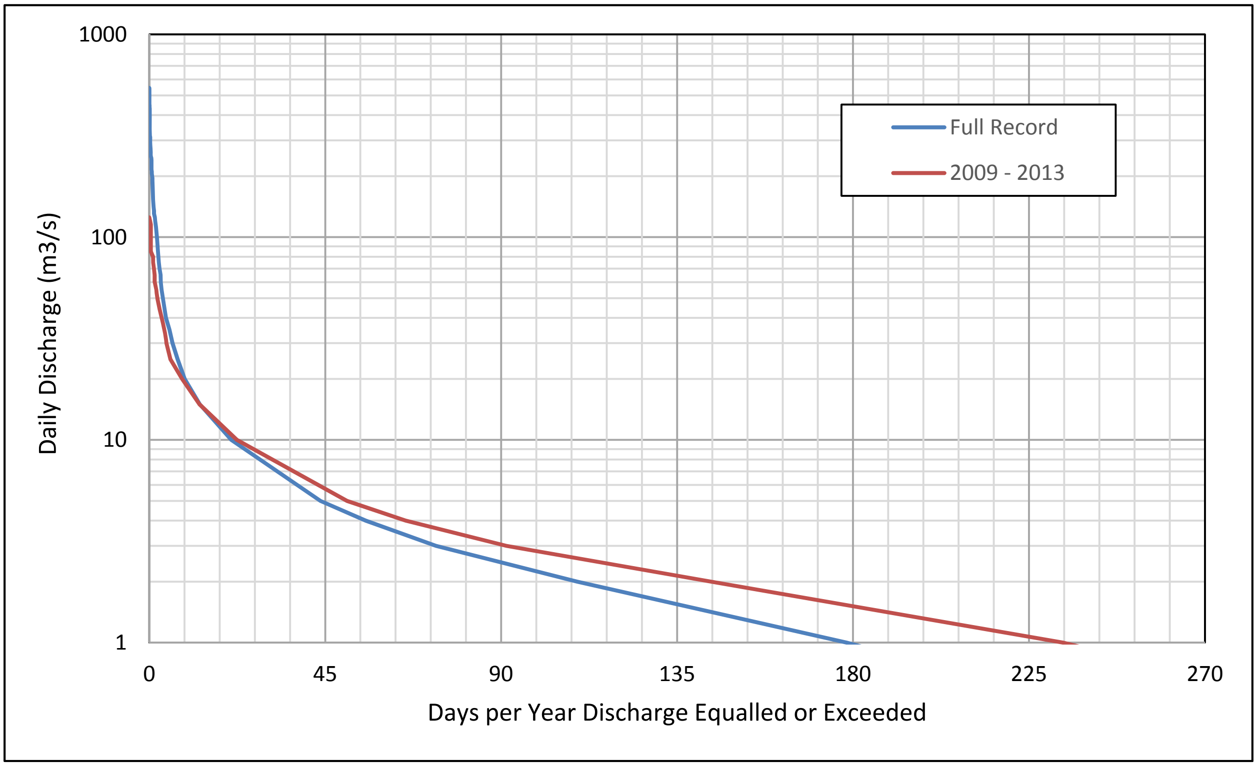


Figure 3. Average daily discharge ***upstream*** of the Tailrace - Exceedance Analysis.

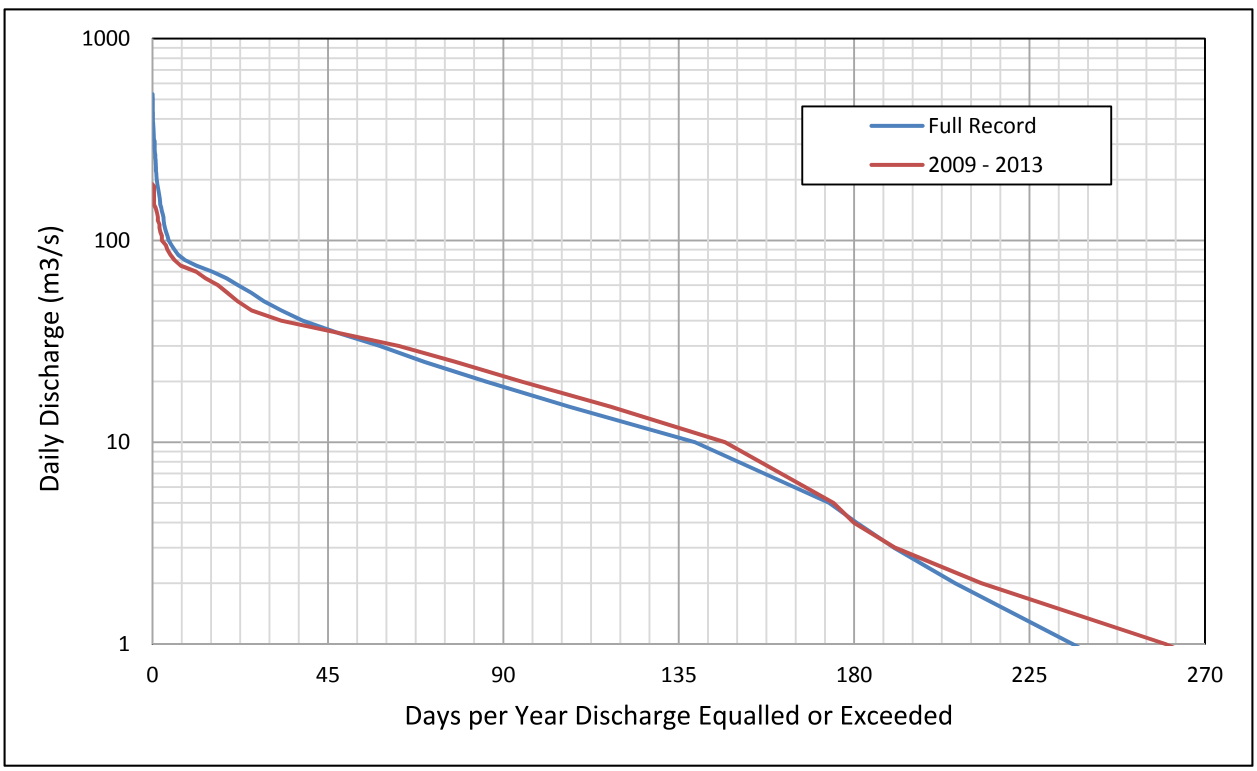


Figure 4. Average daily discharge ***downstream*** of the Tailrace - Exceedance Analysis.

5. OVERVIEW OF PROJECTS

5.1 Overall Objectives and Approach

Currently, DFO does not have any salmon escapement targets for the Jordan River and so there are no agency driven “goal posts” for restoration objectives. Historic records suggest that the Lower Jordan River once supported escapements of roughly 700 coho, 1500 chum, and 3000 pink salmon (Figure 1). Historic numbers of steelhead and searun cutthroat trout are unknown. Whether these escapements are achievable as targets following implementation of this plan is uncertain due to losses of certain crucial habitats (e.g., construction of the dryland sort on prime estuarine habitat, loss of major gravel beds downstream of the tailrace), and ongoing peaking operation of the Jordan River Generating Station. Given existing constraints, and the relatively short length of river available to anadromous fish (1.53 km), the objective of this plan is to outline of set of projects that optimize fish production from the length of river available. This is to be achieved through projects that:

a) Enhance the quality of existing habitat (and thus its productive capacity)

b) Augment existing habitat (e.g., expand the area of existing habitat)

c) Create new habitat (e.g., construction of a sidechannel)

The target species are the ones of historical presence, namely, coho, chum, and pink salmon, as well as steelhead and searun cutthroat trout. The projects identified are intended to address the different life history stages of these species so as to minimize potential production bottlenecks at any one life stage. For example, coho, steelhead, and searun cutthroat have extended freshwater rearing stages and also heavily utilize estuarine nursery habitats. Thus projects for these species need to address limitations in freshwater rearing, overwintering, and estuarine habitats. Chum salmon have minimal freshwater rearing but rely heavily on estuarine habitats for rearing and smoltification. Thus, projects for this species need to address both spawning and estuarine habitats. Pink salmon tend to migrate to the marine environment soon after emergence with little reliance on freshwater or estuarine rearing, and so, the quantity and quality of spawning habitat are the determinants of freshwater production.

5.2 Project List and Priority Rating

Field investigations for this plan resulted in identification of 8 project areas spanning all three anadromous reaches. Summaries of each project are provided in Table 2 with sites listed in order of geographic location beginning with the uppermost site. Types of projects include improvements to fish passage (Site 1), installation of spawning gravel (Sites 2, 3, 4, 5, and 6), LWD placements (Sites 2, 3, and 4), sidechannel construction (Site 7), and creation of complex estuarine habitats (Site 8).

The priority rating for the different projects is given in the last column of Table 2. Sidechannel construction at Site 7 is seen as the top priority for several reasons. First, this project has already received some feasibility assessment through FWCP seed funding (Burt 2014b); second, this project would provide high quality freshwater rearing and overwintering habitat of the type favoured by coho salmon (habitats that are extremely lacking in the Lower Jordan River); third, fish production gains from sidechannel projects can be very high.

Installation of spawning gravel 70 m downstream of the tailrace (Site 5) has been designated as Priority 2 because this location is believed to have historically been the backbone of chum and pink production, but is currently degraded by scour from turbine flows. Restoration of this site is essential if the river is to support historic numbers of pink and chum salmon, as this is the only location with sufficient space to accommodate large numbers of spawners. Given its location in the upper tidal zone, it is likely to only be used by pink and chum salmon (known tidal spawners).

Projects 2, 3, and 4 are similar in that they involve both spawning gravel and LWD installations. The gravel placement prescriptions are intended to improve the quantity, quality, and stability of natural sites. The LWD prescriptions are intended to provide cover for both juvenile rearing and returning adults. They have been designated as Priority 3 through 5, but could be interchanged or don concurrently if machine access and funding permitted.

Project area 2 also includes constructing scour protection for the toe of the mine tailings that extend into the river channel. This work could be completed at the same time as the LWD and spawning gravel work, or phased.

Priority rankings were not given to the remaining projects as it was felt these should wait until there is evidence of greater number of adults returning to the lower Jordan River in order to justify further expenditures. When there are signs that historic runs are rebuilding, priority should be given to Project 8 as estuarine habitats are extremely limiting, and are likely to quickly become a bottleneck to smolt production for all but pink salmon. This project offers the best opportunity for creating a substantial amount of estuarine habitat and may partially offset the estuarine habitat lost by creation of the dryland sort. It is envisioned that the estuary would be restored in a series of phased projects.

Property boundaries and land title aspects have not been identified or address in this overview document.

Table 2. Summary of potential restoration projects for anadromous reaches of the Jordan River.

Project Number	Location	Project Tasks	Description	Habitats Enhanced and Target Species	Components	Rough Cost Estimate	Priority
1	Partial barrier and cascades at lower end of Reach 3	Improve adult passage from the partial obstruction to the large pool 30 m upstream.	Facilitate passage by strategic removal or manipulation of rocks to form series of steps into upstream spawning and rearing habitats.	Facilitate easier access by greater number of adults to spawning and rearing habitat in Reach 3. Target species: coho and steelhead	1) Feasibility/planning survey 2) Develop construction plan 3) Use Site 2 access road 4) Construction	$60,000	
2	Section upstream of big pool (Reach 2)	<u>Primary Tasks:</u> 1) Create access road 2) Install spawning gravel 3) Install LWD <u>Potential Additional Tasks:</u> 4) Remove metal mine refuse 5) Stabilize toe of mine deposition	Enhance existing rock formations which are trapping gravel; remove cobbles/boulders from spawning beds, add additional high quality gravel to these beds	Increased spawning area and higher quality gravel anticipated to allow greater number of spawners and increase smolt production. Target species: coho and chum salmon, and steelhead trout.	1) Feasibility/planning survey 2) Develop construction plan 3) Construct access road (overgrown spur on river right; comes off mine access road) 4) Construction	Primary tasks: $165,000 Additional tasks: $210,000 Monitoring: $15,000	4
3	Big pool (Reach 2)	Add LWD to big pool	This pool is the main adult holding site in the lower river, but it's function is impaired by lack of cover and by infilling with sand and pea gravel.	LWD should encourage scour, removal of sand and pea gravel, deepening of the pool, and provide a source of cover for adults. These features may also help diminish predation by local sea otters. Target species: coho, chum, and possibly pink salmon plus steelhead trout	1) Feasibility/planning survey 2) Develop construction plan 3) Use Site 2 access road 4) Construction	$90,000	5
4	2 sections: one just downstream of big pool (Reach 2) and one just upstream of the tailrace (Reach 1/2 boundary)	1) Install spawning gravel 2) Install LWD	Enhance existing rock formations which are trapping gravel; remove cobbles/boulders from spawning beds, add additional high quality gravel to these beds	Increased spawning area and higher quality gravel anticipated to allow greater number of spawners and increase smolt production. Target species: coho, chum, and pink salmon, and steelhead trout.	1) Feasibility/planning survey 2) Develop construction plan 3) Access road - use Site 2 access or create access road from BC Hydro yard 4) Construction	$95,000	3
5	River right beginning 70 m downstream of the tailrace (Reach 1)	<u>Phase I:</u> Install spawning gravel (maintain existing grade) <u>Phase II:</u> If Phase I successful (i.e., used by spawners and incubation is successful), and if no impact to turbine flows, expand this spawning bed upstream and across the face of the riffle	The quality of existing gravel at this site is diminished by irregular particle sizes, moderate compaction, and the presence of large cobbles among the gravel. Phase I would replace this material with high quality optimal sized gravel free of cobbles. The new material would be installed at the existing grade. Phase II would expand this spawning bed to historic areas and would require a rock weir to help retain gravel under turbine flows.	The provision of a large spawning bed of high quality gravel at this site is anticipated to have a major benefit to the production of chum and pink salmon which historically spawned in this region prior to the relocation of the Jordan powerhouse. Target species: chum and pink salmon.	1) Modelling to assess hydraulics and ensure no effects on turbine outflows 2) Phase I: augment existing gravel keeping same river bottom grade 3) Phase II: Newberry type weirs with additional gravel if modelling indicates no impact on tailrace	1) Planning and design: $125,000 2) Phase I gravel: $150,000 3) Phase II gravel: $250,000 4) Monitoring: $25,000	2
6	The riffle just upstream of the log sort (Reach 1)	1) Install a large rock riffle at the existing riffle location 2) Install a spawning platform on the upstream side	Dredging adjacent to the log sort may result in headcutting of the identified riffle affecting gravel retention. Installation of large boulders in the riffle will reduce this phenomenon and help to retain gravel. High quality spawning gravel would be installed on the upstream side of the riffle if salinity regimes are found to support incubation.	Installation of high quality spawning gravel is anticipated to increase the number of adult spawners supported by the lower Jordan River with subsequent increases in smolt production. Target species: chum and pink salmon.	1) Modelling to assess hydraulics would be covered by Site 5 tasks. 2) Salinity levels and periodicity would need to be investigated to ensure egg tolerances are not surpassed at this location 3) If the above are positive, install large rock riffle and spawning gravel	1) Planning and design: $40,000 2) Construction: $250,000 3) Monitoring: $25,000	
7	Bench on river left between the tailrace and log sort (Reach 1).	Sidechannel creation	430 m long groundwater and creek fed sidechannel to provide new spawning and rearing habitat free of copper leachate. Sources of water anticipated to include Creeks 1, 2, and 3 + subsurface conveyances. A future option may be to extend the sidechannel down to the old tailrace channel.	Sidechannels often yield the greatest returns in fish production relative to dollars spent. This project would create a modest amount of spawning habitat, and extensive high quality rearing habitat free of the dissolved copper found in the mainstem. In addition, the mouth will be low gradient and tidal which would allow mainstem rearing coho to seek refuge in the lower end of the sidechannel. Target species: coho, chum, and possibly pink salmon + anadromous cutthroat trout	1) Feasibility of ground water and creek water sources - funded by FWCP for 2015/16 2) Develop construction plan 3) Construction	1) Feasibility: $65 2) Intake pipe: $200,000 3) Sidechannel: $150,000 4) Monitoring: $20,000 Option 2 (extend SC to old tailrace channel) Feasibility: $75,000 Construction: $250,000	1
8	Flats around the old BC Hydro tailrace channel	1) Install secondary connection to the ocean at the bend in the tailrace channel to encourage tidal flushing. 2) Create estuarine habitats (sedge islands, interconnect tidal channel, salt marsh benches)	The Jordan River lost most of its estuarine habitat with the construction of the dryland sort. This project offers an opportunity to recover some of this habitat through creation of sedge islands, interconnects tidal channels, and salt marsh habitats. If successfully colonized by intertidal invertebrates, the area would become an important nursery area for salmonids prior to their offshore migration.	The creation of estuarine habitat could prove highly important to overall salmonid production from the Jordan. Although all salmonids would benefit from this habitat, species with particular reliance on estuarine nursery habitats are chum and coho salmon, and anadromous cutthroat trout.	1) Land owner consultations 2) Feasibility/planning survey 3) Construction plan 4) Construction	Estuary benching: $100,000 - $1 M Highway culvert: $500,000 Monitoring: $50,000 Total: $875,000 - $1.875 M	

5.3 Potential Habitat and Production Gains

Increases in fish production at a given life stage can be achieved both by creating new habitat for that life stage, or by increasing the quality of existing habitat such that greater fish densities and/or survival rates are provided for that life stage. The projects presented in this plan are anticipated to provide benefits at both levels. This section provides an overview of habitat and fish production gains from identified projects. Specific details on anticipated biological benefits are provided on a site-by-site basis in Section 6.

Estimated gains in spawning habitat from projects in this plan, and number adult spawners supported by these habitats, are summarized in Table 3. Spawning habitat is estimated to increase from the current state of 931 m^2, to a total of 4,097 m^2 after completion of all gravel installations. Upon completion, it is predicted that the lower Jordan River would then be capable of supporting approximately 8,000 pink, 4,000 chum, 310 coho, and 132 steelhead. Greatest gains in spawning habitat, and subsequent spawner capacity, are within the tidal section (Reach 1) due to the expansive riffles that occur there, which allow for installation of large gravel platforms. In comparison, riffle and pool tailout habitats in the non-tidal reaches are constrained by a narrower channel widths and shorter habitat unit lengths resulting in much smaller installations at identified sites. At some point it will be important to explore the option of providing fish passage at the 4.6 m boulder falls at the top of Reach 3 as this would provide access to an additional 900 m of spawning and rearing habitats (a 7 m vertical falls just upstream of Sinn Fein Creek would become the new anadromous limit).

Table 3. Summary of available spawning habitat (m^2) at each prescription site before and after gravel installation, and estimated number of adults supported by these habitats.

Site	Reach	Spawning Area (m^2)		Potential Spawners Supported By Existing Gravel				Potential Spawners Supported After Gravel Placement			
		Current	After Placement	Pink	Chum	Coho	Steelhead	Pink	Chum	Coho	Steelhead
Site 1	3	238	238	na	na	Access?	Access?	na	na	50	34
Site 2	2	58	194	na	42	28	26	na	194	78	52
Site 3	2	20	175	34	16	4	2	388	176	70	46
Site 4 – Upper	2	41	230	74	48	34	0	512	230	92	0
Site 4 – Lower	1	100	200	168	76			444	200		
Site 5	1	474	1500	790	364			3,334	1,500		
Site 6	1	0	1500	0	0			3,334	1,500	20	
Site 7 (sidech.)	1	0	60								
All Sites		**931**	**4,097**	**1,066**	**546**	**66**	**28**	**8,012**	**3,800**	**310**	**132**

Notes:

Spawning area values are based on habitat inventory conducted as part of this study in September 2014. *Potential Spawners Supported* are based on biostandards given in Table 1. For existing gravels, the “natural” spawner biostandards were used; after gravel placement values are based on the “enhanced” site biostandards. “na” refers to not applicable.

Predicted benefits of the projects toward rearing and smolt production of coho and steelhead are summarized in Table 4. The sidechannel option (Site 7) also includes production estimates for searun cutthroat trout as this project is anticipated to offer excellent habitat for this species. Since rearing habitats preferred by coho fry are so limited, much of the LWD installations planned will target this species, however steelhead rearing is also expected to benefit. LWD structures may be of particular relevance to steelhead rearing in the lower regions of Reach 2, as boulder cover diminishes with downstream progressions in this reach (as does trout parr abundance). Smolt yield upon completion of rearing related projects is anticipated to amount to 730 coho smolts and 454 steelhead smolts. The above smolt yield estimates for coho may be conservative in that DFO often uses the work by Marshall and Britton (1990), which predicts 1,800 coho smolts per linear km of stream. For the 555 m of stream length above tidal influence, this predicts an output of about 1,000 coho smolts from the Jordan River.

Table 4. Summary of estimated rearing and smolt production capabilities of existing rearing habitat and after LWD installations and other enhancements.

Site	Reach	Species	Usable Area (m^2)	Current Habitat Capabilities			Capabilities After Enhancement		
				Fry or Parr Density (fish/100 m^2)	Population Supported (# of fish)	Smolt Yield (# of smolts)	Fry or Parr Density (fish/100 m^2)	Population Supported (# of fish)	Smolt Yield (# of smolts)
1	3	Coho Fry	2,880	access?			46	1,325	199
		Steelhead Parr	4,057	access?			10	406	256
2	2	Coho Fry	747	3.2	24	4	46	344	52
		Steelhead Parr	1,787	8.3	148	93	10	179	113
3	2	Coho Fry	1,170	2.0	23	3	46	538	81
		Steelhead Parr	172	1.0	2	1	10	17	11
4	2, 1	Coho Fry	1,105	2.0	22	3	46	508	76
		Steelhead Parr	2,350	1.0	24	15	5	118	74
7	Sidech.	Coho Fry	1,170				92	1,076	323
		Searun cutthroat	1,170				10	117	74
All Sites		Coho Fry			69	10		3,791	730
		Steelhead Parr			174	110		720	454
		Searun cutthroat						117	74

Notes:

Fry and parr densities under current habitat conditions were based on post flow release data from Burt (2013); densities after enhancement used biostandards from Table 1. The exception was the sidechannel where the full Alkalinity Model prediction of 92 fry/100 m^2 due to the high quality coho rearing habitats offered by sidechannels.

6. PROJECT DESCRIPTIONS

This section presents descriptions of the restoration options broken into eight separate projects. The projects are all within the anadromous reach, and locations were previously shown in Figure 2. Topics covered for each project include a descriptive overview, predicted biological benefits, potential access, work plan summary and estimated implementation costs. Preliminary costs have been developed based on site conditions, past project experience and are presented for planning purposes; actual costs could range by a large margin. Additional project details will be developed during subsequent planning and design phases.

6.1 Prescription 1: Fish Passage Improvement at the Bottom of Reach 3

Project Overview

Features of Reach 3 are shown in Figure 5 map. At the foot of this reach is a 3 m falls that has been identified as a low flow obstruction to adult salmonid migration (Photo 1). This is also the point where the river becomes confined between steep canyon walls, and the local gradient increases from 1.4 % to 7.3%. A second and completely impassable 4.6 m falls occurs at the top of Reach 3, 225 m further upstream (Photo 2). Between the partial and complete obstructions, the river bed is characterised by very large boulders (diameter > 2 m) with smaller deposits (gravel and cobble) within pools.

In terms of fish habitat, Reach 3 offers excellent steelhead parr rearing throughout, one large deep pool suitable for adult holding (Rock Face Pool, Photo 3), coho fry rearing potential in the pools, and spawning gravels in pockets with one large continuous bed at the tailout of the large pool.

The purpose of this project is to improve passage at the 3 m partial obstruction located at the bottom of Reach 3 so that adult coho and steelhead are better able to gain access to upstream holding, spawning, and rearing habitats. It is not anticipated that pink or chum salmon will be able to ascend the falls even after project completion.

There may be potential to improve passage at the upper 4.6 m falls as a second project phase to open up an additional 900 m of spawning and rearing habitat for coho and steelhead. The practicality of this project was not investigated as thoroughly as the other sites discussed in this report, and as such, no work plan or cost estimate is presented for improving access at the upper barrier falls.

Predicted Biological Benefits

Improved fish passage at the 3 m obstruction is anticipated to allow greater number of adults to ascend into Reach 3 giving access to additional adult holding pools, and promoting greater utilization of available spawning and rearing habitats in this reach. Facilitating fish access into Reach 3 may also benefit Reach 2 by way of alleviating possible density-dependent effects associated with available spawning and rearing habitat in Reach 2.

Available holding, spawning, and rearing habitats in Reach 3, and potential levels of utilization by coho and steelhead are summarized in Table 5. Habitats include 550 m^2 of holding pool habitat, 238 m^2 of spawning gravel, 2,880 m^2 of coho rearing habitat, and 4,057 m^2 of steelhead rearing habitat. For estimation of the number of adult coho and steelhead supported by the above spawning habitat, the more conservative natural biostandards from Table 1 were used due to a relatively high percentage of fines in the Rock Face Pool tailout. The result is that existing spawning habitat in Reach 3 is predicted to support 50 coho and 34 steelhead spawners. For rearing habitat, the biostandards suggest that Reach 3 can support 1,325 coho fry and 406 steelhead parr, and that smolt yield would be 199 coho smolts and 256 steelhead smolts given survival rates of 15% and 63%, respectively from Table 1.

If this passage project is successful, future consideration should be given to also providing passage at the 4.6 m anadromous obstruction. There are a number of anecdotal reports that coho and steelhead once migrated as far upstream as the vertical bedrock falls about 100 m upstream of the Sinn Fein Creek confluence (Recreation Resources Ltd 2001). This is a 7 m vertical rockface falls and an unquestionable fish barrier. However, the provision of passage at the 4.6 m rubble obstruction would open up an addition 900 m of stream length, which is more than double the current 555 m of non-tidal stream habitat.

Table 5. Summary of the available habitats in Reach 3, and their potential utilization assuming fish passage improvements are successful.

Life Stage	Species	Available Habitat (m^2)	Fish Use Under Current Habitat Situation	Potential Use After Fish Passage Improvement
Holding	Coho and steelhead	550	Passage difficulties may limit use of upstream holding sites	Greater use of upstream holding due to easier access under greater range of flows
Spawning	Coho	238	Limited (1 adult in 2013)	50 adult spawners
	Steelhead	238	Limited	34 adult spawners
Rearing	Coho	2,880	Unknown, dependent on adult recruitment	46 fry/100 m^2 → 1,325 fry → 199 smolts
	Steelhead	4,057	Unknown, dependent on adult recruitment	10 parr/100 m^2 → 406 parr → 256 smolts

Notes:

Available Habitat: Holding area was digitized in ArcMap using 20 cm orthophotos via CRD's internet map service; spawning area was from the 2014 habitat inventory conducted by this study; rearing area was from habitat measurements by Burt (2013). The latter found that under the current fish flow release, Reach 3 had a wetted area of 4,057 m^2 composed of 71% boulder controlled pools, 16% glides, and 11% cascades. Due to the high quality of habitat for steelhead parr, it was assumed that they would use all available habitat, while for coho it was assumed they would only use pool habitats.

Potential Use: Based on biostandards given in Table 1.

Access

Heavy equipment access is not feasible due to the size of the substrate and the steep embankments. Therefore, equipment will need to be carried to the site by hand, either from the foot trail at the north end of the BC Hydro powerhouse, from the trail along the overgrown mine access road on the east side of the river (see Section 6.2 and Figure 6), or from the access route potentially developed along the left bank for Prescription 2 (See Section 6.2). Another option is to long-line equipment in by helicopter.

Work Plan

A detailed reconnaissance will be conducted at fish migration flows to identify the specific migration impediments, possibly assisted by an automated camera system. Once flows recede, the site will be surveyed, and a detailed prescription to manipulate the boulder substrate will be developed. The work plan will identify specific boulders that need to be altered. The work will use hand tools and manual labour, and will involve moving specific boulders to new positions or splitting sections of large rocks. The boulders will be moved using a pulley system that includes grouted eyes in the boulder, and a tailhold with pulley blocks, heavy wire rope and a Tirfor® (in-line winch). Heavy duty bottle jacks may also be used to move very large boulders. Another technique that may be used is splitting boulders. This can be accomplished by strategically drilling holes in the boulder and filling the holes with expanding grout. As the grout dries it expands and will split the rock. The site will be monitored after construction to confirm that the hydraulic conditions have been improved for upstream passage.

Preliminary Estimate of Costs

Preliminary cost estimates were developed based on site conditions and past project experience. These estimates are presented for planning purposes (Table 6); actual costs could range by a large margin. Costs are in 2015 dollars and include a tax allowance. Additional project details will be developed during subsequent planning and design phases, which will allow the refinement of project costs.

Table 6. Preliminary costing for Site 1 works (fish passage improvement).

Item no.	Description	Cost ($,000)
1	Planning and design	15
2	Construction of passage improvement	35
3	Monitoring	10
	Total	**60**

Evaluation of Risk

Other than project damage, there is limited downstream risk to people or existing infrastructure from this project. Possible risks associated with this project are as follows:

- The project could possibly sustain severe damage in the event of a dam break scenario.
- High Elliot dam spillway flows, combined with natural runoff from downstream of the reservoir could result in very high discharges at the project site. These floods could shift boulders, move additional boulders or trees into the migration path, and interfere with upstream fish passage.
- The canyon walls at the project site are very steep with evidence of rock fall and mass wasting. These upslope conditions could contribute large boulders and woody debris to the site and interfere with upstream fish passage.
- Steep boulder reaches can sometimes develop subsurface flow paths, and during dry periods there may be insufficient surface flow to facilitate upstream fish passage.

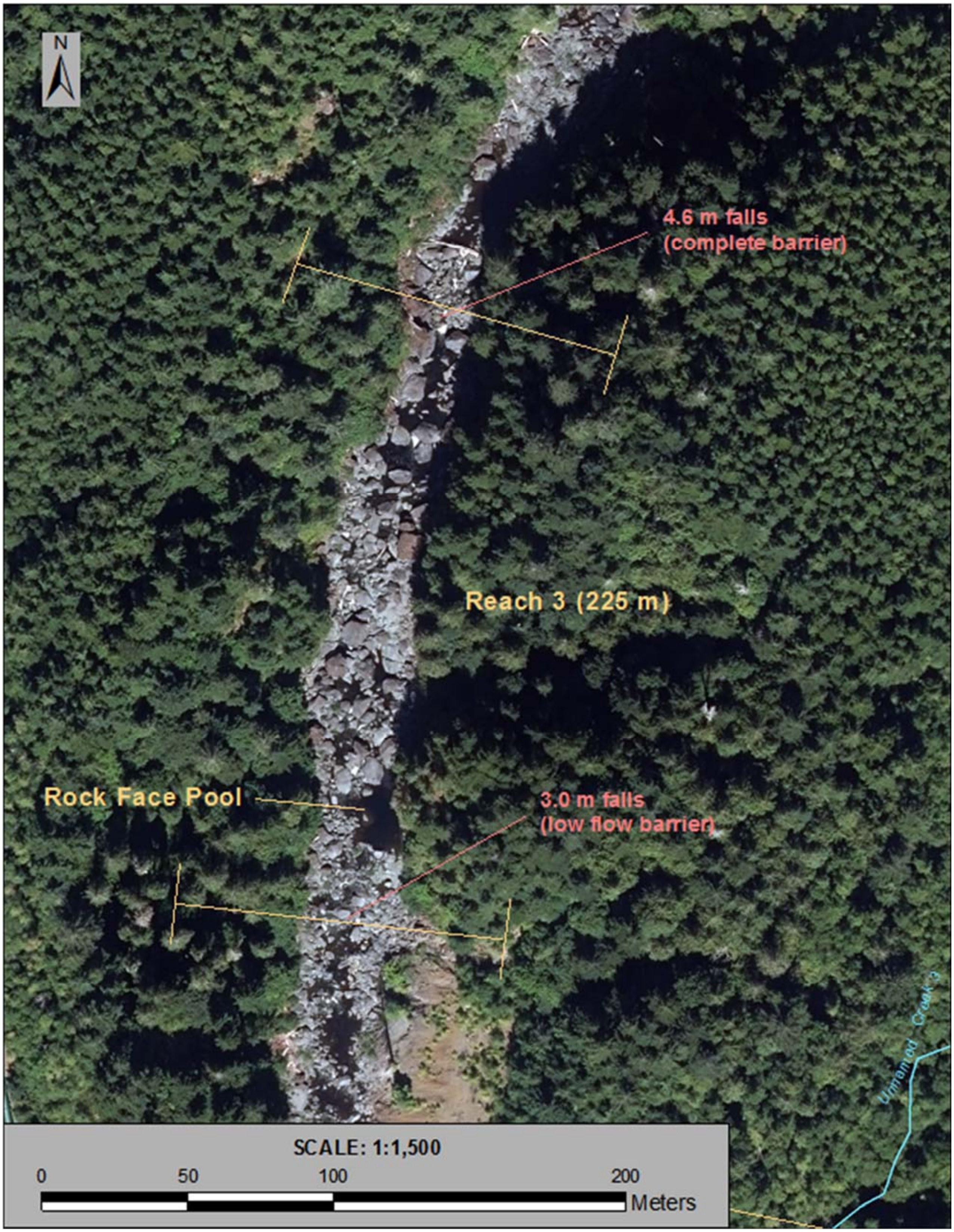


Figure 5. Map showing Reach 3 and location of Prescription Site 1 (3 m falls).

Photo 1. Low flow obstruction at the bottom of Reach 3 (August 31, 2009).

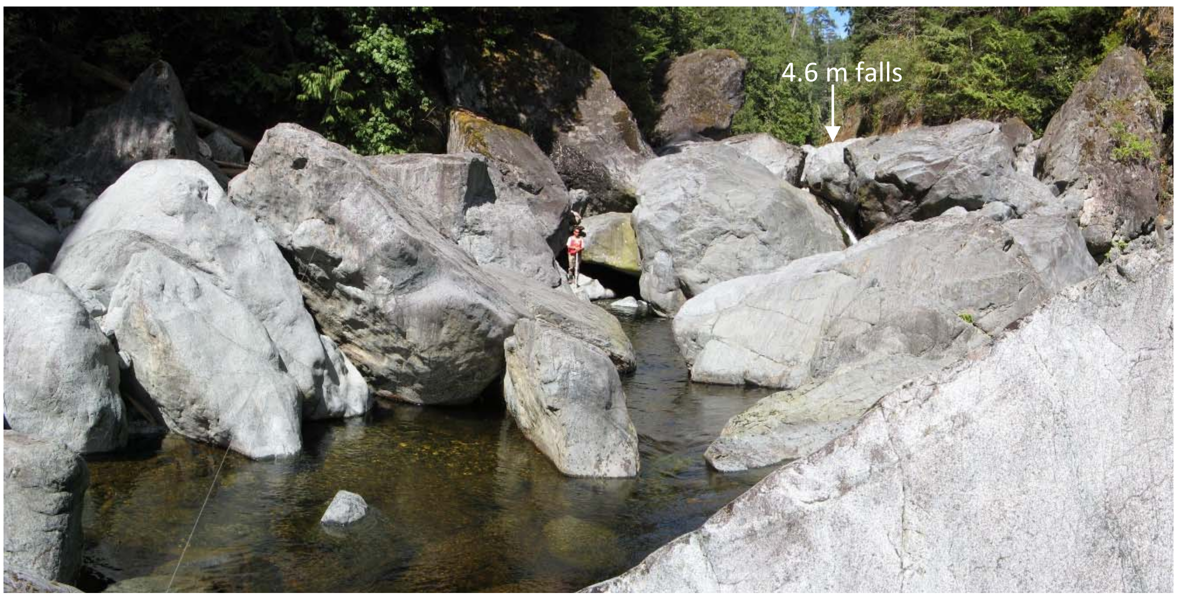


Photo 2. Anadromous barrier at the top of Reach 3 (background) (August 20, 2009).

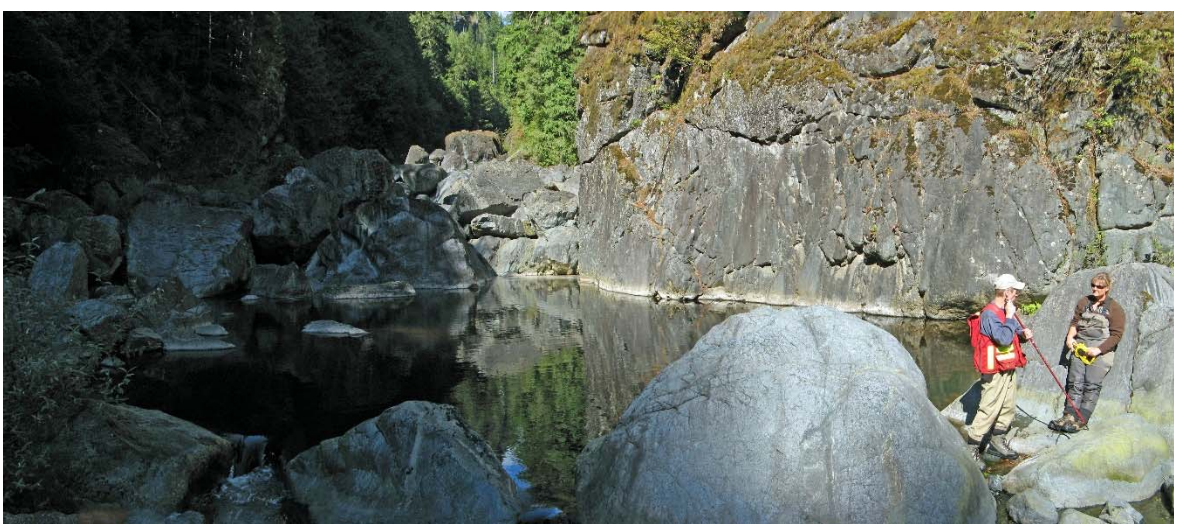


Photo 3. "Rock Face Pool", 30 m upstream from the bottom of Reach 3 (September 3, 2014).

6.2 Prescription 2: Spawning Gravel, LWD, Bank Stabilisation, and Debris Removal

Project Overview

Prescription Site 2 begins immediately downstream of the 3 m falls, and extends downstream for 155 m, ending at a cascade leading into the large pool (Figure 6). In this section the gradient begins to flatten, the channel widens, but remains mainly straight. The level and rod surveys indicated a gradient of 1.4% and bankfull width of 33 m for this site. The substrate is dominated by large boulders (0.5–1.5 m in diameter) and cobbles. Gravels are limited to pockets and short sections protected by boulders (see Photos 4 and 5).

On the left bank there is a large mine deposit (shown in Figure 6) and seepages from this deposit are known to carry high levels of dissolved copper to the Jordan mainstem. The uppermost point of contaminant entry occurs 20 m downstream of the 3 m falls and is shown in Photo 4. A detailed summary and assessment of dissolved copper issues in the lower Jordan River was completed by(Burt 2012). Additional water quality sampling was completed during the 2013 FWCP seed projects (Burt 2014a, b). Results found that Unnamed Creeks 1 and 2 were free of copper contamination, while Creek 3 was clean above the mine access road, but became contaminated below this road. Consequences of the copper inputs on fish using the mainstem were summarised in Burt (2012). The main points were that prior to the fish flow release, dissolved copper levels did not show an effect on spawning or incubation success, but completely prevented rearing stages from occurring, beginning at the point shown in Photo 4 and continuing throughout downstream reaches. Since initiation of the fish flow release in January 2008, the added flows have provided sufficient dilution of dissolved copper inputs that rearing rainbow and coho have colonized the previously "dead zone." In addition, condition factor (weight to length ratio) of rearing fish within the copper affected zone was found to be comparable to fish upstream of this zone, suggesting that under the flow release, rearing fish are able to grow and develop successfully.

Other mine related factors noted in the Site 2 area are the pressence of remnant metal debris within the river channel and embeded throughout the mine deposit on the left bank. Also, the toe of the mine deposit was noted to be unstable and susceptible to scour and sloughing during flood events.

Prescription works proposed for Site 2 include installations of spawning gravel and LWD, removal of metal debris, and stabilizing the toe of the mine deposit.

Predicted Biological Benefits

Anticipated benefits from proposed prescriptions for Site 2 are summarised in Table 7. The addition of LWD within adult holding habitats is anticipated to allow for greater density of adults while assisting in predation avoidance. In addition, when selecting spawning sites, salmonids tend to prefer gravel sites where cover elements are close at hand. The addition of LWD at this site is intended to serve these purposes.

This prescription site is currently the main spawning section for coho salmon (chum and steelhead have also been observed in some years), however, at present available gravel only amounts to 58 m^2 (Table 7). Additions of high quality gravels are estimated to increase this space to 194 m^2, while the improved quality of the gravel is anticipated to allow greater density of spawners per unit area. Capacity after completion is estimated to be 194 chum, 78 coho, and 52 steelhead adults. Pink salmon may not access this site due to the cascade that connects Site 2 to the Site 1 pool.

Rearing habitat within this section was estimated at 747 m^2 for coho (pool habitats) and 1,787 m^2 for steelhead (all habitats). Coho fry rearing is expected to benefit most from LWD additions and a conservative estimate of utilization after project completion is 344 coho fry with a subsequent yield of 52 smolts. Existing habitat is already excellent for steelhead rearing and site 2 was estimated to be able to support 179 steelhead parr, and potentially yield 113 smolts.

Table 7. Summary of anticipated fish use from LWD and spawning gravel placements within Prescription Site 2.

Life Stage	Species	Available Habitat (m^2)	Fish Use With Current Habitat Conditions (including Elliott Dam fish flow releases)	Potential Use After Fish Project Completion
Adult Holding	Chum, coho and steelhead	182	Only 2 small bedrock controlled holding pools	LWD additions will provide cover, encourage greater density of adults, possibly reduce predation
Adult Spawning	Chum, coho, and steelhead	58 (before) 194 (after)	58 m^2 moderate quality, mostly pockets; estimated capacity = 42 chum, 28 coho, 26 steelhead	194 m^2 high quality gravel; potential capacity: 194 chum, 78 coho, and 52 steelhead
Juvenile Rearing	Coho	747	3.2 fry/100 m^2 → 24 fry → 4 smolts	46 fry/100 m^2 → 344 fry → 52 smolts
	Steelhead	1,787	8.3 parr/100 m^2 → 148 parr (current use mostly RB)	10 parr/100 m^2 → 179 parr → 113 smolts

__Notes:__ coho fry and rainbow parr densities under the current habitat situation are the average density in this section for 2008–2010 from Burt (2013).

Access

Heavy equipment access to Site 2 requires investing in redeveloping a steep gradient relic road grade on the left bank (Figure 6) that connects to forest industry roads, and eventually Hwy 14. The road work requires installing new culverts, removing overgrown vegetation, ensuring adequate widths and drainage are provided, and resurfacing sections that have poor soil with crushed rock. This road work is recommended because it would provide long term access for Sites 2 through 4, as well as benefit Site 1 materials staging, crew access and monitoring access. The road grade would end at the river at Site 4 (approximate length is 400 m), and an access path would have to be developed on the left bank of the river channel (approximate length is 225 m), which is dry during the summer low flow period. The river bank access path would be constructed by relocating some of the in-situ boulders, and then surfacing the path with alluvial sand and gravel, which would need to be imported. The surfacing material could be left in place, but would be potentially eroded away during large flood events. If the access path surfacing material is eroded, it would provide a minor beneficial input of spawning gravel to the sediment depleted downstream reach.

Work Plan

There are several components of the work plan. These include: (i) developing road access to the site, (ii) installing pockets of spawning gravel for coho, (iii) installing LWD, (iv) stabilising the toe of the mine tailings embankment (left bank), and (v) removing industrial metal debris.

A description of the road access plan is provided in the ‘access’ description above.

Spawning gravel will be installed in pockets formed by removing strategic boulders with a large hydraulic excavator to create a local deep hole. Each gravel placement site will range from 8 to 120 m^2, with a total combined estimated area of 194 m^2.

Large LWD members will consist of large Douglas fir or Western red cedar trees with the root attached. The trees will have a stem diameter of approximately 750 mm measured above the root flare. Each LWD member will be tethered to in-situ boulders with chain or cable. The LWD placements will be placed in pools to provide adult holding and juvenile cover habitat. Some LWD will also be placed at spawning gravel sites to help retain the gravel.

For the purpose of this river restoration document, we have assumed that the mine tailings will be assessed and remediated as part of a separate project. However, interim recommended work includes stabilising the toe of the tailings embankment. The rational for stabilising the embankment toe is to prevent continued erosion and sloughing of the mine tailing into the river. The toe stabilisation will require some minor grading of the lower tailings slope to provide a uniform subgrade. A geo-fabric or gravel filter will be placed on top of the lower tailings slope, and heavy angular riprap will be placed on the filter. The toe protection should extend to the calculated flood elevation, plus a freeboard allowance.

There are steel railway rails and other industrial metal in the pool and on the bar at Site 4; this material should be removed from the river and disposed of properly off-site.

Preliminary Estimate of Costs

Preliminary costs for Site 2 works were developed based on site conditions and past project experience. These estimates are presented for planning purposes (Table 8); actual costs could range by a large margin. Costs are in 2015 dollars and include a tax allowance. Additional project details will be developed during the subsequent planning and design phases, which will allow refinement of project costs.

Table 8. Preliminary costing for Site 2 works.

Item no.	Description	Cost ($,000)
1	Planning and design	50
2	Develop access from Hwy 4 to Site 2	60
3	Supply and install spawning gravel	30
4	Supply and install LWD	25
5	Construct tailings toe protection (100 m)	200
6	Remove steel debris from the channel	10
7	Monitoring	15
	Total	**390**

Evaluation of Risk

There is limited downstream risk to people or existing infrastructure from this project. Potential risks to the project include:

- The project is potentially within the inundation zone of a tsunami.
- The project would likely sustain severe damage under a dam break scenario.
- High Elliot Dam spillway flows, combined with natural runoff downstream of the reservoir, could result in very high discharges at the project site. The resultant floods could damage the Prescription 2 work by eroding the access path, eroding the spawning gravel sites, or damaging the LWD structures. Large floods could also damage the mine tailing toe protection.
- The monitoring programs conducted for the Jordan Water Use Plan suggested that initiation of fish flow releases from Elliott Dam in 2008 has provided sufficient dilution of copper that adult, incubation, and rearing stages can now be completed successfully in affected zones. Nevertheless, it is possible that subtle physiological or behavioural effects remain that compromise the success of restoration projects in producing more fish (Burt 2012). Due to these uncertainties, the best option is for permanent removal of the source of copper. To that end, a process has been initiated by other parties to achieve this goal (Ken Farquharson, pers. comm.).

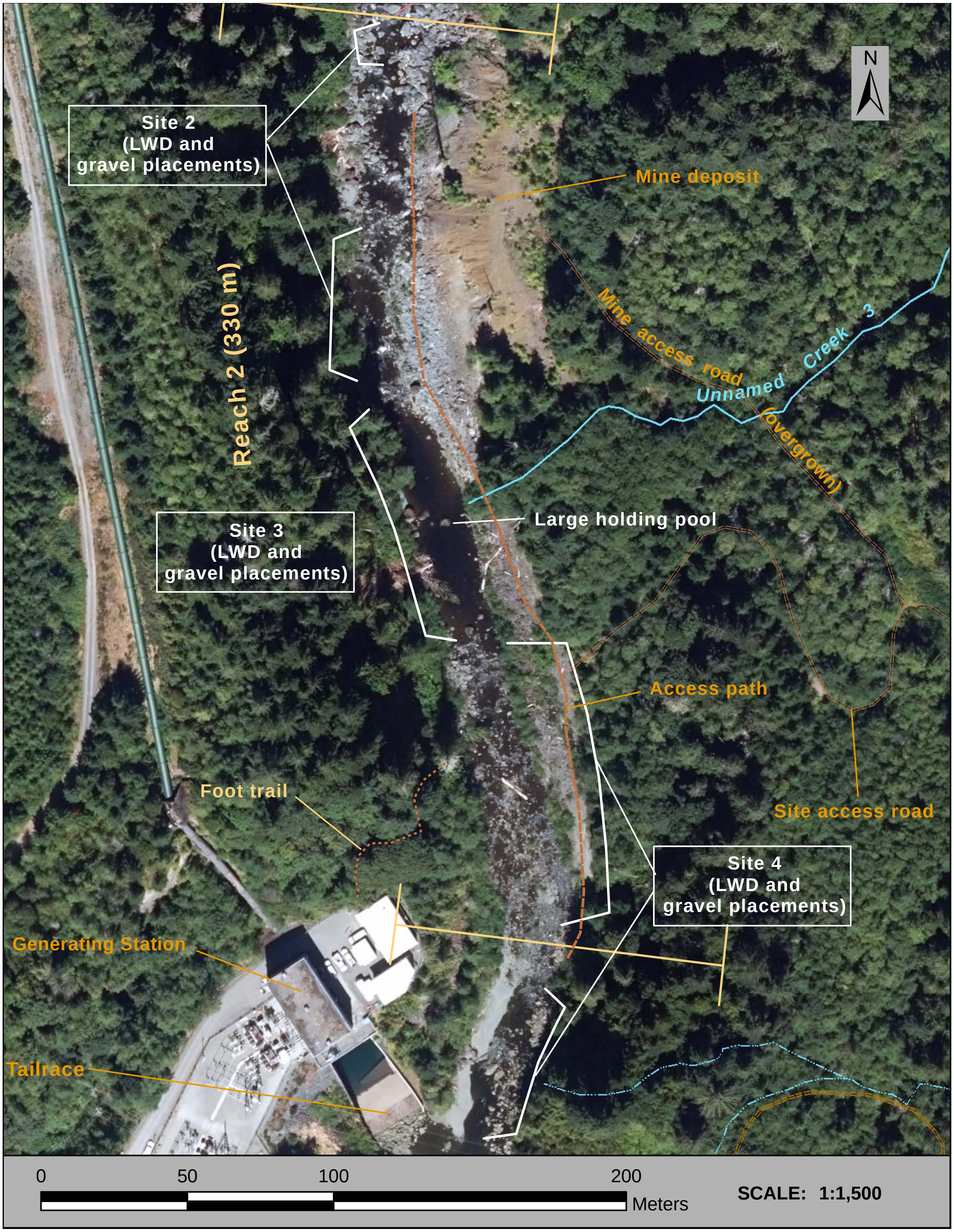


Figure 6. Map of Reach 2 showing prescription sites 2, 3, and 4. Also shown is the proposed machine access route via the old mine road.

Photo 4. View from the top of the 3 m partial obstruction looking downstream at the uppermost section of Prescription Site 2. There is excellent gravel within this habitat unit but it is broken into pockets by the large boulders (Sept. 3, 2014).

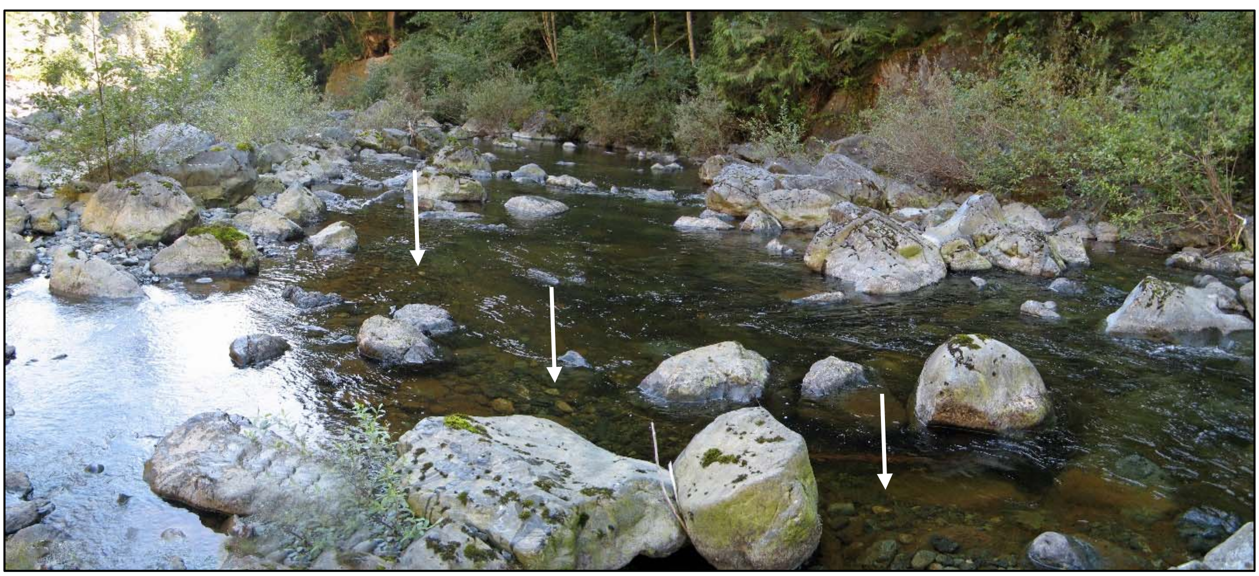


Photo 5. View of the lower section of Prescription Site 2. This is currently the main spawning area upstream of the generating station but gravel tends to be patchy. Arrows point to pockets of gravel.

6.3 Prescription 3: Holding Pool Improvement with Spawning Gravel and LWD

Project Overview

Site 3 is a 90 m long by 19 m wide pool situated immediately downstream of Site 2 (Figure 6). This pool is straight in planform with a maximum depth visually estimated at 2 m. There are many large boulders in the pool, some up to 2 m in diameter. The right bank is steep and forested with mature second growth trees. Unnamed Creek 3 flows in on the the left bank. Habitat improvement works planned for this site include LWD placements along the pool length and installation of spawning gravel in the tailout region.

Predicted Biological Benefits

Anticipated biological benefits from works proposed for Site 3 are summarised in Table 9. The large pool at this site is the only sizeable adult holding pool in Reach 2, and could be improved with increased depth and addition of LWD cover. The tailout area has the potential to support spawning, but existing gravel sites are small in area. The addition of LWD to the holding pool and tailout area, and gravel augmentation in the tailout, are anticipated to remedie these deficiencies and maximize adult holding, spawning, and rearing capabilities of this area. Due to the importance of this pool for adult holding, and its potential for coho rearing, LWD placemetns have substantial biological merit.

After project completion, available spawning area is anticipated to be 175 m^2, with a potential to support 388 pink, 176 chum, 70 coho, and 46 steelhead. Installation of LWD in the large pool and tailout will make these habitats very attractive for coho rearing with some benefits to steelhead rearing. After enhancement, rearing habitats are predicted to be able to support 538 coho fry, and produce 81 coho smolts. Steelhead parr are expected to only use the the smaller tailout area (172 m^2), supporting an estimated 17 parr and producing 11 smolts.

Table 9. Summary of anticipated benefits from LWD and spawning gravel placements at Site 3.

Life Stage	Species	Available Habitat (m^2)	Fish Use Under Current Habitat Conditions (including Elliott Dam fish flow releases)	Potential Use After Fish Project Completion
Adult Holding	Pink, chum, coho and steelhead	825	1 large pool; some depth on right side; LWD cover present in 2013 but swept downstream the following winter	LWD additions will provide cover, encourage greater density of adults, possibly reduce predation
Adult Spawning	Pink, chum, coho, and steelhead	20 (before) 175 (after)	~20 m^2 moderate quality in the tailout; estimated capacity = 34 pink, 16 chum, 4 coho, 2 steelhead	175 m^2 high quality gravel; potentially supporting 388 pink, 176 chum, 70 coho, and 46 steelhead
Juvenile Rearing	Coho:	1,170	2 fry/100 m^2 → 23 fry → 3 smolts	46 fry/100 m^2 → 538 fry → 81 smolts
	Steelhead:	172	1 parr/100 m^2 → 2 parr (mostly RB)	10 parr/100 m^2 → 17 parr → 11 smolts

Note: coho fry and rainbow parr densities under the current habitat situation are based on the average density in this section from Burt (2013) for post flow release years of the study (2008–2010).

Access

The recommended access to the site is the relic road grade on the left bank at the upstream end of Site 4 (See Figure 6).

Another access option for this project is to develop an access path from the north side of the BCH office to the right bank (in the vicinity of the foot trail in Figure 6). The access path could be made large enough for medium size tracked equipment, such as a large skid-steer and tracked excavator. This equipment would need to cross over the river by constructing a temporary path with imported alluvial gravel and a culvert to convey the river flow. A river bank access path would need to be constructed on the left bank bar. The river bank access path would be constructed by relocating some of the boulders and surfacing the path with imported alluvial sand and gravel. This material could be left in place, but may be eroded away during large flood events.

Work Plan

The work plan for Site 3 is to enhance fish habitat values through both LWD and spawning gravel placements. Spawning gravel will be installed in 2 or 3 pockets formed by removing strategic boulders with a hydraulic excavator to create a local deep hole, and at the tailout of the pool near the downstream extents of the project area. The pocket gravel placements will be on the order of 3 to 4 m diameter, with an area of approximately 10 m^2. At the tailout of the large pool, cobble and boulder substrates will be removed and replaced with spawning gravel to create a platform area of approximately 150 m^2.

Large LWD members will consist of large Douglas fir or Western red cedar trees with the root attached. The trees will have a stem diameter of approximately 750 mm measured above the root flare. Each LWD member will be tethered to in-situ boulders with chain or cable. The LWD placements will be placed in the pool to provide adult holding and juvenile rearing cover elements. Some LWD will also be placed at spawning gravel sites to help retain the gravel.

There are scattered steel railway rails and other metal in the pool and on the bar; this material should be removed from the river.

Preliminary Estimate of Costs

Preliminary costs for Site 3 prescriptions were developed based on site conditions and past project experience. Estimated costs are presented for planning purposes in Table 10; actual costs could range by a large margin. Costs are in 2015 dollars and include a tax allowance. Additional project details will be developed during the subsequent planning and design phases, and this will allow project costs to be refined.

Note that the costs for developing the access have been included in Prescription 2; if Prescription 3 is implemented first then there would be additional cost to construct the access route.

Table 10. Preliminary costing for Site 3 works.

Item no.	Description	Cost ($,000)
1	Planning and design	15
2	Develop access from Hwy 4 (included in Project 2)	-
3	Supply and install spawning gravel	30
4	Supply and install LWD	25
5	Remove steel from the channel	10
5	Monitoring	10
	Total	**90**

Evaluation of Risk

There is limited downstream risk to people or existing infrastructure from the project. Risks to the project are summarised as follows:

- The project is potentially in the tsunami inundation zone
- A dam break event would likely cause severe damage to the project features.
- High Elliot Dam spillway flows combined with natural runoff from downstream of the reservoir could result in very high discharge at the project site. The resultant floods could damage the Prescription 3 work by eroding the access path, eroding the spawning gravel sites, or damaging the LWD structures.

6.4 Prescription 4: Spawning Gravel and LWD Placements

Project Overview

Prescription Site 4 spans 180 m from the bottom of the Site 3 pool, downstream to the powerhouse tailrace (Figure 6). The active channel is 22 m wide and the thalweg survey indicated a gradient 1.6%. The channel bed is dominated by boulders and cobbles, with diameters ranging from 0.3–1.0 m. The project area was divided into upper and lower sections. The lower section experiences backwatering on high tides.

The upstream section is 90 m in length and has some pockets of gravel of moderate quality (Photo 6). The downstream section is 50 m in length and contains two consecutive runs, each with excellent gravel along the river right (Photos 7 and 8). This gravel has a mean grain size (D_{50}) of ~ 50 mm, is relatively free of fines and compaction, and thus has excellent spawning potential. Due to tidal backwatering, these gravels are probably limited to pink and chum salmon.

Prescription plans for the two sections of Site 4 include gravel and LWD installations for the purpose of increasing the quantity and quality of spawning habitat, and to provide cover for both adult and juvenile life stages.

Predicted Biological Benefits

Installation of gravel pads in the upper section are intended to increase available spawning area and provide higher quality gravel than currently available in this area. Gravel installations in the lower section are intended to augment existing high quality gravel. LWD installations will serve to provide cover for both adults during migration and spawning, and juveniles during rearing.

Estimated gains in habitat and fish production from this project are given in Table 11. The combined space from individual gravel pads is predicted to total 430 m^2, and potential support up to 956 pink, 430 chum, and 92 coho salmon. The installation of LWD is expected to permit greater density of both coho fry and steelhead parr within treated habitats. The Site 2 area was found to have a low abundance of trout parr compared with upstream sites (Burt 2013), presumably because boulder cover is smaller and less abundant. The LWD additions may offset this deficiency, and encourage greater steelhead rearing in this area. Improved rearing habitats are predicted to potentially support 508 coho fry and 118 steelhead parr, with a possible yield of 76 coho smolts and 74 steelhead smolts.

Table 11. Summary of habitat gains, and potential fish use from gravel and LWD installations at Prescription Site 4.

Life Stage	Species	Available Habitat (m^2)	Fish Use Under Current Habitat Conditions (including Elliott Dam fish flow releases)	Potential Fish Use After Project Completion
Adult Spawning	Pink, chum, and coho	141 (before) 430 (after)	Upper section: gravel in pockets; lower tidal section: 2 runs with good gravel; capacity: 242 pink, 124 chum, and 34 coho	Upper: potential for 4-6 gravel pads Lower: augment exist 2 runs Capacity: 956 pink, 430 chum, 92 coho; may be too close to tidal zone for steelhead spawning
Juvenile Rearing	Coho:	1,105	2 fry/100 m^2 → 22 fry → 3 smolts	46 fry/100 m^2 → 508 fry → 76 smolts
	Steelhead:	2,350	1 parr/100 m^2 → 24 parr (mostly RB)	5 parr/100 m^2 → 118 parr → 74 smolts

__Note:__ coho fry and rainbow parr densities under the current habitat situation are based on the average density in this section from Burt (2013) for post flow release years of the study (2008–2010).

Access

There are several potential access points for this project, however, the recommended one is from the relic road grade on the left bank (see Section 6.2). Other accesses include off the right bank from the north side of the BCH shop (same as described for Site 3). Medium sized tracked equipment would be suitable for constructing this access.

For access to the downstream project section, an equipment trail could be constructed along the edge of the river from either the left or right upstream access points. Alternatively, a ramp could be constructed down the 4 m high embankment along the north side of the tailrace. The access routes to the downstream section would be temporary.

Work Plan

The work plan for Site 4 is involves strategically placing spawning gravel in small pockets in the case of the upstream section, and installation of larger gravel platforms in the downstream section. Both sections would also receive installations of single and small groups of LWD.

For the upstream section, the spawning gravels would be placed in pockets formed by rearranging and removing some of the boulder bed substrate. Each spawning pocket would range from 10 to 60 m^2 in area, and there could be 4 to 6 pockets created for a total area of 230 m^2.

For the downstream section, existing spawning gravels would be enhanced by constructing several low grade control riffles, with gravel platforms immediately upstream of each riffle. The spawning platform size would conceptually be approximately 100 m^2 each for a total of 200 m^2.

Large LWD members will consist of large Douglas fir or Western red cedar trees with the root attached. The trees will have a stem diameter of approximately 750 mm measured above the root flare. Each LWD member will be tethered to in-situ boulders with chain or cable. Some of the LWD should be positioned in pools to provide cover for holding adults and rearing juveniles. Other LWD structures should be positioned to help hold spawning gravel in the pockets.

Heavy equipment for constructing Site 4 could include a medium to large size hydraulic excavator and a tracked skid-steer. The large size excavator will offer further reach and lifting capabilities. The skid-steer could potentially be eliminated depending on the access to the site. If the left bank access route is developed then tandem axle gravel trucks, or an articulating off-road truck, could potentially deliver the LWD and gravel materials directly to the site.

Preliminary Estimate of Costs

Preliminary costs were developed based on site conditions, past project experience, and are presented for planning purposes (Table 12); actual costs could range by a large margin. Costs are in 2015 dollars and include a tax allowance. Additional project details will be developed during the subsequent planning and design phases, which will allow refinement of project costs. The costs for developing the access to the upstream area have been included in Prescription 2; if Prescription 4 is implemented first then there would be additional cost to construct the access route. The cost to develop the access to the downstream section of Prescription 4 has been accounted for.

Table 12. Preliminary costing for Site 4 works.

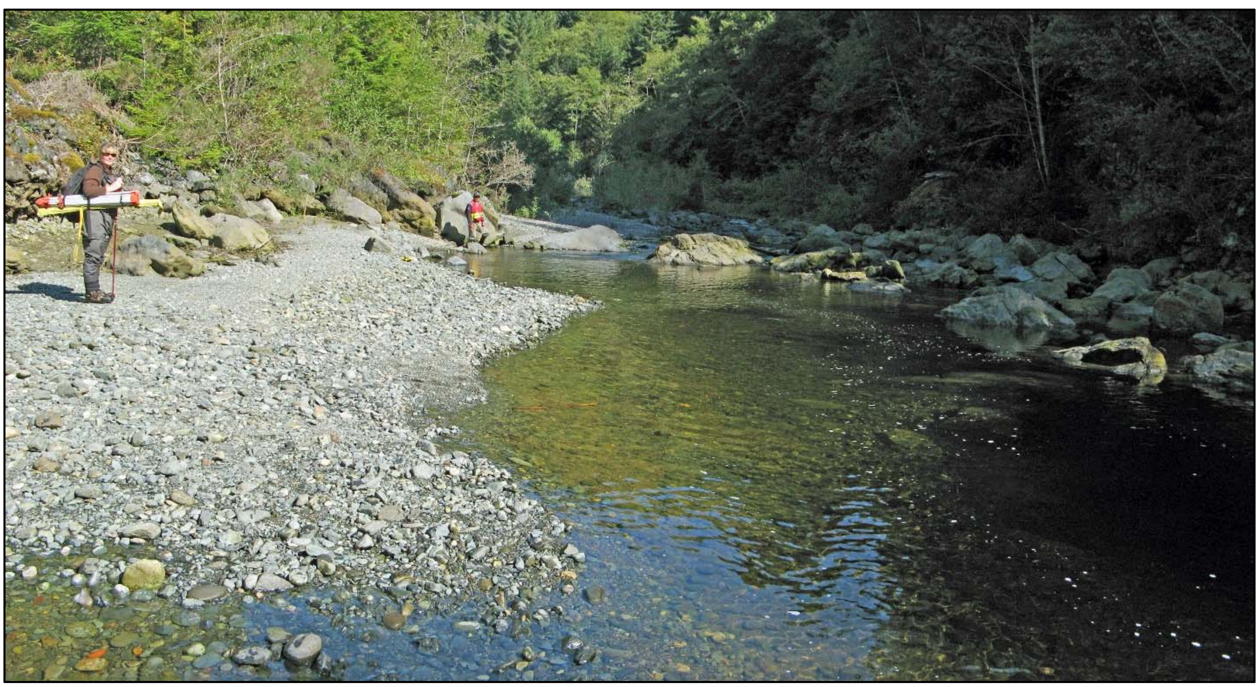
Item no.	Description	Cost ($,000)
1	Planning and design	15
2	Develop access from Hwy 4 (included in Site 2)	-
3	Develop access to downstream section	15
4	Supply and install spawning gravel	30
5	Supply and install LWD	25
6	Monitoring	10
	Total	**95**

Evaluation of Risk

There is limited downstream risk to people or existing infrastructure from this project. Potential risks to the project itself include:

- Tsunami and dam break scenarios would potentially cause severe damage to the project features.
- High Elliot Dam spillway flows combined with natural runoff from downstream of the reservoir could result in very high discharge at the project site. The resultant floods could damage the Prescription 4 work by eroding the access path, eroding the spawning gravel sites, or damaging the LWD structures.

Photo 6. View of Site 4, upper section, looking upstream (Sept. 3, 2014).



6.5 Prescription 5: Reach 1 Spawning Gravel, Phase I and Phase II

Project Overview

Habitats downstream of generating station tailrace consist of a scour pool in the immediate discharge area, followed by a large riffle section, a long run, a second large riffle, and finally a deep pool at the top of the dryland sort. (Burt 2014a) computed the overall composition of this region to be 56% pool/glide habitat, and 44% riffle habitat, with an overall gradient of 0.3%. The Prescription 5 project area is situated on the uppermost riffle at 80 m downstream of the tailrace, and extending downstream for 65 m (Figure 7). This site is toward the upper end of tidal backwatering.

The project site currently has some existing gravel on right side, consisting of an inner band of continuous gravel 495 m^2 in area, and an outer region of patchy gravel 423 m^2 in area (see Figure 7). The quality of this gravel was assessed as moderate due to shallowness of the layer, interspersing of small and large cobbles, and presence of 15% fines. Photos 9 and 10 provide a view of this gravel and its setting. The spawning capability of the exiting gravel was estimated to be 395 pink pairs and 182 chum pairs (Burt 2014a). There appears to be some use of this gravel as Jordan River Generating Station staff observed spawning activity and eggs in the gravel in approximately 2008/2009 (Dwayne Walsh, pers. comm.). Also, during the November 2014 snorkel survey by the Pacheedaht First Nation, a number of chum salmon were observed congregating over this gravel bed.

The presence of natural gravel at Site 5 represents the only location downstream of the tailrace where this occurs. The remainder of the region is indicative of a channel that has been degraded down to a hardened boulder layer, the main causes likely being repeated exposure to turbine discharges, and large spillway releases from upstream reservoirs. The occurrence of gravel at this location was attributed to the orientation of the tailrace, which directs flows obliquely to the opposite bank, which in turn redirects flows directly downstream. This leaves an inside semicircle that is protected from the full force of tailrace flows.

Work proposed for this site are to be completed in two phases. Phase I will replace existing gravel with higher quality gravel; Phase II will expand on the overall size of the spawning area. The target species are pink and chum salmon as they are known to spawn in tidal zones. These objectives are consistent with the first two "Priority Topics" of the Jordan Watershed Plan (BC Hydro 2011), namely: 1) re-introduction of pink salmon, and 2) multiple fish species habitat restoration.

An additional consideration during project implementation will be to place LWD in proximity to the installed gravel to provide cover for adults in a region where the channel is wide and exposed, and adults vulnerable to predation.

Predicted Biological Benefits

Potential benefits from this project for pink and chum salmon spawning are high due to the large area available for gravel addition. Phase I will replace existing gravel with high quality material free of cobbles and provide 500 m^2 of spawning area; Phase II will expand the gravel pad area by 1,000 m^2, resulting in a total area of 1,500 m^2 (shown in Figure 7). Potential numbers of spawners supported after completion of each phase are summarised in Table 13. After completion of both phases, this site is predicted to have a spawning capacity of 3,334 pink salmon and 1,500 chum salmon.

Table 13. Summary of habitat gains, and potential fish use from Site 5 gravel installations.

Life Stage	Species	Available Habitat (m^2)	Estimated Capacity Under Current Habitat Condition	Estimated Capacity After Project Completion
Adult Spawning	Pink and chum	Existing functional: 474 After Phase I: 500 After Phase II: 1,500	790 pink, 364 chum (Burt 2014a)	After Phase I: 1,110 pink, 500 chum After Phase II: 3,334 pink, 1,500 chum

Access

Access to the site is from the right bank using existing BC Hydro yard service roads. The right river bank is approximately 4 m high so a steep ramp would be constructed for heavy equipment to access the river channel. The ramp could be either cut back into the bank or extended into the mainstem using imported fill, preferably spawning substrates.

Work Plan

The pre-construction planning will involve field studies and analysis to confirm the viability of gravel placement at the proposed site. This will include establishing hydrometric, salinity, and DO monitoring stations at the proposed site, and preparing all necessary documentation to allow the project to move forward to the construction stage. The planning and design will involve the following tasks:

- Conducting topographic and bathymetric surveys of the lower Jordan River.
- Installing/monitoring of a water level logger, inter-gravel temperature/salinity probe, and inter-gravel DO probe. In addition, water samples will be collected for copper analysis.
- Digging of test holes for the possible presence of bedrock at the site.
- Snorkel surveys to assess adult salmon abundance in the lower Jordan River and usage of the various prescription sites (including this one).
- A hydrologic analysis.
- A numerical modelling study to assess without- and with-project conditions.
- Preparation of construction documents and design drawings.

The construction phase will require reworking of the existing substrate, including the in-situ boulders. Some large substrate may be excavated from the river to accommodate the design depth of spawning gravel without building up the river bed grade. There are two potential areas for introducing large scale gravel placements, Phase I is the trial project with a target placement area of 500 m^2, and Phase II is the full scale placement with a target placement area of an additional 1,000 m^2.

Preliminary Estimate of Costs

Preliminary costs were developed based on site conditions, past project experience, and are presented for planning purposes (Table 14); actual costs could range by a large margin. Costs are in 2015 dollars and include a tax allowance. Additional project details will be developed during the subsequent planning and design phases, which will allow refinement of project costs.

Table 14. Preliminary costing for Site 5 works.

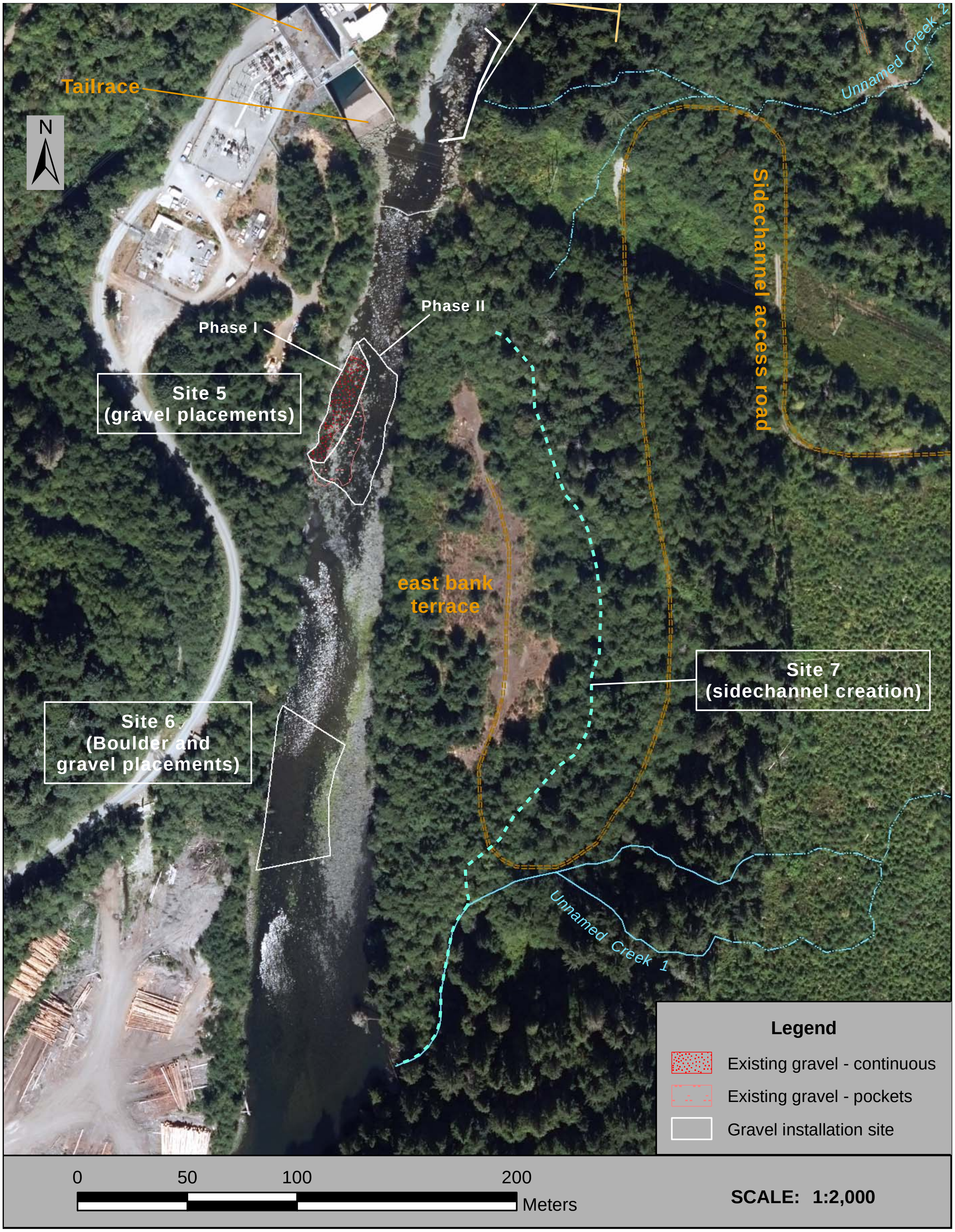
Item no.	Description	Cost ($,000)
1	Planning and design	125
2	Supply materials and construct Phase 1	150
3	Supply materials and construct Phase 2	250
4	Monitoring	25
	Total	**550**

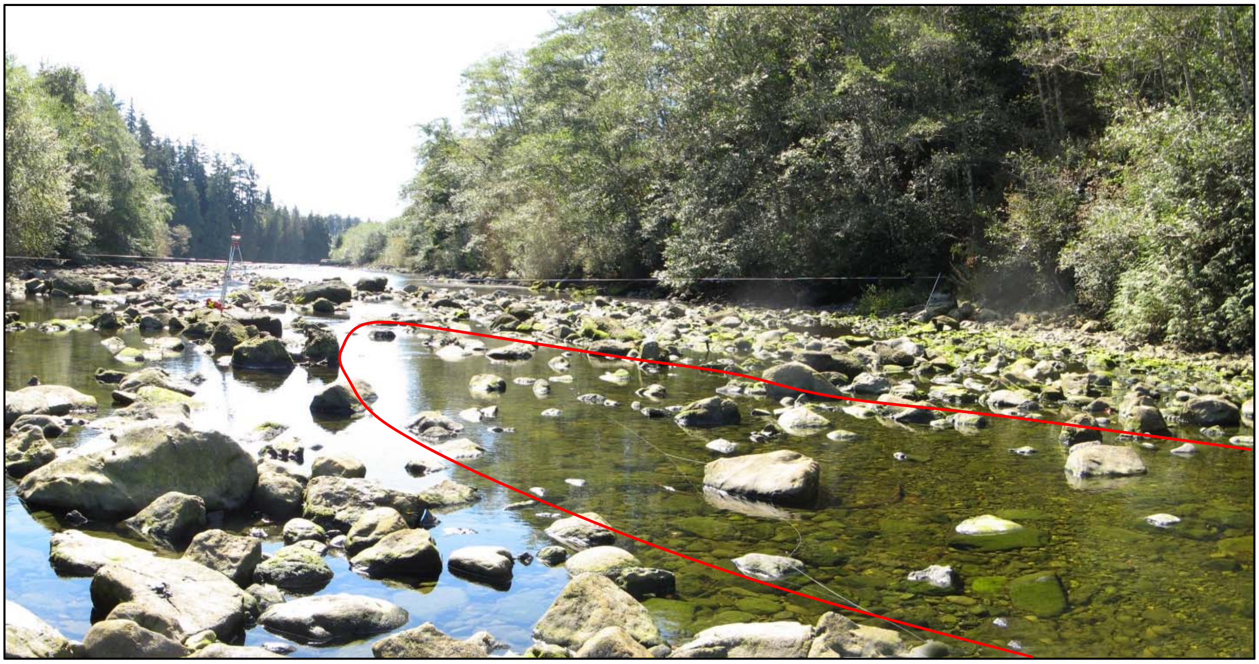
Evaluation of Risk

There is limited downstream risk to people or existing infrastructure from this project, however, if the gravel is eroded during a flood, additional dredging could be required in the log booming area.

Risks to the project infrastructure include:

- The project is within the inundation zone of a tsunami, and would be subjected to high flows in the event of a dam break scenario. Either event could cause severe damage.
- High Elliot Dam spillway flows combined with natural runoff from downstream of the reservoir could result in very high discharge at the project site. The resultant floods could damage the Prescription 5 work by eroding the spawning gravel sites.
- There is a risk that the spawning gravel placements could raise upstream water surface at the tailrace, and potentially affect operational efficiency. This risk will be assessed by completing detailed hydraulic modelling and assessment of without- and with-project conditions. The design concept that should mitigate this risk is to excavate the existing cobble and boulder substrate and replace it with the spawning gravel such that the final river grade is unchanged.
- The project site is tidally influenced and there is a possibility that salinity regimes may affect incubation success. This risk will be mitigated by monitoring the regimes at the project site during the planning and design component.


Tailrace
N
Unnamed Creek 2
Sidechannel access road
Phase I
Phase II
Site 5
(gravel placements)
east bank
terrace
Site 7
(sidechannel creation)
Site 6
(Boulder and
gravel placements)
Unnamed Creek 1
Legend
Existing gravel - continuous
Existing gravel - pockets
Gravel installation site
0
50
100
200
Meters
SCALE: 1:2,000



6.6 Prescription 6: Boulder Riffle and Spawning Gravel Upstream of the Log Sort

Project Overview

The project area for Site 6 is situated downstream of Site 5 and spans the tailout of the long glide and the initial part of the subsequent riffle (Figure 7, Photo 11). The channel width at the site is 55 m, and the bed gradient 0.3%. Existing substrate is mainly cobble and boulders; historic gravel bars have been scoured by high discharges. This site is the downstream-most location where there is an opportunity creation of spawning habitat, however, there is some uncertainty as to whether salinity regimes are acceptable for incubating eggs. Thus, a first priority for this site will be to monitor salinity cycles and relate results to tolerances of pink and chum eggs.

Predicted Biological Benefits

Potential benefits from this project are similar to Site 5 in that there is space for installation of a large gravel platform. Species use is anticipated to be limited to pink and chum salmon due to their ability to spawn in tidal reaches. The project plan involves installation of 1,500 m^2 of high quality gravel, providing an estimated spawning capacity of 3,334 pink and 1,500 chum salmon (Table 15).

Table 15. Summary of habitat gains, and potential fish use from the Site 6 gravel installation.

Life Stage	Species	Available Habitat (m^2)	Estimated Capacity Under Current Habitat Condition	Estimated Capacity After Project Completion
Adult Spawning	Pink and chum	Existing: none (scoured out) After placement: 1,500	none	3,334 pink spawners 1,500 chum spawners

Access

Site access is either from the north corner of the dryland sort, or from the sidechannel project area on the left bank. For either approach, an equipment ramp will need to be constructed to access the river bed. The ramp can be constructed by cutting the bank back, or by installing fill at the toe of the slope. If the fill method is used, then it is recommended that spawning substrates be used.

Work Plan

Prescription 6 would be constructed after Phases I and II of Prescription 5. The Prescription 5 flow model would be used to assess and design the work. The concept is to removed boulder and cobble substrate from the upstream portion of the riffle and the tailout of the pool, and replace these with spawning gravel. The gravel platform area would be approximately 1,500 m^2. The finished grade of the project would be similar to without-project conditions. This will reduce water level changes upstream, and it is expected to reduce shear forces acting on the gravel platform.

Cost Estimate

Preliminary costs were developed based on site conditions and past project experience. These estimates are presented for planning purposes (Table 16); actual costs could range by a large margin. Costs are in 2015 dollars and include a tax allowance. Additional project details will be developed during the subsequent planning and design phases, which will allow refinement of project costs.

Table 16. Preliminary costing for Site 6 works.

Item no.	Description	Cost ($,000)
1	Planning and design	40
2	Supply materials and construction	250
3	Monitoring	25
	Total	**315**

Evaluation of Risk

There is limited downstream risk to people or existing infrastructure from this project. However, if the gravel is eroded during a flood, additional dredging could be required at the log booming area.

Potential risks to the project infrastructure include:

- The project is within the inundation zone of a tsunami, and it would be subjected to high flows in the event of a dam break scenario. Either event could cause severe damage.
- High Elliot Dam spillway flows combined with natural runoff from downstream of the reservoir could result in very high discharge at the project site. The resultant floods could damage the Prescription 6 work by eroding the spawning gravel sites.
- There is a risk that the spawning gravel placements could raise the water surface at the tailrace, and thus potentially affect operational efficiency. This risk will be assessed by completing a detailed hydraulic modelling and assessment of without- and with-project conditions. The design concept that should mitigate this risk is to excavate the existing cobble and boulder substrate and replace it with the spawning gravel such that the final river grade is unchanged.
- This project site is tidally influenced and there is a possibility that salinity regimes may affect incubation success. As with Site 5, this risk will be mitigated by monitoring the salinity regimes during the planning and design component.

6.7 Prescription 7: Sidechannel Development

Project Overview

Salmon production from anadromous reaches of the Jordan River is severely limited by a shortage of both spawning and rearing habitat. Development of a sidechannel at the identified site (Figure 7) has the potential of creating an additional 390 linear meters of new habitat that could support both spawning and rearing life stages. Assuming an average wetted width of 3.0 m, total wetted area offered by the sidechannel would be 1,170 m^2. Furthermore, creation of a sidechannel would provide a protected and productive off-channel environment, which at present, is completely absent in the anadromous portion of Jordan River.

The location for the sidechannel is an alluvial floodplain terrace on the left bank between tailrace and the log sort (opposite bank) (Figure 7). A depression runs the length of the terrace at the foot of the sideslope (Photo 12). Sideslope seepage and subsurface flow from Creek 2 keeps the depression damp with the occasional puddle during the summer. Fall rains result in the depression filling with water with sequences of ponding and flowing water. The sidechannel alignment roughly follows the depression. At 300 m from its top end, the sidechannel would connect with Unnamed Creek 1 (Photo 14), and the remaining 90 m would follow the creek bed.

The floodplain terrace has been decoupled from the river due to scour and degradation of the mainstem channel bed. As a result, the sidechannel centerline starts at approximately 5 m above the river high water mark, but this elevation differential gradually decreases along the sidechannel route. The overall longitudinal gradient of the centerline 1.33% (Burt 2014b). The lower 15 m of Creek 1 is tidally influenced.

The sidechannel would be supplied by Unnamed Creeks 1 and 2, by groundwater intercepted from the east, and a by a diversion pipe from Unnamed Creek 3. Creek 1 flows year-round, but discharge is minimal in the summer; Creek 2 is ephemeral; Creek 3 has the most flow and appears to be spring-fed. The Unnamed Creek 3 water supply is critical to the success of the sidechannel project.

This project will be separated into four stages. The first stage (2015/16 FWCP Grant) is to conduct feasibility investigations that will include substrate and water quality testing at the sidechannel, and a flow diversion study for the summer water supply. As long as the key indicators measured in Stage 1 are positive, the second stage (in 2016/17) will include continued condition monitoring, engineering design, and construction planning. The third stage (in 2017/18) will see the construction and commissioning of the project, while the fourth stage will involve operations and maintenance components.

There is also a potential expansion project that would see the sidechannel extended downstream to the estuary area (see Prescription 8). The expansion would result in a longer channel and increased wetted areas.

Predicted Biological Benefits

There are a number of important benefits of sidechannel creation on the Jordan River:

- Sidechannel habitat is curently absent within the anadromous reaches.
- Sidechannels can be heavily complexed, providing extremely productive summer rearing habitat, excellent overwintering habitat (protected and with warmer water temperatures), the end result often being a high smolt yield per unit area of habitat.
- The proposed sidechannel design would offer aquatic habitat free of the elevated copper levels that still ocurr in the mainstem.
- The outlet of the sidehcannel (Creek 1) is a protected mainstem alcove and already heavily complexed with LWD, and as such, is expected to attract coho fry rearing in the tidal zone (see Photo 13). These fry would have an opportunity to move into and colonize the lower end of the sidechannel.
- The sidechannel would also offer excellent spawning, rearing, and overwintering habitat for searun cutthroat trout, and possibly assist in rebuilding historic runs of this species.

Estimated habitat and fish production gains from sidechannel creation at Site 7 are given in Table 17. The usable area calculations assume 10% of the length is spawning habitat, 8% low gradient ponding, and 82% pool and glide habitats. Total wetted area is estimated to be 1,170 m^2 with an average width of 3.0 m. Riffle sections are anticipated to support 20 adult coho spawners and 40 adult searun cutthroat spawners (may also be used by chum). The most important function of the sidechannel will be in providing rearing and overwintering habitats. For calculation of rearing potential, the full

Alkalinity Model density was used, which predicts the sidechannel could support 1,076 coho fry and 117 cutthroat parr, yielding 323 coho smolts and 74 anadromous cutthroat smolts.

Table 17. Summary of potential habitat and fish production achieved by creation of a sidechannel at Site 7.

Habitat	Species	Habitat (m^2)	Assumptions	Potential Use After Project Completion
Spawning	Coho, searun cutthroat, possibly chum	Assumed 10 riffles, each 4 m in length	**Coho:** 1 spawning pair per riffle (10 pairs) **Searun cutthroat:** 2 spawning pairs per riffle (20 pairs) **Chum:** may also spawn in the sidechannel	**Coho:** 20 adults (fall spawning) **Searun cutthroat:** 40 adults (spring spawning) **Chum:** perhaps 20 adults if they use it
Juvenile Rearing	Coho and searun cutthroat	390 m in length, 3.0 m avg. width = 1,170 m^2	**Summer rearing:** high quality habitat therefore assumed density = 100% of Alkalinity model = 92 coho fry/100 m^2 ;and 10 cutthroat parr/100 m^2 **Overwintering:** high quality overwintering therefore assumed overwintering survival rates of 30% for coho fry, and 63% for searun cutthroat	**Coho:** 92 fry/100 m^2 → 1,076 fry → 323 smolts **Searun cutthroat:** 10 parr/100 m^2 → 117 parr → 74 smolts

Access

Equipment access to the sidechannel site is by an existing gravel road on the east side of the river off of Hwy 14 (Figure 2). This road is in fair condition, and the margins recently machine brushed to the point where it passes under the BC Hydro power lines for the second time (just past Unnamed Creek 2). For the remaining 400 m, the road descends down the sideslope of the bench wall, and the margins are growing in with shrubs and alder shoots, and will need to be brushed. There is also the remains of a fallen tree that will need to be removed by chainsaw. Lastly, where the road ascends onto the bench (at the switchback) there is a plugged culvert, and flows along the depression at the base of the sideslope have partially eroded away the access road. Additional culverts and ditching may be required for the road to ensure it is functional for all seasons. Once on the bench, the ground is flat, stable, and open, giving good machine access to most locations on the bench.

Work Plan

The work plan is divided into 1) planning and feasibility, 2) construction, and 3) operations/monitoring. Some of the preliminary feasibility work has already been completed by the 2013 FWCP seed project (Burt 2014b), and as well as during the field reconnaissance for this report. Remaining feasibility tasks, are related to ensuring and quantifying the intended sources of water for the sidechannel.

For stage 1 (planning and feasibility), the investigation of subsurface water sources will require developing vehicle access to the site along the relic industrial road using a hydraulic excavator. The excavator will then be used to dig 5 test holes along the proposed channel alignment. The substrate and qualitative assessment of the water infiltration rate for each test hole will be logged. A perforated standpipe will be installed vertically in the test holes, and backfilled with native soil. The disturbed soil surface will be seeded with reclamation seed. Caps will be installed on the test well pipes to ensure that birds do not get trapped in the pipes. Standpipe water levels will be monitored bi-weekly in the summer and bi-monthly in the winter. Water quality measurements, including dissolved oxygen (DO) and temperature will be taken at the time of the water level recordings. Total and dissolved metals will be tested for 3 of the test holes.

The investigation of flow augmentation potentials from Unnamed Creeks 1, 2, and 3 will involve assessing their seasonal discharge rates. Spot discharge measurements will be taken in Creeks 1 and Creek 2 approximately bi-monthly using a Swoffer flow meter, or by salt dilution methods.

Creek 3 has been identified in pre-feasibility work as a potential year-round water supply for the sidechannel, and the concept is to potentially divert the full creek via a pipeline. This creek is free of copper above the mine access road, but picks up copper toxicity at the access road crossing, and/or as it travels down the sideslope from the road crossing. Therefore, the proposed pipeline would divert the creek from upstream of the mine road. This approach should have the added benefit of decreasing copper inputs to the mainstem.

A full discharge assessment is planned at Creek 3. The first component will involve mapping the creek upstream of the mine road crossing and identifying any seeps or springs. Once the creek topography is better understood, a water monitoring site will be selected. A semi-permanent v-notch weir will be constructed from aluminum plate, gabions, and EPDM liner, and installed by hand at the selected water monitoring site. The site will be outfitted with a self-contained water level logger, calibrated and programmed to collect water levels at 15 minute intervals. A water level/discharge rating curve will be developed for the v-weir by taking periodic flow measurements in the creek. At the end of the study period a stage discharge relationship will be used create a hydrograph. This information will be used in future project components to design the diversion pipe and sidechannel dimensions.

If the Stage 1 study indicates that the project is feasible, then Stage 2 work will progress. The Stage 2 work will primarily involve design and planning. This will entail conducting a detailed survey, continued flow monitoring on Unnamed Creek 3, preparing construction drawings and specifications, estimating construction costs, and obtaining permits and approvals.

Stage 3 work will be the construction of the sidechannel and intake. The work will be completed with heavy equipment such as hydraulic excavators, gravel trucks and a pipeline labour crew. LWD will be secured in the channel using limited ballast because of the regulated discharge.

The project will be monitored following construction. Some operation and maintenance work should be expected to keep the Creek 3 water diversion operating.

Preliminary Estimate of Costs

Preliminary estimates of costs were developed based on site conditions and past project experience (Table 18). These estimates are presented for planning purposes; actual costs could range by a large margin. Costs are in 2015 dollars and include a tax allowance. Additional project details will be developed during subsequent planning and design phases, which will allow refinement of project costs.

Table 18. Preliminary costing for Site 7 works.

Item no.	Description	Cost ($,000)
1	Planning and design (partially funded)	65
2	Intake pipe construction	200
3	Sidechannel construction	150
4	Operating and monitoring (2 years)	20
	Total	**435**

Evaluation of Risk

There is limited downstream risk to people or existing infrastructure from the project. Potential project risks are summarised as follows:

- The project is within the inundation zone of a tsunami, and it would potentially sustain severe damage in the event of a dam break scenario.
- The intake poses a significant risk for the project in that if it stopped diverting water into the sidechannel, fish could become stranded. Potential reasons for loss of intake flows include insufficient supply flow from Unnamed Creek 3, a blocked intake, a blocked or broken pipe, or a closed/blocked control valve. Mitigation of this risk could be assisted by remote monitoring of the sidechannel flow and/or water level. Other mitigation concepts include excavating deep pools in the channel (with LWD cover) so fish can seek refuge if the intake stops flowing. If the refuge pools are graded lower than the local water table they will not dewater.
- The project is an infrastructure investment, maintenance and operational effort will be needed. There is a risk that the project performance will diminish over time if adequate maintenance and operational effort are not provided.
- Water quality could affect the sidechannel performance. The sidechannel water will need to meet fisheries water quality criteria, and testing will need to include metals, dissolved oxygen, and others.

Photo 14. Beautiful setting at the lower end of Unnamed Creek 1. View is from the right bank, the creek at the base of the photo, and the left bank sideslope with mature timber (Aug. 21, 2013).

6.8 Prescription 8: Estuary Restoration

Project Overview

The purpose of the estuary restoration prescription is to re-establish and compensate some of the estuarine habitats impacted by development. The area of interest is on the left bank around the historic tailrace channel and is roughly bounded by a ridge on the north side, a forested area 250 m to the east, and the West Coast Highway (Hwy 14) 300 m to the south (Figure 8). The total estuarine area that could be created or enhance by this project is estimate be up to 8.26 ha.

The restoration area would generally be graded lower such that an intertidal zone is formed. A network of dendritic channels would be constructed and the historic tailrace channel would serve as the main tidal collector. The design goal will be to simulate natural estuarine morphology.

There is also a potential to connect the Prescription 7 sidechannel to the estuary site by excavating a channel through the ridge that separates the downstream end of the sidechannel and the north side of the estuary site. Alternatively, the two sites could be connected by constructing an intertidal bench that runs from the sidechannel outlet area, skirt around the ridge, then extends east near existing ponds/borrow pits, and finally connects to the historic BC Hydro tailrace channel at the head of estuary site. This route has been conceptually drawn in Figure 8. The concept is that the bench would contain a small intertidal channel that would conduct sidechannel flows along an extended path to ultimately discharge into the top end of the created estuary. This approach would reduce total excavation requirements associated with the ridge while increasing fish values to both prescription sites.

There is also potential to install a singular or multiple large diameter culverts under the West Coast Highway to provide additional tidal exchange. The rationale is that the added complexity and increased tidal exchange may increase primary and secondary production within the estuary site.

Predicted Biological Benefits

This project is estimated to create about 8.26 ha of estuarine habitats including salt marsh benches and islands, dendritic tidal fingers, and possibly a second outlet to the ocean to increase tidal flushing and exchange. This has the potential to compensate most of the estimated 10.3 ha of estuarine habitat lost by creation of the dryland sort.

Quantifying the fish production gains from this type of project are difficult; however, the value of estuarine habitats cannot be understated. They represent the last site of utilization prior to migration into the marine environment, they are typically a location of abundant food supply and rapid fish growth, and they are the site of adaptation to salt water. Given the importance of these habitats, particularly for species such as coho and chum salmon, and steelhead and searun cutthroat trout, and the fact that these habitats are extremely limited, this project is anticipated to be essential if the Jordan River is to rebuild salmonid runs close to historic numbers. It is possible that the lack of estuarine habitat may quickly become a production bottleneck as runs begin to rebuild. Thus, this project should be elevated to a high priority once there are tangible signs of salmonid run rebuilding.

Access

Site access is directly off of the West Coast Highway. There is an existing gravel road network that provides good access to the area.

Work Plan

There are a range of restoration options appropriate for the site. The first steps are to confirm land use approvals. Pending the success of that step, several restoration concepts should be developed and assessed for their expected biological performances. A two-dimensional numerical model should be used to assess the various options, and this model should be coupled with the river model. These would serve as tools to provide important hydraulic outputs such as velocities, shear stress, water depths, and wetted areas for a combination of river flow and tidal conditions. Once the estuary project is selected, a detailed set of construction plans and specification will be created. The project can be separated into multiple phases to spread out the capital costs.

Most of the construction work will require grading the terrestrial area lower to create a range of shallowly sloped intertidal terraces. The terraces will be vegetated with native plants to stabilise the soils and provide fish habitat. A series of dendritic channels will drain the terraces into the relic tailrace collector channel.

Some groundwater and season surface water is expected to provide some fresh water influence on the estuary area. Directing flow from the Site 7 sidechannel through the estuary area would assist with this aspect and could be accomplished with a connector channel from near the downstream end of the sidechannel.

Culvert(s) under the West Coast Highway will require planning and coordination with the BC Ministry of Transportation and Infrastructure (MOTI). The culvert(s) will need to be resistant to salt water corrosion, such as high density polyethylene, concrete, or aluminum pipe. Erosion control will need to be accommodated at the upstream and downstream ends of the culvert(s). A geomorphic assessment is required to review the potential sediment effects from the coast.

Preliminary Estimate of Costs

Preliminary costs were developed based on site conditions and past project experience (Table 19). These are presented for planning purposes; actual costs could range by a large margin. Costs are in 2015 dollars and include a tax allowance. Additional project details will be developed during subsequent planning and design phases, which will allow refinement of project costs.

Table 19. Preliminary costing for Site 8 works (estuary enhancement).

Item no.	Description	Cost ($,000)
1	Planning and design	100 - 200
2	Extend / connect sidechannel	125
3	Estuary benching	100 – 1,000
4	Highway culvert	500
5	Monitoring	50
	Total	**875 – 1,875**

Evaluation of Risk

The potential risks of the project are as follows:

- There is potential risk that the project would interfere with log transport and storage activities. This is considered a low risk because the restoration activity would be focussed on the existing left bank area that is mainly terrestrial, and not currently used by the log sort.
- Breaching Hwy 14 will require a culvert(s). This infrastructure is subject to plugging and degradation over time. Inspections and maintenance will be required.
- The project is within the inundation zone of a tsunami, and it would potentially sustain severe damage in the event of a dam break scenario.
- Though this project is not intended to provide spawning habitat, there is a possibility that spawning could occur in constructed areas. If so, there is a possibility that salinities could adversely affect incubation survival.


N
Dryland Sort
Unnamed Creek 1
Site 8
(Estuarine enhancement)
Sidechannel extension
Original Tailrace Channel
Outer boundary for salt marsh benches and dendritic channels
West Coast Highway
Ocean connection
0
50
100
200
Meters
SCALE: 1:3,000

7. CONCLUSIONS AND RECOMMENDATIONS

Early accounts of the Jordan River speak of a time when the lower river was extremely productive with abundant runs of salmon, steelhead, and searun cutthroat trout (Recreation Resources Ltd 2001). The demise of these runs can be related to a number of industrial activities and events, however, key among these were the introduction of copper to the river, infilling of the estuary to build the dryland sort, and the change in location and operation of the Jordan hydroelectric facility. The implementation of the fish flow releases from Elliott Dam in 2008 was the first tangible step to date, in attending to the needs of Jordan River fish and their aquatic habitat. These flows have provided sufficient dilution of copper that fish can now rear and grow in the lower river. Further, the extra water has improved the quantity and quality of fish habitat and increased the production of aquatic insects (food supply). The goal of this document is to provide a plan that allows for future steps in the recovery of the historic salmonid runs to the Jordan River.

The early escapement records suggest the lower Jordan once supported runs of about 700 coho, 1500 chum, and an even-year run of about 3,000 pink salmon. Estimates are not available for steelhead and searun cutthroat trout, but early accounts by persons knowledgeable of the area, indicate that these species were readily caught at certain times of the year. The spawning habitat components of this plan are estimated to be able to support roughly 8,000 pink, 4,000 chum, 290 coho and 132 steelhead. Thus, if the early escapements are taken as targets, the restoration projects have the potential to meet the spawning needs of pink and chum salmon, but not those of coho (and probably steelhead trout). The difficulty in providing spawning habitat for coho and steelhead is due to the short length of non-tidal stream available, and the inability to install large spawning beds in these reaches. The best option for achieving additional coho and steelhead production gains would be to provide fish passage at the current anadromous barrier.

Typically species such as coho and steelhead are limited more by rearing and/or overwintering space than spawning space. The rearing projects in this plan include LWD additions in the Jordan mainstem to improve the quality of rearing habitat, and hence densities supported; and a sidechannel project to increase the quantity of both rearing and overwintering habitat. The latter would be particularly beneficial to coho rearing and overwintering. Calculated smolt yields from all project is estimated to be 730 coho smolts and 450 steelhead smolts. These are relatively small numbers, which are again, related to the current short anadromous length. In addition, conservative production biostandards were used and actual production could be higher than these estimates. As above, the greatest gains in coho and steelhead rearing and subsequent smolt production, would be achieved by providing fish passage at the 4.6 m anadromous barrier (an additional 900 m of spawning and rearing habitat would become available).

The recommendation of the authors, is that initial restoration efforts be directed towards three separate areas: 1) the sidechannel option (provided feasibility works are positive), 2) a non-tidal spawning gravel and LWD placement project, and 3) Phase I of the tidal Site 5 spawning gravel installation. These three projects are located in three distinctly different zones, and would serve as pilots to determine what strategies work best in terms of both construction logistics, and in fish utilization success. This approach would allow testing of project uncertainties; for example spawning use of gravel installations, salinity regimes and egg survival within tidal spawning platforms. Results could then be used to adapt or modify methods for future projects.

It is also recommended (and planned) that a local stewardship group be formed to be guiding mechanism for implementation of the various projects. The objectives of the group will be to provide a venue for communication and sharing of information, to solicit input and involvement in restoration plan projects, and to ensure all parties are fully informed and have a voice in guiding the recovery of the Jordan River.

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9. ACKNOWLEDGEMENTS

The authors are especially grateful for the ongoing assistance provided by Helen and Jeff Jones of the Pacheedaht First Nation fisheries section. Many thanks for your assistance in the field, for undertaking the fall 2014 snorkel survey, and for untiring support of all things Di Di Daht (Jordan River). Thanks also to the staff and Jordan River Generating Station (Dwayne Walsh, Al Hall, and Brent Mockford) for providing lockout and for ongoing anecdotal observations of fish activities.

This project was made possible through the financial support of the Fish and Wildlife Compensation Program, administered on behalf of program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations, and Public Stakeholders.

APPENDICES

NEWS

Fish and bear in Jordan River to benefit from funding

by Britt Santowski - Sooke News Mirror
posted May 21, 2014 *at* 5:00 AM

According to a press release issued by the Fish and Wildlife Compensation Program (FWCP) — a partnership between BC Hydro, the Province of BC, Oceans Canada, First Nations, and local community groups — two projects have been award to the benefit of Jordan River.

"Two projects aimed at rebuilding salmon stocks and creating dens for Black Bears in the Jordan River watershed will benefit from more than $62,000 in funding from the Fish and Wildlife Compensation Program," reads their May 5 release.

"The salmon project will bring a range of stakeholders together to develop a restoration plan for fish, and fish habitat in the watershed," it continues. "The Black Bear project will create manmade dens to simulate natural dens in large hollow trees, which are in decline in the area."

The projects will start in the spring and end by early 2015.

The Salmon Project refers to a plan to be prepared by D. Burt and Associates from Nanaimo. Their short term goal is "to involve local land owners, stakeholders, First Nations, and agencies to support project objectives and encourage participating in future restoration initiatives."

To this end, D. Burt and Associates from Nanaimo received $34,631.

David Burt has been involved with Jordan River since 2005, when he was awarded a BC Hydro contract to take an annual inventory of juvenile trout at 15 index sites between Elliott Dam and the Jordan River Generating Station tailrace.

"I spent a lot of time putting various reports together," said Burt, referring to the past nine years. "I've kind of made it my pet river." He has worked closely with the Pacheedaht First Nation in compiling his findings, and will continue nurturing that relationship.

"What I've observed over the years," he said in conversation with the Mirror, "is that when you get the different user groups involved, when you get the logging companies involved, eventually they start to acquire the same knowledge and take a vested interest in helping with the river as well, and that starts to affect how they operate within the watershed."

The plan created in this phase will ultimately be used in Burt's longer-term plan "for future restoration efforts in the lower Jordan River," where a roundtable group of various shareholders will be established to work collaboratively in efforts to increase Jordan River's fish stock.

The second project, the Black Bear Project "will create Black Bear dens in existing forest structures, and evaluate opportunities for artificial den creation."

Helen Davis of Artimis Wildlife in Victoria will receive $27,723 for this first part of a two-part project. The Black Bear project is in response to the deforestation in the area, which has removed many of the large trees used by bears to build their dens.

Davis said that they are just in the beginning steps of this project. “I’m still figuring things out and getting organized,” she writes in an email. “We haven’t actually done any work ‘on the ground’ yet.”

However, she does plan to keep the Sooke News Mirror informed, and will provide photos when the first dens are situated.