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Campbell River Spawning - Gravel Placement Project

An Example of Spawning Areas Assessment and Restoration Measures

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Preface

The abundance of non-stream-rearing salmonid species (including sockeye, chum, pink and kokanee) can be limited by the distribution, quantity and quality of spawning areas throughout a stream, assuming flows are within an adequate range. In contrast, stream-rearing species (such as chinook, coho, steelhead, cutthroat, rainbow and char) are limited by the amount and quality of rearing area, including winter refuge and summer rearing areas, along with the productivity of their food chain. Rarely are stream-rearers limited by the quantity and distribution of spawning areas; however, there are examples of such cases, of which Campbell River is one example.

The placement of gravel platforms in Campbell River provides additional spawning area which is a limiting factor for chinook salmon. As WRP Technical Circular 9 describes, this is a process that requires careful attention to certain important factors. The circular explains basic guidelines (Chapter 5) and calculations (tractive forces, Chapter 12), that are needed to predetermine that placed substrate will not be flushed out as bedload at bankfull freshets. This Campbell River project is featured in Streamline to illustrate the degree of assessments and prescriptions needed for successful augmentation of spawning areas. A project of this type may be required in the Watershed Restoration Program where historical spawning sites have been lost or degraded, and are likely to restrict stock recovery.

Introduction

Lakes can affect downstream freshwater habitat in a variety of ways:

- By functioning as settling ponds thereby settling out suspended sediments and bedload.
- By storing water during major storm events thereby providing lower and more stable peak flows downstream.
- By storing water during storm events that is released later thereby providing additional water during low flow seasons.
- By working as heat sinks during the cold winter season thereby preventing the formation of ice downstream and freezing of spawning bed.

In general, lakes have a positive impact on the fish habitat downstream (although man-made reservoirs can cause negative impacts, particularly if not operated to simulate a natural seasonal flow cycle). However, lakes which function as gravel traps can negatively affect fish streams that lack sufficient amounts of suitable spawning gravel. Gravel

continued

This Quarter

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Editor’s Note: The feature articles in this issue provide valuable examples of planning and procedures that can be applied to the restoration of watersheds.

Feature

recruitment downstream is reduced when fluvial deposits of gravel and cobble originating upstream settles in the lake. This is the case in the Campbell River below the John Hart Generating Station. Campbell River has historically been an important area for chinook salmon spawning. Earlier records show that this river supported a mean escapement of 4980 chinook spawners, but chinook spawning capacity had declined to less than 200 fish.

A key factor that sustained the area and quality of the chinook spawning habitat was the recruitment of spawning gravel from glaciofluvial deposits found between 500 and 600 ft. above sea-level. This source of glaciofluvial deposits of gravel and cobble was lost when the John Hart hydro-dam was constructed in 1947. This source of natural gravel recruitment to the Campbell River is no longer available.

The meander pattern of Campbell River is more compressed than is characteristic for a river with a flow regime and bankfull width of this size. The tractive forces in the system are high throughout a large percentage of the wetted area. Over the past 50 years, periodic high flow events have flushed most of the remaining gravel into the estuary and a comparison of streambed gravel composition by Burt and Burns (1995) and Hamilton and Buell (1976) demonstrated an overall increase in substrate size. The riverbed is composed now predominately of large cobble and boulders.

Project Objectives

Burt and Burns (1995) identified the need to restore chinook spawning habitat in the Campbell River. The goal for this project was to create chinook spawning habitat for 4000 adults**.** This target is based on historic escapement records. A target of 20,000 m^2 of chinook spawning habitat was derived using a bio-standard for high quality chinook spawning area of 10 m^2 per spawning pair.

Initially, as much spawning habitat as possible was created in available side-channels. This was considered to be a much safer approach than trying to create spawning habitat in the mainstem. Two major side-channels were built and another is currently being designed. All combined, these channels provide approximately 8676 m^2 of spawning habitat. It became clear that, to meet chinook spawning objectives, additional spawning habitat would have to be created in the mainstem.

An interim flow management strategy was developed for regulating flow releases from the hydro facility. This was necessary to more closely mimic the pre-dammed flows, to minimize the impacts on the fresh-water life history of salmon, and to improve the potential for developing spawning habitat in the Campbell River. A specified target flow regime was established and a 2.0 meter flood buffer was set for the Upper Campbell reservoir. A total release of 453 m^3/s (16,000 cfs) is allowed when the flood buffer is encroached. These regulations, soon to be officially adopted, will improve the opportunities for gravel placement in the river.

To meet the spawning capacity objectives, two approaches for mainstem gravel placement were considered. One option was to dump large quantities of gravel into the canyon and allow the river to distribute the gravel downstream during flood events. The other was to strategically place the gravel at locations where hydraulic conditions were determined to be satisfactory.

Assessment and Prescription

A river engineering specialist investigated the area and concluded that mass dumping of gravel into Elk Falls canyon would be inefficient because of the intense hydraulic flood conditions in the river. The specialist estimated that only 10-15% of the gravel dumped into the canyon would deposit in downstream locations where spawning conditions would be suitable, and predicted that most of the introduced gravel would be flushed out to the estuary. Approximately 4,000 m^3 of gravel would have to be introduced into the canyon every second year to maintain as little as 400 m^3 of questionable spawning habitat.

The better approach was therefore to place gravel in the most hydraulically stable areas. If these sites did not lose gravel too quickly (i.e. less than 2 years) and were found to be successful spawning areas for chinook, other spawning areas in the mainstem could be developed. However, if the most hydraulically stable areas proved unsuccessful, there would be little chance of success elsewhere in the mainstem until flows could be further reduced or rock deflectors and/or groynes could be incorporated into the gravel placement sites.

Site selection criteria were based on: preferred spawning conditions of chinook salmon; accessibility by helicopter long-lining (because of poor access); and hydraulic considerations, such as bankfull widths, water depth, tractive force at various flows, and the presence of existing boulders, large woody debris and back-eddies that would reduce tractive forces and limit the downstream migration of the gravel.

Location

Gravel was placed by helicopter at three sites located in the mainstem Campbell River from the John Hart

Generating Station to 500 metres downstream. A fourth site was located downstream at the new Highway 19 Tamarac bridge site on the Campbell River.

Gravel Placement Criteria

The flow target for the Campbell River during the spawning and the incubation periods is 122 m^3/s (4300cfs) The minimum target is 96m^3/s (3400cfs). Each gravel placement site was provided with a minimum gravel depth of 0.4 meters and was to stay wetted at a flow of 40 m^3/s (1400cfs). The gravel was placed at this discharge. The water depth at each of the gravel placement sites was approximately 0.6 to 1.0 meter during a river discharge of 122 m^3/s.

Four sites were identified for gravel placement. Three of the sites were located at the tail-out of pools in the upper half of the Lower Campbell River where chinook have historically concentrated their spawning. These three sites were located on river sections where the wetted width was widest to minimize the increase in water depth and tractive force during floods. The bankfull widths at these sites were 90 m at site 1, 110 m at site 2 and 100 m at site 3. Since there is no road access to these three sites, a helicopter was used to place the gravel in the river (Figure1). The fourth site was located downstream beside the new Campbell River Island Highway Bridge which was under construction. This site was accessible by road vehicles.

Due to the high tractive forces throughout the system much of the spawning gravel in the river has been washed into the estuary. Therefore, to increase the success of gravel placement the candidate sites were located in low hydraulic gradient sections of the river. The gradient at site 1 was 0.272%; site 2 was less than 0.1% and site 3 was 0.338%. These gradient figures are accurate at a discharge of 122 m^3/s (4300cfs). However, at higher discharges, the hydraulic gradient increases and the change in gradient vs. discharge has yet to be determined.

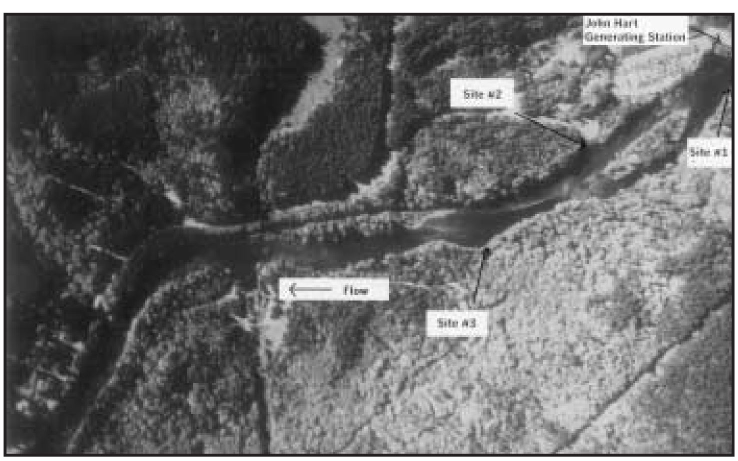

Figure 1. Aerial demonstrating three sites located on the lower Campbell River that could only be accessed by helicopter. Heli-sites were located at the bankfull width is widest.

The tractive force at each site should be low enough to not move the placed spawning gravel. The tractive force at site 1 is 2.72 kg/m^2 @ 122 m^3/s (4300cfs) and approx. 10 kg/m^2 @ 342 m^3/s (12,000cfs) assuming the gradient is 0.5% at 342 m^3/s (the actual gradient is probably less which reduces the tractive force). In theory, gravel 2.72 centimetres in diameter will be stable at 122 m^3/s and gravel 10 centimetres in diameter will be stable at 342 m^3/s.

At site 2, the tractive force is 1 kg/m^2 @ 122 m^3/s (4300cfs) and approx. 10 kg/m^2 @ 342 m^3/s (12,000cfs). At site 3 the tractive force is 3.38 kg/m^2 @ (4300cfs) and approx. 10 kg/m^2 @ 342 m^3/s (12,000cfs).

In theory, if the gravel composition is mainly 10 centimetres in diameter, all three sites should be stable up to a discharge of 342 m^3/s (12,000cfs). Site 1 has large boulders within the placement site. At high discharges, the boulders reduce scouring by creating roughness in the streambed, which reduces tractive force. Site 2 has a natural log and rock weir at the downstream perimeter of the placement site, which helps key-in the gravel; site 3 is far removed from the thalweg.

Tractive forces for a discharge of 453 m^3/s (16,000 cfs) were not calculated. Conceivably, the placed gravel may be stable, depending mainly on the hydraulic gradient at this discharge. The local hydraulic gradient may be lower than the assumed gradient of 0.5% at this flow.

Rehabilitation Works

Sites 1, 2 and 3.

Equipment used at the upper three sites included a Bell 212 helicopter, a track excavater and two cargo buckets to carry the gravel by helicopter.

Due to poor access for conventional earth-moving machines, a Bell 212 helicopter was used to deliver gravel to the upper three sites. Six inch minus washed spawning-gravel was trucked to a staging site near the John Hart Generating Station which was central to the upper three gravel placement sites.

Two self-dumping metal buckets (0.82 meter in diameter by 0.77 meter high and weighing 150 kg.), were fabricated for the helicopter. The gravel capacity was 0.4 m^3. A 34 m long-line was used to carry the buckets and no additional pilot-operated controls were required. The two ends of a cable bridle were fastened

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to each side of the bottom of the bucket with locking shackles. The cables fitted into grooved brackets welded to each side at the top of the bucket. The weight of the filled bucket of gravel kept the cables locked in the grooves and prevented the bucket from tipping over (Figure 2).

Each bucket was filled by an excavator at the staging site. When a full bucket was lowered onto the river-bed the cables slackened and slid out from the grooves. As the bucket was lifted it flipped upside down, dumping the gravel. The empty bucket was returned to the staging area, unfastened by a two-man crew and a second, full bucket attached. A third ground-crew member maintained radio contact with the pilot at the staging site (Figure 1). There were two pilots on site, each flying alternately for one hour, making about 20 round trips during the hour. The helicopter would then be refuelled and the pilot changed.

Initially, the lift capacity of the helicopter was set at 910 kg. After 3 days of flying, the pilots realized they could safely increase their payload to 1135 kg. To capitalize on this, the height of the buckets was increased to 0.9m high, the weight of the buckets and the gravel capacity was increased to 160 kg and 0.47 m^3, respectively. The helicopters began to carry less fuel, to maximize the payload.

Additional personnel was retained on-site to refuel and maintain the helicopter. The helicopter was refuelled at a temporary heli-pad locaterd near the John Hart Generating Station. A cache of 50 gallon barrels of fuel was stored on-site.

Spawning gravel was placed to an average depth of 0.6 to 1.0 meter at the three upper sites.

- Site 1 received 123 m^3, average depth of 0.7 m, spawning area of 175 m^2.
- Site 2 received 136 m^3 ,average depth of 1.0 m, spawning area of 136 m^2.
- Site 3 received 95 m^3, average depth of 0.6 m, spawning area of 158 m^2 .

The three upper sites were located in the Elk Falls Provincial Park. Park officials were notified of the project and the activities involved. Parts of the river and a popular walking trail along the river had to be closed. Information on the project was provided to the public through newspapers, local television, radio, and information notices. Barricades and security personnel controlled access to the trails and river banks where the helicopter was operating, as well as to the staging area at the John Hart Generating Station.

Site 4.
Equipment used at the lower site included a Tandem truck, a Cat IT24F loader, a Swenson Cross Conveyer

Figure 2. Operating the self-dumping buckets that were fabricated for the helicopter.

and a Komatsu PC 200 excavator.

Two spawning platforms were created beside the new Campbell River Island Highway Bridge which was under construction. With the co-operation of the construction company, a temporary bridge that had been placed to construct a concrete support pier in the middle of Campbell River, was used to place 715 m^3 of gravel in the centre of the river. A local contractor delivered 6" minus washed spawning-gravel to the bridge site. Gravel was dumped off the bridge with a loader and a dump truck that had a side-cast conveyer mounted on the back. The Swenson Cross Conveyor (under-gate sander on belt) and loader were used at this site to unload gravel off the bridge. After the temporary bridge was removed an excavator was used to spread the gravel in the river over a specified area. Spawning gravel was placed to an average depth of 0.3 to 0.6 meter at this site.

- Site 4a received 155 m^3 ; average depth of 0.3 meter; spawning area of 455 m^2.
- Site 4b received 560 m^3; average depth of 0.6 meter; spawning area of 934 m^2.

Production Estimates

Total spawning area (m^2) created:

- Site 1 - 175 m^2 (Figure 3)
- Site 2 - 136 m^2 (Figure 4)
- Site 3 - 158 m^2
- Site 4a - 455 m^2
- Site 4b - 934 m^2
- Total - 1858 m^2

Project Proponents and Cost Summary

This project was funded jointly by DFO, BC Hydro, MELP through the Habitat Conservation Fund, and community groups, including: the Tyee Club, the

Steelhead Society and the Tideguide Association. DFO provided engineering, biological support, project administration, and supervision. Dr. Bob Newbury, a hydrologist, provided information on river dynamics, gravel stability and site suitability. Total cost of the project was $154,000, supported from the Tyee Club ($5,000), the Steelhead Society ($5,000), the Tide Guide Association ($5,000), the provincial Habitat Conservation Fund ($23,000), the federal Department of Fisheries and Oceans (construction costs, $87,500; design/supervison, $4,000), B.C. Hydro ($25,000).

Post-assessment:

All the sites have been surveyed and a follow-up survey will be conducted to determine the amount of gravel remaining. Inspections to date, after high flows, indicate the the project has been successful. The platforms will also be snorkel surveyed during the spawning season to determine the degree of utilization by salmon. If flows permit, redds will be sampled to assess egg survival.

Figure 3. Aerial of the river showing the three heli-sites. (Located at the tailout pools where the bankfull width is widest.)

Figure 4. Spawning area created at Site 1.

The weak point at all three gravel placement sites is the perimeter gravel facing the centre of the river. This gravel edge has a slope close to the angle of repose and is obviously prone to erosion. Ideally, this slope would be armoured with rip rap or large boulders. However, there was some objection to doing this because of cost and the potential of creating a hazard to canoers, kayakers and tubers.

A target of 20,000 m^2 of chinook spawning area is required to achieve the target escapement of 4000 adults. This target is based on historic escapement records and a bio-standard requirement of 10 m^2/ spawning pair. Approximately 8676 m^2 of spawning area will be created from side-channel developments in the Lower Campbell River. However, other side-channel opportunities are limited. To meet the target requirement additional spawning habitat is being created in the mainstem. Close to 1900 m^2 of spawning gravel has been placed and is being monitored to determine ulitization by spawners and gravel stability. The pads appear to be stable after being subjected to discharges over 11,000 cfs and were utilized by sockeye, chum and chinook spawners. Based on these preliminary results, additional spawning platforms will likely be installed in the summer of 1998.

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Stream Restoration and Slope Stabilization of a Ravine Landslide

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Introduction

In October 1996, a slope failure occurred at the alignment of a storm drain that traverses a steeply-sloping southern bank of Kendale Ravine in a residential area in northwestern Delta, British Columbia (see Figure 1). The slope failure (shown in Figure 2) occurred within approximately 6 m of a residence situated on a flat-lying, upland plateau area located to the south of the steeply-sloping bank of the ravine. The failure also affected a small fish-bearing stream.

Area Overview

Kendale ravine is a broad, 'U-shaped' valley. It is vegetated with mixed coniferous and deciduous trees as well as mixed shrubs and other low cover plants typical of riparian zones in the Lower Mainland area. Kendale Creek lies at the valley floor of the ravine and flows westward from an area of residential development. The stream flows under River Road in a culvert to a junction box; it is redirected through another culvert to a small tributary joined by a canal to the Fraser River. The invert level of the culvert that empties into the canal is about 0.5 m above the water level in the canal under low tide conditions in the Fraser River. The combination of culverts, junction box and elevated culvert invert are not considered total obstructions to upstream fish passage, although no anadromous fish have been reported in Kendale Creek upstream of River Road in recent times. The creek at present contains resident cutthroat trout. Other species, including stickleback and sculpin, have also been reported (MELP files).

Kendale Creek Before Restoration

Upstream of the River Road culvert, the creek has two distinct reaches. The first extends upstream from River Road for approximately 100 m. It consists of three pools separated by gradients of approximately 18% (Figure 1). Reach 2 extends from the last pool approximately 100 m upstream to the slope failure area. Gradient separations in Reach 1 consisted of rip rap (approximately 200 to 600 mm diameter) which formed a series of small pools that allowed fish passage extending about 100 m upstream to an obstruction. The pools ranged in length from 5 to 35 m long, 3 to 5 m wide and between 0.3 and 0.5 m in depth. The right bank of the pools were densely vegetated with ferns, shrubs, mature coniferous (cedar and fir) and deciduous (principally alder) trees. The left bank of the pools lacked vegetation with the exception of low cover grasses. An existing access road ran parallel to the pools along the left bank and was maintained to provide access for the periodic cleaning of sediments from the pools. The right and left banks of Pool 3 were oversteepened, reflecting previous excavation works that had created the three pools some years ago to provide flood and sediment control. The pools all had considerable accumulations of sediment, presumably as a result of past upstream bank and slope failures. Disposal of household refuse in and adjacent to the pools was also apparent.

The obstruction occurred between the two reaches, located about 100 m upstream from River Road (Figure 1). The obstruction was about 1.5 m in height and was the inferred limit of upstream fish movements, given that no fish were captured or observed above this point. The creek width upstream of the obstruction ranged from 1 to 3 m. Both banks were densely vegetated with shrubs, ferns and deciduous trees (broadleaf maple and red alder). Stream gradients were less than 5%. Reach 2 continues to the bank failure zone approximately 100 m upstream of the obstruction. The creek displays similar characteristics above the failure zone, but limited surveys were undertaken above this zone and the extent to which