Strategy for Spawning Habitat Enhancement and Monitoring in the Lower Campbell River

Project No. COA-F19-F-2905-DCA




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EXECUTIVE SUMMARY

The lower Campbell River supports a high value fishery and provides habitat for Pacific Salmon and other anadromous fish in the 5.6 km section of the river downstream of Elk Falls. A key fisheries concern is the lack of gravel recruitment, which has reduced the area of salmonid spawning habitat in the lower river to the point where gravel placement is required to maintain suitable spawning habitats for species such as Chinook Salmon. This Strategy for Spawning Habitat Enhancement and Monitoring in the lower Campbell River has been developed to provide strategic direction to guide future gravel placement and monitoring projects. The Strategy has been funded by the Fish & Wildlife Compensation Program (FWCP), although components of the Strategy are also relevant to spawning habitat restoration projects supported by other funders.

The FWCP Campbell River Watershed Action Plan (FWCP 2017) prioritized the development of a plan to guide placement and monitoring of spawning habitat that is considerate of the potential for high flows to occur during fall, winter, and early spring in the lower Campbell River. In some years, high flows erode spawning habitats during November to March, after the FWCP application intake window of late October. This hinders the ability of the community to obtain funds to restore habitats prior to the salmon spawning period in the subsequent fall. This Strategy addresses this issue and directly addresses Priority Action #10 in the FWCP Campbell River Watershed Action Plan, which states:

"*Develop a gravel placement and monitoring plan for the lower Campbell River mainstem including Elk Falls Canyon. The plan should address the quantity and locations for gravel placement on annual basis and should be considerate of the high fall/winter flows in the lower Campbell.*"

The Strategy was developed with engagement from representatives of government agencies, First Nations, conservation organizations, BC Hydro, FWCP, and fisheries experts with extensive experience in the watershed. These representatives participated in a workshop held in November 2018, which led to broad agreement about key aspects of the Strategy. Further details were then developed with additional consultation, input from technical experts, and discussions with FWCP. The Strategy proposes a threshold-based assessment in response to high flow events that cause erosion of spawning habitat. Urgent works required to provide habitat for spawning salmon to use in the fall can be considered for FWCP funding under a directed delivery pathway that is separate to the normal application intake period. Once the Strategy is in place, grant applications for gravel enhancement under the Campbell River Watershed Action Plan will need to reference the Strategy for direction on site priorities and monitoring.

Surveys in 2017 indicate that the area of spawning habitat in the lower Campbell River is substantially lower than the amount required to support successful natural spawning of Chinook Salmon. Six priority gravel enhancement sites were identified to guide the design of spawning habitat enhancement projects. The highest priority site is "Site 7", which is in the First Island side channel and was historically well-used by spawning Chinook Salmon. A long-term target was identified to provide 24,000 m^2 of high-quality Chinook Salmon spawning habitat throughout the lower river.

This long-term target is based on the estimated area of habitat necessary to support the target abundance of this species (2,000 pairs), with an assumption that this amount will also provide sufficient spawning habitat for other species. Given the current low abundance of salmon, it would not be cost-effective to fully construct the long-term target area of habitat because it would exceed biological requirements and habitat would erode before salmon escapement increased to target levels. It is therefore appropriate to use a lower spawning habitat target to guide management in the near-term and the minimum area of spawning habitat required in a specific year will depend on factors that include salmon escapement, spawning habitat quality, and the relative distribution of spawning gravel among priority sites at preferred spawning locations. Evaluation of the necessity and scope of spawning habitat enhancement projects should be undertaken by experts familiar with the watershed and should recognize the need to allocate resources cost-efficiently. Reference values are provided to inform decisions about the requirement and scope of spawning habitat construction.

An assessment program is proposed to guide decision-making and project evaluation. This involves monitoring conducted when survey conditions are optimal in summer or early fall. It is also proposed to undertake a high-flow response assessment in the late winter/spring if flow in the lower river exceeds a threshold during the period of late fall through early spring when annual maximum flows typically occur. The purpose of this assessment is to evaluate whether it is necessary to complete works to enhance spawning habitat prior to salmon spawning in the fall. A threshold of 225 m^3/s downstream of John Hart Generating Station has been identified as appropriate to initiate a high-flow response assessment, although this threshold is intended to be adaptive and could be revised if new information indicates that an alternative value is more appropriate.

This Strategy is intended to commence in 2019. Implementation of the Strategy will ultimately depend on factors that include commitment from project proponents and environmental variability. Applications for FWCP Coastal funding will also be considered in the context of other priorities, as described in the Grant Information Kit for applicants (FWCP 2018a). A key recommendation is to form a Campbell River Spawning Habitat Roundtable group that includes First Nations, regulators and stakeholders who can provide informed and coherent advice regarding monitoring and spawning habitat construction. The need to support a roundtable can be considered in FWCP grant applications and FWCP Community Engagement Grants are available that can support engagement activities in the watershed.

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1. INTRODUCTION

The lower Campbell River has high fisheries values and provides habitat for anadromous salmonids in the 5.6 km section of the river downstream of Elk Falls (Map 1). A key fisheries concern is the lack of gravel recruitment, which has reduced the area of salmonid spawning habitat in the lower Campbell River to the point where gravel placement actions are necessary to maintain suitable spawning habitats for species such as Chinook Salmon.

First Nations, agencies and stakeholders have identified a lack of strategic direction for gravel placement actions in the lower Campbell River (FWCP 2017). Action #10 in the Campbell River Watershed Action Plan (FWCP 2017) is to:

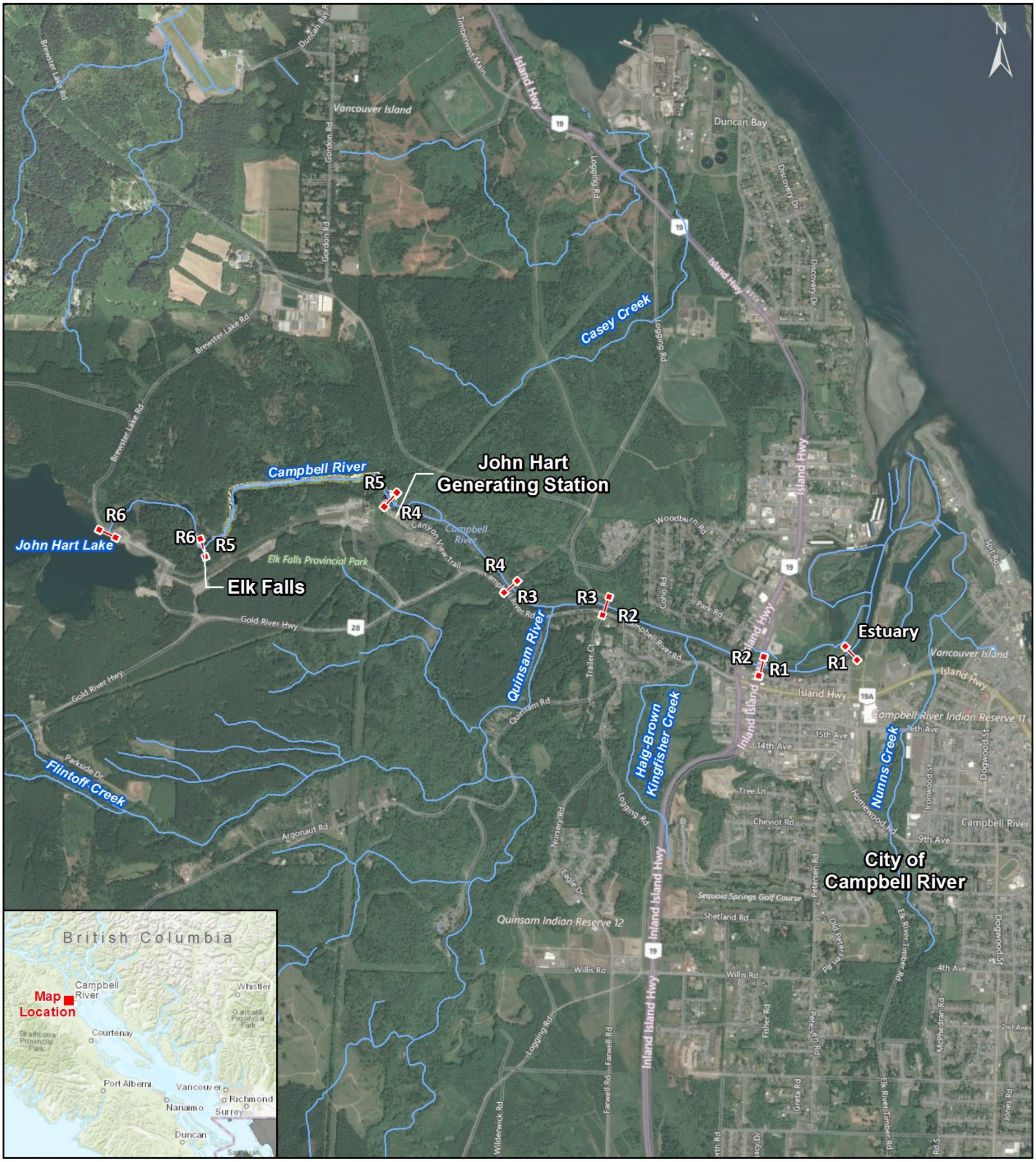
> *"Develop a gravel placement and monitoring plan for the lower Campbell River mainstem including Elk Falls Canyon. The plan should address the quantity and locations for gravel placement on annual basis and should be considerate of the high fall/winter flows in the lower Campbell"* (CBR.RLR.RI.10.01; Priority 1).

To address this action, this Strategy for Spawning Habitat Enhancement and Monitoring in the lower Campbell River has been developed, funded by the Fish & Wildlife Compensation Program (FWCP) in 2018/2019 (Project COA-F19-F-2905-DCA). This Strategy presents details of:

- background to spawning habitat enhancement in the lower Campbell River (Section 2);
- how the Strategy was developed, including details of engagement with First Nations, agencies, community organizations, and BC Hydro (Section 3);
- a recommended decision framework to guide the implementation and monitoring of spawning habitat creation in the lower Campbell River (Section 4);
- a prioritized list of potential gravel enhancement sites (Section 5);
- recommended targets and thresholds to guide spawning habitat restoration (Section 6);
- a proposed monitoring program to evaluate the success of gravel enhancement and identify the need for future works (Section 7); and
- key outstanding uncertainties that could be addressed with research and monitoring (Section 8).

This Strategy is intended to guide future gravel placement and monitoring projects. Ultimately, implementation of the Strategy will depend on factors such as funding; commitment from project proponents; collaboration with partner organizations; environmental variability, and; external drivers that affect project costs and feasibility.

Project Overview



Legend

Reach Breaks

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 0.5 1 1.5 km

Scale: 1:40,000

NO.	DATE	REVISION	BY
1	09/10/2018	1120_JHT_ProjectOverview_2018Oct09	ERL
2			
3			
4			
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Date Saved: 09/10/2018
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 1

Path: M:\Projects-Active\1120-01 John Hart Rehabilitation\6 Mapping\MXD\Overview\1120_JHT_ProjectOverview_2018Oct09.mxd

2. BACKGROUND

2.1. Overview

Background information relevant to the Strategy is summarized here. For further details, readers should consult the background review that was prepared to inform Strategy development (Krogh *et al*. 2018; Appendix A), which includes further details of fisheries values; historical changes in gravel recruitment; hydrology; geomorphology of specific reaches; previous gravel enhancement and monitoring projects, and; recommendations from other studies.

2.2. Fisheries in the Lower Campbell River

The lower Campbell River supports populations of all five species of anadromous Pacific salmon[1], as well as steelhead, resident Rainbow Trout, and Cutthroat Trout (anadromous and resident). Priority fish species in the watershed identified by FWCP are Chinook, Coho, Pink and Chum salmon, steelhead, Cutthroat Trout and Rainbow Trout (FWCP 2017). Chinook Salmon and steelhead are of particular conservation concern (Burt and Burns 1995; FWCP 2017) and targets have been developed for both of these species, in addition to Coho Salmon (Table 1). Salmon abundance is measured annually by DFO using a range of methods that vary in precision and accuracy (DFO 2018). The abundance of spawning Chinook in the Campbell River mainstem has generally declined since the 1960s (Figure 1), and a decreasing trend is particularly evident in the last 30 years (DFO 2018; Nagtegaal *et al*. 2000). Chinook Salmon escapement is now substantially below the target of 2000 pairs (i.e., 4000 fish); e.g., escapement for the ten-year period of 2007–2016 averaged 815 fish (range of values: 353–1212; DFO 2018). Both summer and winter run steelhead stocks are listed as an extreme conservation concern by the British Columbia Conservation Foundation (BCCF) and are currently in decline. Declines of these species have been related in part to the loss of spawning habitat in the lower Campbell River (Burt and Burns 1995; Burt 2004).

Table 2 shows the spawning and incubation periods for salmonid species present in the lower Campbell River. The table indicates that gravel placement activities should occur during July and August to reduce risk to spawning or incubating fish in the lower Campbell River.

[1] Sockeye Salmon are scarce and an absence of lacustrine habitat in the lower Campbell River limits Sockeye Salmon production (Burt & Burns 1995).

Table 1. Escapement and spawning habitat targets for FWCP priority anadromous salmonids in the Campbell River watershed. Targets are from Burt (2004).

Species	Escapement Target	Spawning Habitat Target (m^2)
Chinook	2000 pairs	23,259
Chum	Not established	Not established
Coho	500 pairs	3,519
Pink	Not established	Not established
Steelhead	200 pairs	2,620

Figure 1. Salmon escapement between 1953 and 2017 for the Campbell River (DFO 2018). Chinook (blue) are measured on the right vertical axis.

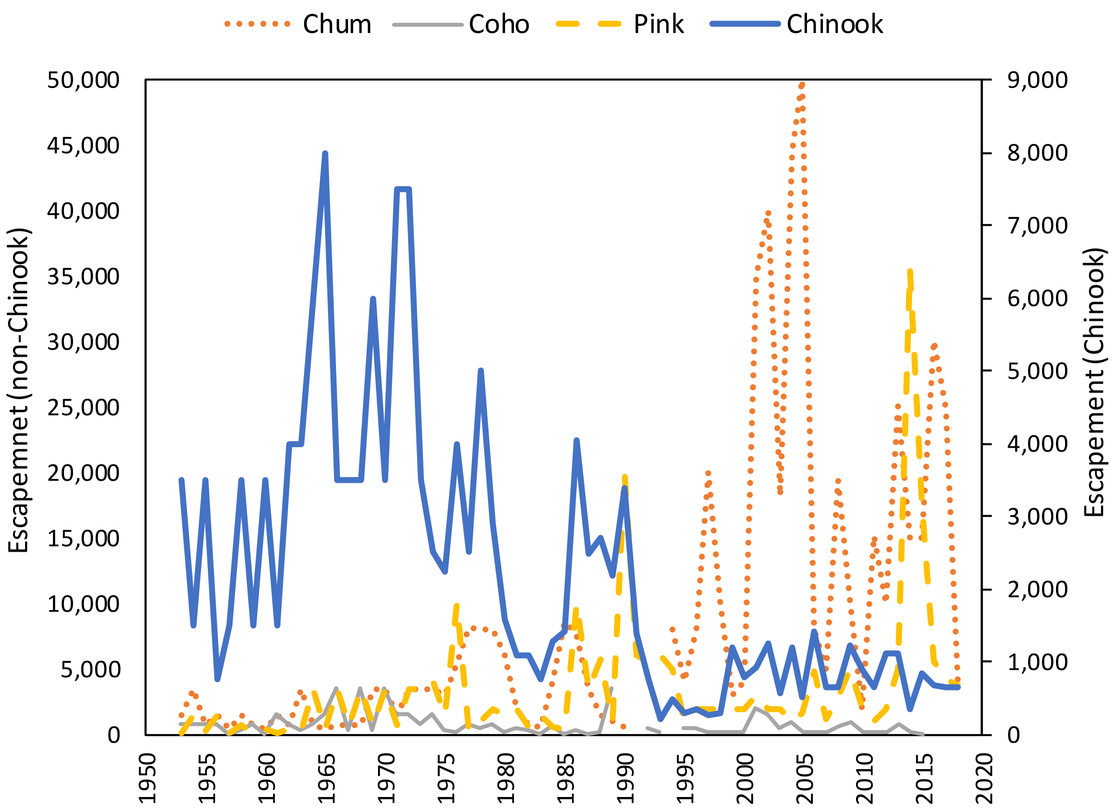


Table 2. Spawning and incubation periods for salmonid species in the lower Campbell River.

Life History	Species	Event	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Life History Stage[1]											
Anadromous	Chinook Salmon	Spawning										■	■	
		Incubation	■	■	■	■						■	■	■
	Chum Salmon	Spawning	■									■	■	■
		Incubation	■	■	■	■						■	■	■
	Coho Salmon	Spawning	■									■	■	■
		Incubation	■	■	■	■						■	■	■
	Pink Salmon	Spawning									■	■		
		Incubation	■	■	■						■	■	■	■
	Sockeye Salmon	Spawning										■	■	
		Incubation	■	■	■	■						■	■	■
	Cutthroat Trout	Spawning		■	■	■								
		Incubation		■	■	■	■	■						
	Steelhead (winter run)	Spawning			■	■								
		Incubation			■	■	■	■						
	Steelhead (summer run)	Spawning		■	■	■								
		Incubation		■	■	■	■							
Resident	Cutthroat Trout	Spawning		■	■	■								
		Incubation		■	■	■	■	■						
	Rainbow Trout	Spawning		■	■	■								
		Incubation		■	■	■	■	■						

[1] Life history timing from Fish Technical Committee (2001)

Critical times ■

2.3. Funding Sources and Priority Actions

FWCP has historically been an important source of funding for gravel enhancement projects in the lower Campbell River. FWCP funds and supports projects that are aligned with the Campbell River Watershed Action Plan (FWCP 2017). Priority Actions listed in the Campbell River Watershed Action Plan (FWCP 2017) that relate to gravel enhancement and monitoring are presented in Table 3. This Strategy addresses Action #10 but it is intended to also provide direction for the other Priority Actions listed.

Other funding sources are available and proponents of spawning habitat enhancement projects are encouraged to seek funding from a range of sources. This Strategy is intended to guide gravel enhancement and monitoring projects in the lower Campbell River generally and it is considered relevant to non-FWCP funded projects.

Table 3. Priority Actions in the Campbell River Watershed Action Plan (FWCP 2017) that relate to gravel enhancement and monitoring. All actions relate to the lower Campbell River.

Action #	Action Type	Short Description	Priority	Target Species	Priority Action
8	Monitoring and Evaluation	CBR.ALL.ME.08.01 Assess success of habitat-based actions supported by FWCP	1	Fish and wildlife	Assess success of habitat-based actions supported by the FWCP. Success could be assessed through monitoring of biological and/or physical habitat responses. Success could be assessed on a graduated schedule such as every 1, 3, 5 and 10 years or based on high flow events or other natural or human-caused disturbances.
9	Monitoring and Evaluation	CBR.ALL.ME.09.01 Conduct condition assessments and/or maintenance on habitat enhancements	1	Fish and wildlife	Conduct condition assessments and/or maintenance on habitat enhancements supported by the FWCP. This could include the development of an inspection and maintenance schedule if required. If part of a multi-year study, provide information about future objectives and actions.
10	Research and Information Acquistion	CBR.RLR.RI.10.01 Develop a gravel placement and monitoring plan	1	Anadromous and resident salmonids	Develop a gravel placement and monitoring plan for the lower Campbell River mainstem including Elk Falls Canyon. The plan should address the quantity and locations for gravel placement on annual basis and should be considerate of the high fall/winter flows in the lower Campbell.
12	Habitat-based Action	CBR.RLR.HB.12.01 Continue augmentation of gravels in Elk Falls Canyon	1	Anadromous and resident salmonids	Continue augmentation of gravels in Elk Falls Canyon. If a gravel monitoring plan has been completed under Action 10, please reference that plan for more information.
13	Habitat-based Action	CBR.RLR.HB.13.01 Gravel placement in the lower Campbell River	1	Chinook Salmon	Gravel placement in the lower Campbell River to improve egg-to-fry survival of salmonids (primarily for Chinook). Possible locations include, extension of First Island Mainstem project, and gravel pads in the mainstem upstream of Second Island. If a gravel monitoring plan has been completed under Action 10, please reference that plan for more information.
23	Monitoring and Evaluation	CBR.RLR.ME.23.01 Conduct gravel monitoring in the lower Campbell River	1	Anadromous and resident salmonids	Conduct gravel monitoring in the lower Campbell River mainstem including Elk Falls Canyon. Gravel monitoring should follow from a gravel placement and monitoring plan (under Action 10) and should inform the quantity and locations for gravel placement on annual basis.

2.4. Historical Gravel Placement Areas

2.4.1. Overview

Gravel has been placed at reaches 1–5 in the lower Campbell River (Map 1–Map 4). Reach breaks and gravel placement site names are based on Burt (2004). Each reach is briefly summarized in the sections below. Reach 6 (Map 1) is upstream of Elk Falls (anadromous barrier) and is not discussed. Further background to each reach and details of the history of gravel placement projects are provided in Krogh *et al.* (2018; Appendix A). Details about specific priority sites that were identified during Strategy development are provided in Section 4.3.

2.4.2. Reach 1

Reach 1 is 725 m long and extends from the Campbell River Estuary to the lower highway bridge (Map 2). This reach has a mean wetted width of 83 m and a gradient of 0.1%. The average of maximum depth measurements collected at multiple sites throughout the reach was 1.4 m. Channel morphology is primarily run (68%) and flat/riffle (38%). Bed material is predominantly small and large cobbles and boulders (23%, 26%, and 20% respectively). Water level and velocity in this reach are influenced by tides.

There are two side channels associated with this reach. Raven Channel runs adjacent to Reach 1 along the left bank, although the inlet to this side channel is located within Reach 2. Flows enter Raven Channel between the southbound and northbound highway 19A bridge crossings and exit into a watercourse locally known as Fred's Slough. There is also a secondary channel, the NCC Channel, which diverges from Raven Channel at its midpoint and flows into Baikie Slough. Chum and Pink salmon spawn in this reach (Burt 2004).

2.4.3. Reach 2

Reach 2 is 1,200 m long and extends from the lower highway bridge to the logging bridge (Map 2). This low gradient, riffle-run reach has a mean wetted width of 73 m and mean maximum depth of 1.8 m. Bed material is primarily large cobbles (21%) and boulders (45%).

Haig-Brown Kingfisher Creek enters the Campbell River in this reach on the right bank 580 m upstream from Reach 1. The entrance to Raven Channel is located on the left side of the river 100 m upstream from Reach 1. Flows enter the channel between the southbound and northbound highway 19A bridge crossings.

Gravel placement sites 10 and 11 are located in this reach (Map 2). The largest of these is Site 11, located at the end of Ebert Road. In the first year following placement, a total of 5,000 Chum Salmon and 20 Chinook Salmon were observed spawning at Site 11 (Guimond 2006). Site 11 is located in a wide, low gradient section of the river, which provides good gravel stability, although gravel at this site was largely eroded following high flows in fall 2016 (NHC 2017a).

2.4.4. Reach 3

Reach 3 is 785 m long and extends from the logging bridge to the downstream end of Second Island (Map 3). This reach has a mean wetted width of 57 m, mean maximum depth of 1.5 m and a mean gradient of 0.6%. This reach is characterized primarily by broken run (49%), run (31%) and flat/riffle (18%) hydraulic types. Bed material is primarily composed of large cobbles (25%) and boulders (30%).

The Quinsam River enters the Campbell River on the right bank in Reach 3, 4.4 km upstream from the mouth and 385 m upstream from Reach 2. The Quinsam River is the largest tributary to the lower Campbell River.

The Elk Falls Side-Channel Network is located in Reach 3 and comprises three side- channels.

2.4.5. Reach 4

Reach 4 is 1,095 m long and extends downstream from John Hart Generating Station to Second Island (Map 3). This reach has a mean wetted width of 72 m, mean maximum depth of 1.4 m and a mean gradient of 0.7%. This reach is characterized primarily by broken run (43%), flat/riffle (33%) and run (21%) hydraulic types. Bed material is primarily composed of large cobbles (23%) and boulders (52%).

Reach 4 has been a major focus for gravel placement and includes Sites 5, 6, 7, 8, and 9 (Map 3). In particular, Site 7 is located at the river right channel around First Island and is an important Chinook Salmon spawning site. Gravel has also been enhanced in the Second Island side channel (Map 3), which contains weirs designed to maintain spawning habitat. These habitats have been used by spawning salmon; the spawning platform that is furthest upstream has been used by Chinook Salmon to the greatest extent, with the two additional spawning platforms receiving low use by Chinook Salmon.

The confluence pool at the outlet of Elk Canyon was historically an important spawning location. Recent upgrades to the John Hart Generating Station and realignment of the tailrace may provide opportunities to create new gravel placement sites in this area. In particular, the riffle crest at the downstream end of this pool has been identified as a potential new site as it may provide relatively stable hydraulic conditions.

2.4.6. Reach 5

Reach 5 is 1,750 m in length and extends upstream from the JHT tailrace to the plunge pool below Elk Falls (Map 4). This canyon section, locally known as Elk Canyon, is deeply entrenched within vertical bedrock walls. Aquatic habitat is stepped in longitudinal profile and composed of repeating sequences of deep pools or runs followed by a cascade or riffle. The last 200 m of the canyon is a long deep pool that provides the only deep pool habitat in the lower Campbell River. The average gradient of this reach is 3% (Burt, 2004). The dominant and subdominant substrates are boulder (76% of habitat units) and bedrock (38% of habitat units) (Parsamanesh *et al.* 2018).

Gravel placement has occurred multiple times in Reach 5 as part of a joint federal-provincial-community effort to restore spawning areas predominantly for Chinook Salmon. The main gravel placement sites are the tailout of the Elk Falls plunge pool (Site 1) and 400 m downstream of the tailout of the falls pool (Site 2) (Map 4). A heavy-lift helicopter has historically been used to place gravel but a new gravel delivery system was built in Elk Falls Provincial Park in March 2016. The system includes an overhead wire that spans the canyon and supports a trolley bucket that is capable of delivering approximately 0.5 m^3 of gravel to the canyon at one time (Damborg 2016). The system was first used in July 2016 to deliver a total of 200 m^3 of spawning gravel to the canyon to create an area of 400 m^2 of new spawning habitat, just below Site 1. The system has since been used in 2017 and 2018 (Damborg 2017, 2018).

2.5. Status of Spawning Gravel in the Lower Campbell River (2017)

The most recent survey of the anadromous reach of the river downstream of Elk Canyon was conducted using an unmanned aerial vehicle (UAV) and ground-based surveys in August 2017 (NHC 2017a). The survey was undertaken in response to high flows in the fall of 2016 (maximum mean daily flow measured in the lower Campbell River was 647 m^3/s). This survey followed a survey conducted in October 2016 that successfully captured images of spawning habitat (Figure 2).

Results showed that little to no spawning gravel remained at Site 7 in August 2017. Much of the gravel that was previously present at Site 7 had apparently been transported 10–600 m downstream along the right bank and deposited within or just upstream of the Second Island side channel. Gravel deposited upstream of the Second Island side was considered to be suitable Chinook Salmon spawning habitat; however, the total volume of gravel in this area was estimated as only 70 m^3 or 4% of the gravel placed at Site 7 in 2016[2]. Most of the gravel at Site 7 was assumed to have been deposited into the Second Island side channel, where it was not considered to be suitable Chinook Salmon spawning habitat and was not mapped as part of the survey.

Gravel placed at Site 9 in 2012 had been transported 90–190 m downstream and distributed along the left bank. These new gravel deposits along the left bank accounted for an estimated total volume of 110 m^3, approximately 8% of the gravel placed at Site 9 in 2012. Another 510 m^2 patch of high-quality gravel was found in the natural depositional zone near the former Catalyst Paper intake. Downstream of the former intake, only 210 m^2 of suitable Chinook Salmon spawning habitat was mapped near the Ebert Road Site.

In total, the survey mapped 3,930 m^2 of gravel downstream of Elk Canyon, of which an estimated 1,250 m^2 was considered suitable spawning habitat for Chinook Salmon. NHC (2017b) estimated that this habitat could support 65–125 pairs of Chinook Salmon. The results confirmed that UAV photography is a suitable tool to assess the extent of gravel patches during low flows and when water clarity is good.

In addition, a gravel assessment was undertaken in Elk Canyon in October 2017 to collect baseline information prior to commissioning the upgraded John Hart Generating Station (Hatfield Consultants 2017). The survey involved collecting UAV imagery, which was used to identify two primary gravel deposits: one (~300 m^2) in the pool at the Skyline drop location near Elk

[2] To address this erosion, a project (COA-F19-F-2765) was funded in 2018–2019 to create approximately 4000 m^2 at the Second Island site.

Falls (Site 1; Map 4) and a second (150 m^2) as a gravel bar on the inside of the bend downstream of Site 2 (Map 4). An important finding of the assessment was that flows of 100 m^3/s that occurred in the canyon on October 3 (undertaken to mitigate potential impacts to drinking water quality during blasting) had not significantly re-distributed gravel placed using the Skyline system in July and surveyed in September (Hatfield Consultants 2017).

Figure 2. Aerial photograph of Site 7-IV taken in October 2016 using a UAV. Image provided by Campbell River Salmon Foundation (Buchanan, pers. comm. 2018).

3. STRATEGY DEVELOPMENT

3.1. Summary of Engagement

This Strategy was developed with engagement from representatives of government agencies, First Nations, conservation organizations, BC Hydro, and fisheries experts with extensive experience of working in the watershed (Table 4). Engagement involved dissemination of a questionnaire, participation in a workshop held in Campbell River, and circulation of the draft Strategy for review. Further details about these engagement steps are provided in the sections below.

Table 4. Individuals consulted during development of this Strategy.

Individual	Organization	Attended Workshop?
Colin McGregor	Fisheries and Oceans Canada	Yes
Daniel Sneep	Fisheries and Oceans Canada	Yes
Dave Ewart	Independent	Yes
Edward Walls	Fisheries and Oceans Canada	Yes
Eva Wichmann	BC Hydro	Yes
Jeramy Damborg	BCCF	Unavailable
Jim Meldrum	A-Tlegay Fisheries Society,Wei Wai Kum First Nation	Yes (facilitator)
Julie Fournier	FWCP	Yes
Kim Duncan	A-Tlegay Fisheries Society	Unavailable
Martin Buchanan	Campbell River Salmon Foundation	Yes
Mel Sheng	Independent	Yes (facilitator)
Mike McCulloch	MFLNRORD	Unavailable
Rupert Gale	Campbell River Salmon Foundation	Yes
Shannon Anderson	Fisheries and Oceans Canada	Yes
Stacey Larsen	Fisheries and Oceans Canada	Unavailable
Stephen Watson	BC Hydro	Yes

3.2. Pre-Workshop Questionnaire

Workshop participants were invited to complete an online questionnaire (Survey Monkey) to canvas viewpoints and develop discussion points for the workshop. The questionnaire included seven questions about challenges and opportunities for managing spawning habitat in the lower Campbell River (listed in Appendix B). The pre-workshop questionnaire was answered, at least in part, by all 14 participants listed in Table 4, with the exception of workshop facilitators who were omitted. The results are summarized here and reproduced verbatim in Appendix C.

No respondents stated they were satisfied with how spawning gravel has been managed in the lower Campbell River, although four respondents stated they were "neutral" or "not sure". The remaining respondents indicated they were "somewhat" (38%) or "very" (31%) dissatisfied with how spawning gravel has been managed in the lower Campbell River. The three greatest challenges to better gravel management were identified by respondents as follows, in descending order of importance:

1) the model of FWCP-funding for gravel placements (e.g., a need to submit proposals in October for work the following year);

2) the amount of funding available for restoration; and

3) lack of geomorphological understanding.

A majority (61%) of respondents agreed there is sufficient knowledge about the lower Campbell River to undertake adequate spawning habitat restoration. Respondents who perceived important gaps identified the following (in no particular order):

- the technical feasibility of building spawning pads that can withstand flows in excess of 300 m^3/s;
- the historical gravel recruitment budget;
- how gravel moves through the lower river;
- annual variability in the extent of gravel at spawning sites; and
- how to foster effective collaboration among multiple groups.

(See Section 7.1 for a more-detailed list of key uncertainties that were discussed during the workshop and could be a focus for future research).

When asked to list their top three priority areas for spawning gravel restoration, respondents provided variable answers. Broadly, the areas identified can be divided into the following main locations/themes:

- Chinook spawning habitat in Reach 4 (see Map 3);
- Chinook spawning habitat that can withstand high flows and/or has proven to be effective; and
- Elk Canyon.

(See Section 5 for a prioritized list of gravel enhancement sites that was subsequently agreed upon during the workshop).

When asked how to improve gravel management, the responses had the following themes:

- Set a minimum target amount of gravel that should be maintained. This amount should ideally be enough to support the escapement target of 2,000 pairs of Chinook.
- Adopt a funding model that allows gravel to be assessed in spring and augmented in summer if required.
- Conduct consistent annual surveys of spawning habitat and make gravel additions when and where necessary.
- BC Hydro should consider having dedicated "maintenance" funds available to cover necessary gravel additions.

3.3. Workshop

The Campbell River Watershed Gravel Placement and Monitoring Strategy workshop was held on November 2, 2018 in Campbell River from 0930 to 1400. Attendees at the workshop included the participants recorded in Table 4, plus three additional facilitators from Ecofish Research Ltd (T. Hatfield, I. Murphy and J Abell).

The workshop included presentations on background information about spawning habitat in the lower Campbell River, lessons from spawning habitat enhancement projects in other watersheds, and a review of potential monitoring methods. Mel Sheng also gave a presentation about a field trip that he conducted with Dave Ewart to inform Strategy development. This included providing an update on the current status of spawning habitat around Second Island and presenting details of additional potential enhancement sites that had been identified at riffle crests downstream of John Hart Generating Station.

The workshop also included structured discussions to identify solutions to address challenges that had been identified during pre-workshop engagement. These discussions led to recommendations that the group broadly accepted. These recommendations provide additional context in relation to some of the ideas provided in response to the pre-workshop questionnaire (Appendix C). Key recommendations were:

- High annual maximum flows in the lower Campbell River (e.g., 300–600 m^3/s) are expected to occur during fall through early spring every few years – the Strategy should reflect this and provide flexibility to fund urgent works to apply gravel in areas where erosion has occurred, prior to salmon spawning in the fall. This requires a direct funding process that is separate from the current FWCP open application process. The current process requires project proposals to be submitted in October, prior to the period when high flows are most likely to occur. A clear decision framework is required to guide the annual cycle of FWCP grant application, spawning habitat monitoring, and project implementation that is specific to the lower Campbell River.

- Flow management (i.e., BC Hydro operations) is not expected to be a component of this Spawning Habitat Enhancement and Monitoring Strategy. This approach can be summarized as, "The Strategy won't drive flows; flows will drive the Strategy".

- There is a need for two types of monitoring. First, monitoring is recommended to be undertaken in spring (~March) if high-flow events occurred over the previous fall to spring period. The purpose of this monitoring is to assess the requirement to undertake urgent works to restore high priority spawning areas that had been eroded during the high flow event. Design criteria for existing spawning pads provide a useful reference to identify the flow threshold(s) required to trigger this monitoring requirement. Second, routine status monitoring in the summer/fall is recommended to provide synoptic information about the abundance and distribution of spawning habitat in the lower Campbell River. This information can be used to inform the priorities for enhancement of spawning sites, proposed via the annual intake of grant applications (Open Projects). Based on the results of surveys undertaken in 2016 (Figure 2) and 2017, a survey with an unmanned aerial vehicle

(UAV) undertaken in summer would likely provide suitable information, although some additional ground-based survey effort would also be necessary.

- It would be beneficial to establish a committee/roundtable that meets routinely (e.g., annually) to review and adjust implementation of the Strategy.
- Gravel augmentation should be undertaken annually at priority sites for a duration of at least 4–5 years to provide better availability of spawning habitat. This sequence of gravel enhancement would need to be restarted if high flow events occur that cause severe erosion.
- The Strategy allows for different proponents to implement projects.

Further, discussions were held about key knowledge gaps. These discussions built on the uncertainties identified during the pre-workshop engagement (Section 3.2) and the discussions led to the identification of several outstanding uncertainties that could be addressed with research projects. These uncertainties are listed in Section 7.1.

4. STRATEGY IMPLEMENTATION

4.1. Overview of Strategy Implementation

This Spawning Habitat Enhancement and Monitoring Strategy is intended to commence in 2019. A key component of the Strategy is the recommendation to prioritize spawning habitat enhancement works in the Campbell River watershed for funding under a directed delivery approach ("Directed Works"). With this approach, FWCP Coastal could approve funds required for urgent works to provide habitat for spawning salmon to use in the fall. The Strategy also allows for funding of projects via the existing FWCP funding process of annual intake of grant applications in October (Open Projects), with approved projects then being undertaken during the following financial year. Further details about the proposed annual funding and implementation cycle are provided in Section 4.2.

Open Projects that relate to spawning habitat restoration in the lower Campbell River should be aligned with this Strategy. This is required by Priority Actions 12, 13 and 23, which require this Strategy to be referenced once developed (Table 3). A prioritized list of gravel enhancement sites is provided in Section 5, based on feedback during the November 2018 workshop (Section 3.3). Details of targets that can guide the implementation of Habitat-Based Actions over multiple years are presented in Section 5.2. Regular monitoring (Section 7) provides information to evaluate progress towards targets and guide the prioritization of projects and allocation of funding. Following a major erosion event, there would be an opportunity for FWCP to direct funds for urgent restoration of priority spawning habitats.

This proposed funding model is specific to projects supported by FWCP grants. However, components of the Strategy, such as restoration targets (Section 5.2), may be relevant to other funders (i.e., non-FWCP projects) and proponents are encouraged to seek additional sources of funding to complement FWCP-funded projects and improve cost-efficiencies.

4.2. Funding and Implementation

Please refer to FWCP's Grant Information Kit for more information about the lower Campbell River Salmon Spawning Habitat Framework.

4.3. Engagement and Evaluation

Community engagement is a strategic objective of FWCP (FWCP 2017). Implementing spawning habitat enhancement and monitoring projects is expected to involve engagement by First Nations, government, and community groups. Two key groups are proposed to support Strategy implementation: 1) the FWCP Coastal Region Board; 2) a Campbell River Spawning Habitat Roundtable (CRSH Roundtable).

The FWCP Coastal Region Board meets in January each year to review applications for projects throughout the Coastal region. The Board may consider the current status of spawning habitat in relation to targets (Section 5.2) and the allocation of funds to support a high flow response assessment and Directed Works.

Establishment of a community roundtable was a key recommendation made during development of this Strategy (Section 3.3). Roundtables can be proposed by proponents as a means to meet the objectives of a priority action. Roundtable meetings should be considered as a component of the implementation of the Strategy and associated prioritized projects. The CRSH Roundtable could include representatives of groups listed in Table 4 and could be similar to the gravel committee that previously operated in the watershed. A key role of the CRSH Roundtable would be to provide recommendations to the FWCP Board about the scope and implementation of urgent spawning habitat assessment and restoration works, opportunities for collaboration, and monitoring proposals that are submitted through the Open grant application process. The CRSH Roundtable could also review monitoring results (Section 7) and may advise if it is desirable to undertake modifications to approved Open Projects, based on monitoring results.

Funding for a CRSH Roundtable to operate is not secured, which presents a risk to ensuring the ongoing operation of the group. To minimize this risk, it is recommended that proponents consider the need to fund engagement, including operation of a CRSH Roundtable, when preparing applications for Open Projects (see Section 4.4). Unless urgent monitoring and restoration is triggered (Section 7.3), operation of a CRSH Roundtable could require a low level of commitment from members; e.g., participation in telephone calls and e-mail correspondence. If Directed Works are required, then greater involvement by a CRSH Roundtable could be required; e.g., a half-day meeting in late spring/early summer with associated communications. The composition and operational processes of a CRSH Roundtable will likely develop during the duration of the Strategy.

4.4. Guidance for Grant Applicants

Potential project proponents should consider the following:

- projects relating to spawning habitat should be aligned with this Strategy;
- proposals should reflect FWCP's strategic objective of community engagement. This could include considering the need to support annual activities of a CRSH Roundtable described in Section 4.3. Proponents should note that FWCP offers the option to apply for Community Engagement Grants, which permit a maximum allowable grant of $1,000 per organization/fiscal year (FWCP 2018b);
- proposals to conduct habitat-based actions should consider monitoring requirements (Section 7) necessary to evaluate the performance of constructed spawning habitats;
- proponents of habitat-based actions should consider land access requirements/approvals. Access to some sites (e.g., Site 9) may require a park use permit from BC Parks, while access to BC Hydro property needs prior approval;
- proposals to conduct research actions such as modelling should provide clear rationale for how the work will inform FWCP's strategic objectives, which include conservation and sustainable use; and
- FWCP recognizes that it can be challenging for proponents to find resources to prepare applications. To support this, proponents are encouraged to consider applying for seed funding, which can provide up to $5,000 to help with preparing proposals for large projects. For projects that require repeated applications for funds, proponents are encouraged to include details in reports that can be readily used in future proposals. Applicants are encouraged to visit fwcp.ca for more information in grant application information kits (FWCP 2018a).

5. PRIORITY GRAVEL ENHANCEMENT SITES

5.1. Site Selection

An outcome of the November 2018 workshop (Section 3.3) was the identification of six priority sites for spawning habitat enhancement, listed from highest to lowest priority:

1. Site 7 (Reach 4);
2. Site 5 (Reach 4);
3. Site 9 (Reach 4);
4. Upstream End of Second Island (Reach 4);
5. Elk Canyon (downstream of Skyline operations in Reach 5); and
6. Ebert Road (Reach 2).

Table 5 lists these sites and relevant example projects with associated costs. These sites are in addition to the site in Elk Canyon that is serviced by the Skyline system (Section 5.6). Workshop attendees agreed that this system should continue to be used to augment gravel, providing that this action is supported by assessments that consider technical merit, cost-effectiveness, and urgency.

In addition, opportunities were identified to enhance spawning habitat at new sites, although further evaluation is required to confirm suitability (Section 8). Pending further investigation, these sites could be added to this list of priority sites during a future review of the Strategy.

Table 5. Priority sites for gravel enhancement, with details of example projects and 2008 cost estimates from project descriptions developed by NHC (2008; in bold). Reaches are shown on Map 1.

Priority	Site Description	Example Projects[1]					
		Year	Habitat Created (m^2)	Peak Design Flow (m^3/s)	Target Species	# of Chinook Pairs[2]	Cost ($)
1. Site 7 (Reach 4)	Downstream end of First Island on river right	2016	2,250	260	Chinook	225	UNK
		2013	2,100	225	Chinook	210	173,300
		2009	1,600	225	Chinook	160	118,600
		2008	**2,400**	**--**	**Chinook**	**240**	**232,975**
		2006	1,600	--	Chinook	160	118,600
2. Site 5 (Reach 4)	River right John Hart Generating Station tailrace pool	**2008**	**2,100**	**--**	**Chinook**	**210**	**226,625**
		1997	175	--	Chinook	18	154,000[3,4]
3. Site 9 (Reach 4)	River left just upsteam of Second Island	2012	1,825	225	Chinook	183	142,800
		2008	**2,200**	**--**	**Chinook**	**220**	**230,369**
4. Upstream End of Second Island (Reach 4)	River right at the upsteam end of Second Island	2018	4,000	--	--	400	27,430[5]
5. Elk Canyon (Reach 5)	The reach between Elk Falls and John Hart Generating Station	2017	400	--	Chinook & steelhead	40	68,600[4]
		2016	400	--	Chinook & steelhead	40	66,000[6]
		2008	**405**	**--**	**Chinook & steelhead**	**41**	**58,800[3]**
6. Ebert Road (Reach 2)	End of Ebert Road just upsteam of the southbound Highway 19 bridge	2005	5,929	--	Chinook	593	116,536

[1] **Bold** entries are 2008 estimates from NHC (2008). Other entries are based on as built surveys and actual costs reported in project final reports (see Krogh *et al*. 2018).

[2] Based on 10 m^2 per female, from Table 6 in Burt (2004)

[3] Gravel placed by heavy lift helicopter

[4] Cost is for three similar sites

[5] Cost does not include a considerable in-kind donation from DFO

[6] Gravel delivered via Skyline system

5.2. Site 7

Site 7 is situated in the downstream third of the First Island side channel along the right bank. Historically, this site was well used by spawning Chinook Salmon (Hamilton & Buell 1976). The site has been targeted for gravel enhancement several times in the past 20 years, with the most recent work occurring in 2016 (NHC 2017b). This site has the potential to also be used by Coho, Chum, and steelhead (Burt 2004). Burt (2004) estimates that Site 7 could support up to 2,400 m^2 of spawning gravel. This is slightly larger than placements that have been conducted, the largest of which was 2,250 m^2 placed 2016. The cost estimate to construct the 2,400m^2 pad was $232,975 in 2008 (NHC 2008).

Access to Site 7 has been via BC Hydro's helicopter pad at the John Hart Generating Station. A steep (20–25% grade) ramp from the helicopter pad down to the river has been constructed and remediated to support each of the previous gravel placements. The ramp crosses the Canyon View trail in Elk Falls Provincial Park, requiring a detour of the trail (Anderson 2007, NHC 2010, NHC 2013a, NHC 2017b).

5.3. Site 5

Site 5 is located at the tailout of the John Hart Generating Station trailrace. In 1997, a heavy lift helicopter delivered 175 m^2 of gravel to the left bank of the tailrace pool (Burt 2004). Velocities and proximity to cover make Site 5 ideal for Chinook and steelhead spawning, with Chinook Salmon also using the tailrace for holding. Concerns have been raised in the past about the potential for works at Site 5 to interfere with BC Hydro's operations or the possible dewatering of redds in the event of a turbine failure (Burt 2004). Upgrades that are currently underway to the John Hart facility include the addition of a bypass tunnel which eliminates the dewatering risk from a turbine failure. Site 5 could support up to 2,100 m^2 of spawning habitat at an estimated 2008 cost of $226,625 (NHC 2008).

Vehicle access to Site 5 will be necessary if large amounts of gravel are to be added and is has been suggested to build a ramp from the edge of the BC Hydro parking lot to allow this (NCH 2008). Prior to any construction at Site 5, access may need to be revised and discussions held with BC Hydro to confirm whether gravel placement may be affected by BC Hydro operations.

5.4. Site 9

Site 9 is located along the left side of the Campbell River mainstem, approximately halfway between the former Catalyst Paper pump station diversion, and the downstream end of First Island. In 2012, 1,825 m^2 of Chinook Salmon spawning gravel was added to the site. In 2012, the site was accessed from the service road that extends from Duncan Bay Main to the former pump station. From here, river access was gained via the decommissioned Elk Falls 3 intake access road. After the project was completed, the access ramp was deactivated and vegetated with native plants. Surveys conducted in the fall of 2012 showed that the pad was used by 100 Chinook and 100 Chum salmon

(NHC 2013b). Prior to the 2012 construction, surveys suggested that Site 9 could support up to 2,200 m^2 of gravel at a 2008 cost estimate of $230,369 (NHC 2008).

5.5. Upstream of Second Island

The area along the right bank just upstream of Second Island was historically valuable Chinook spawning habitat (Burt 2004). The area has been enhanced with natural deposition of spawning gravel eroded from Site 7 and possibly Site 9 (NHC 2017b). A project was undertaken in 2018 to create 4,000 m^2 of spawning habitat at the upstream end of Second Island.

Access to the river upstream of Second Island can be challenging. Burt (2004) suggested the possibility of using automated wheelbarrows to access the site using the existing park trail network and a plastic pipe to deposit the gravel from the trail into the river. In the river, a Bobcat could be used to spread the gravel. Alternatively, a helicopter could be used, or a combination of the two approaches.

5.6. Elk Canyon

There have been numerous gravel enhancement projects in Elk Canyon over the past two decades. Due to difficult access, all of the projects up until 2016 were carried out using helicopters (Krogh *et al.* 2018). Starting in 2016, and continuing in 2017 and 2018, gravel was added to the first pool below Elk Falls via an overhead cable and trolley system ('Skyline'). The system is capable of delivering approximately 0.5 m^3 of gravel per trolley load and in both 2016 and 2017, 400 m^2 of new spawning habitat was created (Damborg 2017, 2018). The system was also used in 2018. It is expected that the Skyline system will continue to be used regularly, although it may not be required if an assessment shows that minimal gravel transport has occurred and the existing pad is functional (Damborg 2018). Other priority enhancements within the canyon will likely require a heavy lift helicopter. Gravel placed in the canyon is likely to benefit Chinook, Coho, steelhead, and resident rainbow trout (Burt 2004).

5.7. Ebert Road

Located on the left side of the river just upstream of the southbound Highway 19 bridge, the Ebert Road site was selected for a significant enhancement in 2005 when nearly 6,000 m^2 of spawning habitat was created (Guimond 2006). Historically this site was the most important Chinook spawning area in the lower reach of the Campbell River (Burt 2004). Although planned for Chinook Salmon, the site was ultimately most used by Chum Salmon (Guimond 2006). Access to the Ebert Road site in 2005 was accomplished by building an access ramp from the end of Ebert Road into the river. This required crossing approximately 20 m of land owned by the District of Campbell River.

6. TARGETS AND THRESHOLDS

6.1. Flow

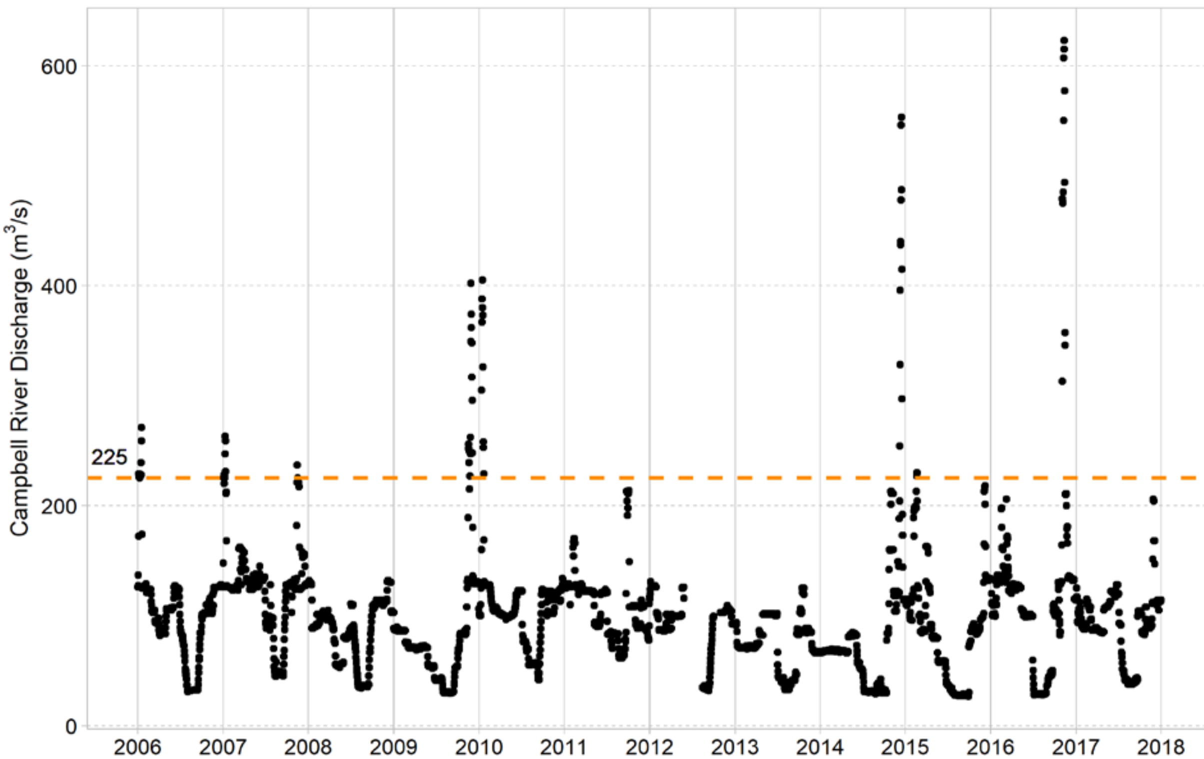
Discharge (flow) in the lower Campbell River is controlled by the John Hart facility, which is operated in accordance with the Campbell River Water Use Plan (BC Hydro 2012). Since the Water Use Plan was implemented, mean daily flow in the lower Campbell River, downstream of John Hart Generating Station, ranges from ~40 m^3/s in summer to ~140 m^3/s in winter (Figure 3 in Appendix A). Further, background to the hydrology of the lower Campbell River is provided in Section 2.3 of Krogh *et al*. 2018 (Appendix A).

Previous gravel enhancement projects in the mainstem have been designed to resist significant erosion unless flow exceeds 225–260 m^3/s (Table 5; NHC 2008, 2010, 2013a, 2013b 2017b). Accordingly, an **adaptive threshold of 225 m^3/s** downstream of John Hart Generating Station (gauge 08HD003) has been identified as appropriate to initiate a high-flow response assessment. Depending on results of this assessment, Directed Works may be required to complete spawning habitat enhancement prior to the fall spawning period in order to repair damage caused by high flows. This threshold can be revised if monitoring indicates an alternative value is more appropriate, or if future enhancement projects have different design criteria. Further, the threshold could be refined to vary by reach, depending on the outcomes of further investigations and the spatial distribution of flow gauges. The threshold is considered precautionary; e.g., previous monitoring has shown that a flow of 265 m^3/s led to negligible changes to a gravel pad at Site 7 that had a design flow of 225 m^3/s (NHC 2008). Nonetheless, the threshold is considered appropriate to initiate some level of assessment (Section 7), recognizing that Directed Works will only be undertaken if the assessment shows that actions are urgently required.

Since the introduction of operations in 2006[3] consistent with the Water Use Plan, mean daily flow has exceeded 225 m^3/s in six of 12 years for at least one day, with all exceedances occurring between November and January (Figure 3). Mean daily flow exceeded this threshold for a total of 71 days or 1.6% of all days in the 12-year period. Thus, it reasonable to expect this threshold to be exceeded approximately every other year on average.

[3] The WUP was implemented in 2012; however, BC Hydro has managed operations in accordance with the WUP since 2006 (discussed in Perrin *et al*. 2017).

Figure 3. Mean daily discharge in the lower Campbell River (Water Survey of Canada station 08HD003) for 2006–2017. The dashed horizontal line denotes the proposed flow threshold of 225 m^3/s.



6.2. Spawning Habitat

The **long-term target** for the lower Campbell River is to provide **24,000 m^2** of high-quality Chinook Salmon spawning habitat. This target is based on the value estimated by Burt (2004) and presented in Table 1. It is assumed that providing this amount of habitat will also ensure sufficient spawning habitat for other Pacific salmon species and steelhead, recognizing that there is overlap in spawning habitat preferences among these species.

This long-term target is expected to exceed the habitat requirements of the number of salmon that currently return to the river (Figure 1). Thus, it would not currently be cost-effective to aim to construct 24,000 m^2 of high-quality habitat because it would exceed biological requirements and habitat would erode before salmon escapement increased to target levels. It is therefore appropriate to use a lower spawning habitat target to guide management in the near-term until salmon abundance increases. The minimum area of spawning habitat required in a specific year will depend on factors that include salmon escapement, spawning habitat quality (e.g., gravel size and depth), and the relative distribution of spawning gravel among priority sites at preferred spawning locations.

Evaluation of the necessity and scope of spawning habitat enhancement projects should be undertaken by experts (e.g., the CRSH Roundtable) who consider the factors listed above in the context of up-to-date monitoring results and a need to ensure that resources are allocated cost-efficiently. For context, reference values are provided in Table 6 to inform decisions about the requirement and scope of spawning habitat construction. Table 6 shows that the area of spawning habitat present during the 2017 surveys was less than 50% of the estimated lower range of the habitat area required to support the median Chinook Salmon escapement over the last 10 years (756 fish).

For further reference, Table 7 shows the design targets from previous gravel enhancement projects at the six priority sites (Section 5). These values are presented to provide context to inform what is achievable at these sites. Table 7 indicates that it is feasible to provide 17,600 m^2 of spawning habitat at these sites, which is estimated to provide sufficient habitat for 1,760 pairs of Chinook Salmon when spawning pads are in a newly constructed (optimum) condition.

Table 6. Reference values to inform spawning habitat construction in the lower Campbell River.

Reference Values	Area (m^2)	Details
Spawning area required per female Chinook Salmon, assuming optimum (recently constructed) gravel conditions	10.0	Area used by Burt (2004). Applies to recently-constructed spawning pads that are in optimum condition.
Biostandard for spawning area required per female Chinook Salmon based on natural conditions	20.1	Based on ~4 × redd area; reported in Reiser and Bjornn (1979), based on Burner (1951)
Area of Chinook Salmon spawning habitat present in 2017	~1,700	Based on area of suitable habitat mapped downstream of Elk Canyon (1,250 m^2; NHC 2017a), plus area of primary gravel deposits in the canyon (~450 m^2; Hatfield Consultants 2017)
Estimated spawning habitat area required for 10-year median escapement	3,800–7,600	Based on spawning area requirements of 10.0–20.1 m^2 per pair, DFO (2019) Chinook Salmon escapement data for 2009–2018, and a 1:1 sex ratio
Estimated spawning habitat area required for 10-year maximum escapement	6,100–12,200	Based on spawning area requirements of 10.0–20.1 m^2 per pair, DFO (2019) Chinook Salmon escapement data for 2009–2018, and a 1:1 sex ratio
Long-term spawning habitat area target	24,000	Burt (2004) estimated a target habitat area of 23,259 m^2, which was subsequently rounded up. This estimate was originally calculated as the amount of habitat present in 2003 (9,879 m^2) when there were estimated to be 662 females, plus additional habitat required to support a total of 2000 females, estimated by assuming 10 m^2 per female.

Table 7. Areas of spawning habitat that could potentially be constructed at six priority sites, as determined by pre-build surveys.

Priority	Site Name	Fully Built Target (m^2)	Pairs of Chinook Supported[1]
1	Site 7[2]	2,250	225
2	Site 5[3]	2,100	210
3	Site 9[3]	2,200	220
4	Upper End Second Island[4]	4,000	400
=5	Elk Canyon (Site 1)[5]	300	30
=5	Elk Canyon (Site 2)[5]	150	15
6	Ebert Road[3]	7,500	750
Sum		17,600	1,760

[1] Assumes 10 m^2 per pair (Burt (2004)

[2] NCH (2017)

[3] NCH (2008)

[4] Results of project COA-F19-F-2765

[5] Hatfield Consultants (2017)

7. MONITORING PROGRAM

7.1. Overview

Two separate spawning habitat monitoring components are proposed. First, monitoring is proposed to be undertaken in the summer or early fall (Section 7.2) when survey conditions are optimal for making observations (low flows and high visibility). This monitoring will provide a snapshot of conditions that can be used to evaluate progress towards meeting spawning habitat targets (Section 6) and inform the design of gravel enhancement projects. Second, a high-flow response assessment (Section 7.3) is proposed to be undertaken if flow exceeds a threshold value that may result in substantial erosion. This monitoring is proposed to be undertaken in early spring to potentially inform subsequent works.

7.2. Summer/Fall Status Monitoring

The primary aim of the proposed summer/fall status monitoring is to provide an estimate of spawning habitat area (i.e., gravel pad size in m^2) for priority sites (Section 5) in the lower Campbell River. Monitoring should be undertaken using cost-effective and repeatable methods that will provide a time series of spawning habitat area at priority sites over multiple years, in alignment with Priority Action #23 (Table 3). The requirement to undertake monitoring will depend on flow conditions and surveys are not necessarily required to be conducted every year, especially if high flows have not occurred since the previous survey. Proponents should consider the rationale and urgency of monitoring when preparing proposals for this activity. Proponents should consider contacting the FWCP Coastal Region manager as program partners may have information relevant to the rationale and scope of a monitoring proposal.

Based on the successful results of previous surveys (Section 2.5; Figure 2), a UAV survey is considered to be a suitable monitoring method to provide a synoptic survey of gravel availability in the lower river. The survey should focus on the lower Campbell River from the Elk Canyon confluence to the lower Highway 19 bridge (Map 2, Map 3). It is desirable to also collect aerial images at spawning habitats in Elk Canyon; if it is not feasible to use a UAV in Elk Canyon, then the key sites immediately downstream of Elk Falls plunge pool could be surveyed from the bank and/or photographed from Elk Falls suspension bridge.

Broadly, the UAV survey should be timed for summer or early fall when flows are lowest and visibility is optimal; previous surveys have demonstrated that good-quality images of spawning habitat can be obtained in August and October, if flow conditions are suitable for observations (Section 2.5). There is an advantage to conducting the survey when salmon are spawning or staging on spawning habitats; e.g., during early October when Chinook and, potentially, Chum and Coho salmon spawn (Table 2). Conducting the survey at this time will provide information about variability in spawning habitat use among species, which is a recognized uncertainty (Section 8). However, a risk to conducting the survey in the fall is that visibility may be limited by high flow events, which historically have occurred after mid-September (see Figure 3 of Appendix A). Thus, it is advisable to adjust the timing of the survey based on current knowledge of spawning habitat area and distribution. For example, if a major high-flow event has occurred during the preceding winter, then it may be desirable to schedule the UAV survey for July or August (when flows are typically lowest) to obtain the most accurate data possible regarding the current extent of spawning habitat. Conducting the survey in the summer could also inform modifications to the detailed design of instream works scheduled for that year. Conversely, if large changes are not anticipated to have occurred since a previous survey, then it may be preferable to schedule the monitoring for early October with the aim of also collecting valuable data to improve understanding of spawning habitat use, recognizing that there is a risk that flows may be unsuitable for making precise observations.

Additional field work is proposed to support the UAV survey because a UAV survey has limited potential to provide information about habitat quality, e.g., gravel depth. This could involve a snorkel survey of the same reach and accompanying bank walk to assess gravel suitability characteristics using methods based on applicable standards (RIC 2001, Lewis *et al.* 2004). Variables to be measured could include: substrate size, embeddedness, and compaction, although the extent of additional data collection will depend on survey conditions (e.g., visibility, velocity) at each site. There may be opportunities to collect additional data in Elk Canyon by extending the scope of the JHTMON-15 snorkel surveys, which are currently scheduled to be undertaken annually during February to April for a fixed period (BC Hydro 2016). Similarly, there may be opportunities to collect additional information about spawning habitat use by modifying the scope of snorkel surveys conducted routinely by DFO in the fall; however, the main focus of these surveys is Pink Salmon enumeration and there may be limited potential to collect information about Chinook and Chum salmon distribution (Walls, pers. comm. 2018). The use of *in situ* methods to monitor gravel depth should also be considered (discussed in Section 7.3 below).

Analysis of monitoring data should focus on quantifying the area of spawning habitat throughout the lower river to understand how habitat availability varies among sites and years. Habitat areas should be compared with long-term and interim targets (Section 6.2), in addition to as-built targets for individual sites (Table 7) to quantify the area of habitat at each site as a percentage of the estimated maximum that can be provided. This information should be made available to potential project proponents to inform project design.

7.3. High-Flow Response Assessment

The objective of proposed high-flow response assessment is to evaluate whether Directed Works are required to urgently repair spawning habitats that have been eroded during high flow periods, based on monitoring during the spring. The outcome of a high-flow response assessment will also inform the scope of Directed Works if they are required. The assessment should at least involve collecting quantitative estimates of the area of available spawning habitat at a subset of the highest priority sites (Section 5). To inform the assessment, there may be value in contacting the FWCP Coastal Region manager as program partners may have key information from stream walks to inform the assessment.

The scope of a high-flow response assessment will vary depending on the characteristics of high flows (which affect the estimated extent of erosion) and survey conditions. Typically, flows are high during the early spring period, so it is unlikely to be possible to collect useful imagery of spawning habitat with a UAV at this time of year. Also, standard topographic surveys of spawning habitat (Bunte 2004) are unlikely to be feasible at this time of year. Instead, monitoring to inform the assessment may include a bank walk along the lower river from the Elk Canyon confluence to the lower Highway 19 bridge; a snorkel survey may also be possible if flow conditions are suitable. The potential to use *in situ* instruments to measure the depth and area of spawning habitat should also be considered. Options may include using passive instruments such as scour chains or sliding bead monitors, which can be installed in gravel substrate and then manually examined after an erosion event to measure the depth of gravel scour (Nawa and Frissell 1993). Alternatively, there may be scope to use digital instruments to provide near-continuous data, which may provide greater understanding of how flows affect habitat stability. Options may include installing accelerometers in gravel substrate (Gendaszek *et al*. 2013) or installing water level sensors at the upstream and downstream regions of constructed gravel pads to measure changes in hydraulic grade, which may indicate gravel erosion. Applicable *in situ* monitoring methods are expected to vary among sites, depending on hydraulic and morphological characteristics. Installing and operating instruments could be considered when designing individual gravel enhancement projects. Alternatively, there is scope to conduct a broader monitoring and evaluation program, which could align with the existing Monitoring and Evaluation Priority Action to conduct gravel monitoring in the lower mainstem (Priority Action #23; Table 3).

Quantitative estimates of the area of available spawning habitat at a subset of the highest priority sites should be evaluated (e.g., by CRSH Roundtable members; Section 4.3) and compared with spawning habitat targets to evaluate whether Directed Works are required. If required, it may be possible to use data collected later in the year during monitoring (Section 7.2) to inform detailed design of projects.

8. DISCUSSION AND OUTSTANDING UNCERTAINTIES

This Strategy provides direction to guide Spawning Habitat Enhancement and Monitoring in the lower Campbell River, recognizing that implementation of the strategy will depend on commitment from project proponents, environmental variability (e.g., flow conditions). Applications for FWCP Coastal funding will also be considered in the context of other priorities, as described in the Grant Information Kit for applicants (FWCP 2018a).

Key outstanding uncertainties are listed below; these were identified and discussed at the November 2018 workshop (Section 3.3) or during subsequent discussions. These uncertainties could be addressed through future Research and Information Acquisition projects.

- There is uncertainty about the feasibility of bulk gravel loading. Potentially, this method may provide a relatively cost-effective and longer-term solution to gravel enhancement. This could involve adding a large volume of gravel at a single accessible location (e.g., at the upstream end of Elk Canyon, pending work to enhance access). Subsequent flows are then relied on to transport the gravel downstream and passively replenish priority sites.

- There may be additional gravel enhancement sites that could provide suitable spawning habitat and better resilience to high flows. In particular, riffle crests in reach 4 (Map 1) may be suitable. Hydraulic modelling could be used to investigate the suitability of potential new sites and there are opportunities to build on existing work to minimize resources required for a modelling study. Modelling could also help to understand how gravel is transported at different flows, thereby informing appropriate responses to specific high flow events.
- A target of 24,000 m^2 of spawning habitat provides a suitable target to support Chinook Salmon abundance of 2000 pairs. However, the workshop attendees agreed it is reasonable to implement a lower interim spawning habitat target while Chinook Salmon escapements are building. There is uncertainty about what these interim targets should be and the interim target provided in Section 6.2 may need to be revisited as new information accrues.
- Chinook Salmon in the lower Campbell River have likely evolved spawning habitat preferences that differ from preferences for the species more generally. Habitat suitability criteria that have been applied to the lower Campbell River are general curves used throughout BC; it may be beneficial to refine the spawning criteria to be specific to spawning habitat enhancement in the lower Campbell River.
- There is uncertainty about how spawning habitat use varies among salmon species. It would be useful to examine this further by analyzing monitoring data collected with a UAV or snorkel surveys (Section 7.2). In particular, there is uncertainty about why Chinook Salmon seem to make limited use of spawning habitats at certain sites that could otherwise provide substantial areas of habitat, e.g., Ebert Road (Section 5.7). If/when suitable data are available, it may be useful to examine whether use of these sites is positively correlated with escapement. This would help to understand whether limited recent use of these sites mainly reflects low fish abundance, or inherent unsuitability of the habitat.
- When designing future gravel placement projects, it would be beneficial to consider opportunities to use *in situ* instruments (e.g., scour chains or accelerometers) to monitor gravel depth. The suitability of such methods is expected to vary among sites, e.g., based on hydraulic conditions (Section 7.3).

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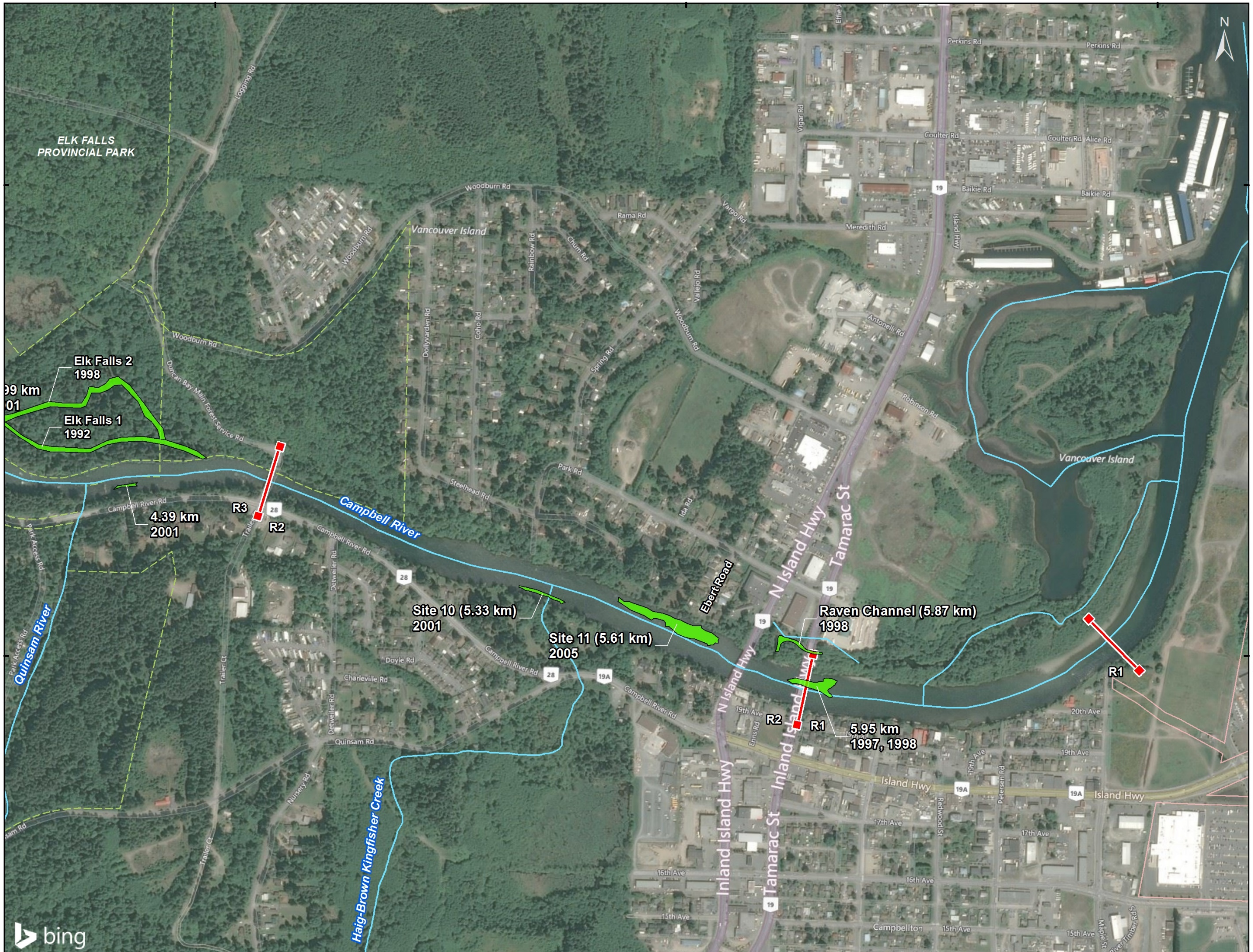
PROJECT MAPS



Historical Spawning Gravel Placements on the Campbell River

Legend

- Gravel Placement Location
- Reach Breaks
- Parks and Protected Areas
- First Nation Reserve

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

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Map 2

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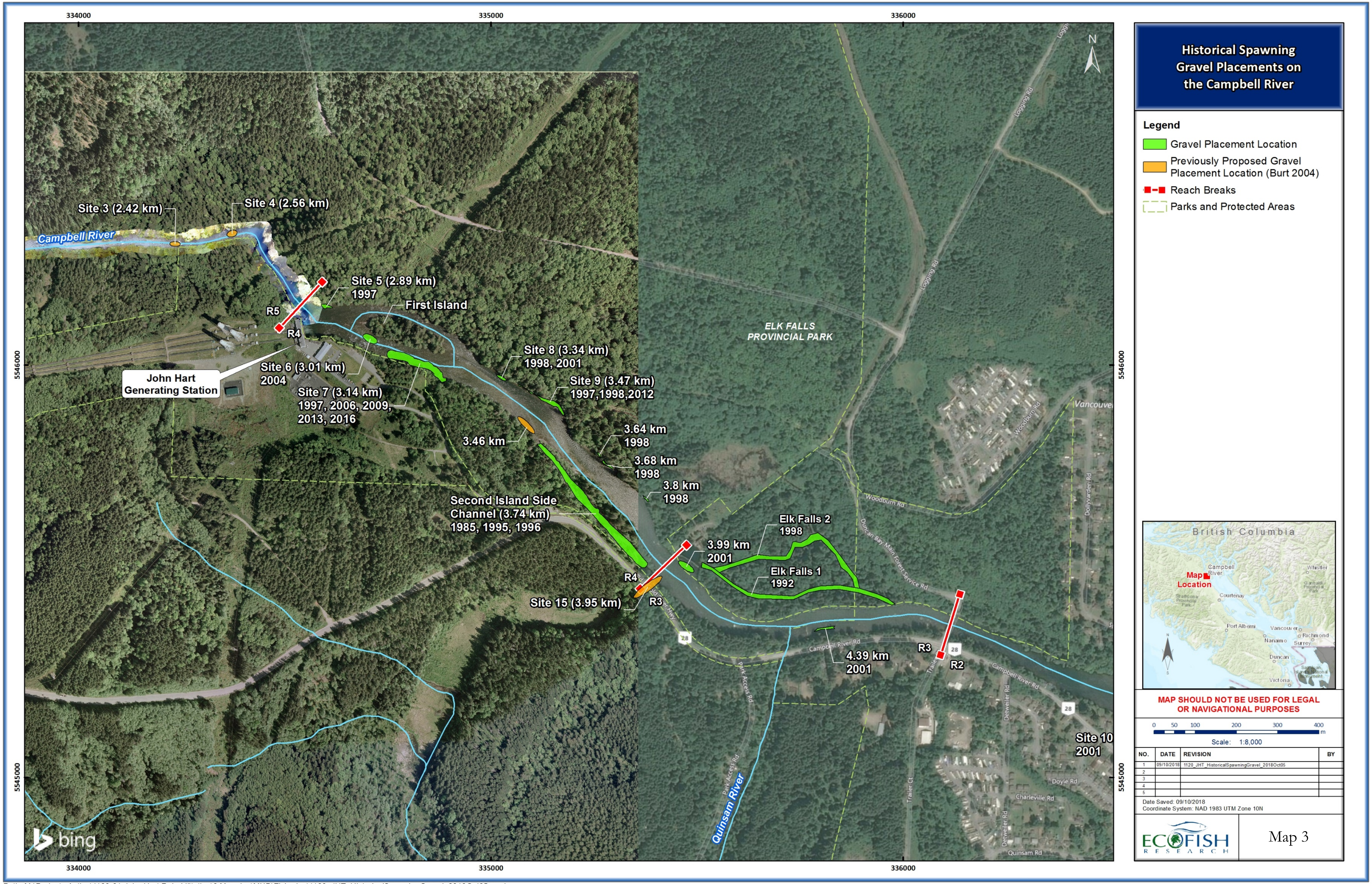

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Historical Spawning Gravel Placements on the Campbell River

Legend

- Gravel Placement Location
- Previously Proposed Gravel Placement Location (Burt 2004)
- Reach Breaks
- Dam
- Parks and Protected Areas

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Map 4

APPENDICES

Appendix A. Review of Gravel Placement in the Lower Campbell River

Fish and Wildlife Compensation Program

Review of Gravel Placement in the Lower Campbell River

Prepared for:

Fish and Wildlife Compensation Program – Coastal
British Columbia Hydro and Power Authority
6911 Southpoint Drive – 16th Floor
Burnaby, BC, V3N 4X8

October 22, 2018

Prepared by:

Ecofish Research Ltd.

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EXECUTIVE SUMMARY

The objective of this desktop review is to describe the history of spawning gravel placement in the lower Campbell River, downstream of Elk Falls. This review is intended to inform the development of a Long-Term Strategy for Gravel Placement and Monitoring in the Campbell River watershed (the Strategy), which has been funded by the Fish and Wildlife Compensation Program in 2018/2019. Specifically, this review is intended to provide background for a workshop scheduled for November 2018. The review may be updated to include additional information presented at the workshop and we intend to present material from this review in the Strategy.

This review is based an earlier memo prepared by Schulz and Buchanan (2012) for BC Hydro, which has been updated to include activities up to 2018. Historical gravel placement and monitoring projects are reviewed, with information described in relation to five separate reaches of the lower Campbell River. Since 2012, gravel has been placed in the river in multiple years and at multiple sites, particular near First Island where a combined 4,350 m^2 of gravel was placed in 2013 and 2016. In March 2016, a new gravel delivery system was built in Elk Falls Provincial Park that permitted gravel addition to Elk Canyon via a skyline (200 m^3 in 2016 and 300 m^3 in 2017). Recommendations that reoccur in previous reports are presented to provide context for development of the Strategy. A key historical recommendation is to consider a new funding model to support gravel augmentation projects that allow for gravel pads to be assessed in the spring, and augmented where necessary in the summer, ready for use by spawning salmon in the fall.

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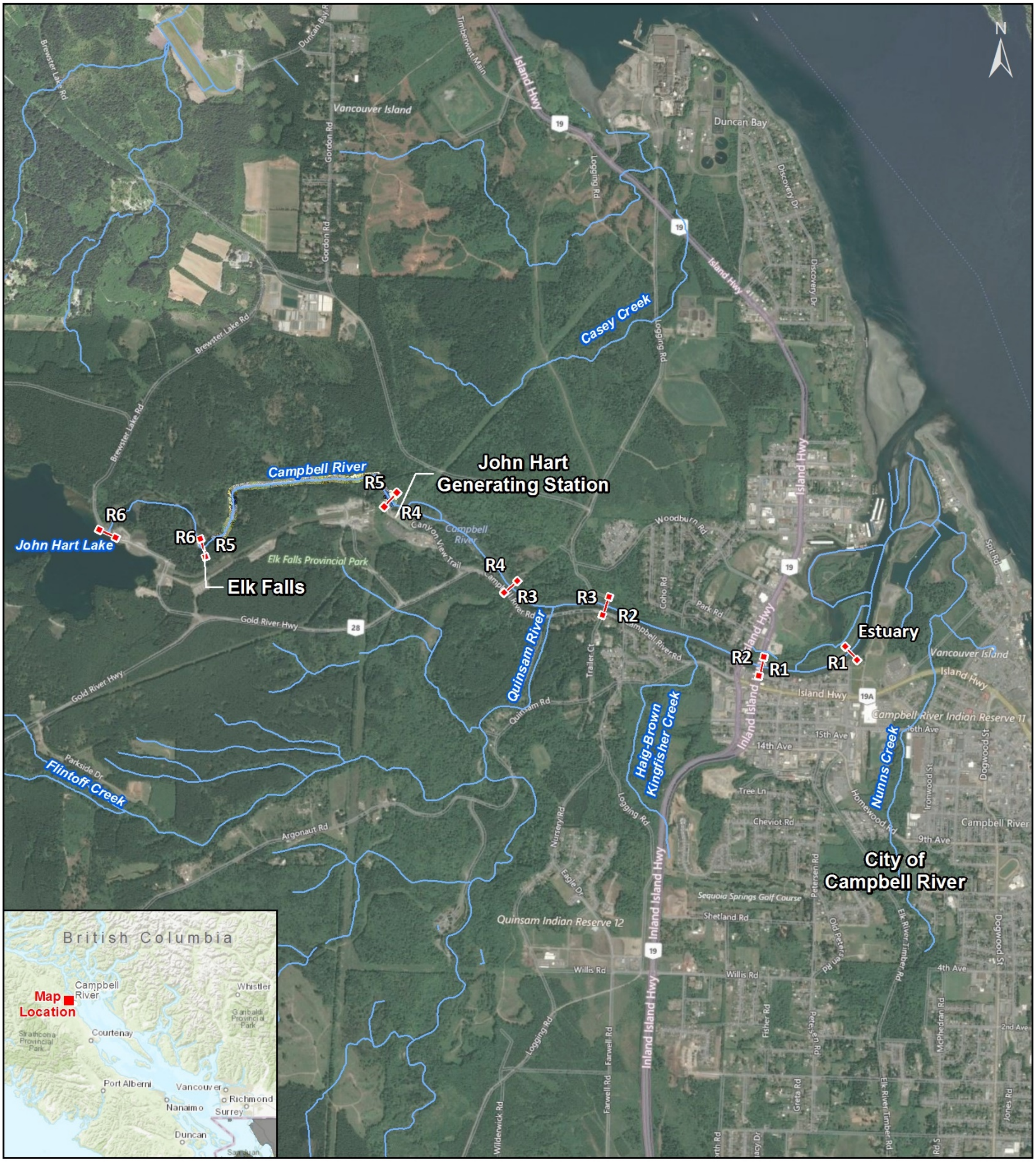
1. INTRODUCTION

The objective of this desktop review is to describe the history of spawning gravel placements in the anadromous reach of the lower Campbell River, downstream of Elk Falls. This review is intended to inform the development of a Long-Term Strategy for Gravel Placement and Monitoring in the Campbell River watershed (the Strategy), which has been funded by the Fish and Wildlife Compensation Program (FWCP) in 2018/2019. Specifically, this review is intended to provide background material for a workshop scheduled for November 2018. The review may be updated to include additional information presented at the workshop. This review is based on an earlier memo prepared by Schulz and Buchanan (2012) for BC Hydro, which has been updated to include activities up to 2018, based on review of relevant reports prepared for FWCP from 2003 to 2018. The study by Schulz and Buchanan (2012) drew extensively on a gravel placement inventory completed in 2003 (Burt 2004) and the results of a geomorphic survey undertaken in 2010 (NHC 2011).

Section 2 below presents general background to fish and fish habitat in the lower Campbell River, including general geomorphological information about reaches in the study area. Section 3 presents the results of the review of previous gravel placement and monitoring activities. Key recommendations that were made in previous reports and have not been fully completed are presented in Section 4. These historical recommendations are presented here to provide context for discussions at the workshop and different priorities may be identified during Strategy development.

Project Overview



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Reach Breaks

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Map 1

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2. BACKGROUND

2.1. Fisheries in the Lower Campbell River

The lower Campbell River supports populations of all five species of anadromous Pacific salmon[1], as well as steelhead, resident Rainbow Trout, and Cutthroat Trout (anadromous and resident). Priority fish species in the watershed identified by FWCP are Chinook, Coho, Pink and Chum salmon, steelhead, Cutthroat Trout and Rainbow Trout (FWCP 2017). Chinook Salmon and steelhead are of particular conservation concern (Burt and Burns 1995; FWCP 2017). The abundance of spawning Chinook in the Campbell River mainstem generally declined since the 1960s (Figure 1), and a decreasing trend is particularly evident in the last 30 years (DFO 2017; Nagtegaal *et al*., 2000). Both summer and winter run steelhead stocks are listed as an extreme conservation concern by the British Columbia Conservation Foundation (BCCF) and are currently in decline. Declines of these species have been related in part to the loss of spawning habitat in the lower Campbell River (Burt and Burns 1995; Burt 2004).

Table 1 shows the spawning and incubation periods for salmonid species present in the lower Campbell River. The table indicates that gravel placement activities should occur during July and August to reduce risk to spawning or incubating fish in the lower Campbell River.

[1] Sockeye Salmon are scarce and a lack of lacustrine habitat in the lower Campbell River likely limits Sockeye Salmon production (Burt & Burns 1995).

Figure 1. Salmon escapement between 1953 and 2016 for the Campbell River. Note that Chinook (blue) are measured on the right vertical axis. Sockeye are not shown (scarce).

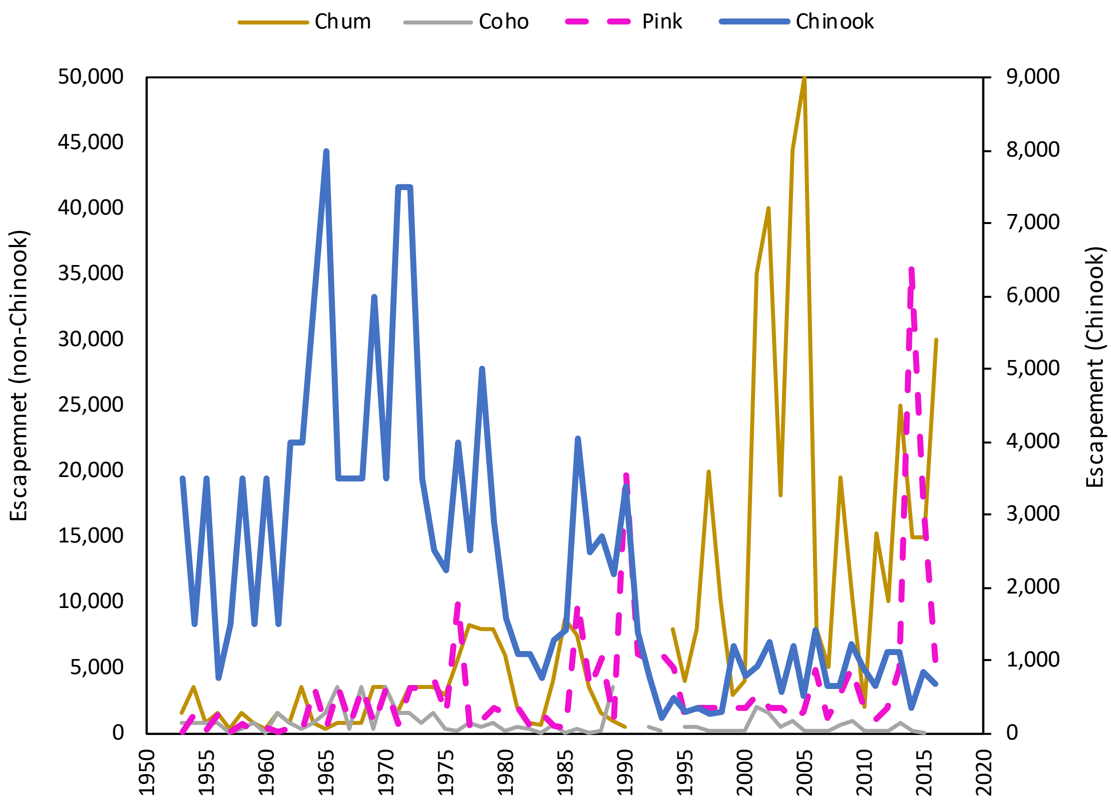


Table 1. Spawning and incubation periods for salmonid species in the lower Campbell River.

Life History	Species	Event	Life History Stage[1] Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anadromous	Chinook Salmon	Spawning												
		Incubation												
	Chum Salmon	Spawning												
		Incubation												
	Coho Salmon	Spawning												
		Incubation												
	Pink Salmon	Spawning												
		Incubation												
	Sockeye Salmon	Spawning												
		Incubation												
	Cutthroat Trout	Spawning												
		Incubation												
	Steelhead (winter run)	Spawning												
		Incubation												
	Steelhead (summer run)	Spawning												
		Incubation												
Resident	Cutthroat Trout	Spawning												
		Incubation												
	Rainbow Trout	Spawning												
		Incubation												

[1] Life history timing from Fish Technical Committee (2001)

Critical times

2.2. Gravel Recruitment

Historically, gravel recruitment to the lower Campbell River originated from the 10 km reach between Campbell Lake and the upper end of Elk Falls Canyon, including tributaries within this section of the river (Burt, 2004). This ongoing gravel input provided abundant areas of spawning gravel for anadromous Pacific salmon (Hamilton and Buell 1976). Construction of John Hart Dam reduced gravel recruitment in the lower Campbell River and, as gravel was transported downstream, there was a net loss of gravel in the size range suitable for spawning (Burt, 2004). Over time this effect has reduced the area of naturally occurring spawning substrate in the lower Campbell River (Burt and Burns 1995; Burt, 2004). In addition, flow management prior to the institution in 1997 of the Interim Flow Management Strategy (IFMS) meant that the spawning habitat in Elk Falls Canyon was effectively lost due to the occurrence of extreme low flows. Since that time, minimum flows in Elk Canyon have been implemented and salmonids can now access this habitat for spawning (Campbell River Hydro/Fisheries Advisory Committee 1997).

In 1973, the lower Campbell River was estimated to contain 134,760 m^2 of spawning gravel, with total Chinook spawning habitat estimated at 87,740 m^2 (Hamilton and Buell 1976). By 1993, estimates of spawning gravel and Chinook spawning habitat were 14,000 m^2 and 2,350 m^2 respectively, and the substrate was noted to be of poor quality because of the large particle size within remaining spawning areas (Burt and Burns 1995). Note that both of these estimates did not include the canyon section because surveys were performed before the IFMS restored useable habitat in this part of the river. High flow events have significantly changed the distribution of gravel in the river since those surveys (discussed further below).

Increasing spawning capacity in the lower Campbell River has become a management priority and has prompted habitat restoration initiatives and spawning gravel placements since 1997. Following the enhancement efforts, an extensive inventory of spawning gravel in the Campbell River was completed by Burt (2004); it was concluded that enhancement between 1997 and 2003 had restored spawning habitat to above target levels (Table 2)(Campbell River Hydro/Fisheries Advisory Committee 1997) for all salmonid species except Chinook. The author estimated that 9,879 m^2 of Chinook spawning habitat (enough for 662 pairs whereas the target is 2000 pairs) was present in the lower Campbell River; this was approximately 13,380 m^2 below the target for this species. An additional 16,675 m^2 of gravel has been placed in the Campbell River since 2003 in an effort to further increase the capacity for Chinook spawning. However, the gravel pads have continued to shift downstream over time. Flooding in the fall/winter of 2009/2010 contributed to the erosion of gravel placements in the lower Campbell River to downstream areas (NHC, 2010a). Most recently, extreme high flow events occurred in December 2014 (peaking at 546 m^3/s) and November 2016 (peaking at 650 m^3/s) (NHC, 2017). The 2016 high flow event likely mobilized much of the spawning gravel added over the previous decades.

Table 2: 2003 status of lower Campbell River spawning habitat in relation to escapement targets. Adapted from Table 6 in Burt (2004).

	Chinook		Chum		Coho		Pink		Steelhead	
	Habitat	Pairs	Habitat	Pairs	Habitat	Pairs	Habitat	Pairs	Habitat	Pairs
Target	23,259	2,000	-	-	3,159	500	-	-	2,620	200
Status 2003	9,879	662	22,235	13,034	3,679	532	9,473	10,047	5,303	553
2003 % of Target	42%	33%	-	-	105%	106%			202%	277%

NOTE: All habitat areas are reported in m^2

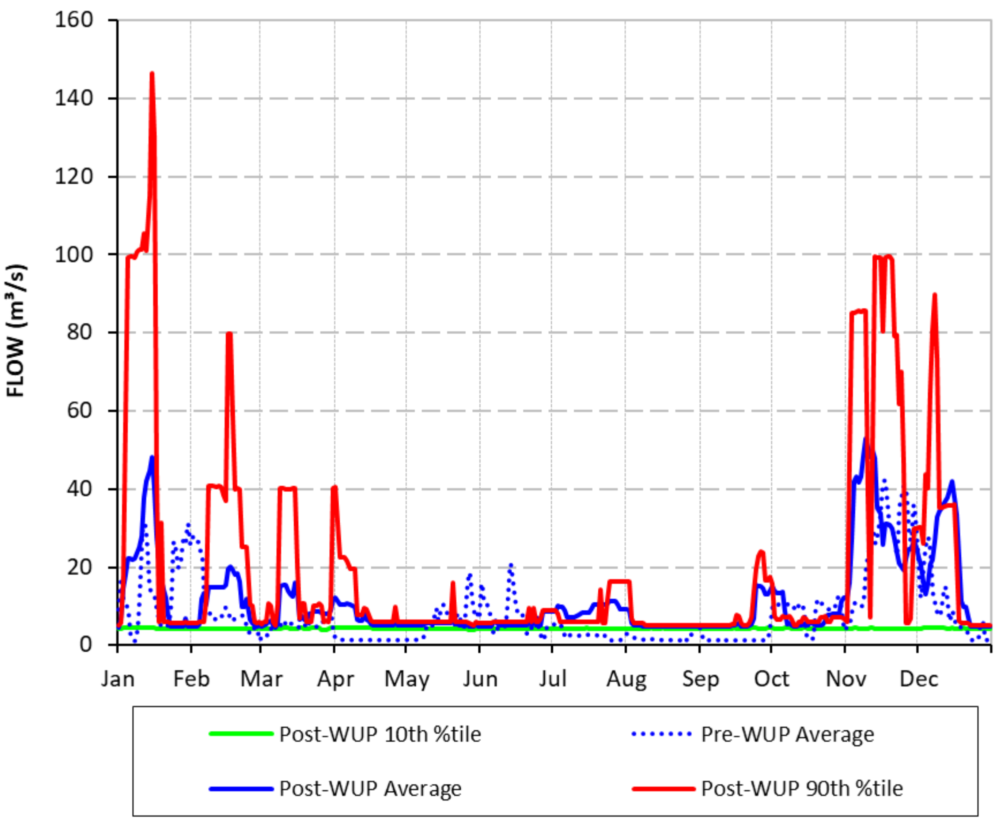
2.3. Hydrology

Flow in the Elk Canyon (Reach 5, Map 2) is directly controlled by the amount spilled over John Hart Dam and, until 1997, this flow could decline to only the flow that was able to leak around the dam. Post 1997, when the IFMS was introduced BC Hydro agreed to maintain a flow of 4 m^3/s to maintain fish habitat (BC Hydro 2012). The current Water Use Plan (WUP) stipulates a minimum flow of 4 m^3/s in Elk Canyon from April 16 to March 31 and a minimum flow of 7 m^3/s from April

1 to April 15 (BC Hydro 2012). A series of pulse flows are also required in spring (≥10 m^3/s) and fall (≥7 m^3/s) (BC Hydro 2012).

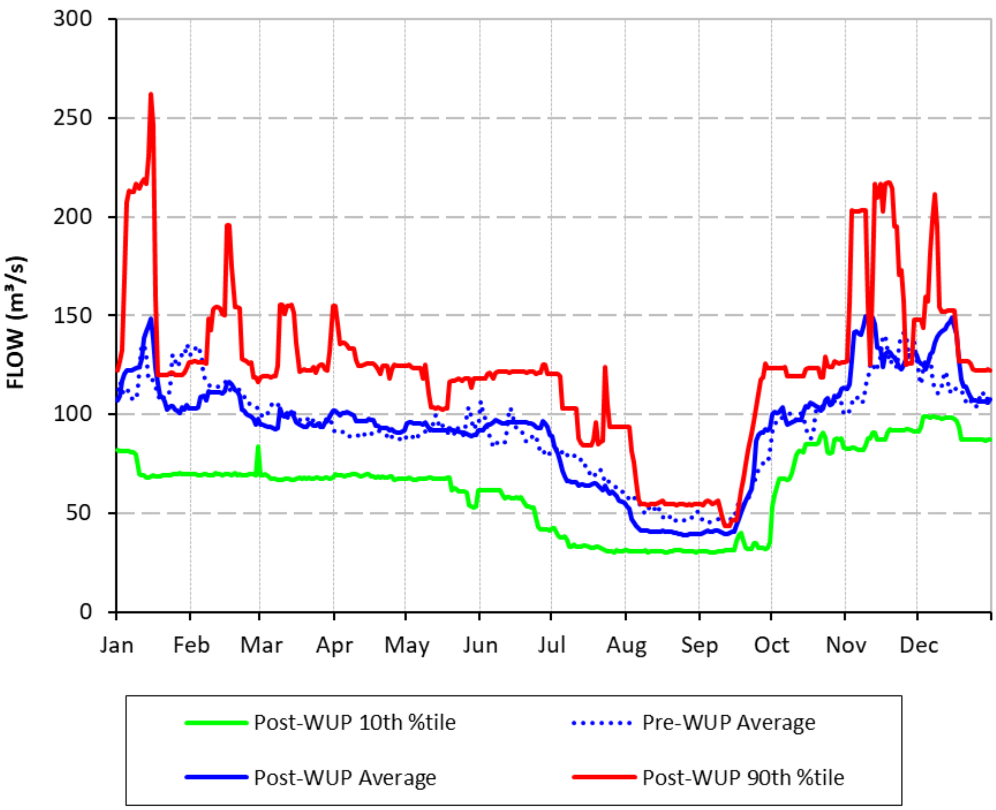
Downstream of the Elk Canyon, where flows are augmented with those from the John Hart Generating Station, the lowest flows occur in late summer, with values of approximately 40 m^3/s, peak flows are highly variable but occur between November and March when values can reach over 650 m^3/s (NHC 2017). Figure 2 and Figure 3 show hydrographs for the Elk Canyon (Map 2) and the Campbell River downstream of the John Hart generating station.

Figure 2. Hydrograph for the Campbell River in Elk Canyon (Non-Power Release). Dates are summarized for periods before (pre-2006) and after (2006-2016) implementation of the Campbell River Water Use Plan operations[2].



[2] The WUP was implemented in 2012; however, BC Hydro has managed flows in the lower Campbell River in general accordance with the WUP since 2006 (discussed in Perrin *et al.* 2017).

Figure 3 Hydrograph for the Campbell River, downstream of the John Hart Generating Station. Data are summarized for periods before (pre-2006) and after (2006-2016) implementation of the Water Use Plan operations.



2.4. Study Area

The study area encompasses the entire lower Campbell River from Elk Falls to the estuary, a 6.5 km long stretch that comprises five reaches consistent with the delineation of reaches in Burt and Burns (1995) (Map 1). The physical features of each reach are described in the following paragraphs based on data in Burt and Burns (1995) unless otherwise indicated. In contrast, the study area for the geomorphic survey (NHC 2011) covered only the length of river from the lower section of Elk Falls Canyon to the northbound Highway 19 bridge (lower part of Reach 5 to the downstream end of Reach 2). As a result, substrate data are not available for Elk Falls Canyon and Reach 1. It should also be noted that subsequent high flows (e.g., 2016) have likely substantially altered the substrate characteristics (NHC 2017).

2.4.1. Reach 1

Reach 1 is 725 m long and extends from the Campbell River Estuary to the lower highway bridge (Map 4). This reach has a mean wetted width of 83 m and a gradient of 0.1%. The average maximum depth measurements at multiple sites throughout the reach is 1.4 m. Channel morphology is primarily run (68%) and flat/riffle (38%). Bed material is predominantly small and large cobbles and boulders (23%, 26%, and 20% respectively). Water level and velocity in this reach are influenced by the tide.

There are two side channels associated with this reach. Raven Channel runs adjacent to Reach 1 along the left bank[3], although the inlet to this side channel is located within Reach 2. Flows enter Raven Channel between the southbound and northbound highway 19A bridge crossings and exit into a watercourse locally known as Fred's Slough. There is also a secondary channel, the NCC Channel, which diverges from Raven Channel at its midpoint and flows into Baikie Slough.

2.4.2. Reach 2

Reach 2 is 1,200 m long and extends from the lower highway bridge to the logging bridge (Map 4). This low gradient, riffle-run reach has a mean wetted width of 73 m and mean maximum depth of 1.8 m. Bed material is primarily large cobbles (21%) and boulders (45%).

Haig-Brown Kingfisher Creek enters the Campbell River in this reach on the right bank 580 m upstream from Reach 1. The entrance to Raven Channel is located on the left side of the river 100 m upstream from Reach 1. Flows enter the channel between the southbound and northbound highway 19A bridge crossings.

2.4.3. Reach 3

Reach 3 is 785 m long and extends from the logging bridge to the downstream end of Second Island (Map 3). This reach has a mean wetted width of 57 m, mean maximum depth of 1.5 m and a mean gradient of 0.6%. This reach is characterized primarily by broken run (49%), run (31%) and flat/riffle (18%) hydraulic types. Bed material is primarily composed of large cobbles (25%) and boulders (30%).

The Quinsam River enters the Campbell River on the right bank in Reach 3, 4.4 km upstream from the mouth and 385 m upstream from Reach 2. The Quinsam River is the largest tributary to the lower Campbell River.

2.4.4. Reach 4

Reach 4 is 1,095 m long and extends from downstream of Second Island to John Hart Generating Station (Map 3). This reach has a mean wetted width of 72 m, mean maximum depth of 1.4 m and a mean gradient of 0.7%. This reach is characterized primarily by broken run (43%), flat/riffle (33%) and run (21%) hydraulic types. Bed material is primarily composed of large cobbles (23%) and boulders (52%).

[3] Right and left banks are defined by looking in a downstream direction.

Reach 4 has been further subdivided into five sub-reach breaks based on past work completed by Mainstream in 2008 (Stewardson and Lansley, 2008; Hemmera, 2010). Spawning habitat in the canyon confluence is non-existent and only one small, isolated pocket of gravel exists within the confluence sub-reach. Overhanging vegetation is generally present in the downstream end of the lower canyon, large wood debris is minimal, and water velocity tends to be slow (Hemmera, 2010). The tailrace sub-reach is 4 – 1.2 m deep, riparian cover is limited, and a single isolated pocket of gravel exists between a concrete slab and a bedrock shelf on the left side. Boulders and back eddies provide rearing habitat, although generating flows fluctuate, altering the suitability of this habitat (Hemmera, 2010). The First Island channels (left and right channels) contain spawning habitat from gravel placements in the upstream and downstream ends of the right channel, within gravel pockets at the upstream end of the Island, and scattered throughout the left channel. Boulder riprap lines the right bank leading into the right channel. Fish habitat suitability in Reach 4 is highly influenced by discharge from the JHT powerhouse and Elk Falls Canyon (Hemmera, 2010).

2.4.5. Reach 5

Reach 5 is 1,750 m in length and extends upstream from the JHT tailrace to the plunge pool below Elk Falls (Map 2). This canyon section, locally known as Elk Falls Canyon, is deeply entrenched within vertical bedrock walls. Aquatic habitat is stepped in longitudinal profile and composed of repeating sequences of deep pools or runs followed by a cascade or riffle. The last 200 m of the canyon is a long deep pool with virtually no velocity and offers the only deep pool habitat in the lower Campbell River. Bed materials are dominated by large boulders, bedrock, and cobble. The average gradient of this reach is 3% (Burt, 2004). In 2016 Ecofish conducted a Level 1 fish habitat survey in the Elk Canyon, a total of 1,764 m of habitat were assessed. The dominant and subdominant substrates were boulder (76% of habitat units) and bedrock (38% of habitat units) (Parsamanesh *et al.* 2018).

3. PREVIOUS GRAVEL PLACEMENT AND MONITORING

Spawning gravel placements have occurred in the lower Campbell River mainstem since 1997 and are summarized in Table 3. The approximate location and original spatial extents of gravel pads from past placements are shown in Maps 2-4.

3.1. Reach 1

Bed material in the reach was historically dominated by small and large cobbles and boulders, 23%, 26%, and 20% respectively (Burt and Burns 1995). Substrate composition in this reach has likely changed since this assessment as a result of gravel accumulating in this reach from the erosion of gravel placements further upstream.

In 1997, a 1,390 m^2 area of spawning gravel was created near the highway bridge that serves as the reach break between Reach 1 and 2. A survey conducted in 2004 concluded that the size of the gravel pad at the site had grown to 1,749 m^2 (Table 3). In 1993, Burt and Burns (1995) reported 14,354 m^2 of "natural" spawning gravel at the site and Burt (2004) estimated that it represented

7,608 m^2 of useable Chum spawning habitat. An additional 7,177 m^2 of gravel (3,804 m^2 of it useable for Pink Salmon) were reported on the left bank of the river below the Highway 19 bridge (Burt and Burns 1995, Burt 2004).

At sites near the upstream end of Fred's Slough, 576 m^2 of gravel (288 m^2 of it useable for Pink and Chum salmon) were reported in 1993 (Burt and Burns 1995; Burt 2004). Gravel deposits extend into the estuary and while flows in Reach 1 are backwatered by the tide, Chum and Pink salmon are known to spawn in this reach (Burt, 2004).

3.2. Reach 2

Burt and Burns (1995) reported that bed material was primarily composed of large cobbles (21%) and boulders (45%). The geomorphology survey data support this; the reach is currently dominated by larger substrates (cobble, boulder) with some sand and pockets of large gravel. The latter are used by Chum Salmon and some Chinook. The only Pink Salmon spawning substrate (small gravel) is found between the two highway bridges at the bottom of Reach 2.

Of the 758 m^2 area of spawning gravel placed along the right bank of the Campbell River near the confluence with Haig-Brown Kingfisher Creek in 2001, 606 m^2 of gravel remained in 2004. This gravel pad has eroded considerably since 2004 and as of 2011 was only minimally used by spawning Chum Salmon (S. Anderson, pers. comm., 2011 and D. Ewart, pers. comm., 2011). A small gravel pocket of 157 m^2 remained in 2011 along the left bank between the southbound and northbound highway bridge, near the mouth of Raven Channel.

In 2005, gravel was placed on the left side of the Campbell River just upstream of the southbound Highway 19 bridge crossing, at the end of Ebert Road (Site 11 based on recommendations made by Burt, 2004) in an attempt to re-create historical Chinook spawning habitat (Guimond, 2006) (Map 3), creating a new spawning area of 5,292 m^2. In the first year following placement, a total of 5,000 Chum Salmon and 20 Chinook Salmon were observed spawning on the gravel pad (Guimond, 2006). However, by 2010 a survey of the platform showed that spawning area had decreased by 1,407 m^2 and that gravel had shifted downstream 100 m from the upstream end and 50 m from the downstream end of the original placement (NHC, 2010a). The Ebert Rd. pad is located in a wide, low gradient section of the river, which provides better gravel stability. This site appears to have withstood the floods of fall/winter of 2009/2010 (NHC, 2010a) but the effects of subsequent floods are not documented in the reports that were reviewed.

Natural gravel accumulations in the downstream end of site 10 (Map 3) have been observed by DFO hatchery staff (D. Ewart, pers. comm., 2011). These accumulations are likely the result of erosion and subsequent deposition of gravel from earlier placements further upstream. The location of the gravel near the tail-out of the Sandy Pool is similar to historic gravel distribution noted by Burt (2004), although the area of available gravel is much smaller than it was historically. Chinook Salmon and Chum Salmon have been observed holding over the gravel; however, no redds have been observed (D. Ewart, pers. comm., 2011).

3.3. Reach 3

In 1993, bed material was primarily composed of large cobbles (25%) and boulders (30%) (Burt and Burns 1995). The substrate survey data indicate that the reach is currently dominated by large cobble, with gravels located at sites along the mainstem margins. In addition, spawning habitat is provided in the Elk Falls side channels.

The Elk Falls Side-Channel Network is located in Reach 3 and is described in detail in Burt (2004). This network is composed of three side- channels: Elk Falls 1, Elk Falls 2, and Elk Falls 3 (the entrance to the latter is located in Reach 4). Spawning habitat is primarily located in Elk Falls 1 and 2. Elk Falls 1 was built in 1992 to provide spawning habitat, primarily for Chinook Salmon. Elk Falls 2 was built in 1998 to provide both spawning and rearing habitat. Together Elk Falls 1 and 2 provide approximately 2,400 m^2 of spawning habitat (Burt, 2004). As described by Burt (2004), only small numbers of Chinook have returned to spawn in this network. This may be due to the fact that Campbell River Chinook tend to spawn in mainstem and large side-channel habitats, whereas the Elk Falls Side-Channel complex is relatively small in terms of size and flow. However, due to suspected poor ocean survival in recent years, quantifying the extent of Chinook use of these side-channels would require additional monitoring.

Reaches 3 and 4 contain the majority of the Chinook spawning habitat in the lower Campbell River. Many of the spawning beds used by Chinook in the Campbell River are found in depositional areas upstream of the Quinsam River confluence (Burt and Burns 1995; Nagtegaal *et al.*, 2000). While any consistent patterns of where Chinook hold or spawn are not clear (Nagtegaal *et al.*, 2000), it is known that low numbers migrate to the canyon and canyon confluence. The distribution in the remaining areas between Reaches 3 and 4 varies highly from year to year. This variability is likely consistent with shifts in gravel pad distribution among the reaches. Chinook in the Campbell River prefer areas with higher flows than provided by side channel habitats and thus, the poor use of spawning channels by this species has supported a focus of enhancement efforts on mainstem gravel placements (Burt, 2004).

Historically, spawning gravel accumulated on the left and right banks of the Campbell River opposite the gravel placement at 3.99 km (Burt, 2004) (Map 3). As of 2011, there was still some spawning gravel near the downstream end of the 3.99 km gravel placement patch on river left; however, few spawning Pink, Chum, and Chinook have been observed using the gravel in this area (D. Ewart, pers. comm., 2011).

There is a natural gravel accumulation along the right bank downstream of Second Island and opposite the 3.99 km gravel placement (Map 3). Chum and Coho have been observed spawning at this location during high flows (S. Anderson, pers. comm., 2011 and D. Ewart, pers. comm., 2011).

Spawning gravel was placed downstream of the Quinsam River confluence in 2001, creating 970 m^2 of chinook spawning habitat (Anderson *et al.*, 2002). By 2003, only two small pockets (240 and 36 m^2) of spawning gravel remained and more recent DFO snorkel survey observations found little gravel and few spawning salmon (S. Anderson, pers. comm., 2011 and D. Ewart, pers. comm., 2011).

In contrast, the substrate survey data (NHC 2011) indicated that additional gravels are located along the river margins on both banks of the Campbell River. However, the extent to which these areas are utilized for spawning is not clear.

3.4. Reach 4

Historically, bed material in this reach was composed primarily of large cobbles (23%) and boulders (52%) (Burt and Burns 1995). Though the reach is still dominated by cobble, the area of gravel substrate has been improved through numerous gravel placements since 1997.

Gravel has been placed at numerous locations downstream of the JHT tailrace and in the river right channel around First Island to increase spawning gravel areas: 136 m^2 area was created in small clusters along the right bank adjacent to First Island in 1997 (Anderson *et al.*, 2002); 160 m^2 area was created in the tail-out of the tailrace in 2004 (Anderson, 2004); 1,600 m^2 area was created in the river right channel around First Island in 2006 (Anderson, 2007); an additional 2,000 m^2 was created just upstream of the 2006 placement in 2009 (NHC, 2010b); 2,100 m^2 was added in 2013 to further enhance and extend in the downstream direction the previous additions (NHC 2013); and 2,250 m^2 was added in 2016 to further extend the 2006 and 2013 pads downstream (Map 3). Very high flows in the fall of 2016 likely removed much of the added spawning beds (NHC 2017).

The 2006 placement represented a new Chinook habitat enhancement strategy for DFO. Previously, gravel had been placed in channels and protected areas to maximize gravel stability; however, snorkel observations showed that Chinook were slow to take advantage of these new spawning gravel areas, as adult Chinook are known to spawn in deep, fast mainstem habitats. Given this habitat preference, in 2006 DFO began placing gravel in faster, deeper areas with more dynamic flow patterns, despite the greater risk of erosion. The new strategy was effective: in the fall of 2006 following the gravel placement, 350 Chinook, 150 Coho, and 60 Chum were observed actively spawning on the new pad (Anderson, 2007).

However, as expected the majority of gravel from the 2006 and 2009 placements was eroded and transported downstream during flood events and 271 m^2 (approximately 8%) of gravel from 2006 and 2009 gravel placements remained as of 2010 in the First Island channel near the right bank (NHC 2010a). The substrate survey showed that only a limited amount of gravel remained in the right channel following two significant flood events that occurred in the fall and winter of 2009/2010 (NHC, 2010a). Gravel that is transported downstream will likely be re-distributed and while the source area may become eroded over time, gravel may settle in areas downstream that provide other suitable spawning habitats. Gravel eroded from earlier placements in Reach 4 appears to have accumulated along the right bank, upstream of Second Island making this area shallower than in the past. Salmon species including Chinook were observed spawning on the new pad in

2010. The gravel accumulation upstream of Second Island may become more suitable for spawning as spawning fish excavate and redistribute the gravel (D. Ewart, pers. comm., 2011).

Gravel additions to Second Island Side-Channel occurred in 1985, 1995, and 1996. The side channel is 425 m long and 15-20 m wide and consists of a series of three rock-weirs with the upstream side of each weir loaded with spawning gravel. The weirs have been notched in the middle and flows cascade over these into the next spawning platform. The weirs effectively divide the Second Island Side-Channel into three long and wide spawning platforms. As of 2004, the Second Island Side-Channel provided 5,585 m^2 of spawning gravel (Map 3). Since the construction and ongoing rehabilitation of Second Island Side-Channel, Chinook have spawned in the uppermost section of the side channel in relatively large numbers. Chinook (10 to 20 pairs) and Chum Salmon (~8,000) also spawned in the lower two sections of the side channel. Recently, the gravel deposit at the top of Second Island has reduced flow in the side channel and subsequently very few Chinook were observed in the upper section in 2010. In general, spawning use has decreased throughout the side channel.

Gravel was placed at four primary locations along the left bank between 100 and 500 m upstream of the Elk Falls Pumphouse in 1998 and again in 2001. These gravel placements were last surveyed in 2004 and occupied an area of 60 m^2, 122 m^2, 42 m^2 and 739 m^2 respectively.

In 1997, a 175 m^2 gravel pad was placed along the left bank of the mainstem Campbell River in the canyon confluence pool, just downstream from the outlet of Elk Falls Canyon (Map 3). A survey conducted in 2004 indicated that this gravel pad remained intact (178 m^2 of spawning gravel remained). Chum spawn at this location and some of the gravel displacement is thought to have resulted from gravel being moved by spawning fish (D. Ewart, pers. comm., 2011).

3.5. Reach 5

The deeply entrenched Elk Falls Canyon has minimal spawning gravel. Gravel placements in the canyon reach were a joint federal-provincial-community effort to restore spawning areas predominantly for Chinook salmon. Gravel was placed in the canyon in 1999, 2002, 2005, 2008, 2011, 2016, and 2017. Two locations in Elk Falls Canyon received the majority of the gravel during each placement: the tailout of the Elk Falls plunge pool (Site 1), and 400 m downstream of the tailout of the falls pool (Site 2) (Map 2). The lower canyon/confluence and the mid-canyon areas of Reach 5 appear to be a favourable location for Coho spawning and holding (Stewardson and Lansley, 2008; 2009).

Use by spawning salmon of the lower gravel pad was exceptionally high in October 2008, as evidenced by high rates of disturbance by actively spawning salmon (Pellett, 2009). A snorkel survey was conducted following the floods that occurred in the fall and winter of 2009/2010 to monitor the distribution and location of spawning gravel in the canyon (Pellett and Murphy, 2010). The majority of the gravel placed in 2008 near the tailout to Elk Falls (Site 1) had been displaced; only 20 m^2 on the left bank still remained (Pellett and Murphy, 2010). The 2010 survey found 60% of the overall spawning area on the lower gravel pad (Site 2) remained intact (Pellett and Murphy, 2010).

On July 14, 2011 a new spawning gravel pad was placed in the Elk Falls Pool tail-out by the BCCF using a heavy-lift helicopter (O'toole *et al.*, 2011). On July 29, 2011, an Ecofish snorkel crew photographed and measured the pad to provide a baseline for future monitoring studies. The new gravel pad covered an area of 163 m^2 (O'toole *et al.*, 2011).

In March 2016, a new gravel delivery system was built in Elk Falls Provincial Park. The system makes use of an overhead wire spanning the canyon with a trolley bucket capable of running along the wire and able to delivery approximately 0.5 m^3 of gravel to the canyon at one time (Damborg 2016). The system was first used in July 2016 to deliver a total of 200 m^3 of spawning gravel to the canyon, just below site 1. Extreme high flows in late 2016 are assumed to have moved much of this gravel to lower reaches of the canyon (Damborg, 2017). In July 2017 the system was used for the second time to deliver approximately 300 m^3 of gravel (Damborg, 2018).

Table 3. Summary of spawning gravel placements in the lower Campbell River 1985 – 2018 (adapted and updated from Burt, 2004).

Location (Reach)	Year	Project	Site Description	Spawning Habitat Created (m^2)	Partners[1]	Reference
1 and 2	1997	Mainstem Gravel Placement	Hwy 19 Bridge (Site 4a and 4b)	1390	Tyee Club, HCF, Tide Guide Assoc., Steelhead Society, DFO, BC Hydro	Sheng et al., 1998; Anderson, 2002; Van Tine et al., 2002; D. Ewart, pers. com., 2011
2	1998	Raven Channel	River left between northbound and southbound highway crossings	860	Tyee Club, HCF, Tide Guide Assoc., Steelhead Society, PSF, DFO, BC Hydro, District of Campbell River	Van Tine et al., 2002; Burt, 2004
2	1998	Mainstem Gravel Placement	Hwy 19 Bridge (Site 4C)	660	BC Hydro, Tyee club, DFO, Tide Guide Assoc, HCF	Sheng et al., 1998; Anderson, 2002; Van Tine et al., 2007; D. Ewart, pers. com., 2011
2	2001	Mainstem Gravel Placement	Right bank at confluence with Haig-Brown Kingfisher Creek	758	BC Hydro (BCRP), DFO	Anderson et al., 2002; S. Anderson and D. Ewart, pers. comm., 2011
2	2005	Mainstem Gravel Placement - Ebert Road	River left approximately 100 m upstream of southbound highway crossing (Site 11 as identified by Burt, 2004)	5292	BCRP, Tyee Club	Guimond, 2005
3	2001	Mainstem Gravel Placement	River right, Quinsam River confluence	970	BC Hydro (BCRP), DFO	Anderson et al., 2002;S. Anderson and D. Ewart, pers. comm., 2011
3	1992	Elk Falls Channel	River left at Elk Falls Pumphouse	1200	DFO, HCF, BC Hydro	Van Tine et al., 2002; Burt, 2004
3	1998	Elk Falls 2	Elk Falls Twin channel on river left near Elk Falls Pumphouse	1200	Tyee Club, DFO, BC Hydro	Van Tine et al., 2002; Burt, 2004
4	1985	Second Island	Second Island Side-Channel (right bank of Campbell River)	6500	DFO	Van Tine et al., 2002; Burt, 2004
4	1995	Second Island Reconstruction	Second Island Side-Channel (right bank of Campbell River)	8000	Tyee Club, DFO, community groups	Burt, 2004
4	1996	Second Island Reconstruction	Second Island Side-Channel (right bank of Campbell River)	8000	BC Hydro, DFO	Burt, 2004
4	1997	Mainstem Gravel Placement	Tailout pool river left adjacent to tailrace (Site 1)	175	Tyee Club, HCF, Tide Guide Assoc., Steelhead Society, DFO, BC Hydro	Sheng et al., 1998; Anderson et al., 2002; Van Tine et al., 2002
4	1997	Mainstem Gravel Placement	River right near First Island Island (Site 2)	136	Tyee Club, HCF, Tide Guide Assoc., Steelhead Society, DFO, BC Hydro	Sheng et al., 1998; Anderson et al., 2002; Van Tine et al., 2002
4	1997	Mainstem Gravel Placement	River left approx. 400 m upstream of Elk Falls Pumphouse (most upstream site -Site 3A)	158	Tyee Club, HCF, Tide Guide Assoc., Steelhead Society, DFO, BC Hydro	Sheng et al., 1998; Anderson, 2002; Van Tine et al., 2002

Table 3. Continued.

Location (Reach)	Year	Project	Site Description	Spawning Habitat Created (m^2)	Partners[1]	Reference
4	1998	Mainstem Gravel Placement	River left approx. 400 m upstream of Elk Falls Pumphouse (Most upstream site-Site 3A)	393	BC Hydro, Tyee club, DFO, Tide Guide Assoc, HCF	Sheng et al., 1998; Anderson et al., 2002; Van Tine et al., 2002
4	1998	Mainstem Gravel Placement (multiple sites)	Left bank between 100-500 m upstream of Elk Falls Pumphouse (Site 3B, 3C, 3D, 3E)	173	BC Hydro, Tyee club, DFO, Tide Guide Assoc, HCF	Sheng et al., 1998; Anderson et al., 2002; Van Tine et al., 2002
4	2001	Mainstem Gravel Placement (multiple sites)	Left bank between 400-500 m upstream of Elk Falls Pumphouse (Site 3A and 3B become one continuous site)	230	BC Hydro (BCRP), DFO	Anderson et al., 2002
4	2001	Mainstem Gravel Placement (multiple sites)	Left bank between 100-300 m upstream of Elk Falls Pumphouse (Norske Skog pumphouse road (3+820 - 3+938)	207	DFO	Anderson et al., 2002
4	2004	Gravel Placement JHT Generating Station	River right tailout of JHT tailrace (Site 6)	160	BCRP, Tyee Club	Anderson 2004,
4	2006	Mainstem Gravel Placement - First Island	River right between First Island and right bank of the Campbell (Site 7 as identified by Burt 2004).	1600	BCRP, MOE, CRSF	Anderson, 2007; Arnold, 2010
4	2009	Mainstem Gravel Placement - First Island	River right between First Island and right bank of the Campbell (Site 7-II as identified by Burt 2004).	2000	Unknown	NHC, 2008; Arnold 2010
4	2012	Mainstem Gravel Placement	Left bank approximately halfway between Catalyst Paper pump station and the end of First Island (Site 9)	1825	FWCP, CRSF, DFO	NHC, 2013
4	2013	Mainstem Gravel Placement - First Island	River right between First Island and right bank of the Campbell (Site 7 as identified by Burt 2004).	2100	FWCP, CRSF, DFO, RFCPP	NHC, 2013
4	2016	Mainstem Gravel Placement - First Island	River right between First Island and right bank of the Campbell (Site 7 as identified by Burt 2004).	2250	FWCP, CRSF, DFO	NHC, 2017
5	1999	Elk Falls Canyon	Tailout of Elk Falls Plunge Pool	200	MELP (HCF), BC Hydro	McCulloch, 2002; Burt, 2004
5	2002	Elk Falls Canyon	Tailout of Elk Falls plunge pool and 400 m downstream	unknown (94.0 m^3)	BC Hydro (BCRP), MWLAP (HCTF)	McCulloch, 2002

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Table 3. Continued.

Location (Reach)	Year	Project	Site Description	Spawning Habitat Created (m^2)	Partners[1]	Reference
5	2004	Elk Falls Canyon	Tailout of Elk Falls plunge pool and 400 m downstream	unknown (94.9 m^3)	BC MOT, HCTF, MWLAP	McCulloch, 2005
5	2005	Elk Falls Canyon	Tailout of Elk Falls Plunge Pool and 500m downstream (Site 1 and 2 as identified by Burt 2004)	230	BCRP, HCTF, BCCF	McCulloch, 2006
5	2008	Elk Falls Canyon	Tailout of Elk Falls Plunge Pool and 500m downstream (Site 1 and 2 as identified by Burt, 2004)	405	BCRP,BCCF	Pellett, 2009; Pellett and Murphy, 2010
5	2011	Elk Falls Canyon	Tailout of Elk Falls Plunge Pool	unknown (98.9 m^3)	FWCP, CRSF, LR-GB/VI, BCCF, MOE	Pellett, 2012
5	2016	Elk Falls Canyon	First pool tailout below Elk Falls	400	FWCP, MOE, DFO	Damborg, 2017
5	2017	Elk Falls Canyon	First pool tailout below Elk Falls	400	FWCP, CRSF, RFCPP, LR-GB/VI	Damborg, 2017

Note: Habitat created (m^2) represents the quantities at the time of installation and they may differ from quantities currently present

[1] Partner Abbreviations:

BCCF	British Columbia Conservation Foundation
BCRP	Bridge Coastal Fish and Wildlife Restoration Program
CRSF	Campbell River Salmon Foundation
DFO	Department of Fisheries and Oceans
FWCP	Fish and Wildlife Compensation Program
HCF/HCTF	The Habitat Conservation Fund (HCF) operated from 1981 to 1996 and was succeeded by the Habitat Conservation Trust Fund (HCTF) in 1996
MELP	Ministry of Environment, Lands and Parks
MWLAP	Ministry of Water, Lands, and Air Protection (currently Ministry of Environment)
MOE	Ministry of Environment
MOT	Ministry of Transportation
LR-GB/VI	Living Rivers - Georgia Basin/Vancouver Island
RFCPP	Recreational Fisheries Conservation Partnership Program

4. PREVIOUS RECOMMENDATIONS

The following recommendations reoccur in past reports and are presented here to provide context for developing the Strategy (Anderson 2007, NHC 2010b, Guimond 2006, NHC 2017, NHC 2013a, NHC 2013b). Recommendations have been generalized and are not reproduced verbatim:

- Consider a new funding model that allows for gravel pads to be assessed in the spring and augmented where necessary in the summer, ready for the returning salmon in the fall.
- Undertake geomorphological monitoring of the gravel pads to record how the quantity and characteristics of gravel change on an annual basis. Possible monitoring techniques include same line surveys, erosion chains, or aerial photos. The goal of such monitoring is to detect when gravel is depleted and thus enhancement is necessary to support continuous use of spawning pads. Establishing thresholds of minimum gravel area may support this.
- Improve the quality of biological monitoring by ensuring consistency in timing and methods. This could be achieved by undertaking annual snorkel surveys to document the use of each enhanced spawning pad.
- Develop a sediment transport model of the lower Campbell River. The model could be used to answer several important management questions, including whether bulk gravel placements are a viable option to maintain spawning habitats; i.e., whether it is feasible to place gravel at an upstream location and allow excess gravel to be transported to suitable spawning habitats downstream.
- If sediment transport model results show that bulk gravel additions are a viable option for maintaining spawning habitat, then a more-detailed feasibility study of bulk gravel additions should be undertaken.

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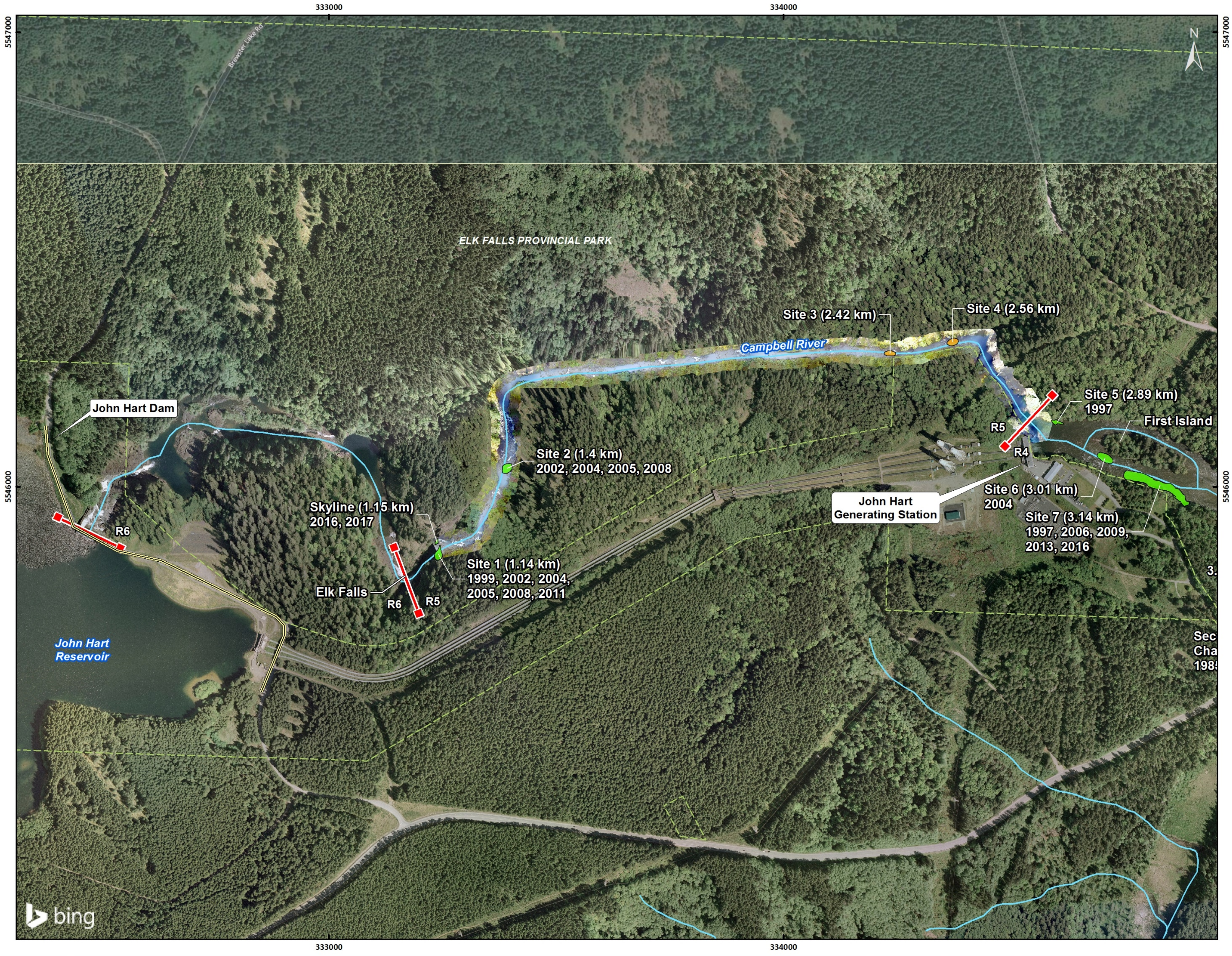
PROJECT MAPS



Historical Spawning Gravel Placements on the Campbell River

Legend

- Gravel Placement Location
- Previously Proposed Gravel Placement Location (Burt 2004)
- Reach Breaks
- Dam
- Parks and Protected Areas

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 50 100 200 300 400 m

Scale: 1:8,000

NO.	DATE	REVISION	BY
1	09/10/2018	1120_JHT_HistoricalSpawningGravel_2018Oct05	
2			
3			
4			
5			

Date Saved: 09/10/2018
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 2

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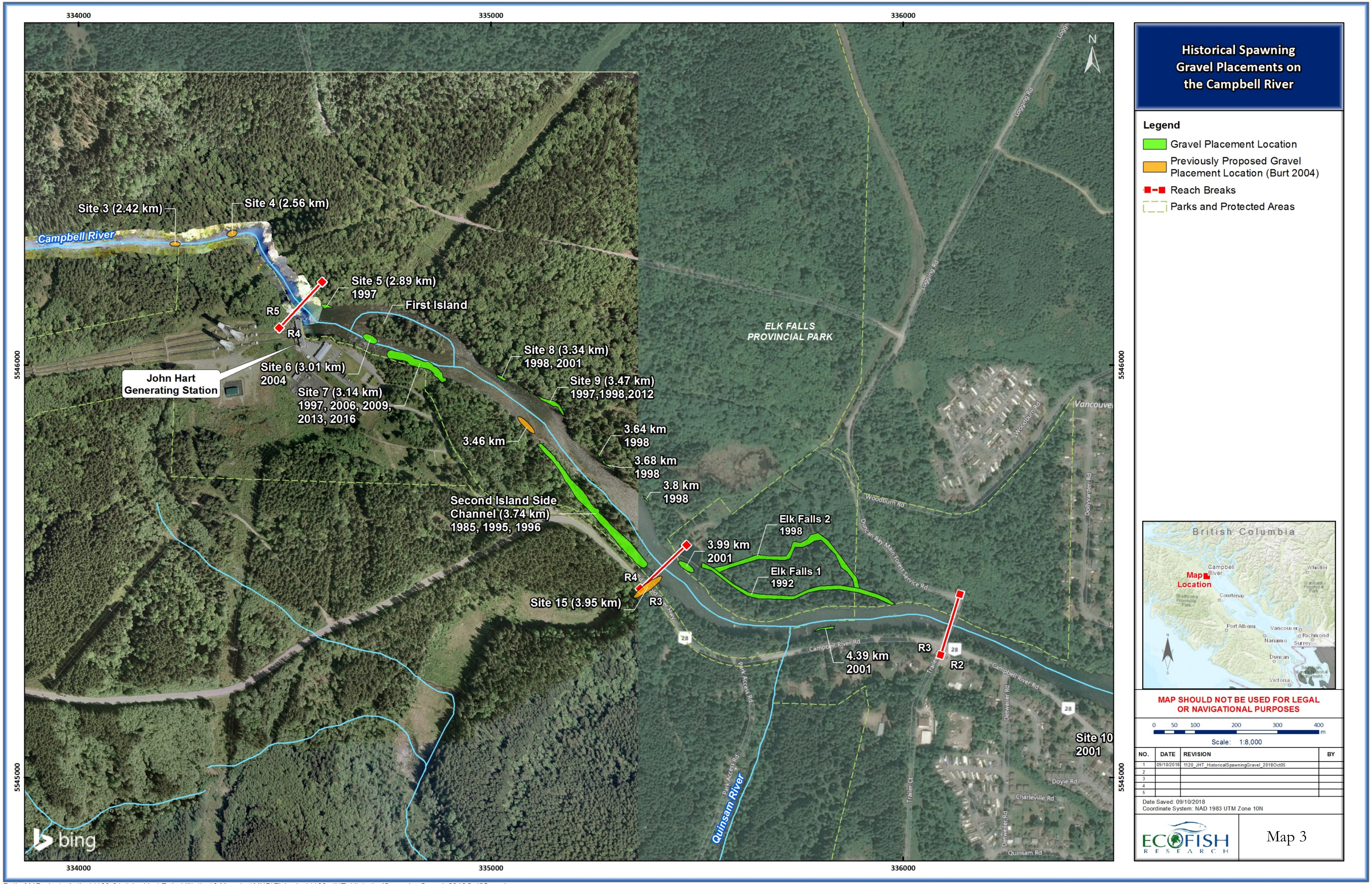

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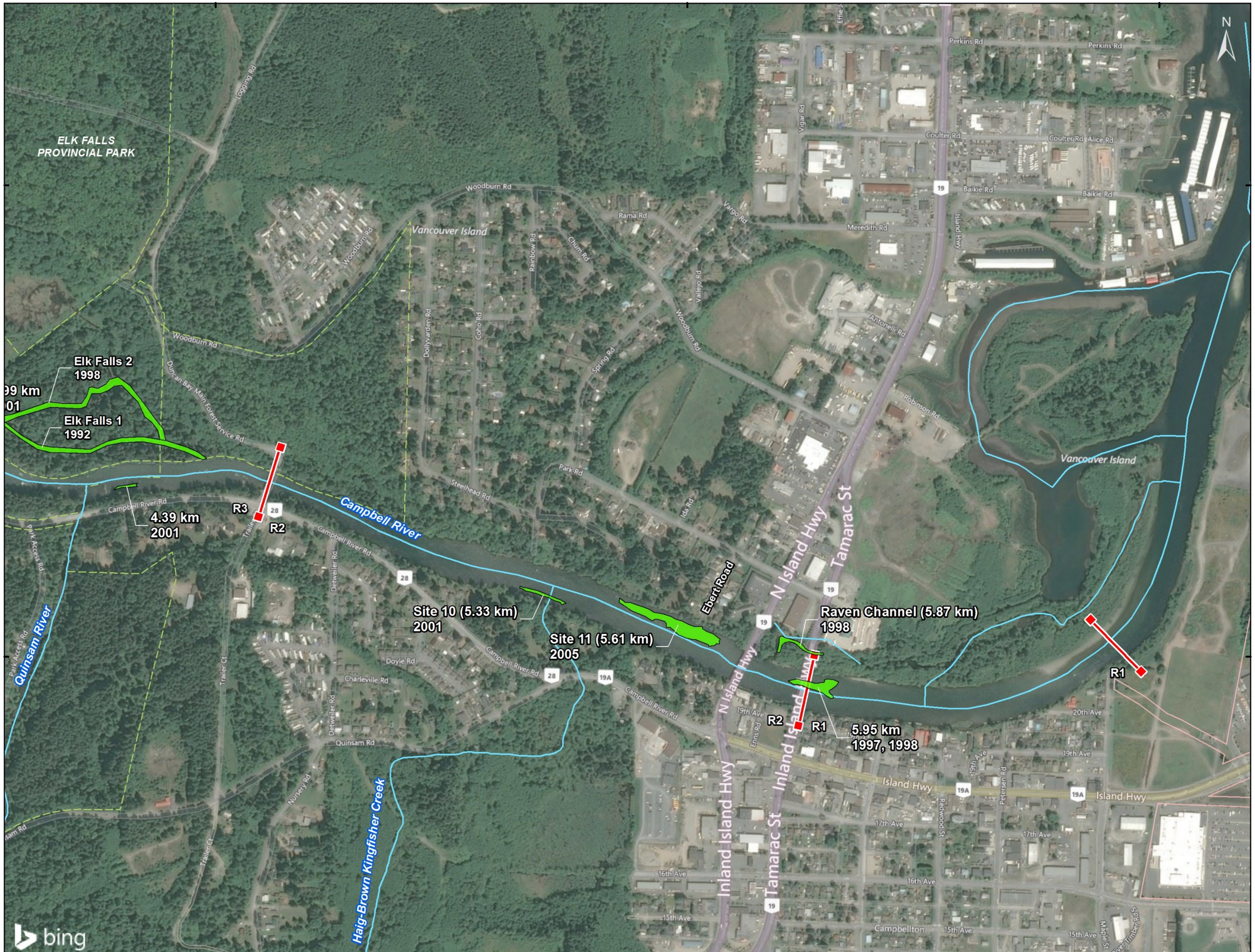

Historical Spawning Gravel Placements on the Campbell River

Legend

- Gravel Placement Location
- Reach Breaks
- Parks and Protected Areas
- First Nation Reserve

British Columbia
Campbell River
Map Location
Courtenay
Port Alberni
Vancouver
Richmond
Nanaimo
Surrey
Duncan
Victoria
Whistler

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 50 100 200 300 400 m

Scale: 1:8,000

NO.	DATE	REVISION	BY
1	09/10/2018	1120_JHT_HistoricalSpawningGravel_2018Oct05	
2			
3			
4			
5			

Date Saved: 09/10/2018
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 4

Path: M:\Projects-Active\1120-01 John Hart Rehabilitation\6 Mapping\MXD\Fisheries\1120_JHT_HistoricalSpawningGravel_2018Oct05.mxd

Appendix B. Pre-Workshop Questionnaire

Question 1.

2018 Campbell River Gravel Strategy Workshop Survey:

Pre-Engagement Questions

*** 1. How satisfied are you with current gravel management in the lower Campbell River?**

- ◯ Very satisfied
- ◯ Somewhat satisfied
- ◯ Neutral
- ◯ Somewhat dissatisfied
- ◯ Very dissatisfied
- ◯ Not sure

Next

Question 2

ECOFISH RESEARCH

2018 Campbell River Gravel Strategy Workshop Survey:

Pre-Engagement Questions

*** 2. Which of the following do you think have been the biggest challenges to gravel management in the lower Campbell River? Rank 0 (not a challenge) to 5 (a major challenge)**

	0	1	2	3	4	5
The amount of funding available for restoration	○	○	○	○	○	○
The model of FWCP-funding for gravel placements (e.g., a need to submit proposals in October for work the following year)	○	○	○	○	○	○
Logistical constraints (e.g., access)	○	○	○	○	○	○
Lack of geomorphological understanding	○	○	○	○	○	○
Lack of biological understanding	○	○	○	○	○	○

Other comments

Prev Next

Question 3

2018 Campbell River Gravel Strategy Workshop Survey:

Pre-Engagement Questions

*** 3. Do you think there are important gaps in our understanding of the system that inhibit restoration of spawning habitat?**

◯ Yes

◯ No

If yes, please note these gaps

Prev Next

Questions 4 – 7

2018 Campbell River Gravel Strategy Workshop Survey:

Pre-Engagement Questions

* 4. What specific gravel restoration projects do you think are the highest priority? Rank up to three.

#1 ______

#2 ______

#3 ______

* 5. When deciding on whether gravel restoration should be conducted each year, do you have any thoughts on what thresholds or triggers should be used to determine if more gravel is necessary?

* 6. Please see the accompanying review of historical gravel enhancement. Are you aware of important information sources that have not been considered?

* 7. Do you have any specific suggestions for how to better manage gravel in the lower Campbell River?

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Appendix C. Responses to Pre-Workshop Questionnaire

Table 8. Responses to Pre-Workshop Questionnaire

ID	How satisfied are you with current gravel management in the lower Campbell River?	Which of the following do you think have been the biggest challenges to gravel management in the lower Campbell River? Rank 0 (not a challenge) to 5 (a major challenge)					Other comments
		The amount of funding available for restoration	The model of FWCP-funding for gravel placements (e.g., a need to submit proposals in October for work the following year)	Logistical constraints (e.g., access)	Lack of geomorphological understanding	Lack of biological understanding	
1	Somewhat dissatisfied	4	5	1	1	0	further look into the possibility of a true 'bulk gravel project' (dumping gravel by the truckload during high water events). there may be options right downstream of JHT (above elk falls). gravel will naturally distribute (and move) through all anadromous portions of the Campbell.
2	Somewhat dissatisfied	4	5	3	4	1	managing discharges and velocities released from reservoirs due to extreme storm events- impacts to mainstem spawning habitat where Campbell Chinook preference for spawning
3	Very dissatisfied	5	5	1	1	0	The model of the FWCP annual lottery needs to change. Since gravel recruitment was stopped by the construction of the John Hart dam, gravel needs to be added regularly to mimic the natural recruitment lost. Should be considered the same as dam maintenance.
4	Very dissatisfied	5	5	0	1	0	
5	Very dissatisfied	3	4	2	3	2	Also, flow management which sees gravel placements washed away.
6	Neutral						
7	Not sure	3	0	0	4	3	Lack of operations understanding in the watershed as it relates to design requirements. Lack of awareness around gravel movement expectations. Also, installation costs. Lastly, gravel expectations are challenging.
8	Somewhat dissatisfied	1	4	4	3	1	
9	Somewhat dissatisfied						
10	Very dissatisfied						
11	Neutral	5	5	4	3	2	
12	Somewhat dissatisfied	5	3	2	3	2	
13	Very dissatisfied	5	5	4	4	2	
14	Neutral	2	4	1	2	2	
	Average	3.8	4.1	2	2.6	1.4	

Table 8. Continued.

ID	Do you think there are important gaps in our understanding of the system that inhibit restoration of spawning habitat?		What specific gravel restoration projects do you think are the highest priority? Rank up to three.		
		If yes, please note these gaps	Rank 1	Rank 2	Rank 3
1	No		CR above Quinsam	ELk Falls	
2	Yes	is it possible to design effective/usable Chinook mainstem spawning habitat that can function biologically and hydrologically with the new normal discharges in excess of 300m3/s (to 600m3/s)	Mainstem CR Chinook spawning design effective at 300m3/s+	Mainstem Chinook spawning downstream of canyon upstream of Quinsam confluence	EF canyon pool
3	No	In the pre dam system gravel came and went, now it just leaves	Site 7	Site 9	Canyon, not only 3 sites in serios need
4	No				
5	No		Not sure		
6					
7	Yes	I think the historical gravel recruitment/budget is still a gap in setting expectations around the current situation.	gravel targeting DFO/MFLNRO species of concern for the watershed	Projects with proven install techniques	Project designed to hold in place under moderate spill events or mobilize to
8	Yes	Understanding how the placed gravel moves through the system, where it accumulates and if it results in a net loss/gain of useful spawning habitat over time.	Chinook spawning gravel		
9					
10					
11	No		Upper island area	Improvements to second island channel	
12	No				
13	No		Anything in reach 4	Anything in reach 3	Anything in reach 5
14	Yes	Monitoring year to year to better understand where to place gravel the follow year - better river knowledge within a ever changing system. Also, that groups better work together towards a common goal of providing spawning gravel/utilizing resources/in-kind works.	First Island	Second Island	Below Quinsam

Table 8. **Continued.**

ID	When deciding on whether gravel restoration should be conducted each year, do you have any thoughts on what thresholds or triggers should be used to determine if more gravel is necessary?	Please see the accompanying review of historical gravel enhancement. Are you aware of important information sources that have not been considered?	Do you have any specific suggestions for how to better manage gravel in the lower Campbell River?
1	Total amount of suitable gravel available in main river, and canyon (areas to be treated separately)	No	FWCP should not be the main income source for gravel projects, BCH should have dedicated annual funds to perform a quick annual assessment and implement the gravel placement on a annual/bi annual basis. ie assess in one year add gravel the next. rinse and repeat
2	Inventroy gravel - effectiveness, preferred areas, usage, consider discharges effecting spawning habitatsTarget for system is Chinook spawn= 20000m3/s - 2000prs present escapement is around <600prs,	Hamilton Buell direct reference for historical areas (are you considering this is covered in Burt 2004?) Burt 2004 gravel inventory included channels built for chinook, but not used. Personal comments from 2011 could have been updated to more recent info/observations, Quinsam H swims CR - provide use of gravel areas, DFO surveys avail to show some fo the early gravel migration after placments. nhc - modelling in advance of Ebert rd to inform impact potential to Campbellton. this is an important part of gravel monitoring and planning - wrt to City of CR - with the amount of gravel deposited around Hwy 19 bridges -will this continue-flood control issues. Information from late 1990s considered bulk gravel placement not effective in producing functional habitat - Newbury I think- check with JVT or Mel. Ensure diversity of spawning/migration/holdign habitats maintained/improved. Gravel gradation recipes.	We are trying to manage effective spawning habitat, as well as gravel recruitment. We have no control at this point over dicharges that impact spawning.
3	High sustained flows move gravel, we monitor the flows. Not rocket science that when we have sustained 600 m3/s flows the gravel is flushed downstream	Yes	Take action following extreme events
4			
5	Not sure	Campbell River Salmon Foundation Gravel Survey 2017	Need to find ways to make placements more resilient in the face of high flows.
6			
7	Is gravel present in the system approaching full capacity under normal flow.	Still need to review. Sorry!	This gravel strategy will be valuable tool.
8	A minimum threshold of available spawning gravel.	No.	Consider a new funding model that allows for gravel pads to be assessed in the spring and augmented when necessary in the summer.
9			
10			
11	Surveys annually to determine the need.	No	Need gravel assessments done every year on lower water. Doesn't have to be full blown survey, could be a swim, aerial survey, etc. Just needs to be consistent and standardized.
12			
13	We need to be looking at a minimum area of spawning gravel to support at least 1000 CN pairs (12,000m2) and preferably 2000 CN pairs (24,000m2). This should be assessed in the spring	No	In the big picture managing water flow would solve most of our issues with gravel just not staying put. To do that we maybe need to look at the much larger impacts that deforestation has on the ability of the watershed to slow down the inflows of water in the Hydro storage reservoirs. We also need to find a way to keep putting gravel in, the dam stops any natural recruitment of gravel into the Campbell River and historically, even in high water events, at least gravel was being replaced as it washed downstream.
14	Monitoring should indicate this. Once the group identifies how much gravel should be in what reach, when high flow conditions move gravel our or the gravel amount goes below the desired goal (by say 25%), it's then topped up or re-shaped.	No.	Better work as a team through this working group.