Proposed 2020 Vedder River Sediment Removal Project

Nova Pacific Environmental

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1.0: INTRODUCTION

The Vedder River Area Management Committee (VRMAC) manages the floodway capacity of the Vedder River in part, through periodic sediment removals. This ongoing effort has reduced the risk of flooding while maintaining habitat values for regionally significant fish along the Vedder River for over 25 years. The Vedder River exhibits ongoing accumulation of sediments such that the capacity of the channel diminishes over time. To meet provincial flood protection recommendations to maintain 1 in 200-year flow capacity (Q200), gravel accumulation and dyke freeboard are assessed and, based on this assessment, excavations are planned. These excavations are then planned and implemented in even numbered, non-pink salmon spawning years.

For the 2020 cycle VRMAC retained Kerr Wood Leidal Associates, Ltd. (KWL) to conduct hydraulic modeling of the Vedder River to determine where the excavations should occur to address the flood potential and Nova Pacific Environmental, Ltd. (NPE) to address fish habitat and other environmental and regulatory concerns. The purpose of this document is to provide information required by Fisheries and Oceans Canada (DFO) and the BC Ministry of Forests, Lands, Natural Resource Operations, and Rural Development (MFLNRORD) to support the applications for required permits under the *Fisheries Act* and *Water Sustainability Act* respectively.

Three accompanying documents are being submitted separately as part of the application package to the DFO and MFLNRORD. These documents are referenced in this report and are identified as follows:

1. 2020 Vedder River Hydraulic Assessment (KWL - Apr 2020)
2. 2016 Vedder River Gravel Excavations Habitat Changes and Environmental Impacts (NPE - May 2016)
3. 2016 Vedder River Sediment Removal - Monitor's Report (NPE - Dec 2016)

1.1: 2020 Vedder River Gravel Removal Program

Based on the results of the hydraulic assessment a maximum of eight excavation sites are proposed for the fisheries window of 2020, with a total potential volume of 95,000 cubic meters. This volume is higher than the long-term biennial average accumulation of sediments in the Vedder River. Terms of reference provided by the updated Vedder River Management Area Plan (EBA Tetratech, 2015) recommends removing 90% of the long term average biennial sediment accumulation volume in low flow years. Accordingly, the total volume will be limited to 66,600 m^3. Final decisions to reduce or drop specific sites will be based on results of agency reviews, freshet changes, site specific effectiveness, habitat protection and enhancement considerations and logistics.

The 2018 gravel removal program was cancelled due to relatively low sediment aggradation, due in part to smaller freshets during the previous few years and the hydraulic model indicating an improvement in freeboard within the freeboard limited section of the dyke from 2016 to 2018 (see KWL 2020 report - Appendix A-1). Additionally, sediment input to the Vedder River may have been reduced due to an avulsion upstream of Vedder Crossing. The avulsion happened in December 2015 and directed the flow into a substantial off channel pond which has been observed to fill over the past few years. The area where filling occurred was estimated from Google Earth to be approximately 50,000 square meters. The survey data indicates that sediment in the upper reach of the Vedder River has mobilized downstream over the last two freshets and hydraulic modeling shows the 1:200 year flood profile has increased in the lower reach of the river, where the dyke freeboard does not meet the provincial standard of .75 meters. The 2020 proposed excavation locations are focused in the lower reach and the canal section to improve flow conveyance and dyke freeboard in the lower reach of the river in accordance with the recommendations in the Vedder River Management Area Plan.

The eight (8) sediment removal locations for 2020 (shown in Figure 1) have been selected to:

- Effectively lower water levels where dyke freeboard is limited;
- Trap gravel upstream of the freeboard limited area;
- Reduce future excessive excavation requirement in the Lower Reach when a large flood occurs;
- Increase capacity in the canal section of the river to lower the backwater curve to lower water levels in the freeboard limited area; and/or
- Provide optimum habitat outcomes while meeting flood protection objectives for sediment removal.

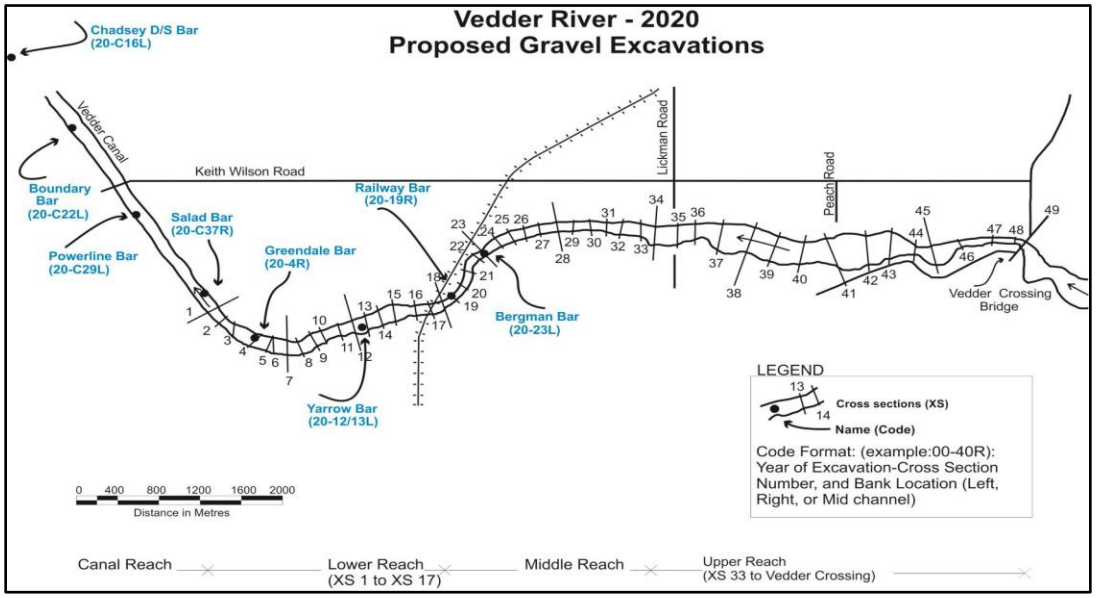

Figure 1: Locations of proposed excavations for the 2020 Vedder River Gravel Removal Program.

Each of the eight excavations proposed for 2020 is adjacent to actively used fish habitat for spawning, rearing, and/or migration. This report will provide details of each proposed excavation, the adjacent fish habitats, expected fish utilization, potential impacts and mitigating measures to be implemented during excavation.

1.2: General Habitat Assessment and Monitoring Post-Excavation

The assessment protocol includes detailed evaluation of habitat types both before and after the excavation. In addition, spawning locations for pink and chum salmon have been tracked on the entire Vedder River for the years, 1994 to 2014, as part of the excavation assessment activities. As of 2014, this spawning tracking was scaled back to look at habitat and spawning only at and around the individual excavation sites.

A detailed review of the fish habitat and excavation work conducted as part of the 2016 program, has been attached to this submission (Appendix A-2). A similar approach to program assessment will be followed in 2020. Current habitat conditions are noted for each proposed excavation in Section 7 of this document and more detailed habitat mapping will be conducted post-2020 freshet and prior to excavation and will be provided to the agencies once available.

Assessments of previous excavations similar to the ones proposed for 2020 has allowed for the development of sediment removal procedures that focus on providing optimal outcomes for fish and fish habitat. However, it is important to remember that the Vedder River is subject to significant natural changes arising from the deposition and erosion of the bed material. For details on the hydrological rationale for the removals, the reader is referred to the Vedder River Hydraulic Profile 2020 Report (KWL 2020).

1.3: Applicant Information

Land ownership along the Vedder River includes the cities of Abbotsford and Chilliwack as well as Provincial Crown Lands and these three entities are stakeholders in VRMAC. The City of Chilliwack has taken the lead administrative role on behalf of VRMAC for the gravel removal planning process and is therefore the applicant for the purposes of permitting applications. A summary of the applicant's information associated with the proposed work is provided in Table 1. The proponent has provided a letter to allow NPE to work on their behalf regarding all permitting activities for the proposed project.

Table 1: Applicant information for the proposed Vedder River Sediment Removal Program.

Name:	City of Chilliwack
Contact Name:	Frank Van Nynatten
Email:	vanny@chilliwack.com
Mailing Address:	City of Chilliwack 8550 Young Road Chilliwack, BC V2P 8A4

2.0: EXCAVATION SITE SELECTION

2.1: Planning and Implementation Process Overview

Annual gravel accumulations are currently approximately 37,000 cubic meters per year on average with more gravel moving in years of major flow events and less gravel in years with lower flow. The estimate of material required for removal in each cycle is based on the results of surveys conducted at the start of each cycle and the hydraulic modeling as discussed below.

Each excavation cycle on the Vedder River begins with an updated survey of more than 70 previously determined cross sections. This information is used for hydraulic modeling that identifies areas of accumulation and degradation of substrate, determines quantities of gravel in various sections of the river, and predicts the water level and dyke freeboard in a 1 in 200-year flood (KWL 2020).

Aerial photographs of the river are taken prior to the spring freshet of an excavation year to help identify potential excavation locations. The candidate bars are then assessed in the field to identify key habitat features, identify potential habitat enhancement opportunities, and to devise a site-specific excavation plan based on the established guidelines in the Vedder River Area Management Plan, to ensure optimal habitat outcomes. The guidelines are applied to ensure the protection of existing features and optimization of anticipated post excavation conditions. Logistic issues are also evaluated at this stage, including access, stockpile locations, and potential effects on other resource users.

Once a set of feasible and environmentally sound excavations are identified they are compared to the identified freeboard deficiencies and calculated volumes of material required to meet channel capacity objectives. Additional hydraulic modeling is completed using this information to determine the effect of the removals on flood water levels and freeboard. A final set of target excavations is then selected to meet the flood reduction objectives while minimizing disruption to fish habitat. Once the program plan is established, permitting is initiated.

In the implementation stage, the suite of excavation sites that have been selected are tendered. During removal, a qualified environmental professional (QEP) monitors the activities to ensure that the excavations proceed in environmentally sound manner and in accordance with the plans and program objectives. A survey is undertaken after the removal to determine the actual removal volume. One year after removal, a biological assessment by a registered professional biologist is completed to assess habitat changes along the river and canal and a report of this assessment is submitted to VRMAC, DFO and MFLNRORD.

2.2: Timing Considerations

Planning and implementation of this biennial sediment removal program requires that planning be completed following the fall freshet but preceding the spring freshet due to the need to complete the works during the reduced risk fisheries window. Cross sectional surveys are usually completed in February with hydraulic modeling, and site selection and design following in March and April. Coordination of the new information and optimization of the program is targeted for the beginning of May to allow as much time as possible for permitting and to allow removal contracts to be let. The start of excavations is dependent on dropping water levels as well as the July 15 to September 15 fishery window. Accordingly, the excavations usually begin around August 1 and continue to September 15. Detailed assessment of excavations and related habitat conditions is usually completed in the early fall and incorporates observations of spawning around the excavations.

2.3: Candidate Bars and Final Bar Selection for 2020

To ensure that the best possible suite of sediment removal sites are selected, a preliminary overview of 15 sites was conducted (Table 2). From these, a set of eight have been selected that best meet the VRMAC objectives to maintain floodway capacity while optimizing fish habitat value (Table 3).

Table 2: List of Candidate Bars Considered for 2020 Sediment Removals (identified from upstream to downstream).

#	Bar Name	Plan Developed	Yield (m^3)	Comments
1	Bergman Bar	Y	20,000	Large bar, easy access. Upstream of target area but has gravel trap potential. Several previous successful excavations with positive habitat outcomes.
2	Railway Bar	Y	4,000	Relatively small but accessible. Frequent previous excavations. Gravel trap potential.
3	D/S Rail Bridge Bar	N	n/a	Good candidate, but access is very challenging. High habitat enhancement potential.

4	Yarrow	Y	7,000	Established access. Proximal to freeboard limited zone. Several previous excavations.
5	Heron Bar	N	n/a	No access to the bar.
6	Community Bar	N	n/a	No access to the bar.
7	Greendale Bar	Y	6,000	Access is feasible but challenging. Higher habitat sensitivities. Proximal to freeboard limited zone. Several previous successful excavations.
8	Salad Bar A	Y	6,000	Small volume. Accessible. Several successful past excavations.
9	Salad Bar B	N	n/a	High habitat risk, access possible but will need new access to be prepared.
10	Powerline Bar	Y	8,000	Similar profile and size to KWB. Next in line for canal D/S to U/S strategy initiated in 2014.
11	Keith Wilson	N	n/a	Recently excavated and habitat improvements retained. Only partially refilled.
12	Boundary Bar	Y	19,000	Excavated twice previously. Has reformed since 2014 excavation.
13	Chadsey Bar	N	n/a	Same as above but smaller. Excavated once previously.
14	Chadsey D/S Bar	Y	25,000	Large bar with relatively fine substrate. Needs new access.
15	HWY 1 Bar	N	n/a	Too small. Access requires large effort.
	Total		**95,000**	

Table 3: Final Selection of Bars for Sediment Removal in 2020.

#	Bar Name	Plan Developed	Yield (m^3)	Lat/Long
1	Bergman	Y	20,000	49.095976°, -122.031645°
2	Railway	Y	4,000	49.092699°, -122.035152°
3	Yarrow (pit+scalp)	Y	7,000	49.090072°, -122.047443°
4	Greendale (two pits)	Y	6,000	49.088964°, -122.062111° and 49.088464°, -122.058978°
5	Salad A	Y	6,000	49.092540°, -122.067031°
6	Powerline	Y	8,000	49.101119°, -122.076004°
7	Boundary	Y	19,000	49.108821°, -122.083095°
8	Chadsey D/S	Y	25,000	49.116460°, -122.090187°
	Total		**95,000**	

3.0 FISH HABITAT IN THE VEDDER AND EXCAVATION DESIGN

3.1: General Considerations for Fish Habitat

Salmonids known to occur within the Vedder River include all five Pacific salmon species; Chinook *(Oncorhynchus tshawytscha)*, chum (*Oncorhynchus keta)*, coho *(Oncorhynchus kisutch)*, pink *(Oncorhynchus gorbuscha*) and sockeye *(Oncorhynchus nerka)* salmon, as well as steelhead trout *(Oncorhynchus mykiss)*. The life stages of salmonids within the Vedder River include spawning, rearing, and migration. All excavation planning and implementation decisions consider these species and their utilization of habitats within the Vedder River. Excavations take place within the window where fish utilization is at its lowest, after most juvenile salmonids have migrated out of the area and before spawning. In addition, excavations are conducted in non-pink salmon spawning (even) years.

Protecting spawning habitat for salmonids is of critical concern for gravel removal efforts on the Vedder River including preserving known spawning habitat areas and identifying opportunities to enhance or create new spawning habitat opportunities for these species. Typically, only chum and pink salmon spawn in the river reaches where the excavations take place. Generally, pink salmon have been noted to spawn in channel tail-out areas, above riffles and excavations are designed to ensure that these riffle areas are not bypassed by the excavation footprint. Chum salmon most often spawn below riffles and within side channels where sub-gravel flows are emerging and all excavations are designed to avoid disruption to these sub-gravel flows and even seek opportunities to enhance flows in these habitat channels. Sockeye and coho salmon along with steelhead travel through the Vedder River on route to their preferred spawning areas. Very occasionally, spawning Chinook salmon or their redds have been observed in the Vedder River.

The excavations are planned to minimize changes that could detrimentally impact redds placed post excavation.

Salmonids are known to rear in many locations along the river including around the excavations. Concentrations of juvenile salmonids have been noted in pools, downstream of riffles in glide tails, along channel edges where cover is available, and within microchannels that are frequently found along the inside edge of gravel bars. Each gravel removal site is designed to avoid changes that would result in detrimental impacts to these habitat features and frequently incorporate measures to enhance these habitat features. The guidelines provided in the next section address the key approaches that are used.

Both adult and juvenile salmonid migration can be affected by the proposed excavations and mitigation steps will be undertaken to minimize any of these potential impacts. These consist primarily of deep wide openings to the excavations and avoiding leaving pits that could become isolated pools.

Habitat mapping is conducted annually during low flows and comparisons are made before and approximately one year after for each excavation site. Detailed habitat mapping has not been completed during the years of 2018 and 2019 due to the hiatus of the gravel removal program, however aerial photography of the river was obtained in the fall of 2018 and again in March 2020. This aerial imagery was used in conjunction with prior habitat mapping, data from spawning surveys, and recent physical assessments of the candidate bars to develop a cursory update of the habitat conditions along the river.

3.2: Environmental Inputs to Excavation Design

Each excavation has been prepared in accordance with best management practices developed specifically for the Vedder River Sediment Removal Program. These were developed in cooperation with the Vedder River Technical Committee (VRTC) and VRMAC with significant contribution and collaboration with DFO and MFLNRORD staff in the years between 1994 and 2012. Designs incorporate inputs from professional biologists and hydrologists and rely on the documented experience from 90 individual excavations since 1994, to predict what will happen post construction and to fine tune the designs to ensure neutral or beneficial outcomes. Amendments have been made to the design guidelines to expand the range of removal options and improve fish habitat outcomes. The guidelines underwent a comprehensive review as part of the 2015 Vedder River Management Area Plan update. The latest version of the guidelines is presented in Table 4.

Table 4: Guidelines and Constraints Followed During Excavations.

No.	Guidelines
1	No excavations in pink spawning years in the reach where most pink salmon spawn.
2	Avoid excavating in areas of sub-gravel percolation as this may impact chum salmon spawning and water levels in enhanced off-channel habitat.
3	Work only in isolation from flowing water.
4	Leave the upstream third of bars.
5	Adherence to the fisheries windows.
6	Avoid digging consecutive bars because of potential interaction between them.
7	Excavate channels to replicate natural streambed shape to minimize post-excavation changes.
8	Protect areas adjacent to points where secondary channels branch off from the main flow.
9	Avoid excavating in areas adjacent to sensitive habitat.
10	Avoid digging long pits associated with elevation drops or which can affect long sections of the river.
11	Leave gently sloped inside edges on the upper end of cuts to prevent head cutting and to leave stable habitat for chum salmon spawners.
12	Open the upstream end of deep gravel pits so that headcutting can occur, and to encourage gravel flow into the pits.
13	Construct internal, cross channel berms in long pits or where there is a significant elevation drop.
14	Leave the downstream ends of bars since this will preserve tailouts which provide rearing and spawning opportunities.
15	Ensure riffles are not bypassed by excavation.
16	Adjacent dry channels should be deepened and stabilized with flow control structures such as LWD complexes.
17	Leave pits with large head differences closed to prevent chum spawning within them or fish trapping.
18	Open excavations thoroughly to avoid creating fish traps. Two deep openings adjacent to the main channel should prevent this problem.
19	Use caution when designing excavation where the thalweg approaches the pit at an angle of more than a few degrees. Design mitigation may include options to reduce the opening or move the excavation or the opening downstream when this condition is encountered.

Potential sediment removal sites are evaluated, based on their potential to provide an effective removal while avoiding harm to fish and fish habitat. The guidelines (Table 4) were developed through adaptive management to provide optimal habitat outcomes from the sediment removal program and inform the design, monitoring and assessment of the excavations over several

iterations of sediment removal. Several guidelines, such as adhering to the fisheries window and working in isolation of flowing water, are typically requirements of the authorization and are intended to avoid detrimental impacts during the excavation.

Each excavation site is designed to yield optimal habitat in its post excavation condition. Gentle slopes, strategic flow inlets and outlets, and careful placement and delineation of the excavation footprint are employed to ensure habitat impacts are minimal. Large channel changes and post excavation effects such as head-cutting are avoided by not bypassing riffles, leaving the upstream ends of bars and avoiding sequential gravel bars. Habitat mitigation and enhancements are incorporated where appropriate and include placement of large woody debris (LWD), enhancement of secondary or micro-channels, and occasionally other initiatives such as constructing channels or riparian planting.

The habitat mapping exercise is intended to provide an evaluation of the changes or effects at and beyond the footprint of the excavation. Commencing in 1994, habitat mapping was used to evaluate changes along the entire river. A few years ago, it was determined that most of the changes could be evaluated by looking at a smaller area around the excavation. Typically extending one XS up and one XS down will capture substantially all of the changes related to each excavation. However, the effects of natural changes are difficult to extricate from effects caused by the gravel removal operations. In effect, we are looking for the impact of the changes due to the excavations on a dynamic and constantly changing system.

The habitat methodology and most recent assessments have been attached to the application (Appendix A-2). Given the similarity of the excavation forms and locations over the years and the consistent application of guidelines per our described methodology, outputs from past habitat mapping provide the best predictor for possible impacts from the currently proposed excavations. This includes a vast amount of data that has already been collected, analyzed in depth and shows that the program generally yields a net gain fish habitat on average. Section 7 of this document includes a discussion of the anticipated outcome for each proposed excavation.

3.2.1 LWD Placement Strategy

Large Woody Debris (LWD) placement within the excavations are a key element in habitat enhancement at each excavation. LWD placement at each site is dependent on the local availability of suitable logs and root wads as well as suitable locations. As LWD placement is frequent and repeated with each excavation cycle, a percentage of washouts and other natural modifications are expected.

No anchors are employed due to the changing nature of the target placement locations and concerns that anchoring materials such as cable and ballast would detrimentally affect river conditions, fish habitat and constitute a safety hazard to recreational users of the river.

GPS coordinates are recorded for each of the major LWD placements and a photographic record is created. Additional single LWD pieces will be keyed in on occasion but some of these may not be tracked. This aspect of LWD placement is considered mitigation and not generally considered in determining net impacts to habitat.

4.0 CONSTRUCTION MITIGATION MEASURES AND MONITORING

Once the final set of sediment removal sites is approved, removals are monitored to ensure that the excavations follow the design and that Best Management Practices (BMPs) are followed. Several of the key BMPs that are universal to all work on the Vedder are discussed here and in more detail for specific bars in Section 7 of this document.

All works are to be completed with adherence to the following Best Management Practices (BMPs):

- Standards and Best Practices for Instream Works. BC Ministry of Water, Land and Air, March 2004;
- Measures to Avoid Causing Harm to Fish and Fish Habitat. Fisheries and Oceans Canada, 2013;
- A User's Guide to Working in and Around Water; Understanding the Regulation under British Columbia's Water Act. BC Ministry of Environment, May 2005; revised 2009; and
- A Field Guide to Fuel Handling, Transportation and Storage. BC Ministry of Water, Land and Air Protection, 2002.

Excavations for maintaining the capacity of the Vedder River will be conducted "in the dry" or outside the flowing waters of the Vedder River. This means that a perimeter buffer zone or berm will be maintained throughout the excavation process to ensure no deleterious materials from the excavation enter the River. Bar access is selected to limit disruptions from any culvert crossings and to minimize destruction of riparian habitat. Most locations have existing access that requires only minimal clearing of small-scale vegetation and construction of a ramp down to the bar surface. All machines will be cleaned and inspected before commencing work at any of the Vedder River sites. Machines will use environmentally friendly hydraulic fluid and be free of any leaks, soil or contaminants.

4.1: Hauling and Stockpiling Activities

During hauling, water can flow out of the loaded gravel trucks, and there is more potential for spillage, particularly on access ramps, if the water content of the excavated material is high. Generally, the monitor will direct the operators to briefly stockpile the material adjacent to the pit so it can drain before being loaded into the trucks. Where conditions warrant, the monitor will allow material to be loaded directly from the pit to the trucks however, if excess water is apparent on the bar surface, ramps or roads this will be halted. Water runoff will be limited to areas that are still to be excavated or the footprint of the access route that is to be restored. Any runoff will be directed to the excavation footprint or to a temporary settling pond using grading or silt fencing as required. Small amounts of water dripping along the haul routes during dry weather periods is effective at limiting dust generation. Runoff from excavated material, once it is transported to the stockpile site also has the potential to enter sensitive habitats if the stockpiles are near any of these habitats or watercourse or drainages that connect to these habitats. Due to its small footprint and relatively high expected height, all material destined for the Wilson Road stockpile site should be excavated using the two step approach, first moving the material out of the pit and onto the bar and then after time to drain into the trucks. All stockpile areas will be monitored carefully during active use to ensure that all sediment and runoff water remains within the footprint.

Silt fencing will be available on site for use at the discretion of the environmental monitor when there is insufficient as yet excavated area or berm elevation to ensure that silt laden water will not enter the flowing channel of the river.

4.2: Excavation Openings

Once each excavation is complete, it will be necessary to open the excavation to the main flow of the river to ensure that the completed excavation interacts with the main channel as intended and to ensure that fish, including salmon fry and adult spawners do not get trapped within an isolated pond. The “opening” of the gravel bar will produce a one-time turbidity event as the turbid water contained within the enclosed area is flush. Although dependent on the size of the excavation the period of turbidity will be short in duration.

To minimize the impact of this one-time turbidity event that occurs, the environmental monitor will be on site and will direct the pit opening. Typically, this would involve opening the downstream end first so disturbed sediments can be directed into the pit. When the upstream end is subsequently opened, the disturbed sediments naturally flow into the pit as the river flow enters. The excavation acts as a settling pond for the larger sediments. The openings will be excavated to the maximum extent possible before breaking containment to keep the turbidity in the excavation footprint as low as possible. Turbidity monitoring and plume tracking during

previous excavations shows that the turbidity is within acceptable limits except for a short distance downstream, typically across a narrow part of the channel. Previous experience has shown that the plume dissipates quickly as the water contained in the pit is flushed out and diluted. Turbidity data collected during previous higher flow periods will be provided for comparison purposes.

4.3: High Water Considerations

Occasionally, during the work window for this project, high water conditions may require the need to repair or build up sections of the berm to maintain containment. To ensure that this is done safely, excavators may be allowed to briefly enter the wetted channel but only in areas that were recently dry. This approach to berm repair is preferable to allowing river flows to enter the excavation area as that could result in erosion and related sediment deposition and stranding of fish within an excavation that is temporarily open to the flowing channel.

4.4: Access to Sites

Access to the sites is managed according to well established practices. Generally, all of the bars are accessible via existing routes. Bars with a lack of suitable access usually results in exclusion from the gravel removal program. Access routes include the tops of dykes and existing armoured banks with access roads already in place and other existing access roads and trails. The access routes may require some trimming of branches to assure safe conditions on the haul roads, but clearing is not normally required. If vegetation removal is required, it will only be to the extent necessary to access the bar. Any trees noted in the area will be protected where possible. Access to the bar surface usually requires a ramp down from the bank and often the crossing of small secondary channels or microchannels near the toe of the bank. Traffic on the gravel bars will be confined to the footprint and a single access track with pullouts if required. Details of access for each bar are provided in Section 7.

Culverts will be sized to ensure that flow to affected channels is maintained. An environmental monitor will supervise their installation. The culverts will be carefully placed, and flow directed through them before ramp construction begins. Typically, a single wet crossing by an excavator is allowed to access material for ramps and cover for the culverts. This material is usually obtained from the excavation footprint but on occasion it is necessary to use a borrow pit that is refilled once access to the footprint area is completed. Culvert length will be such that spillage from haul trucks does not enter the flowing water. This is particularly critical where a channel is adjacent to the bank and culverts are required for the ramp. Where appropriate, isolation of the work area and fish salvage will be conducted before ramp installation.

4.5: Turbidity Monitoring

Previous field studies will be used to develop a turbidity monitoring system that would be adaptable to sediment removal sites and to collect turbidity data during construction works. Turbidity measurements will be taken prior to the start of excavations and daily (upstream and downstream from excavation area) during the gravel extraction works.

Prior to opening each excavation, turbidity readings from the enclosed pit will also be collected. Additional readings will be taken downstream as the plume of turbid water exits the excavation site. The turbidity readings will be obtained using a LaMotte 2020we Turbidimeter. The 2020we meter meets or exceeds EPA (Environmental Protection Agency) design specifications for NPDWR (National Primary Drinking Water Regulations) and NPDES (National Pollutant Discharge Elimination System) turbidity monitoring programs as specified by the USEPA method 180.1.

5.0 POST-EXCAVATION ASSESSMENT

Assessment of the excavation includes follow up surveys to ensure that objectives are being met, and detailed habitat mapping to ensure that habitat changes are in balance with expectations and to demonstrate that there is no net loss of habitat arising from the sediment removal program. Habitat mapping provides an objective method for tracking and rating habitat conditions before and one year after each sediment removal activity.

The habitat mapping is conducted through analysis of aerial photos of the excavation locations taken at the same flow levels as the pre-construction in conjunction with ground-truthing at each bar. Habitat elements are mapped out to attain an overall habitat ranking value for the excavation location both before and after the excavation. Each habitat element (i.e. pool, riffle, glide) is given a habitat rating based on a methodology developed specifically for the Vedder River to compare pre and post habitat values in the vicinity of the excavation sites. Spawning surveys are also conducted for chum salmon each year and for pink salmon during non-excavation years.

More detail on this can be found in the assessment report for the 2016 excavations that has been included as Appendix A-2. Note that this report is the latest in a series of reports that describe monitoring and assessment works completed on the river. A full list of reports on the Vedder River prepared by NPE is found in Appendix B.

The habitat mapping exercise is intended to provide an evaluation of the changes or effects related to each individual excavation. Until 2014, habitat conditions were evaluated along the entire river. Recently, it was determined that virtually all of the changes linked to the excavation activity could be evaluated by looking at a smaller area. Typically extending one XS up and one

XS down will capture substantially all of the changes related to each excavation. However, the effects of natural changes are difficult to extricate from effects caused by the gravel removal operations. In effect, we are looking for the impact of our changes on a dynamic and constantly changing system. Given the similarity of the excavation forms and locations over the years and the consistent application of guidelines per the described methodology, the results of this assessment provide an excellent predictor of anticipated outcomes. A vast amount of data has already been collected, analyzed in depth and shows that the program generally yields a net gain on average to fish habitat. This is not a surprising outcome given that optimization of fish habitat is a key driver of the program and is paramount at the tactical (specific excavation detail planning) level.

6.0: ANTICIPATED EFFECTS FROM THE EXCAVATIONS

Once the excavations are completed, they are opened to the flowing water of the river. The downstream end is opened first to ensure that water levels do not increase in the pit. When the upstream end is opened, sediments are washed into the pit where they settle. The water in the pit, however, retains high turbidity and this creates a temporary increase in turbidity downstream as it is displaced, usually within a few hours.

With the onset of the fall freshet, higher flows will tend to modify the shape of the excavation. Filling begins immediately as openings widen and outer berms are eroded. In some cases, the erosion of the berm is encouraged by excavating to a steeper slope. Some head cutting is possible which can affect adjacent riffles near the upstream end of the excavation, but this is normally avoided by leaving gentle slopes and a substantial upstream buffer from areas of head differences.

There are usually more wetted habitats present when the detailed follow up assessment is completed one year later. Habitat diversity is often increased as a result of the excavations and the habitat ratings calculated provide a mix of increases and decreases to habitat value. These changes occur in an environment that is changing with each freshet and separating the effects of the excavation from the natural changes is challenging. However, the changes related to the excavations are similar to the natural changes and no net loss in habitat is anticipated.

One apparent long-term trend is that after excavation and some time for channel adjustment, that habitat is improved or similar in the majority of cases. Later, as gravel fills in the various aquatic habitats, habitat ratings tend to drop.

The long-term strategy of removing annual expected targets has led to some degradation of the channel bed over the last few cycles when peak flows have been relatively lower. This was exacerbated by the 2018 avulsion to, and subsequent accumulation of gravel in, the old habitat

pond near Soowahlie, just upstream of Vedder Crossing. However, gravel continues to move through the system resulting in the recurrence of freeboard limitations in the lower reach. The upper sections of the river show some degradation as material has continued to move through the system despite lower inputs from above Vedder Crossing. This leads to the question whether ongoing degradation may influence fish habitat values.

Fish habitat values could be negatively affected if the channel were deepening leading to a loss, for example, of riffle areas and a net loss of habitat. Riffles are a very high value habitat due to their contribution to primary productivity and associated larval insect grazers as well as the feeding niche they provide for juvenile salmonids. Serious negative habitat outcomes have been noted where gravel depletion has occurred from uncontrolled sediment removal (Kondfolf et al 2002) but removals from the Vedder are limited to long term average inflows and there is not really any evidence of systemic effects from lowering of the channel at the rates established by the Vedder River Management Area Plan Update (EBA Tetratech 2015). The type and distribution of habitats remains similar with increases in shallower wetted habitats and habitat complexity, providing for a positive outcome. Arguably, there is more habitat complexity from braiding and changes in the areas where degradation has occurred.

The detailed habitat mapping that has been done provides good evidence that riverbed degradation is not of concern within the sustainable long-term strategy in effect for the Vedder River. Where the sediment removal program results in lowering of the bed there appears to be a corresponding lowering of the water level as the geomorphology of the river remains similar. There are also natural changes occurring in the river, such as bank erosion, natural channel shifts and the continuous downstream movement of sediment. Periodic erosion which tends to widen the active channel also contributes to channel capacity without lowering the riverbed.

To ensure that this remains the case and to ensure that longer term changes do not arise annual mapping of habitats is an ongoing component of the Vedder River Sediment Management Program. The most recent completed assessment is provided in Appendix A-2. In addition to providing the results from the 2016 excavation, this report provides a detailed description of the habitats in the Vedder River as well as the methodology used for the assessment.

7.0: INDIVIDUAL EXCAVATION DETAILS

Plans for each of the eight proposed excavations are provided in the following pages along with a brief description of location, access, stockpile sites, existing habitats, and site-specific mitigation plans.

Estimated quantities have been calculated to take sloped edges into account. Specific LWD placements have not been identified, although it is expected that each excavation will include some LWD. Habitat enhancement excavations have been added to pits where appropriate and these will likely receive LWD as well.

Each bar is identified with a unique identifier that includes the year, cross section and location within the channel. The first two digits show the year, the next two digits show the cross section, followed by a 'C' for cross sections in the canal. The final letter shows position, 'R' for bars adjacent or near the right bank, 'L' for bars adjacent or near the left bank and 'M' for mid channel bars (e.g. 20-23L for Bergman Bar, see Figure 1).

A description of the habitat conditions found at each of the excavation sites is provided in this section. These conditions will be delineated and quantified using the habitat mapping methodologies described in (NPE 2016). An updated set of aerial photos will be taken to ensure that unrelated changes occurring during the current freshet are excluded from the analysis.

Habitat descriptions are consistent with the terminology used during the assessment phase as in the previous Vedder River gravel removal habitat assessment report (NPE 2016).

7.1: Bergman Bar

Site Name: Bergman Bar **Site Number:** 1
Identifier: 20-23L **Coordinates:** 49.095976° N, -122.031645° W
Location: Adjacent to Bergman Stockpile, near the north end of Bergman Rd.
Ownership: Provincial Crown

Previous Excavations: 1994, 1998, 2000, 2002, 2006, 2010, 2014, & 2016 (approximate location by XS identifier)
Stockpile: Bergman Stockpile

Length: 154 m
Width: 42 m
Depth: 4 m
Expected Gravel Yield: 20,000 m^3

Bar Access

North on Bergman Road, past setback dyke to Bergman Stockpile. Upstream end of bar can be accessed with a constructed ramp from the top of the armoured bank. Culvert probably not required this year (Figure 2).

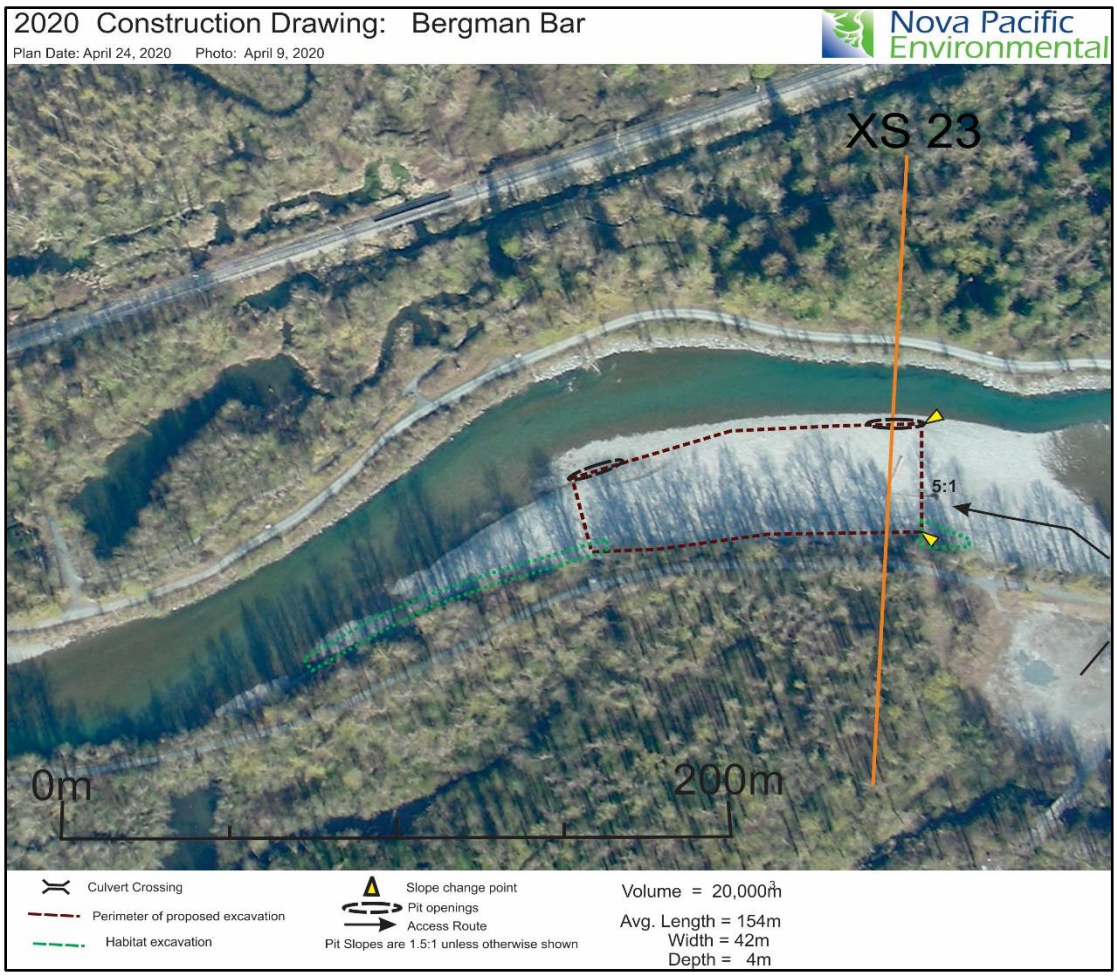

Figure 2: Bergman Bar excavation.

Objectives and Effectiveness

The main purpose of this excavation would be to intercept gravel upstream of the area of freeboard limitation. The bar is estimated to be 1m in height above low water levels resulting in a 4m excavation depth and higher yield of gravel.

Mitigation Plans

Mitigation measures described in Section 4.0 of this document apply at this location. The proposed outlet includes a connection to both the mainstem and the lower portion of the habitat channel. The downstream habitat is being maintained but due to the rapid aggradation upstream the upstream connection to the habitat component will be omitted. Excavation of these channels is straightforward and will contribute additional gravel with limited extra cost.

Habitat Considerations

Habitats upstream include a glide tail, habitat edge on the right bank and a gravel bar (Peach Creek Bar) on the left. A significant riffle extends between the upstream end of Bergman Bar and

the downstream end of Peach Creek Bar. To ensure that this feature remains intact and these habitat features persist, a large segment of the upstream bar will be left.

Immediately below the riffle, a section of glide habitat continues along the length of the excavation, gradually becoming shallower until the next sequence of glide tail and riffle downstream of the excavation footprint. Habitats along the main channel which include the riparian zone on the right bank will remain unaffected through this changing configuration. At the toe of the riffle an eddy pool, which provides a holding location for adult spawners and chum spawning habitat is present is expected to remain as it is sufficiently upstream of the pit and opening. A narrow steep sided berm will be left with the expectation that it will tend to collapse into the pit as water levels rise.

On the left bank, the riparian overhang is excellent and there is a temporary or seasonal channel beneath. At various times this channel has been deeper so that it provides year round rearing potential and spawning opportunities for chum salmon. The inlet at the head of the bar tends to close off but there is significant subgravel percolation due to the head differential created by the bar head. Again, leaving a substantial part of the upstream of the bar protects this habitat feature.

Habitat focused excavation along the downstream section of the bar adjacent to the riparian zone would increase habitat complexity at this location. If conditions warrant, a channel section above the pit could be excavated as a groundwater fed channel. The excavation extends to the left bank so that as the bar refills, more of the left bank habitat channel is likely to reform with water provided by sub-gravel flow. The habitat channel would be enhanced with LWD as has been done in past cycles. Flows out of the pit will be directed primarily back to the main channel but with an appropriately sized opening to the habitat channel as well. The downstream end of the excavation is left perpendicular to the direction of the flow, so the outflow tends to mimic the unaltered conditions and the pattern downstream is not altered.

Fish Habitat Utilization

The configuration at Bergman Bar is fairly consistent despite frequent excavation. In particular, the riffle upstream of the site separating this area from the Peach Creek Bar is persistent and provides spawning opportunities for both pink and chum salmon.

Chum salmon spawning has been observed downstream of the riffle at the downstream end of the bar, along the bar edge between the riffles, and in the left bank microchannel. Significant chum spawning was apparent within the constructed habitat channel along the left bank during the spawning assessments of 2016 and 2017. Following the excavation of 2016, the pit remained open and unfilled. Chum salmon spawned along the upstream and left bank pit edges during 2016 and 2017.

Pink salmon spawning has been observed at both the upstream and downstream ends of the bar, which is associated with glide tail habitat

Fry rearing along the left bank when the habitat channel is wetted is significant. This habitat channel has since filled in but will be partially re-established during the 2020 excavation, predominantly along the downstream section of the bar.

Anticipated Outcome

Regular excavation at this location has served to limit erosion on the opposite bank as this bar has proven to be a regular deposition zone. It is expected this excavation would refill quickly. However, a channel through the middle of the bar may persist as occurred in 2016. This would contribute to habitat value through additional diversity.

Adjacent riffles, the upstream glide tail, and the eddy pool near the upstream inlet to the excavation will be protected by the large buffer at the upstream end of the bar. Maintaining this structural element will limit changes in this area to the area of the excavation and the channel adjacent between the openings. This extra large buffer and the flat slope will help ensure that in the event that spawning does occur in the pit, it will not be compromised by headcutting/erosion.

This would be a large excavation that would allow for a significant amount of sediment to be retained. The lowered sediment accumulations downstream will significantly lessen the future quantity of material that would be required to be removed from the freeboard limited sections.

7.2: Railway Bar

Site Name: Railway Bar **Site Number:** 2
Identifier: 20-19R **Coordinates:** 49.092699° N, -122.035152° W
Location: Approximately 180m upstream from the railway bridge
Ownership: Provincial Crown

Previous Excavations: 1994, 1998, 2004, 2006, 2008, 2010, 2014, & 2016 (approximate location by XS identifier)
Stockpile: Hooge Stockpile

Length: 140 m
Width: 7 m
Depth: 3 m
Expected Gravel Yield: 4,000 m^3

Bar Access

From Keith Wilson Road, south on Sinclair Road, then east along the setback dyke to the parking area and stockpile location. Proceed west along the trail following the existing bank protection works (Figure 3).

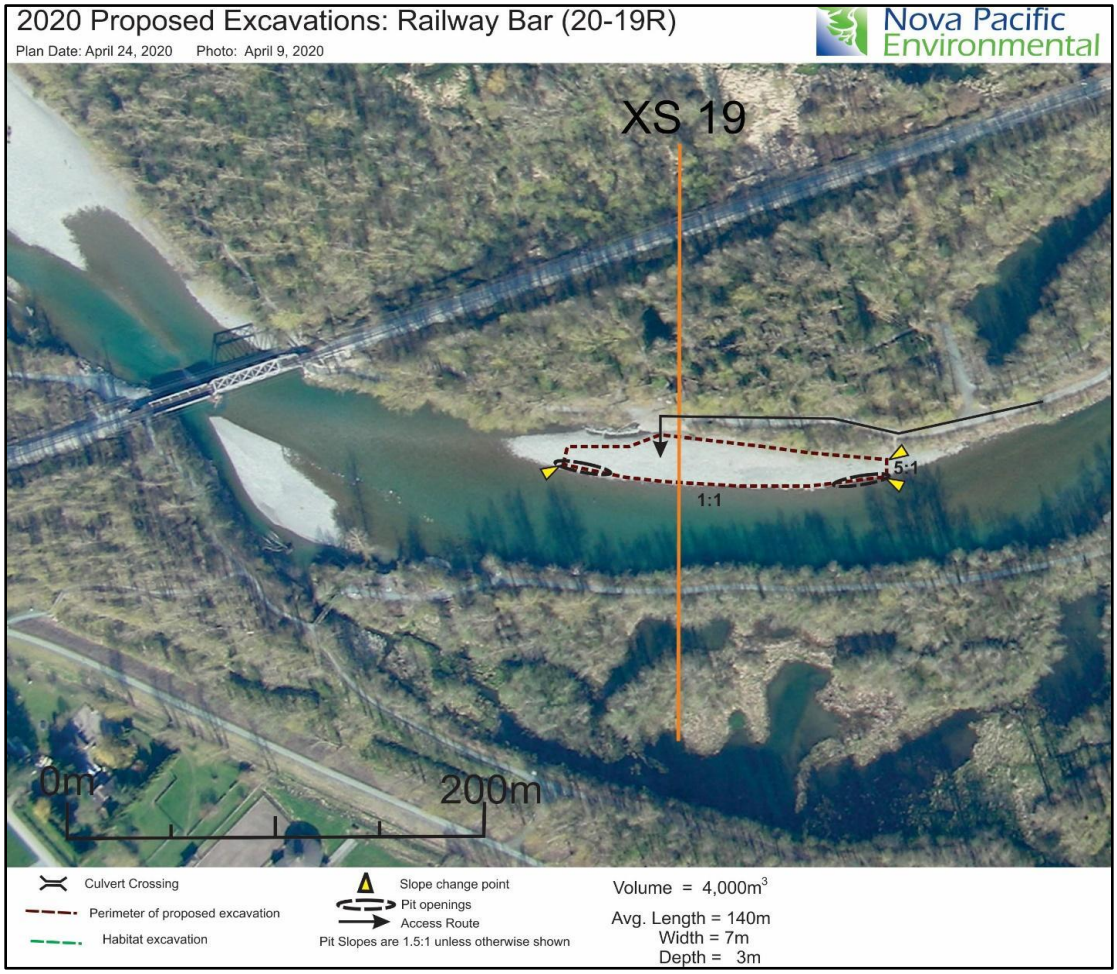

Figure 3: Railway Bar excavation.

Objectives and Effectiveness

This small excavation should reduce the amount of gravel moving downstream into the freeboard limited segment of the river as excavations at this location have shown to refill quickly in the past.

Mitigation Plans

The mitigation measures described in Section 4.0 of this document will be followed. In addition, the excavation will avoid the riprap at the new culvert outlet to ensure that it does not slump into the pit. The excavation has also been set back from the existing habitat channel on the right bank.

Habitat Considerations

Due to the flatter slope at this location, the pattern of glide, glide tail and riffle is less evident but there are slight glide-riffle sequences upstream and downstream of the proposed excavation. Immediately downstream of the excavation, on the right bank, there is an area of habitat edge with overhanging riparian vegetation. The habitat edges provide suitable rearing opportunities for salmonid fry. The opposite bank provides habitat complexity particularly where parts of the original bank armour has disintegrated providing cut bank and boulder clusters.

Significant chum salmon spawning has been noted in the channel along the right bank at the downstream portion of the bar and this has been maintained concurrently with this excavation in the past. This work may continue but with the recent habitat works, a prior discussion with DFO will be undertaken.

Abundant pink salmon spawning has also been recorded between the downstream end of the bar and the railway bridge. Maintenance of these habitats is a critical concern in the design of this excavation.

Fish Habitat Utilization

Heavy spawning of chum salmon has been observed within the microchannel along the right bank extending downstream into the riffle area and beyond the study area.

A significant area of pink salmon spawning was observed in the main channel downstream of the excavation area. This activity is associated with a glide tail/riffle sequence. The complex shallows habitat on the left bank is located above the riffle downstream so it also functions like a glide tail in attracting pink spawners. Some pink salmon spawning was also observed throughout the channel along the bar and in the backwater.

The diversity of habitat on the left bank provides lots of fry rearing opportunity but this area typically remains undisturbed by the activity at Railway Bar.

Anticipated Outcome

Railway Bar has been excavated several times in recent years as it tends to refill in the same pattern each year. Only minor changes to the surrounding habitat configurations are expected as a result of this removal.

7.3: Yarrow Bar

Site Name: Yarrow Bar **Site Number:** 3
Identifier: 20-12/13L **Coordinates:** 49.090072° N, -122.047443° W
Location: North end of Wilson Road, approximately 600m downstream of railway bridge
Ownership: City of Chilliwack

Previous Excavations: 1994, 1995, 1996, 1998, 2000, 2004, 2006, 2008, 2010, 2012, 2014, & 2016 (approximate location by XS identifier)

Stockpile: Wilson Road Stockpile (or restored stockpile located along setback dyke near the railway)

Length (pit): 98 m
Width (pit): 17.5 m
Depth (pit): 3.5 m
Expected Gravel Yield (pit): 6,000 m^3

Length (scalp): 92.5 m
Width (scalp): 19.5 m
Depth (scalp): 0.5 m
Expected Gravel Yield (scalp): 1,000 m^3

Bar Access

From the north end of Wilson Road, around the perimeter of the stockpile site to avoid wells (Figure 4). A culvert will likely be required to access the bar.

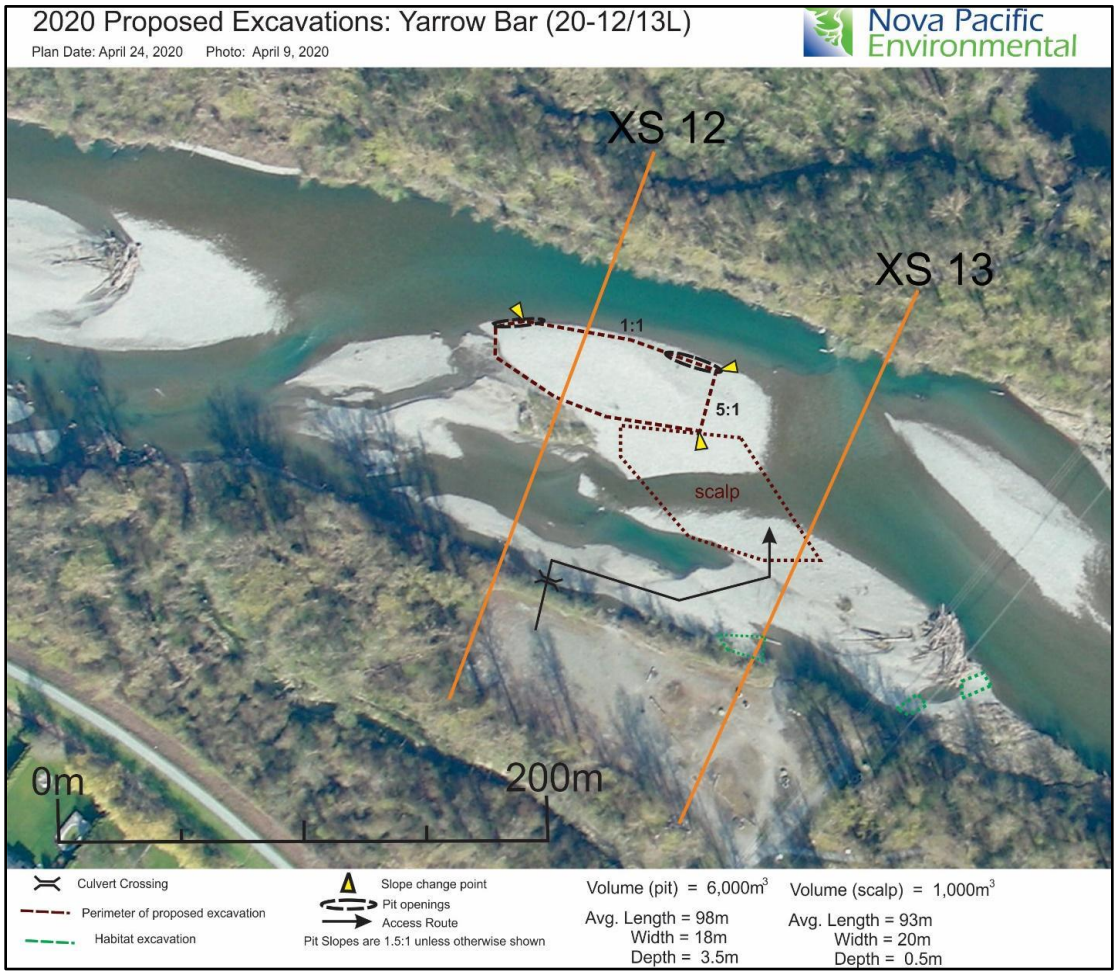

Figure 4: Yarrow Bar excavation.

Objectives and Effectiveness

This excavation is at the upstream end of a freeboard limited zone and is expected to contribute to increased floodway capacity. In addition to the excavation, a scalp is being proposed to encourage flow toward the left bank across the main bar and increase riffle habitat in this area.

Mitigation Plans

The mitigation measures described in Section 4.0 of this document will be followed. Measures including "stand-by" silt fencing, sediment traps and strict maintenance would be incorporated to prevent input of sediment into the river or habitat channel related to any culverts that are required. The pit has also been located with a large enough buffer to maintain the integrity of the riffle upstream and decrease the likelihood of pit spawning by chum salmon.

Habitat Considerations

Yarrow Bar has many complex habitat features including braided flow, riffle habitat at the bar head, within the braided channels, and in the main channel downstream of the bar. At the upstream end of the bar, a large LWD complex ties into the habitat channel and provides cover for pool habitat beneath it.

A section of glide habitat along the right bank across from the bar is bordered on the right by a good quality habitat edge with significant riparian habitat.

Braided channels are also evident at the bar immediately downstream of Yarrow Bar, which continue the habitat complexity of this part of the river. The proposed scalp will provide new riffle habitat across the bar and enhance the pool habitat remaining from the prior excavation. LWD features will be incorporated where suitable.

The habitat channel along the left bank was constructed during the 2016 sediment removal program. This habitat channel provides habitat for chum salmon spawning as well as rearing opportunities for juvenile salmonids. It is connected to the habitat channel constructed in the heavily vegetated bar during a previous excavation and this channel has become connected to the main channel as erosion of the left bank upstream continued. The 2020 excavation includes the re-opening of the upstream end of the constructed left bank habitat channel as well as opening a secondary blocked section providing a secondary opening.

Fish Habitat Utilization

Yarrow Bar provides multiple smaller channel habitats with a mixture of pools and riffles throughout the bar that vary with the flow levels of the Vedder providing a diversity or rearing habitats. Pink salmon spawning has been observed above the glide tail/riffle sequence upstream and downstream of the excavation. The downstream area provided a significant contiguous area of spawning that extended downstream beyond the end of the study area.

Anticipated Outcome

It is expected this excavation would refill in a similar configuration. However, a low flow channel through the middle of the bar may persist as occurred in 2016. It is expected that the high degree of fish habitat complexity will be retained at this site. This excavation is at the upstream end of the freeboard limited zone and would allow for a sediment trapping at that location.

7.4: Greendale Bar

Site Name: Greendale Bar **Site Number:** 4
Identifier: 20-4R **Coordinates:** 49.088964° N, -122.062111° W (downstream)
49.088464° N, -122.058978°W (upstream)
Location: Adjacent (upstream) to Greendale Stockpile site
Ownership: City of Chilliwack

Previous Excavations: 1994, 1998, 2000, 2004, 2006, 2008, 2010 & 2012 (approximate location by XS identifier)
Stockpile: Greendale Stockpile

Length (d/s): 85.5 m **Length (u/s):** 35.5 m
Width (d/s): 21 m **Width (u/s):** 26.5 m
Depth (d/s): 3 m **Depth (u/s):** 2.5 m
Expected Gravel Yield (d/s): 5,000 m^3 **Expected Gravel Yield (u/s):** 1,000 m^3

Bar Access

The upstream pit is accessible from the bank, with the downstream pit requiring two culvert crossings for access (Figure 5). One of the culvert crossings will cross the secondary channel between the right bank and island, and the second will cross the microchannel present along the upstream end of the island.

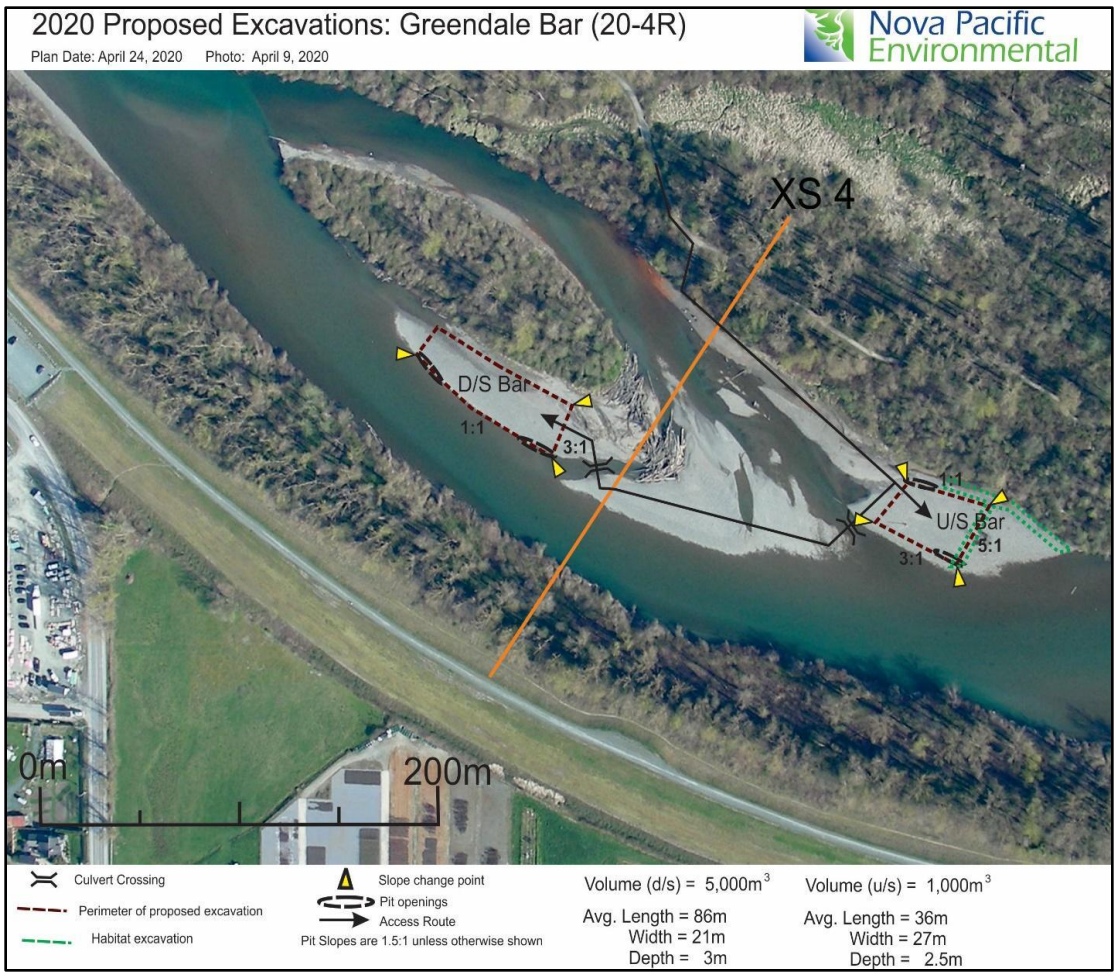

Figure 5: Greendale Bar excavation.

Objectives and Effectiveness

Increase the freeboard of downstream areas of the freeboard limited section of the river and maintain the existing habitat channels along the right bank.

Mitigation Plans

The mitigation measures described in Section 4.0 of this document will be followed. Particular care will be taken when constructing culvert crossings across the high-value habitat channels present at the bar. The downstream excavation has also been situated such that the integrity of the island channel and LWD complex is maintained. Measures including “stand-by” silt fencing, sediment traps and strict maintenance of these structures would be incorporated to prevent input of sediment into the river or habitat channel related to any culverts that are required.

Habitat Considerations

Greendale Bar is adjacent to the only vegetated island within the Vedder River. The flow splits around the island with the main flow on the left bank and a secondary channel along the right

bank. This secondary channel provides riffle habitat at its upstream extent and glide habitat downstream. There is high-quality riparian habitat along the length of the banks and the island.

The downstream excavation site is adjacent to high-quality microchannel habitat that runs under a large LWD complex. This habitat channel must be crossed using culverts to access the downstream site. The culvert crossing will be put in a location that maintains the integrity of this channel and LWD complex. Along the right bank upstream of the upstream excavation site, a habitat channel will be constructed to tie into the pit.

Fish Habitat Utilization

Greendale Bar is a complex bar with lots of high-value habitat, particularly on the island side. The microchannel and LWD complex at the upstream end of the island provide excellent rearing opportunities for juvenile salmonids.

Pink salmon spawning habitat is abundant in this area, extending from Salad Bar upstream along the outer edge of the island and continuing to the upstream bar.

Anticipated Outcome

The two proposed excavations at Greendale Bar will provide additional channel capacity at the downstream end of the freeboard limited section of the river. The excavations are expected to refill slowly over the next few freshets.

7.5: Salad Bar A

Site Name: Salad Bar A **Site Number:** 5
Identifier: 20-Canal 37R **Coordinates:** 49.092540° N, -122.067031° W
Location: Adjacent (downstream) to Greendale Stockpile site
Ownership: City of Chilliwack

Previous Excavations: 2004, 2006, 2008 & 2014
Stockpile: Greendale Stockpile

Length: 117.5 m
Width: 26 m
Depth: 2.5 m
Expected Gravel Yield: 6,000 m^3

Bar Access

Ramp down from the dyke and culvert across the existing channel at the upstream end of the bar. Salad Bar A and Greendale Bar can be reached by travelling south from Keith Wilson Road along the dyke on the right bank of the river (Figure 6).

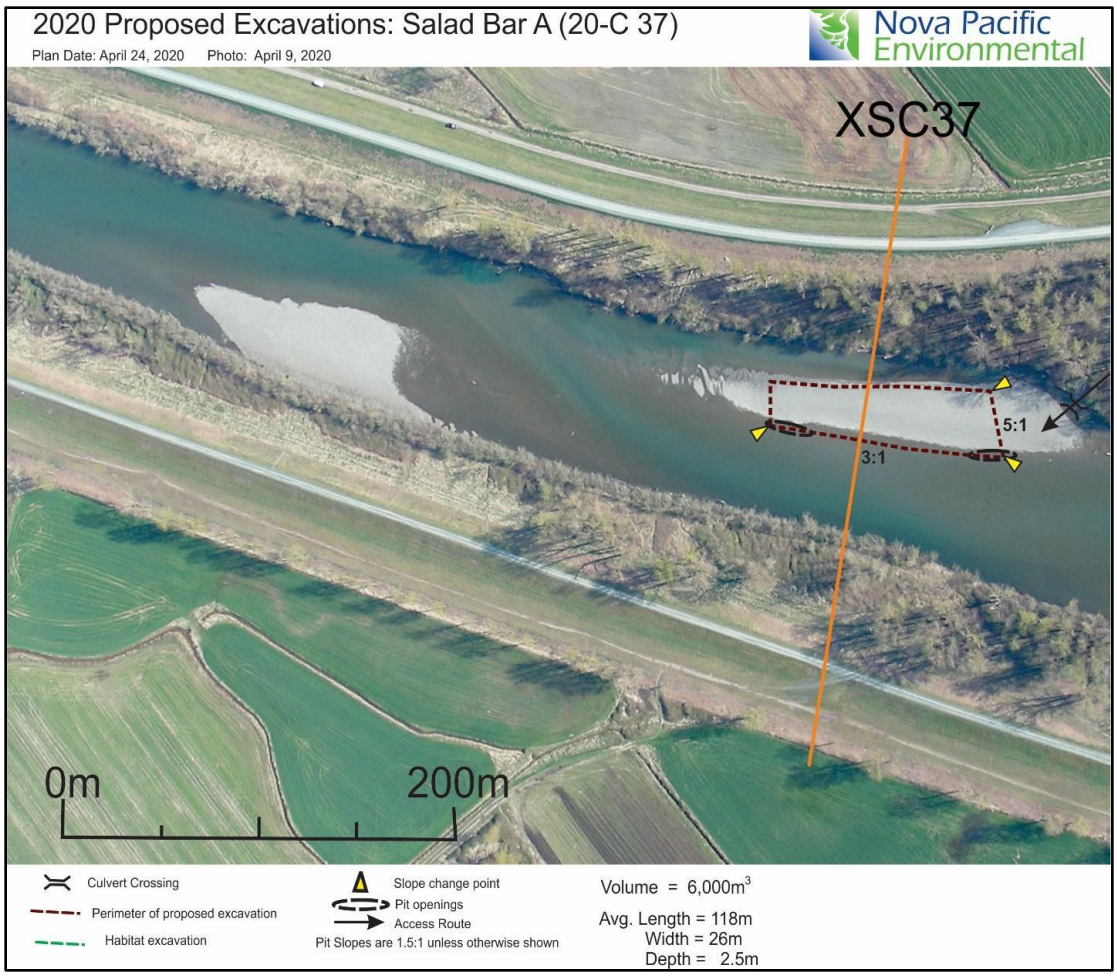

Figure 6: Salad Bar A excavation.

Objectives and Effectiveness

Lower water levels in the freeboard limited area through backwater curve reduction. Ensure that the pink salmon spawning habitat upstream and the existing habitat channel along the right bank are maintained.

Mitigation Plans

The mitigation measures described in Section 4.0 of this document will be followed. The excavation perimeter has been set back from the microchannel along the right bank to maintain the integrity of existing habitat. A flatter slope along the outer edge has been incorporated to maintain the existing riffle configuration. Measures including "stand-by" silt fencing, sediment traps and strict maintenance would be incorporated to prevent input of sediment into the river or habitat channel related to any culverts that are required.

Habitat Considerations

The primary habitat considerations at Salad Bar A are the existing habitat channel along the right bank and the availability of pink salmon spawning opportunities along the bar. There is LWD at

the upstream end of the habitat channel that provides instream cover and areas of flow velocity reduction. The riparian vegetation along the right bank provides good quality cover, while the left bank is much more sparse as the river heads into the canal section.

There is very little enhancement opportunity at this bar, but LWD will be keyed in if/when appropriate. The existing habitat channel along the right bank will be maintained and culverts will be utilized to cross the channel at the upstream end of the bar.

Fish Habitat Utilization

The existing habitat channel along the right bank provides great rearing habitat for juvenile salmonids. There is significant overhanging vegetation as well as some LWD availability for cover. This channel will be maintained during the excavation process.

Along the entirety of Salad Bar A, a riffle perches the flow, which provides excellent opportunities for pink spawning along the whole outside edge of the bar.

Anticipated Outcome

Increased riffle habitat as the excavation fills in.

7.6: Powerline Bar

Site Name: Powerline Bar **Site Number:** 6
Identifier: 20-Canal 29L **Coordinates:** 49.101119° N, -122.076004° W
Location: 200 m upstream of Keith Wilson Bridge
Ownership: City of Chilliwack

Previous Excavations: 1994 & 2004
Stockpile: Boundary Road Stockpile

Length: 120.5 m
Width: 23 m
Depth: 3 m
Expected Gravel Yield: 8,000 m^3

Bar Access

North along the left bank dike road from the Fisherman's Corner parking lot to Keith Wilson Bridge. The existing ramp down from the dyke road allows trucks to travel under the bridge and then upstream to the bar access point (Figure 7). A ramp down to the bar will need to be constructed and at least one culvert would be required.

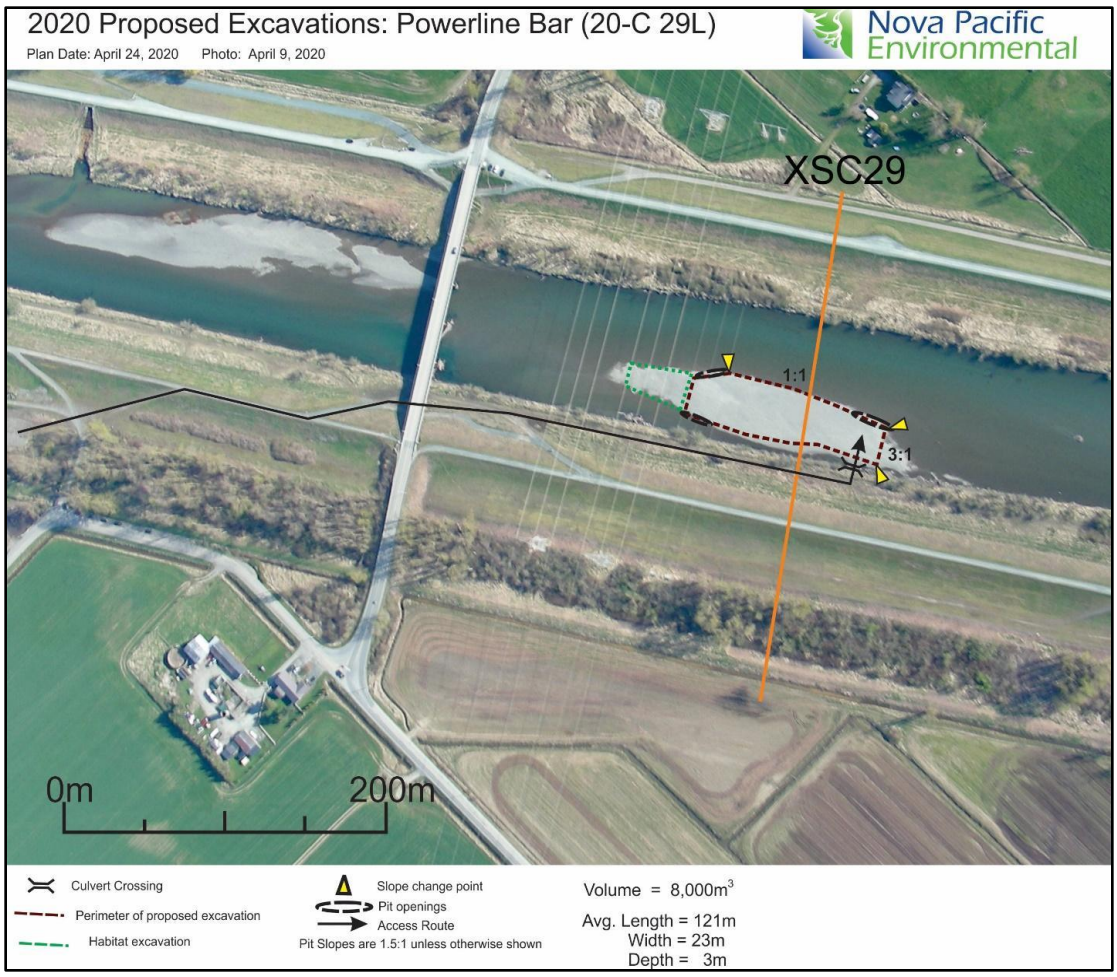

Figure 7: Powerline Bar excavation.

Objectives and Effectiveness

Lower water levels in the freeboard limited area through backwater curve reduction. This excavation will likely refill slowly, providing benefits through a few freshet cycles.

Mitigation Plans

The mitigation measures described in Section 4.0 of this document will be followed, particularly in relation to culverts. The excavation area has been set back from the microchannel along the left bank to maintain the integrity of the existing habitat. Measures including "stand-by" silt fencing, sediment traps, and strict maintenance would be incorporated to prevent input of sediment into the river or habitat channel related to any culverts that are required.

Habitat Considerations

The habitat channel along the left bank is the primary habitat consideration at Powerline Bar. Additionally, maintenance of riffle habitat at the upstream and downstream extents of the bar will be important.

Protection of the secondary channel along the left bank is required, and as such the pit excavation has been offset from the channel accordingly. This channel will further be enhanced with LWD if any is available. The lateral riffle downstream of the bar will be enhanced by scalping the downstream end of Powerline Bar to water level or below to encourage flow.

Fish Habitat Utilization

The canal section of the Vedder River in general is primarily used by salmonids for migration to and from spawning areas upstream, however this section of the river provides rearing and foraging habitat for salmonids and is utilized by other fish as well.

Powerline Bar has a well-established habitat channel along the left bank that provides potential rearing and spawning habitat for fish. This channel will be maintained during the excavation of the bar and enhanced where possible with LWD found during sediment removal.

The shallow riffle habitat along the head and edge of the bar provides potential habitat for juveniles and potential spawning opportunities for pink salmon.

Anticipated Outcome

It is expected this excavation will slowly refill. The habitat complexity along the right bank will be increased until refilling is complete. Additional riffle habitat will be provided by the habitat excavation at the downstream end of the bar.

7.7: Boundary Bar

Site Name: Boundary Bar **Site Number:** 7
Identifier: 20-Canal 22L **Coordinates:** 49.108821° N, -122.083095° W
Location: 800 meters downstream of Keith Wilson Bridge
Ownership: City of Abbotsford

Previous Excavations: 2002 & 2014 (approximate location by XS identifier)
Stockpile: Boundary Road Stockpile

Length: 184.5 m
Width: 56.5 m
Depth: 2.5m
Expected Gravel Yield: 19,000 m^3

Bar Access

Northwest along the left bank dike road from the Fisherman's Corner parking lot. A ramp down from the dyke top to the low bank and then a second ramp down to the bar would be required (Figure 8). A culvert is not likely to be needed during excavation.

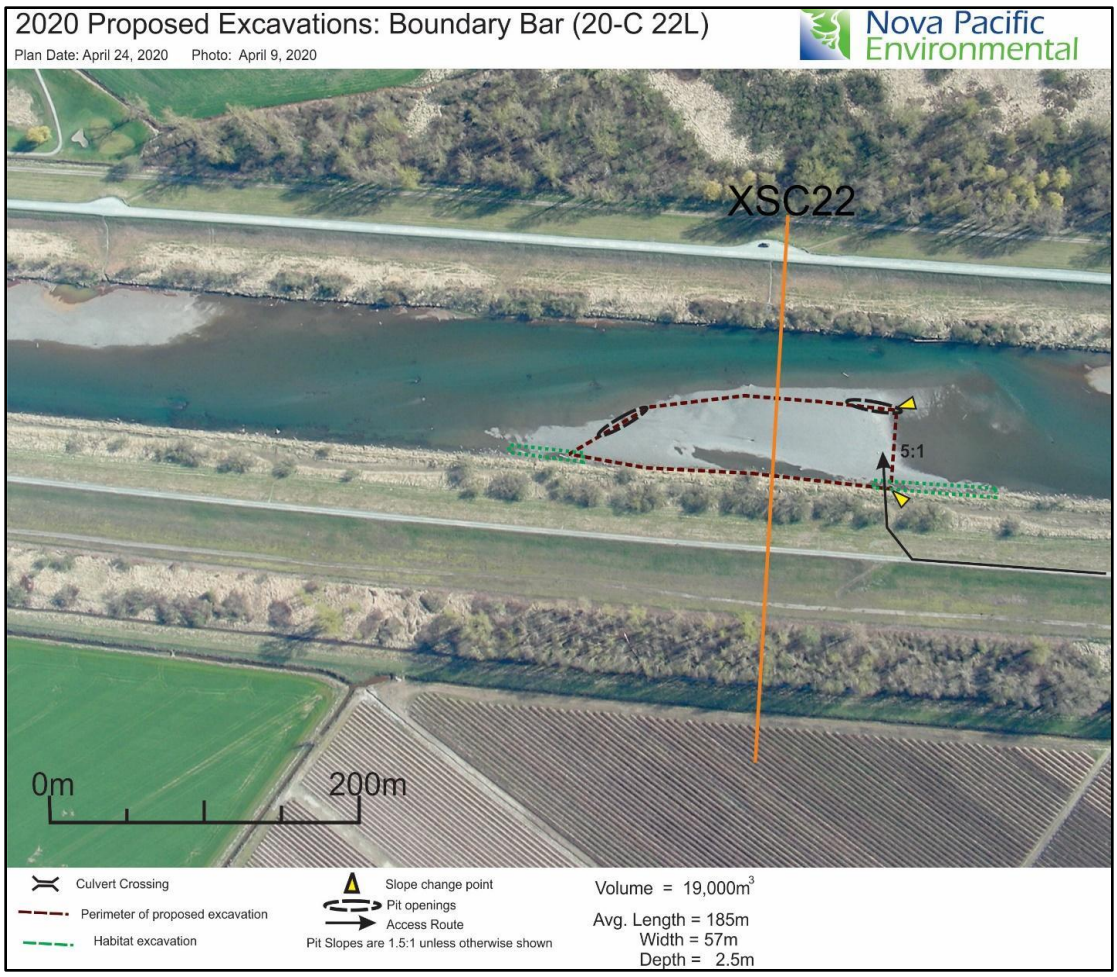

Figure 8: Boundary Bar excavation.

Objectives and Effectiveness

To improve the backwater curve reducing risk of dyke overtopping upstream in the freeboard limited section of the Vedder River.

Mitigation Plans

The mitigation measures described in Section 4.0 of this document will be followed, particularly those related to hauling material. Measures including "stand-by" silt fencing, sediment traps and strict maintenance would be incorporated to prevent input of sediment into the river or habitat channel related to any culverts that are required.

Habitat Considerations

The excavation will be constructed with habitat channels at the upstream and downstream ends of the bar against the left bank. Previously a habitat channel was provided along the full length but proved to be too shallow. Accordingly, excavation to the bank is proposed. LWD pieces found during excavation will be incorporated into the upstream and downstream habitat channels as

well as along the bank. Due to the low profile instead of the typical perpendicular downstream pit edge, a wedge shape will be left in order to split flow, partially back to the thalweg and partially along the bank to provide additional habitat complexity and limit accumulation of fine sediments along the bank.

Fish Habitat Utilization

Boundary Bar has not been noted to provide opportunities for chum or pink salmon spawning due to relatively slower flows and fine substrate size. As with other canal reach bars, there is limited riparian vegetation and LWD along the edges of Boundary Bar. The canal section of the Vedder River in general is primarily used by salmonids for migration to and from spawning areas upstream along with some rearing habitat opportunities for salmon fry noted along the bar edges.

Anticipated Outcome

Presence of fines and woody debris may limit the excavation depth. It is expected this excavation will significantly improve water levels upstream through removal of a significant amount of sediment from the canal section of the Vedder River. Impacts to fish are expected to be neutral with some loss of glide edge habitat offset by increases in habitat edge and microchannel habitat.

7.8: Chadsey D/S Bar

Site Name: Chadsey D/S **Site Number:** 8
Identifier: 20-Canal 16L **Coordinates:** 49.116460° N, -122.090187° W
Location: 1,900 meters downstream of Keith Wilson Bridge
Ownership: City of Abbotsford

Previous Excavations: n/a
Stockpile: Boundary Road Stockpile

Length: 248 m
Width: 44 m
Depth: 2.5 m
Expected Gravel Yield: 25,000 m^3

Bar Access

Northwest along the left bank dike road from the Fisherman's Corner parking lot. A ramp down from the dyke top to the low bank and then a second ramp down to the bar would be required (Figure 9). A culvert is not likely to be needed during excavation.

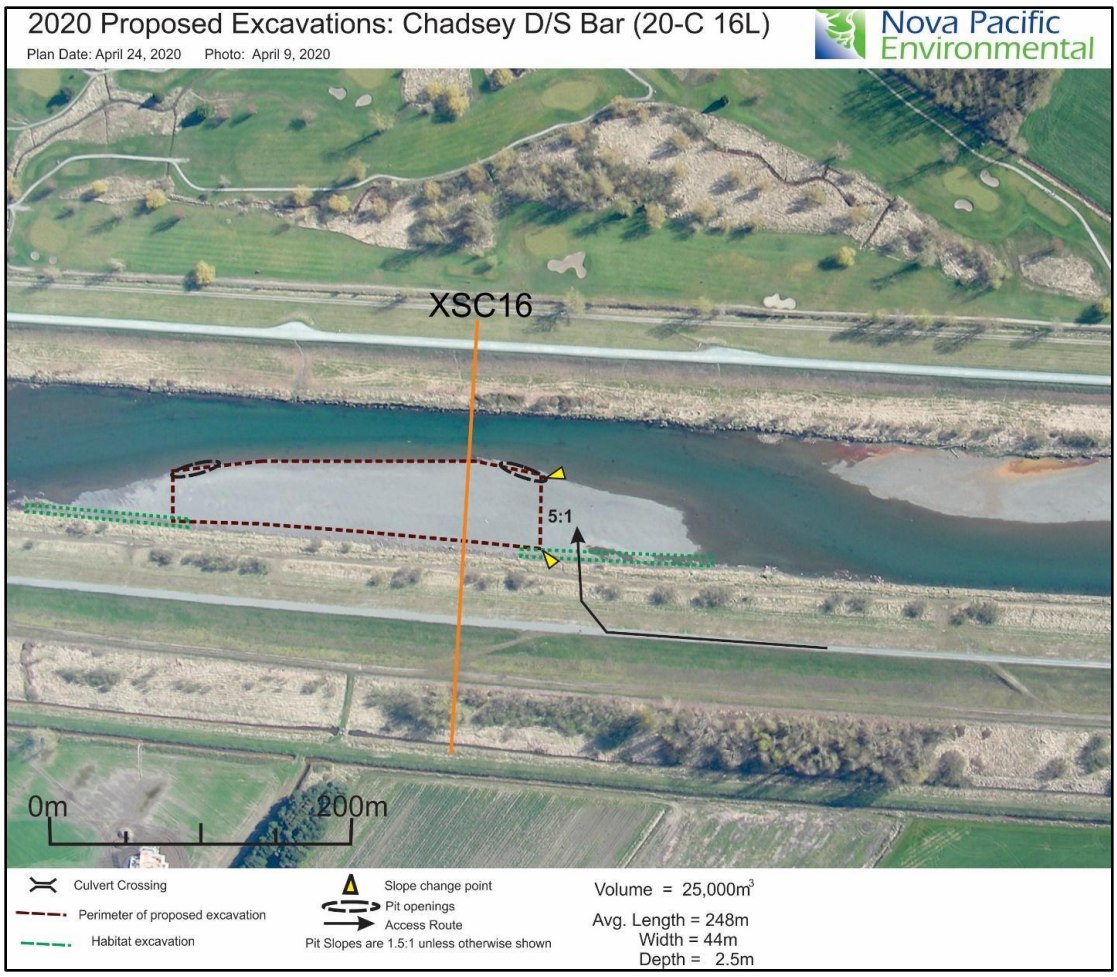

Figure 9: Chadsey D/S Bar excavation.

Objectives and Effectiveness

This bar has not been previously excavated and it extends across approximately 2/3 of the channel. In addition to significant backwater curve benefit to the freeboard limited section of the river, (KWL 2020) this excavation should alleviate the erosion occurring on the right bank which appears to be new and related to the recent formation of this bar.

Mitigation Plans

The mitigation measures described in Section 4.0 of this document will be followed, particularly those related to hauling material. Measures including "stand-by" silt fencing, sediment traps and strict maintenance would be incorporated to prevent input of sediment into the river or habitat channel related to any culverts that are required.

Habitat Considerations

Chadsey D/S Bar is a large, uniform bar with little habitat complexity. Remnants of a habitat channel along the left bank are present, which will be enhanced along the upstream and

downstream ends of the bar, connecting to the pit. Enhancement of the remnant habitat channel along the bank will increase the availability of rearing habitat for salmonids. LWD found within the excavation area will be keyed in at strategic locations along the bank and channel. The downstream section of the bar has a significant amount of fine sediments, which are generally not useful for fish habitat particularly for spawning.

Erosion along the right bank of the river is apparent as the flow is directed around the bar. Excavation of the bar will take some of the pressure off this bank and help to maintain the integrity of the bank without the requirement of armoring. Reduced erosion should allow riparian vegetation to colonize the area and limit the introduction of fine sediments into the river at this location.

Fish Habitat Utilization

The canal section of the Vedder River in general is primarily used by salmonids for migration to and from spawning areas upstream along with some rearing habitat opportunities for salmon fry. Very little spawning of salmonids has been observed downstream of the Keith Wilson Bridge along the Vedder River.

Chadsey D/S is a large, uniform bar with larger gravel at the head and finer gravel at the tail. Due to the finer substrate at this bar conditions to support salmon spawning do not exist. The shallow sections at the head end of the bar provide potential rearing habitat for juvenile salmonids, as evident by electrofishing at the efforts at other bars in the past, which have shown this utilization in similar conditions.

Anticipated Outcome

This excavation is the largest of the proposed excavations for the 2020 program and also is expected to produce a significant improvement to the dyke freeboard limited areas through the backwater curve effect. Impacts to fish are expected to be neutral with some loss of glide edge habitat offset by increases in habitat edge and microchannel habitat. Mitigating erosion on the right bank at this location is expected to yield a small improvement of habitat edge properties on the right bank. It is anticipated that this bar will fill slowly, providing increased pool habitat and microchannel habitat along the left bank as this happens.

8.0: OFFSETTING

Following the flood of 1975 and subsequent setback dyke construction, the Vedder River Management Area Plan identified the ongoing need to remove gravel and to maintain pink and chum spawning habitat within the river.

Since 1994, mapping of habitats has shown that the ongoing removal program as it has been executed has allowed habitat values to persist. A higher percentage of excavations that show an increase in habitat value from pre to post suggest that ongoing aggradation tends to lower the habitat ratings as measured by the method employed and that periodic excavation allows an increase in habitat ratings. The adaptive system of constraints, guidelines and planning procedures in use at least since 1998 has provided a successful approach for meeting floodway capacity objectives while maintaining habitat values, the core objectives of the VRMAC. Standard mitigation measures including excavation site slopes, excavation outside of flowing waters, and location of site in relation to existing river features and sensitive habitats have resulted in a mostly positive or neutral set of outcomes across the 90 previously completed excavations. It is worth noting that the changes to the river following each excavation are attributable both to the freshet conditions and high volumes of gravel moved each year as well as the excavations. While these effects are not readily separated, natural changes can be seen to outweigh those that appear to be related to the excavations.

Overall, this approach results in a no net loss of habitat but there remains some short-term effects which in turn are offset by habitat excavation and enhancement activities that are built into each individual excavation. Broadly speaking, sediment removal replaces areas of higher bar habitat with large pools that begin to return to the previous condition with the beginning of fall freshet conditions. During higher flows, these submerged bar habitats are reduced. A second concern relates to use of the pits by spawners which could lead to losses if the excavations are not stable. This effect is mitigated by the characteristics of each pit.

Habitat mitigation consists primarily of placement of LWD, deepening entrances to secondary channels, complexing secondary channels, creating riffles, particularly at inlets and outlets to excavation sites, and excavating modest secondary and microchannels in conjunction with the larger pit type excavations. Placement of LWD is dependent on local supply and opportunity for placement but typically most sites allow for 2 to 4 LWD complexes consisting of 1 to 3 pieces. Entrances to channels are deepened as required to ensure that secondary channels continue to flow. Channel enhancements are undertaken when previously existing channels have filled or when temporary channels can be effectively deepened. An additional benefit arises where gravel flows can be enhanced by deepening channels adjacent to excavations. Typically, one or two significant channel improvement projects are undertaken in each cycle. For 2020, this includes a channel at Bergman and Chadsey D/S, with additional smaller channel enhancements at Yarrow, Greendale, and Boundary to re-establish flow along the riparian zone. Enhancement of riffle habitat at Powerline Bar has also been included.

The following table shows the specific offsets planned for each site and mitigations of the temporary impacts that have been incorporated into the excavation design. These mitigations

are different to the construction management BMPs discussed in Section 4 of this document. Due to the nature of the river and the large amount of sediment movement, the impacts and benefits are uncertain. There is also potential for spring freshet changes to alter the conditions so that planned habitat work is not feasible or desirable. Should this be the case, changes to the habitat work will be discussed along with the habitat mapping after the 2020 spring freshet.

Table 5: Mitigation and Offsetting Measures Proposed for Vedder River 2020 Sediment Removal Program

Bar Name	Bar ID	Mitigation Measures	Offsetting Measures
Bergman Bar	20-23L	This excavation is designed to maintain the riffle upstream of the bar which has persistently been shown to support pink and chum spawning. The proposed outlet includes a connection to both the mainstem and the lower portion of the habitat channel.	The habitat channel on the left bank will be enhanced with LWD as has been done in past cycles.
Railway Bar	20-19R	The excavation will avoid the riprap at the new culvert outlet to ensure that it does not slump into the pit. The excavation has also been set back from the existing habitat channel on the right bank.	

Yarrow Bar	20-12/13L	The pit has been located with a large enough buffer to maintain the integrity of the riffle upstream and decrease the likelihood of pit spawning by chum salmon. Additionally enough of the bar will be left in place to protect the habitat channel on the left bank.	The habitat channel on the left bank will be enhanced to maintain flow and LWD will be keyed into the bank of the channel. Additional riffle habitat across the existing bar will result from the scalp.
Greendale Bar	20-4R	Particular care will be taken when constructing culvert crossings across the high-value habitat channels present at the bar. The downstream excavation has also been situated such that the integrity of the island channel and LWD complex is maintained.	The upstream scalp should provide additional riffle habitat and increase flow toward the side channel on the right side of the vegetated island. The small habitat channel on the right bank at the upstream end of the bar will be enhanced in an effort to maintain flow and reduce iron staining along the right bank.
Salad A Bar	20-C37R	The excavation perimeter has been set back from the microchannel along the right bank to maintain the integrity of existing habitat. A flatter slope along the outer edge has been incorporated to maintain the existing riffle configuration.	

Powerline Bar	20-C29L	The excavation area has been set back from the microchannel along the left bank to maintain the integrity of the existing habitat. The excavation will also preserve the bar head and associated riffle habitat which can be utilized by rearing fry.	The habitat channel will be enhanced with LWD if any is available. The area of lateral riffle downstream of the bar will be increased by scalping the downstream end of Powerline Bar to just below the low flow water level. A berm will be employed to allow this work in the dry.
Boundary Bar	20-C22L	Instead of the typical perpendicular downstream pit edge, a wedge shape will be left in order to split flow, partially back to the thalweg and partially along the bank to provide additional habitat complexity.	The excavation will be constructed with habitat channels at the upstream and downstream ends of the bar against the left bank. LWD will be used to enhance these channels if available.
Chadsey D/S Bar	20-C16L	It is expected this excavation will remove a significant amount of sediment from the canal section of the Vedder River mitigating erosion on the right bank at this location.	A habitat channel along the left bank will be excavated along the upstream and downstream ends of the bar, connecting to the pit.

9.0: CONCLUSION

Fish utilize a wide variety of habitats in the Vedder River and are present in wetted habitats adjacent to each proposed excavation. The pattern of that usage is correlated to habitat types that are the focus of the ongoing assessment and management of the Vedder River Sediment Removal Program. The program relies on careful and detailed application of the excavation design guidelines to avoid detrimental impacts to these habitats and to ensure that high habitat values are maintained in the Vedder River despite the high rate of natural and anthropogenic change.

The proposed work is expected to substantially meet the program objectives to increase flow conveyance and improve dyke freeboard with no net loss to fish habitat.

10.0: REFERENCES

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Wright, B.F., T. Kozlova, and M. Richard. (2018). 2016 Vedder River Gravel Excavations Habitat Changes and Environmental Impacts. Prepared for the Vedder River Management Area Committee.

APPENDIX A – LIST OF DOCUMENTS BEING SUBMITTED WITH PERMITTING APPLICATIONS TO DFO & MFLNRORD

THESE DOCUMENTS HAVE BEEN REFERENCED THROUGH THIS REPORT AND ARE BEING SUBMITTED DIRECTLY TO DFO/MFLNRORD IN PDF FORMAT AS APPENDICES TO THE PERMIT APPLICATIONS

1. 2020 Vedder River Hydraulic Assessment (KWL - Apr 2020)
2. 2016 Vedder River Gravel Excavations Habitat Changes and Environmental Impacts (NPE - May 2016)
3. 2016 Vedder River Sediment Removal - Monitor's Report (NPE - Dec 2016)

APPENDIX B – LIST OF VEDDER RIVER ENVIRONMENTAL REPORTS PREPARED BY NPE FROM 1994 to 2016

COMPENDIUM OF VEDDER RIVER ENVIRONMENTAL REPORTS PREPARED BY NPE FROM 1994-2016

Most of these reports are available at: http://vedderriver.ca/

1. Wright, B.F. and M. Robinson. (1994). Environmental Monitors Report Vedder River Gravel Removal Project 1994. Prepared for the Ministry of Environment and Vedder River Management Committee. 16 p.
2. Wright, B.F. and M. Robinson. (1995). Assessment of the Environmental Impacts from 1994 Vedder River Gravel Bar Excavations. Prepared for Ministry of Environment Lands and Parks, District of Chilliwack, City of Abbotsford. 13 p.
3. Wright, B.F. and M. Robinson. (1995). Vedder River Gravel Removal Environmental Monitor's Report 1995. Prepared for Ministry of Environment Lands and Parks, District of Chilliwack, City of Abbotsford. 14 p.
4. Wright, B.F. (1997). Evaluation of Habitat Changes and Environmental Impacts Following the 1995 Gravel Excavations. Prepared for B.C. Ministry of Environment Lands and Parks. 24p.
5. New Pacific Ventures. (1999). Habitat Changes and Environmental Impacts Following 1996 Gravel Excavations on the Vedder River. Prepared for the Vedder River Management Committee. 22 p.
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7. Scholz, P.S., Wright, B.F., M.C. Robinson, and V. Galay. (2001). Habitat Changes and Environmental Impacts Following 1998 Gravel Excavations on the Vedder River. Prepared for the Vedder River Management Area Committee. 45 p.
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9. Wright, B.F. and P.S. Scholz. (2003). Habitat Changes and Environmental Impacts Following 2000 Gravel Excavations on the Vedder River. Prepared for the Vedder River Management Area Committee. 35 p.
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14. Coe, K., Wright, B.F. and R. Murray. (2007). 2006 Vedder River Gravel Excavations Environmental Monitors Report. Prepared for the Vedder River Management Area Committee. 29 p.
15. Nova Pacific Environmental. (2008). Post Excavation Assessment of 2006 Vedder River Gravel Excavations. Prepared for the Vedder River Management Area Committee. 57 p.
16. Nova Pacific Environmental. (2008). 2008 Vedder River Gravel Excavations Environmental Monitors Report. Prepared for the Vedder River Management Area Committee.
17. Wright, B.F., P.S. Scholz and K. DeBoer. (2010). 2008 Vedder River Gravel Excavations Habitat Changes and Environmental Impacts. Prepared for the Vedder River Management Area Committee.
18. DeBoer, K. and B.F. Wright. (2010). 2010 Environmental Monitors Report. Prepared for the Vedder River Management Area Committee. 48 p.
19. Wright, B.F., and T. Kozlova. (2012). 2010 Vedder River Gravel Excavation – Habitat Changes and Environmental Impacts. Prepared for the Vedder River Management Area Committee.
20. Kozlova, T. and B.F. Wright. (2010). 2012 Vedder River Sediment Removal Environmental Monitors Report. Prepared for the Vedder River Management Area Committee.
21. Wright, B.F., T. Kozlova, and C. Hegele. (2014). 2012 Vedder River Gravel Excavations Habitat Changes and Environmental Impacts. Prepared for the Vedder River Management Area Committee.
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23. Wright, B.F., T. Kozlova, and D. Campbell. (2016). 2014 Vedder River Gravel Excavations Habitat Changes and Environmental Impacts. Prepared for the Vedder River Management Area Committee.
24. Wright, B.F. and T. Kozlova. (2016). 2016 Vedder River Sediment Removal Environmental Monitors Report. Prepared for the Vedder River Management Area Committee.
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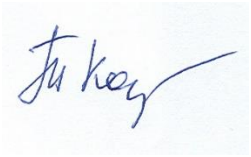
Date and Signature Page

The effective date of this report titled "Proposed 2020 Vedder River Sediment Removal Project" is May 29, 2020.

Signed,

Bruce F. Wright, B.Sc. MBA, RPBio Dated: May 29, 2020

Signed,



Tatiana Kozlova, PhD, RPBio Dated: May 29, 2020

Signed,

Michael Richard, B.Sc. Geo/Env Sci Dated: May 29, 2020

Signed,

Stefanie Schoenberger, B.Sc. Bio, BIT Dated: May 29, 2020