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NHC Reference 3008512
December 9, 2024

Regional District of Nanaimo
6300 Hammond Bay Road
Nanaimo, BC, V9T 6N2

Attention: Elaine Mcculloch, Regional District of Nanaimo
Copy to: Barb Riordan, Mid Vancouver Island Habitat Enhancement Society
Via email: emcculloch@rdn.bc.ca; info@mvihes.bc.ca

Re: **French Creek Estuary Habitat Enhancement**
Evaluating Dike Removal and Alternative Options within the French Creek Estuary Nature Preserve – Final, Rev. 0

1 Introduction

Northwest Hydraulic Consultants Ltd. (NHC) was retained by the Regional District of Nanaimo (RDN), who is working with Mid Vancouver Island Habitat Enhancement Society (MVIHES), to complete a high-level options assessment for habitat enhancement of the French Creek Estuary Nature Preserve. The purpose of the habitat enhancement is to improve fish habitat while preserving and protecting the existing habitat. The RDN requested an assessment of the feasibility of removing a dike and exploring alternative habitat enhancement options.

This project assesses the feasibility of removing the dike at the mouth of French Creek and suggests alternative habitat enhancement options while keeping the dike in place (Figure 1.1). The alternative options under assessment were developed by NHC in discussion with RDN and MVIHES. The list of options evaluated for this assessment are as follows:

- Full removal of the French Creek Dike
- Full removal of the French Creek Dike and lowering river left[1] bank
- Adding culverts through the French Creek Dike
- Placing large woody debris (LWD) structures over top of existing riprap protection along the French Creek Dike

Initially the RDN wanted the assessment to focus on an assessment of the benefits and drawbacks of removing the dike. NHC and the RDN refined the project objectives as part of the analysis process, and the RDN determined that preservation of the existing freshwater habitat behind the dike was a key objective. This important objective guided the results of this analysis. This report provides background information about French Creek and presents the results of the options assessment, including a decision

[1] River direction is determined from viewing the downstream orientation.

matrix outlining the benefits and drawbacks of the identified habitat enhancement options and preliminary high-level cost estimate for the preferred option identified by the RDN.

This study relies on a desktop-based assessment of options using available information. No additional surveys or field data were collected for this study. A scoping site visit was completed on August 23, 2023 with Elaine McCulloch (RDN), Barb Riordan (MVIHES), Pat Ashton (MVIHES), Lynn Brooks (MVIHES), Wil Hilsen (NHC), and Kylie Knox (NHC). A second site visit was completed by Kylie Knox (NHC) and Dave McLean (NHC) on October 24, 2023, after meeting Denise Foster (MVIHES) to discuss recent flood events.

Following a presentation of preliminary results of the four habitat enhancement options under assessment, the RDN and MVIHES determined that the impact to habitat behind the dike associated with the dike removal option was unacceptable. The focus of the assessment then shifted to improving the habitat quality of the existing dike, rather than removing or lowering it, or installing culverts through it. Figure 1.2 provides a relative elevation map to illustrate the changes in site topography.

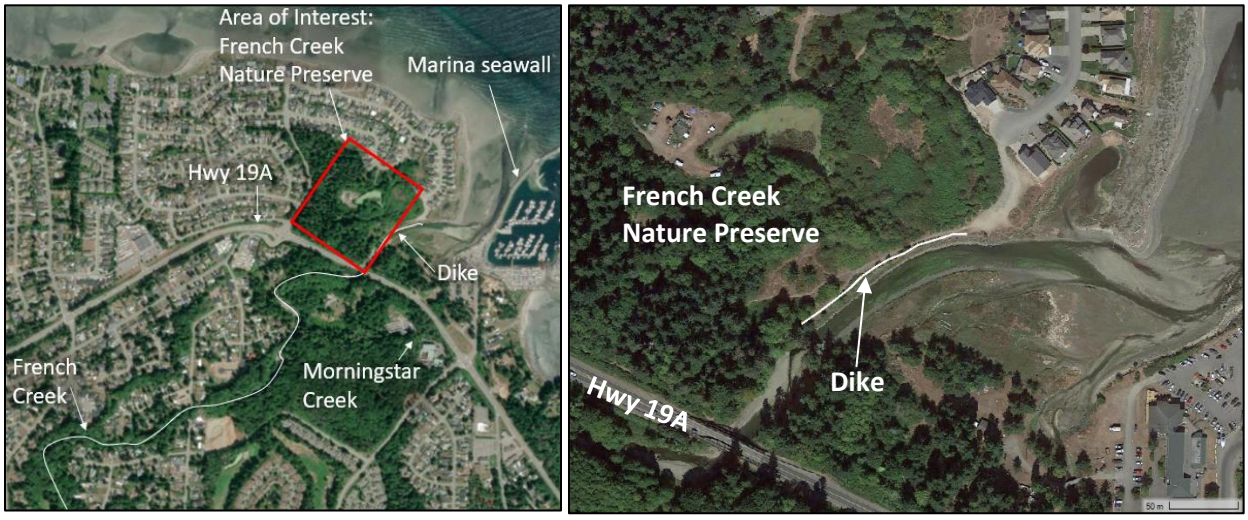

Figure 1.1 Project location (left) and zoomed-in view of French Creek Dike (right) (source: Google Earth 2016).

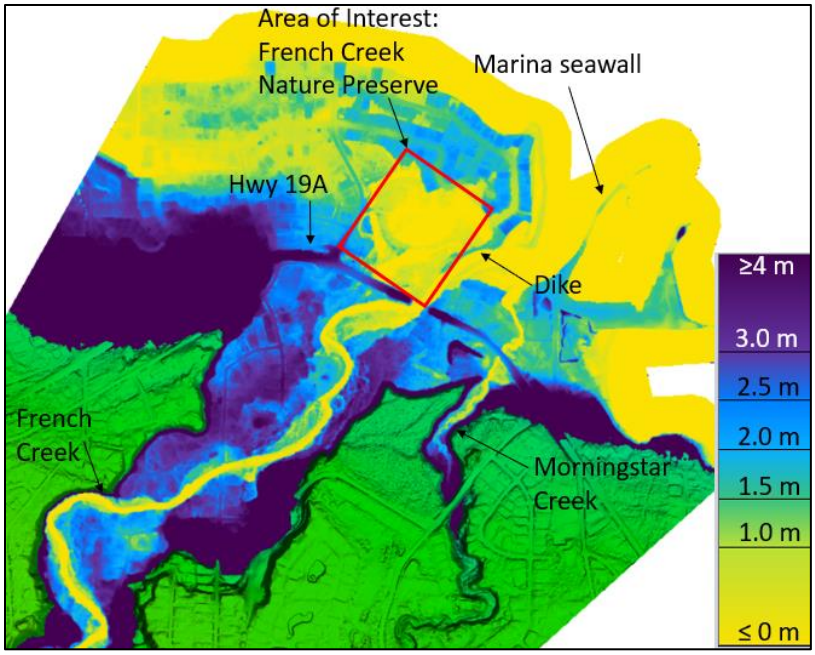

Figure 1.2 Project location shown using a relative elevation map (source: LidarBC 2019 LiDAR)

2 Background

This section outlines the background data available for the habitat enhancement options analysis, additional available data for future studies, and the project scope of work.

2.1 Available Information

A listing of the information available for the French Creek watershed and estuary is provided in this section.

2.1.1 Information Provided to NHC

MVIHES has kept record of a number of data sources including:

- Water quality parameters at the pond within the Nature Preserve and at the Water Survey of Canada (WSC) gauge at Barclay Bridge. Parameters include temperature, conductivity, dissolved oxygen (DO), turbidity. Data was collected weekly from June 2021 to June 2022.
- Water levels within the Nature Preserve at the pond and in a relict channel near Highway 19A. Data for the pond was collected weekly from June 2021 to June 2022. The relict channel data was collected weekly with some missing records from November 2021 to June 2022.
- Photos from a river flood event in December 2018.
- Photos from the king tide event in December 2022.
- Historical photos of the French Creek Estuary from 1951.

- Reports:
  - Assessment of Historic Aerial Photography for Dike Construction (Nahirnick, n.d.).
  - Statutory Right of Way Agreement (Storm Drainage) Land Title Act documentation from the Ministry of Transportation and Infrastructure ([MOTI, 2003] now Ministry of Transportation and Transit) for drainage along Nature Preserve northeast boundary from Juan De Fuca Boulevard to Admiral Tyron Boulevard.
  - Biophysical Assessment Report Columbia Drive Estates, French Creek BC (Revised November 23, 2017) (Aquaparian, 2017).
  - Geotechnical engineering report with recommendations for measures to mitigate the effects of flooding and erosion at the French Creek Estuary (EBA Engineering, 1994).
  - Preliminary Development Proposal and Rezoning Application for French Creek Estates (Moore Planning, 1981).
  - Construction And Testing of New Test Wells R-1 And R-4 And Testing of Existing Anderson Test Well 1-88 for French Creek Estates in the French Creek Area of Vancouver Island (Pacific Hydrology, 1994).

MOTI also has the following records of the drainage infrastructure for the neighbourhood:

- Easement/Culvert Locations Map: shows locations of MOTI operated and maintained easements and culverts.
- Easement Locations Map: Shows locations of MOTI operated and maintained drainage easements.
- Easement Plan EPP84505 for drainage from Columbia Drive to the French Creek Nature Preserve.

The information on drainage in the area is lacking, as most of the subdivisions were created before MOTI required official stormwater management plans (pers. Comm. Tammy Thompson, October 31, 2023). Aquaparian (2017) states the following regarding drainage and connectivity from the estuary to the French Creek Nature Preserve:

"*A recent inspection of the flap gate was found to have no present connectivity to the ponds or the side channels during tidal fluctuations along French Creek. Most of the channels were found to be completely dry by April/May and all the channels observed to be dry by mid-June. The channels are predominantly influenced by elevated groundwater levels during fall/winter rains and run-off from the highway and surrounding residential development.*"

2.1.2 Other Information Sources

The following are additional available information sources gathered by NHC; listed material that was relied upon for reporting is included in our Reference List:

- French Creek Water Allocation Plan, BC Ministry of Environment (MOE, 1994). Describes watershed characteristics, precipitation, and runoff.

- French Creek Watershed Study, Ministry of Water, Land and Air Protection (MWLAP, 2002). Includes hydrological assessment and flood frequency estimates of discharges on French Creek.
- Regional District of Nanaimo Community Watershed Monitoring Network data summary and analysis reports (2011 – 2015, 2018, 2021, 2023). Provides information on water quality parameters in regional watersheds, including French Creek.
- Coastal Flood Hazard Map Atlas, Map Series 2/8: Flood Construction Level Regulatory Maps for 1.0 m of relative sea level rise (Ebbwater Consulting & Cascadia Coast Research Ltd., 2019). Shows flood construction level (FCL) and flood extent for a 200-year ocean level with 1.0 m of sea level rise.
- University of British Columbia aerial photos for the following years: 1949, 1957, 1962, 1977, 1984, 1992, 1998. These show historic watershed and estuary conditions for French Creek.
- LidarBC 2019 open LiDAR Data (Government of British Columbia, 2019). This provides elevations for the topography, and can be used to create a digital elevation model (DEM) of the area. This would be needed to develop designs and create design drawings.
- Condition and Risk Assessment of BC's Orphan Dikes (KWL, 2020)

3 French Creek Watershed

This section provides information about the characteristics of the French Creek watershed including an overview of the watershed, French Creek hydrology, coastal water levels at the estuary, information about the estuary, fish species present in French Creek which could benefit from the project, and information about the French Creek Dike.

3.1 Watershed Characteristics

The French Creek Watershed Study from MWLAP (2002) states that French Creek is approximately 25 km long with headwaters in the steep, forested Beaufort Mountains at 1,080 m mean sea level and flows east into the Strait of Georgia between Parksville and Qualicum Beach, BC. From the mountain range, French Creek drains through lowlands used for farming, rural residential, commercial, and urban residential development. The largest body of water in the watershed is the Hamilton Marsh, which drains into French Creek downstream of the Alberni Highway (Highway 4) (MWLAP, 2002). Mount Arrowsmith causes a rain shadow effect; approximately 80% of the annual precipitation is received between October and May (MWLAP, 2002). Floods occur between October and March and are generated by heavy rainstorms combined with snowmelt from higher elevations in the watershed.

The weather station at Qualicum Beach Airport reports an annual total rainfall of 1695 mm. According to NHC (2021a), the mean annual precipitation for the adjacent Englishman River watershed (southeast) is 2013 mm, and the adjacent Qualicum River watershed to the west has a MAP of 1982 mm. Based on the mean annual precipitation in these adjacent watersheds, the mean annual precipitation for the French Creek watershed is estimated to be around 2000 mm.

The Fresh Water Atlas (FWA) states a total watershed area of 69.7 km^2 up to the estuary (Figure 3.1). French Creek is an ungauged watershed and therefore, direct runoff measurements are not available. To determine anticipated flood flows for given return periods, a number of gauged watersheds operated by Water Survey of Canada (WSC) were investigated to determine suitable proxy gauges to regionalize flows for French Creek.

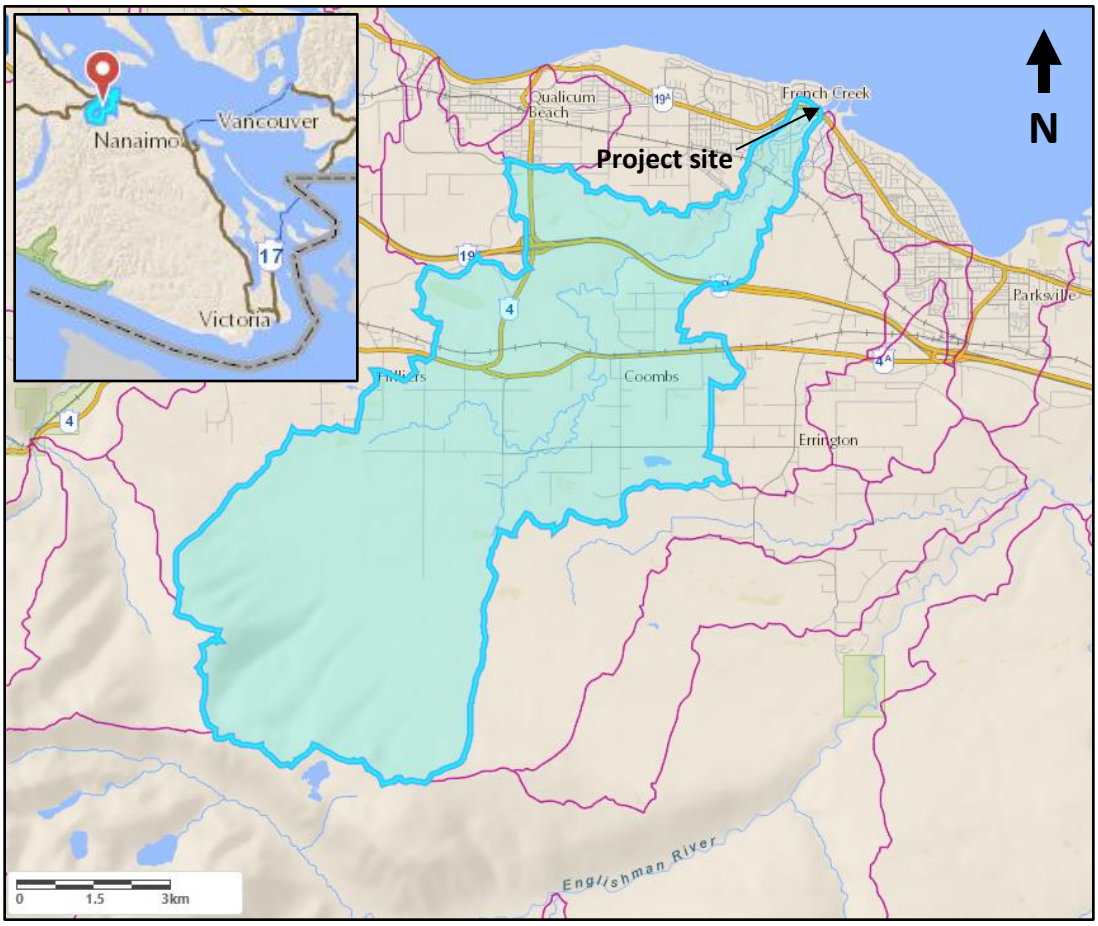

Figure 3.1 French Creek Watershed area and project site location (source: FWA and iMapBC).

3.2 French Creek Hydrology

The French Creek Watershed Study from MWLAP (2002) provides flood frequency estimates of discharge for French Creek. These estimates were referenced and updated during a previous study by NHC (2021b). The study by NHC considered several streams on the west coast of southern Vancouver Island for regionalizing discharge to the French Creek watershed. Characteristics considered to determine the most appropriate gauged rivers were watershed area, gauge elevation, median basin elevation, mean annual precipitation, and whether the watershed was regulated. Of the 11 streams reviewed, Dove Creek (WSC gauge ID 08HB075) was determined to be an appropriate proxy watershed and was adopted for regional flood frequency analysis. The Log Normal distribution provided the best fit to data for the Dove Creek flood frequency analysis where discharge was on an increasing trend at

greater return periods. Results of the analysis were updated to represent hydrology at the French Creek Estuary and are presented in Table 3.1.

French Creek has experienced periodic flooding and erosion hazards, as described in NHC (2014), CTV News (2017), NHC (2021b), and Times Colonist (2021). Additional photos from MVIHES also indicated flooding in 2018 and 2022.

Table 3.1 Peak instantaneous discharge (QPI) for given return period at French Creek Estuary.

Return Period	Annual Probability of Occurrence	French Creek QPI (Log Normal) (m^3/s)
200	0.005	224
100	0.01	201
50	0.02	178
20	0.05	149
10	0.1	127
5	0.2	105
2	0.5	73

3.3 Coastal Water Levels

A study by NHC (2023) presented tidal elevations for the Englishman River estuary, which can be referenced at the adjacent French Creek estuary (Table 3.2). These elevations were based on the tides presented in Volume 5 of the Canadian Tide and Current Tables (Fisheries and Oceans Canada, 2022).

Table 3.2 Summary of tides at the Englishman River estuary from reference to the Northwest Bay secondary port (NHC, 2023).

Sea State	Tide Elevation (m, CD)	Tide Elevation (m, CGVD2013)
Higher high water large tide (HHWLT)	5.20	2.32
Higher high water mean tide (HHWMT)	4.63	1.75
Mean water level (MWL)	3.22	0.34
Lower low water mean tide (LLWMT)	1.32	-1.56
Lower low water large tide (LLWLT)	0.16	-2.72

The RDN undertook coastal floodplain mapping studies in 2019 and 2020, including French Creek (Ebbwater Consulting & Cascadia Coast Research Ltd., 2019). The published coastal Flood Construction Level was 5.1 m (Canadian Geodetic Vertical Datum 2013 datum [CGVD2013]). It was reported that the water level represents a 0.5% frequency of occurrence (200-year return period) and includes a

freeboard allowance of 0.6 m and an additional 1.0 m to account for sea level rise. The corresponding present day 200-year ocean level (without freeboard) is 3.5 m (CGVD2013).

Figure 3.2 shows a portion of the RDN's coastal floodplain map near French Creek. The flood levels and flood extent only represent ocean water levels and do not account for effects of riverine flooding from French Creek. Therefore, flood levels and extents will be higher than depicted on the map in some areas due to the combined effect of river flows and tides. The map shows large portions of the lowland west of the creek lies inside the coastal flood line, with some land lying up to 3 m below the FCL. The map also shows the coastal flood zone extends over 200 m upstream of the Highway 19A bridge.

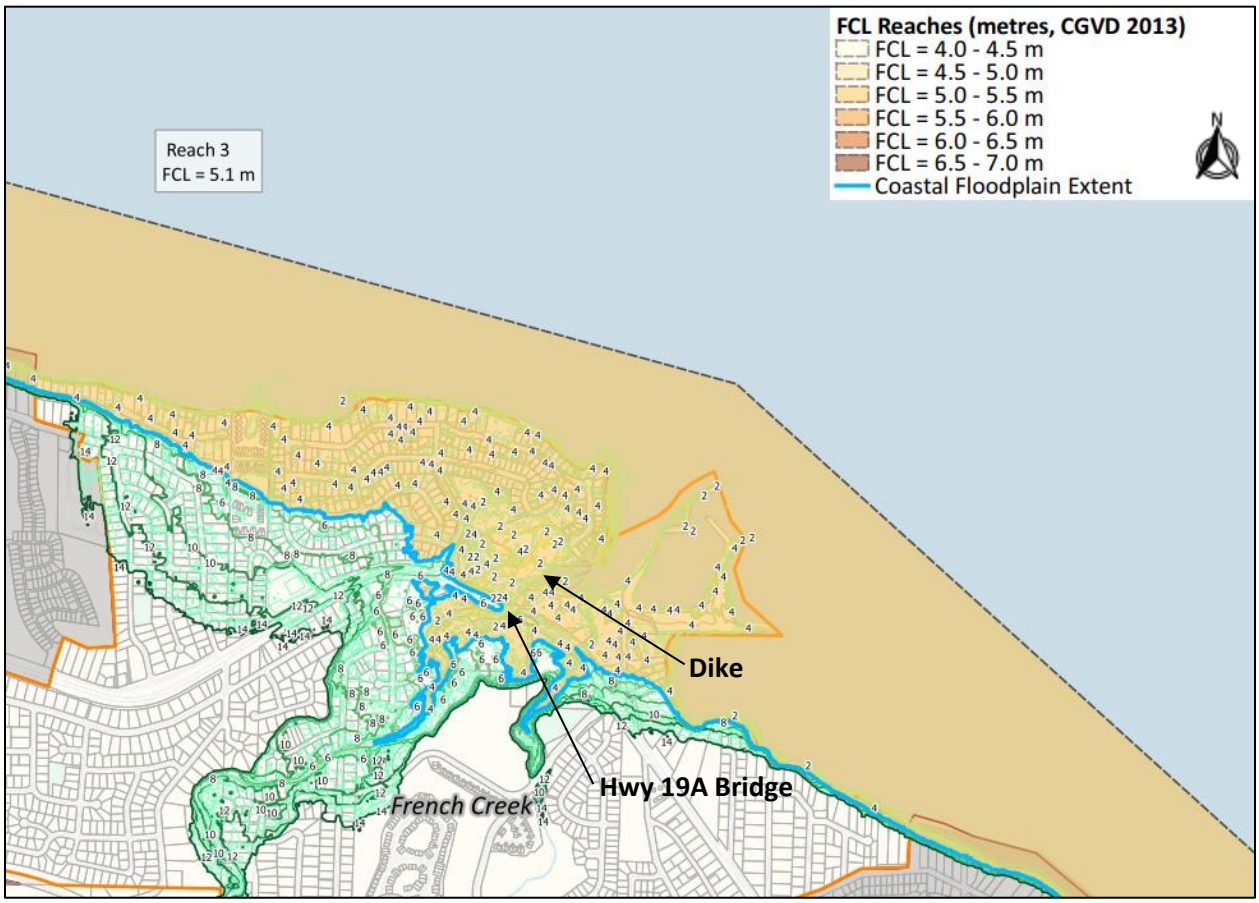

Figure 3.2 Extract of a portion of RDN coastal flood hazard map, Series 2/8: Flood Construction Level Regulatory Maps for 1.0 m of relative sea level rise (Ebbwater Consulting & Cascadia Coast Research Ltd., 2019).

3.4 French Creek Estuary

French Creek has a depth of approximately 1.4 m along the project reach. The width of French Creek varies from approximately 20 m at the upstream end of the reach at the Highway 19A Bridge, to 30 m at the upstream end of the dike. The 20 m width remains relatively constant for approximately 50 m, then transitions to an approximate typical width of 30 m until it encounters the dike feature about 60 m

downstream. At the upstream end of the dike, French Creek begins to widen and transition to the French Creek Estuary. The channel substrate from the Highway 19A Bridge downstream to the estuary is composed of cobbles, gravels, and fines; substrate size reduces within the estuary (Figure 3.3). Prior to land development in the area, French Creek had several side channels and was well connected to the floodplain. Once the area was developed and the dike installed, French Creek became a single channel into the estuary and disconnected from the floodplain (Figure 3.4). Morningstar Creek contributes to the French Creek estuary, and confluences with French Creek approximately 370 m downstream of the Highway 19A Bridge.



Figure 3.3 French Creek substrate downstream of Highway 19A Bridge (top) and in estuary (bottom).



Figure 3.4 French Creek Estuary in 1949 (top) and 2016 (bottom) with reference relict side channel.

3.5 Fish Species in French Creek

According to Aquaparian (2017), the following fish species are present in French Creek:

- Steelhead salmon
- Cutthroat trout
- Chum salmon
- Coho salmon
- Chinook salmon
- Pink salmon
- Rainbow trout

The watershed study from MWLAP (2002) states that the cutthroat, steelhead, and coho salmon use French Creek for spawning, incubation, and year round rearing. Pools, wetlands, and smaller tributaries, particularly with cover and LWD, are important habitat features for the fish species present.

3.6 French Creek Dike

The French Creek Dike begins at the parking lot off the south end of Admiral Tyron Boulevard and continues for approximately 150 m upstream on French Creek towards Highway 19A. It appears to be an earthen-fill structure with riprap armouring on the river left bank (Photo 3.1). During the two site visits that NHC attended, a location at the end of the dike was noted that appeared to have some damage, likely due to the woody debris in river concentrating flow at the dike (Figure 3.5 and Figure 3.6).



Photo 3.1 French Creek Dike with riprap armouring. Photo taken October 24, 2023 from parking lot off end of Admiral Tyron Boulevard, facing southwest in the upstream direction.

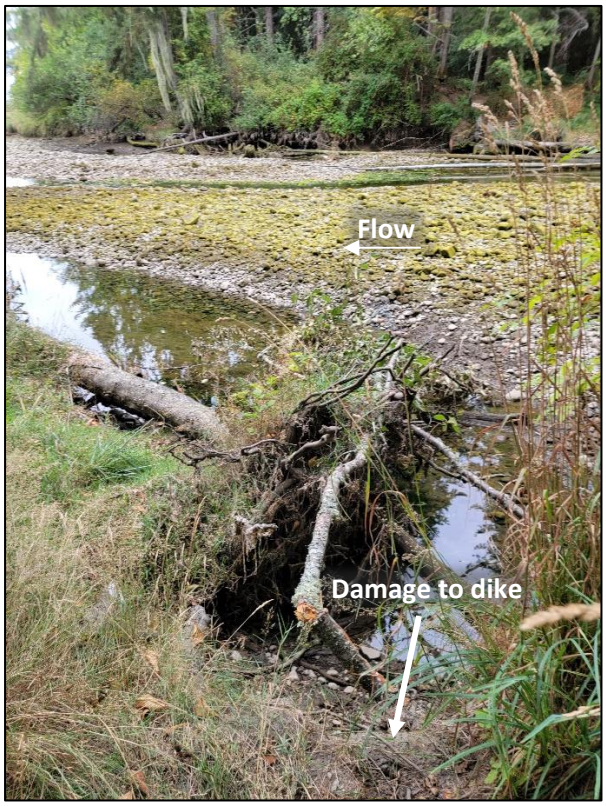

Figure 3.5 Damage on French Creek Dike due to woody debris. Photo from August 23, 2023, viewing east towards river right.

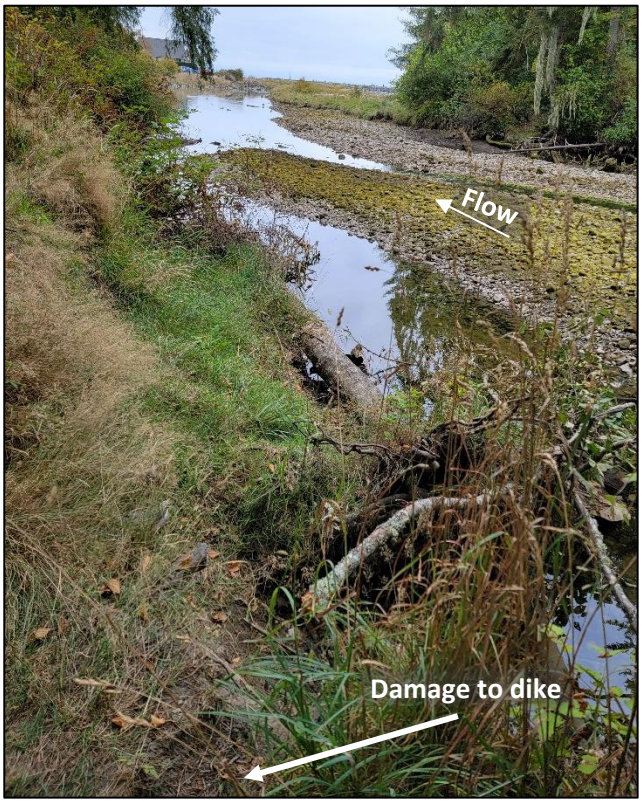

Figure 3.6 Reference for location of damage on French Creek Dike due to woody debris. Photo from August 23, 2023, viewing northeast towards estuary.

The French Creek Dike is not listed in the BC Flood Protection Works Database nor is it listed in a risk assessment of BC's orphan dikes published in 2020 (KWL, 2020). Additionally, the Deputy Inspector of Dikes indicated there were no files on the French Creek Dike available from the Deputy Inspector of Dikes office (pers. comm. Adam Marriner, November 6, 2023). While it hasn't been confirmed, these two factorsiwhich suggest this dike is not regulated under the Dike Maintenance Act (DMA). This structure is therefore considered an *orphan dike* structure. As defined in the DMA, this is a structure that:

1. has no identified *diking authority*, and
2. is not a *private dike*

The French Creek Dike does not provide effective flood protection as defined in the BC dike design guidelines (MECCS, 2003). The coastal FCL from the RDN coastal floodplain mapping study is over 2 m above the dike crest, and the present 200-year ocean level is approximately 0.5 m above the dike crest (Ebbwater Consulting & Cascadia Coast Research Ltd., 2019). Furthermore, these estimates only account for ocean water levels; the influence of French Creek would cause water levels to be higher. The dike is prone to overtopping during floods and, since the dike does not tie-in to high ground, flood water is

capable of spilling over the low bank upstream of the dike. However, the dike does provide some level of flood protection and provides some function in limiting bank erosion over the extent of the riprap protection. Figure 3.7 indicates the positioning of the dike from when it was installed, up to 2005. From review of aerial imagery, no major discernable erosion has occurred since 2005. Figure 3.8 provides a plan view of the locations with stationing for reference when viewing the profile of the French Creek left bank (Figure 3.9), and three sections across the creek, extending into the Nature Preserve (Figure 3.10 to Figure 3.12).



Figure 3.7 French Creek Dike positioning 1972 – 2005 (modified from Nahirnick (n.d.))



Figure 3.8 Plan view of French Creek Estuary with elevation gradient, Google Earth 2016 photo, and locations of reference profile and sections.

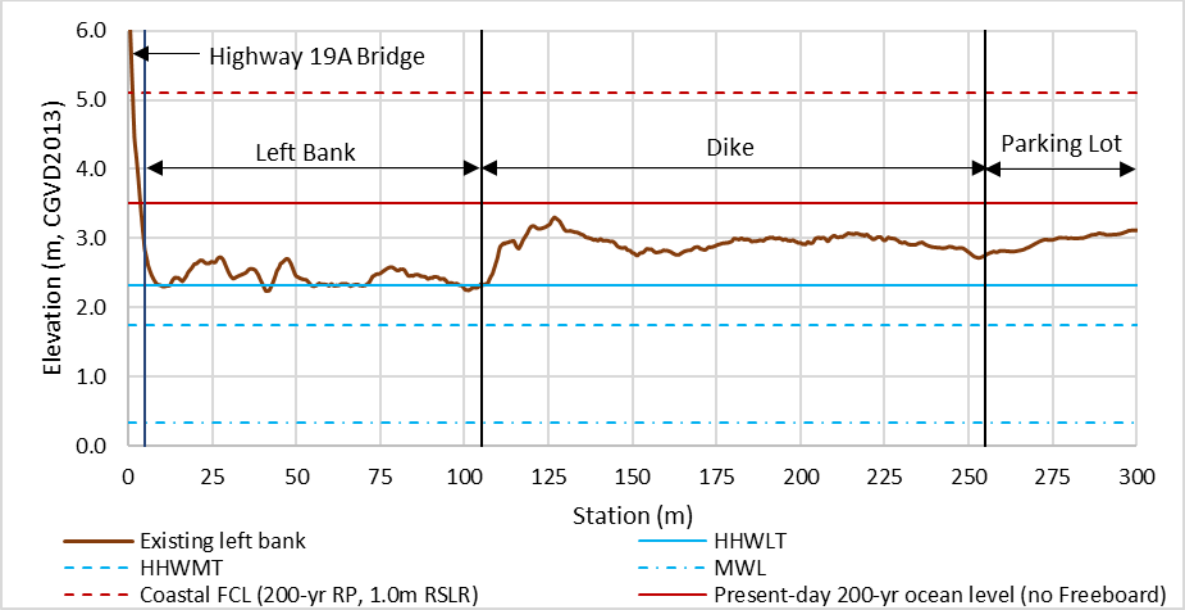

Figure 3.9 Dike Profile – terrain, tidal elevations, and Ebbwater Consulting & Cascadia Coast Research Ltd. (2019) Flood Construction Level (FCL) for 200-year return period (RP) with 1.0 m relative sea level rise (RSLR), and present-day 200-year ocean level for reference. These water levels do not include consideration for French Creek water levels.

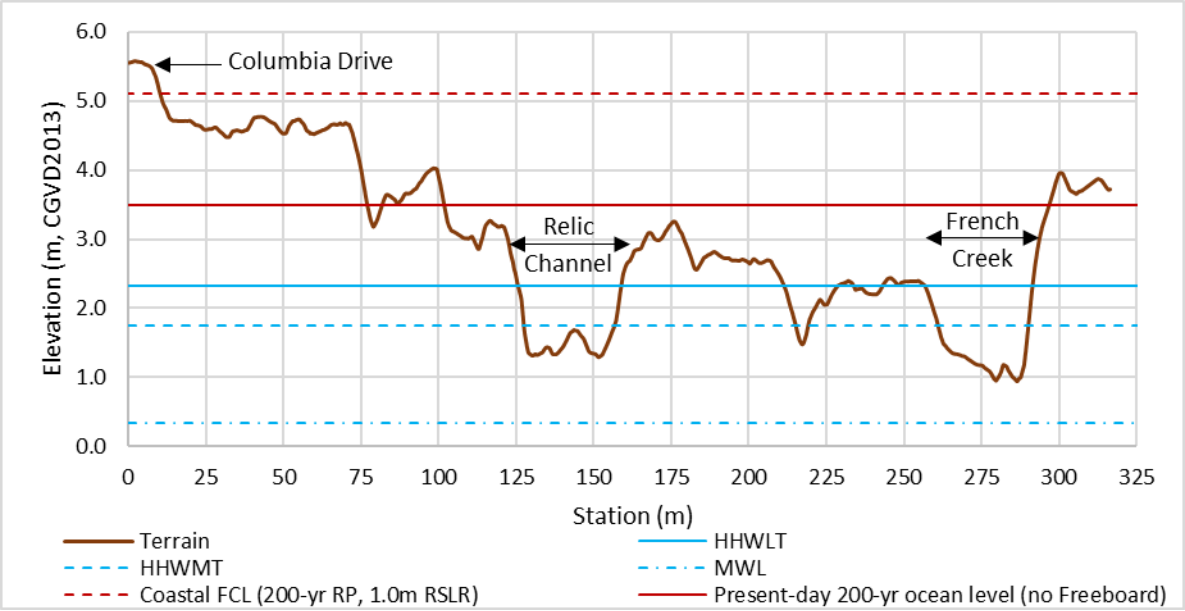

Figure 3.10 Section 1 – terrain, tidal elevations, and Ebbwater Consulting & Cascadia Coast Research Ltd. (2019) Flood Construction Level (FCL) for 200-year return period (RP) with 1.0 m relative sea level rise (RSLR), and present-day 200-year ocean level for reference. These water levels do not include consideration for French Creek water levels.

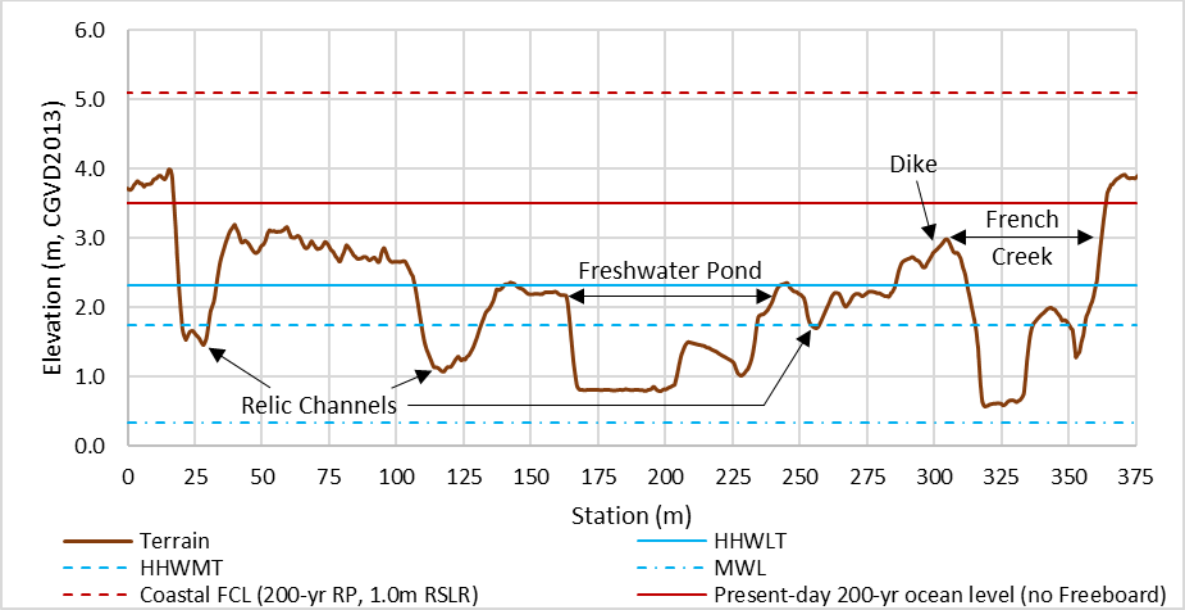

Figure 3.11 Section 2 – terrain, tidal elevations, and Ebbwater Consulting & Cascadia Coast Research Ltd. (2019) Flood Construction Level (FCL) for 200-year return period (RP) with 1.0 m relative sea level rise (RSLR), and present-day 200-year ocean level for reference. These water levels do not include consideration for French Creek water levels.

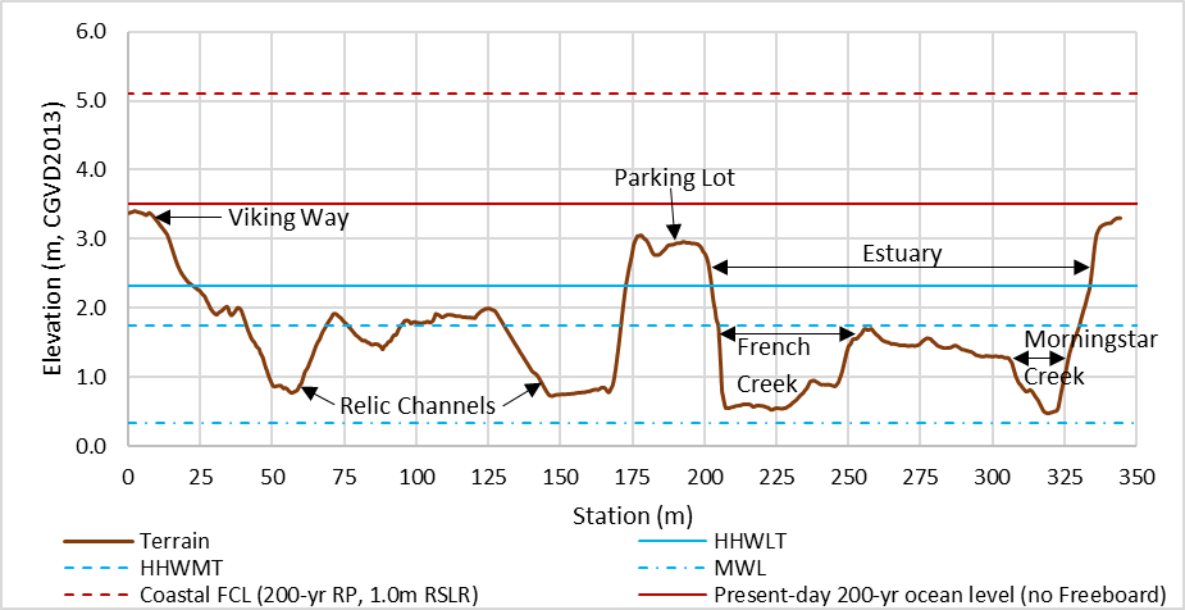

Figure 3.12 Section 3 – terrain, tidal elevations, and Ebbwater Consulting & Cascadia Coast Research Ltd. (2019) Flood Construction Level (FCL) for 200-year return period (RP) with 1.0 m relative sea level rise (RSLR), and present-day 200-year ocean level for reference. These water levels do not include consideration for French Creek water levels.

4 French Creek Estuary Habitat Enhancement Options

The habitat enhancement options under assessment are as follows:

- Option 1: Full removal of the French Creek Dike.
- Option 2: Full removal of the French Creek Dike and lowering river left bank.
- Option 3: Adding culverts through the French Creek Dike.
- Option 4: Placing LWD structures over top of the riprap protection along the French Creek Dike.

This section describes these habitat enhancement options and assesses the strengths, weaknesses, opportunities, and threats associated with each option. A preliminary high-level cost estimate for the one selected habitat enhancement concept was also prepared, intended for preliminary planning purposes only. At this stage, these are design concepts only and are intended to help guide future planning purposes. Additional field surveys and engineering investigations are required to assess the technical feasibility of the habitat enhancement works and their hydraulic effects. Additional biological studies are also required to refine the objectives of the project and to assess the environmental benefits and adverse impacts, if any. As an *orphan dike*, the French Creek dike is not a private dike and has no identified authority, and it is possible that any alteration of the dike structure may trigger the provincial government to formally assign authority. The 2020 risk assessment of orphan dikes recommended the Inspector of Dikes, “determine an appropriate process to remove, abandon or upgrade the works and if the latter, an appropriate authority be identified to operate and maintain the works to provide reliable protection for the local areas” (KWL, 2020).

4.1 Option 1: Dike Removal

This habitat enhancement option involves the removal of the approximately 150 m long dike along French Creek (Figure 4.1). The land forming the dike would be lowered by approximately 1 m to the lowest natural elevation between the dike and Highway 19A (approximately el. 2.3 m [CGVD] as shown on Figure 4.2). This elevation coincides with a large tide level (HHWLT). Due to the effects of river inflows, this water level could occur several times during the year (additional hydraulic analysis would be required to assess actual water levels along the reach). The salinity content of the overbank spill is expected to vary over the year, depending on the river inflows and tide conditions. Ongoing sea level rise will increase the frequency of overtopping over time.

Removing the dike will affect the level of flood protection afforded to properties that lie behind the dike, and additional assessment would be required to assess the potential for transfer of flood risk associated with the removal of the dike.

Additional habitat enhancement opportunities could be undertaken with this habitat enhancement option, such as revegetating the left bank to restore riparian cover, and establishing an additional freshwater pond in the depression that abuts Highway 19A, southwest of the existing pond. The establishment of an additional freshwater pond could be done independent of the dike removal. A summary of the results of the analysis of this option is presented in Table 4.1.

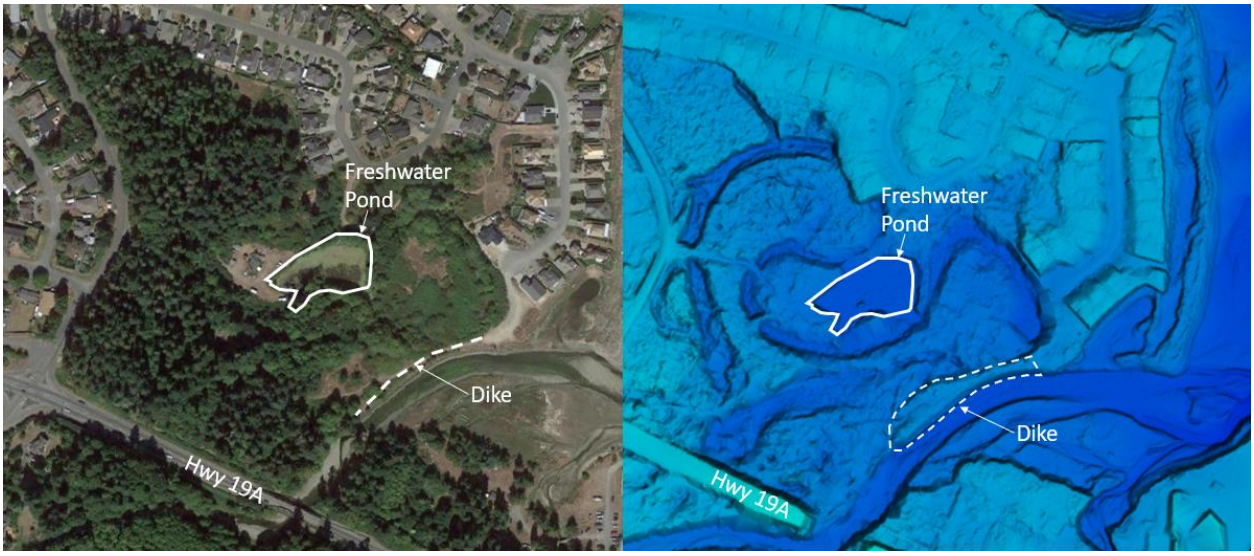

Figure 4.1 Option 1: Full removal of the French Creek Dike in the area indicated by the white dashed line. This would likely maintain the freshwater pond (source: World Imagery 2019, and LidarBC 2019 LiDAR).

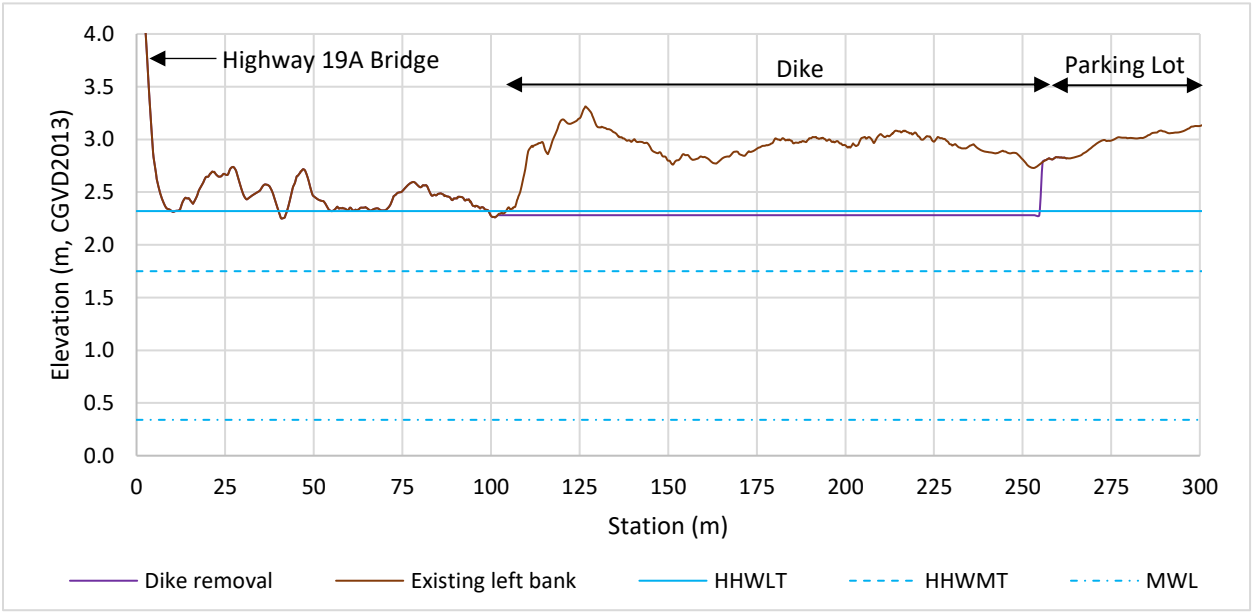

Figure 4.2 Profile of left bank with habitat enhancement Option 1 (purple line), and existing left bank profile of French Creek (dark-brown line).

4.2 Option 2: Dike and Riverbank Lowering

This habitat enhancement option involves the removal of the French Creek Dike and lowering of an additional approximately 100 m between the Highway 19A bridge and existing dike (Figure 4.3). The land forming the dike would be lowered by approximately 1.5 m, and the left bank between the bridge and dike would be lowered approximately 0.8 m (Figure 4.4). This level is 0.25 m lower than normal high tide, so that overtopping would occur nearly daily throughout the year. This would allow regular river flow and tides into the French Creek Nature Preserve.

This option would be beneficial to fish in providing off-channel habitat for spawning, incubation, and rearing however, it has the greatest risk to the neighbouring developments, relative to the other options assessed. Similar to option 1, this option will affect the level of flood protection afforded to properties that lie behind the dike, and additional assessment would be required to assess the potential for transfer of flood risk associated with the removal of the dike.

This option allows uncontrolled flow into the preserve, which increases the current flood risk. Mitigation measures such as creating a set-back dike along the perimeter of the preserve would help manage this risk. With the introduction of brackish water to the Nature Preserve, the existing freshwater pond would become brackish, and any additional ponds would also be brackish. Additional habitat enhancement opportunities could be undertaken with this habitat enhancement option, such as establishing a new pond in the depression that abuts Highway 19A, indicated in Figure 4.3. The relict flow path present within the Nature Preserve would likely become reactivated. To enhance the fish habitat, LWD could be installed along the relict channel and connections could be re-established in key locations along the relict channel where the walking trail network currently blocks. A summary of the results of the assessment of this option is presented in Table 4.1.

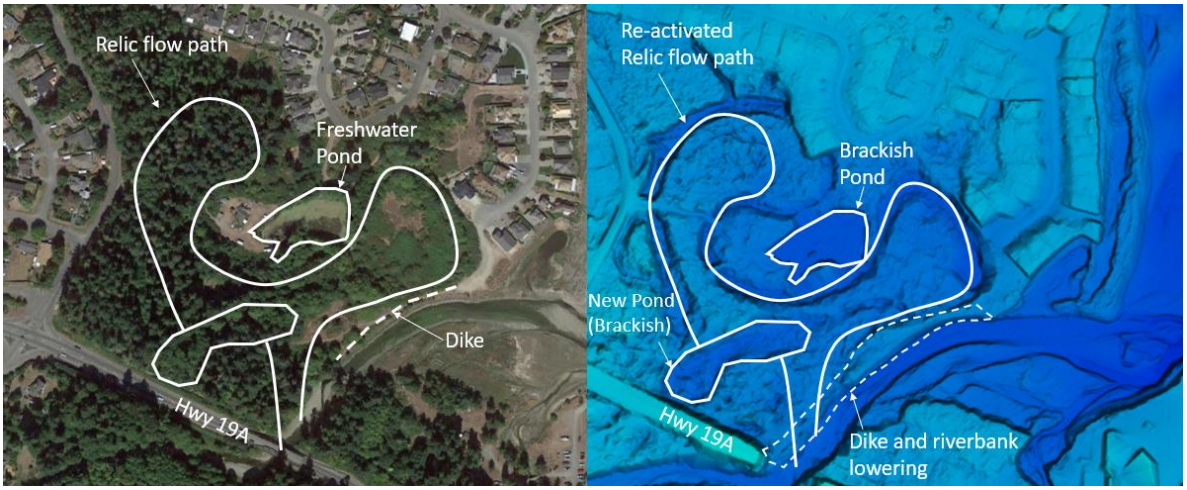

Figure 4.3 Option 2: Full removal of the French Creek Dike and lowering river left bank. The right image provides the design markup and details, the left image provides an aerial image for reference in locating these features. Dike and riverbank alteration would occur in the area indicated by the white dashed line on the right image. This would reactivate the relict channel indicated by the white line, convert the existing freshwater pond to a brackish

pond, and facilitate development of a new brackish pond (source: World Imagery 2019, and LidarBC 2019 LiDAR).

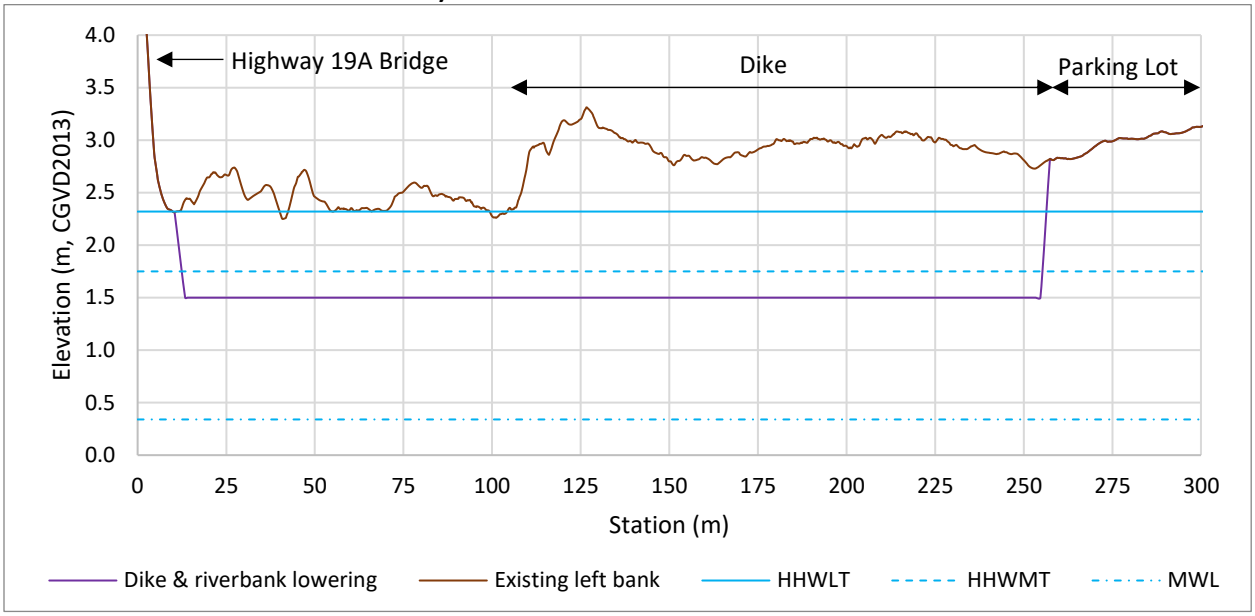

Figure 4.4 Profile of left bank with habitat enhancement Option 2 (purple line), and existing left bank profile of French Creek (dark-brown line).

4.3 Option 3: Culverts Through the Dike

Under this habitat enhancement option, the French Creek Dike would remain, with culverts through the dike to allow flow from the river into the Nature Preserve (Figure 4.5). Different sizes of culverts could be placed at differing elevations to allow a range in flow and tidal levels into the Nature Preserve (Figure 4.6). Culvert lengths would likely be as short as possible; constructed channels would provide passage from the culvert to the new brackish habitat within the Nature Preserve. Culvert specifications and placement locations would be determined during detailed design. The culverts would be installed with gates, which could be passive (i.e., move with water pressure) or mechanical (i.e., someone would need to physically close the gate).

As with habitat enhancement option 2, this option would allow regular river flow into the French Creek Nature Preserve; it would be beneficial to fish for spawning, incubation, and rearing; and it would pose a flood risk to the neighbouring developments. This option would allow controlled flow into the preserve, which increases the flood risk relative to current conditions, although the risk is relatively lower than under options 1 or 2. Mitigation measures such as creating a set-back dike along the perimeter of the preserve would help manage this risk. The existing freshwater pond would become brackish once the dike is infiltrated, and any additional ponds would also be brackish. Additional habitat enhancement opportunities could be undertaken with this habitat enhancement option, such as riparian planting along the dike. A summary of the results of the assessment of this option is presented in Table 4.1.



Figure 4.5 Option 3: Infiltrating the French Creek Dike using culverts with mechanical gates; example locations shown. This would reactivate the relict channel indicated by the white line and facilitate development of a new brackish pond (source: World Imagery 2019, and LidarBC 2019 LiDAR).

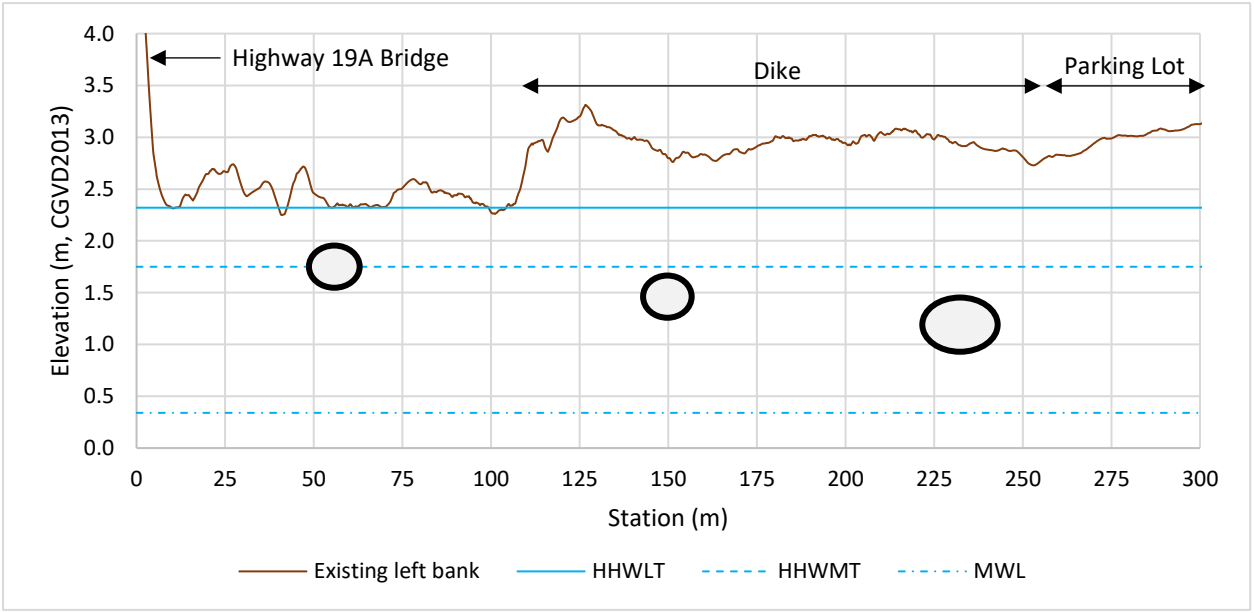

Figure 4.6 Profile of left bank with habitat enhancement Option 3 – culverts are shown as examples of potential numbers, locations, and sizes; details would be determined in a future project phase. Existing left bank profile of French Creek shown as dark-brown line.

4.4 Option 4: Supplementing Riprap with LWD along the Dike

This habitat enhancement option would preserve the French Creek Dike and supplement the hard armouring along the river left bank with LWD structures for a more nature-like aesthetic (Figure 4.7). Configuration concepts and placement locations would be determined during detailed design. NHC provided the design and construction oversight for LWD structures that have been installed for bank protection on French Creek (NHC, 2010, 2013), approximately 2 km upstream of the project location (Figure 4.8, Photo 4.1). Additional LWD configuration examples are provided in Figure 4.9 and Figure 4.10. A concept worth considering for the present project would be to extend the LWD upstream of the dike to the Highway 19A bridge. This would help redirect flow forces away from the dike. Any structures proposed for installation near enough to the Highway 19A bridge that it could alter river hydraulics would require engagement with the Ministry of Transportation and Transit (formerly known as the Ministry of Transportation and Infrastructure).

This habitat enhancement concept would not alter the crest height, width, or extensiveness of rock armour along the dike structure and therefore has the least project risk relative to other options evaluated. Additionally, this option would not alter conditions at the existing freshwater pond. The LWD would improve the habitat quality by providing cover and creating complexity within the channel, and promoting scour-formed pools. Additional habitat enhancement opportunities could be incorporated with this habitat enhancement option. For instance, a second freshwater pond or marsh could be established behind the dike and riparian planting could be incorporated along the channel banks. Planting along the dike is not recommended without first engaging further with other government agencies with respect to the ownership and administration of the dike structure, including the Inspector of Dikes. The guidelines for management of flood protection works in British Columbia (MELP, 1999) indicate that vegetation on the dike *side slopes should consist of closely trimmed grass or low ground cover* and trees and brush growth should be removed. A summary of the results of the assessment of this option is presented in Table 4.1.

Removing the riprap and replacing it with LWD was evaluated, however, it could make the dike more vulnerable to erosive forces over the course of the LWD design life, and at the end of the LWD design life the dike would no longer have any erosion countermeasures in place. Without ongoing operation, maintenance, and renewal of the LWD structures over the long term, removing the riprap would increase the vulnerability of the dike to failure.

Based on a review of aerial imagery, the dike showed no major discernible erosion. A condition assessment of the riprap was not undertaken; however, it appears to be providing functional armouring of the dike. As such, keeping the riprap in place and installing LWD structures overtop would reduce the risk of erosion to the dike, reduce construction costs since riprap would not require removal and relocation, and would allow more time for the RDN at the end of the LWD design life to install new protection for the dike.



Figure 4.7 Option 4: Existing riprap protection along the French Creek Dike would remain in-place with addition of LWD structures to improve habitat quality; example location and configuration shown. This would maintain the freshwater pond (source: World Imagery 2019, and LidarBC 2019 LiDAR).



Figure 4.8 LWD used for bank protection on French Creek at Miller Road Community Park, approximately 1.9 km upstream of Highway 19A Bridge. Top photo from September 2012 shortly after construction (NHC, 2013); bottom photo from March 2014 site performance review shows natural vegetation and natural accumulation of smaller debris (NHC, 2014). Photos show LWD in both triangle, and single log configurations.



Photo 4.1 LWD used for bank protection on French Creek at Miller Road Community Park, March 19, 2014 (NHC, 2014). Viewing upstream direction, photo depicts single log LWD configurations.

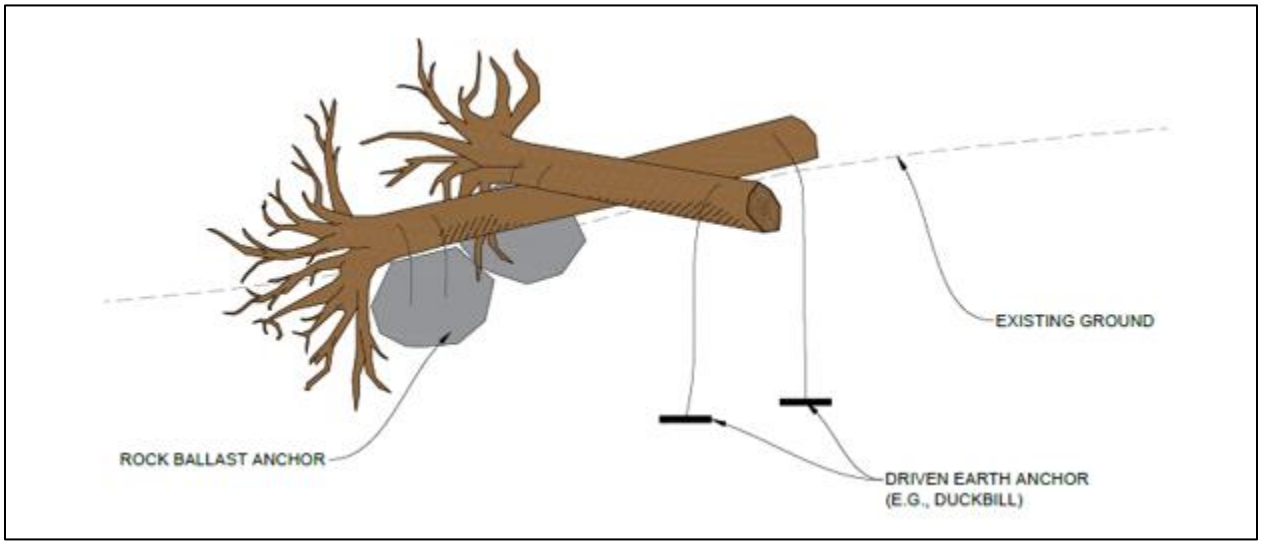

Figure 4.9 Example of a LWD structure secured with partially embedded rock ballast and driven earth anchors.



Figure 4.10 Examples of Bank attached LWD structures in triangular configuration on streams.

4.5 Comparison of Options

Table 4.1 presents a summary of results of the analysis undertaken for the four habitat enhancement options under consideration for the French Creek Estuary. *Strengths* and *weaknesses* describe the options' advantages and disadvantages under present conditions, while *opportunities* and *threats* refer to long-term, future conditions.

Construction timelines would be confirmed during the detailed design phase. All options require some degree of monitoring and maintenance to ensure the alteration is functioning properly. From the analysis, and discussions with the RDN, BC Parks Foundation, and MVIHES, incorporating LWD overtop of the riprap is preferred (option 4). The main drawback of this option is that the anticipated design life of LWD is approximately 10 to 25 years (without maintenance or periodic repairs). However, the riprap armour along the dike would remain at the end of the LWD design life. This option has the least risk and threats, and the most strengths and opportunities out of the options reviewed. The following comments provide additional justification for the assessments:

- If the dike were removed, it has the potential to transfer flood risk. Discharge would likely cause erosion along the left bank and erode into the Nature Preserve. This would happen more readily if the left bank were lowered. Armouring would be needed at the parking lot at the end of Admiral Tyron Boulevard to ensure it would not be eroded by French Creek. As the left bank erodes, the creek would become wider downstream of the bridge, altering seasonal channel depths and widths. Creek widening would cause sediment to be deposited at this location, which could become an issue for fish passage during low flows.
- There is a notable relict side channel within the Nature Preserve that would likely become reactivated if the left bank were lowered or if the dike were penetrated with culverts. Properties abutting the preserve could experience erosion from the introduction of flow to the area and would be at greater risk of flooding. Additionally, allowing flow into the preserve would likely reduce the walking trail network.
- Introducing brackish water to the Nature Preserve would alter the freshwater and low-oxygen pond, and could eventually change the landscape from terrestrial to estuarine. Removing the

dike would increase river connectivity to the floodplain, which would reflect a more natural river environment. However, the three habitat enhancement options of dike removal, lowering of the left bank, and culvert installation, increase the flood risk to the properties neighbouring the Nature Preserve.

- Maintaining the dike would help convey sediment through the area to the estuary. River training structures that narrow the channel, such as the French Creek Dike, provide deeper channels. Dikes isolate rivers from floodplains however, in an estuary environment such as this project site, the dike enables terrestrial and freshwater habitat in the preserve. Removal of the dike or lowering of the left bank could convert the area from terrestrial to estuarine.
- There is a length of approximately 100 m between the dike and Highway 19A bridge on the left bank of French Creek that is unprotected. This length of riverbank has no erosion protection and is approximately 1 m lower than the dike. With ongoing morphological channel changes, rising sea levels and potential for greater peak discharge rates due to a changing climate, this length of bank could become eroded over the next several years to decades and allow brackish water into the Nature Preserve. If this is undesired, the left bank of French Creek should be monitored. Monitoring should be conducted from the Highway 19A bridge to the parking lot at the end of Admiral Tyron Boulevard and should include the chosen habitat enhancement option. Maintenance should be undertaken when needed.

Table 4.1 Summary of the results of the analysis of the four habitat enhancement options under consideration for the French Creek Estuary.

	Option 1: Dike Removal	Option 2: Dike and Riverbank Lowering	Option 3: Culverts Through Dike	Option 4: Supplementing Riprap with LWD Along the Dike

Strengths	• Reverts estuary to more natural landscape through removal of river-training feature.
	• Improves aesthetic through removal of riprap armouring.
	• Low maintenance option reducing required monitoring.
	• Minimal disturbance to the area.
		• Reconnects river to floodplain.
		• Improves aesthetic through removal of riprap armouring.
		• Provides additional spawning, incubation, and year-round rearing habitat.
			• Reconnects river to floodplain.
			• Keeping the dike intact with controlled infiltration:
			  • Enables flood protection for adjacent properties.
			  • Helps convey sediment.
			  • Provides a deeper channel.
			  • Allows for terrestrial habitat in the Nature Preserve.
			Provides additional spawning, incubation, and year-round rearing habitat
			.
				• Improves habitat by providing LWD structures, which fish can use for cover, protection, foraging, shade, etc.
				• Improves aesthetic through concealing of riprap armouring.
				• Keeps the dike intact:
				  • Preserves the flood protection for adjacent properties.
				  • Helps convey sediment.
				  • Provides a deeper channel.
				  • Allows for terrestrial habitat in the Nature Preserve.
				• Least risk to properties adjacent to the Nature Preserve.

Weaknesses	• Will result in some degree of transfer of flood risk. • Does not significantly improve habitat for fish, counter to the project intent. • The proposed dike removal would not allow water into the French Creek Nature Preserve more frequently than current occurrences. Therefore, habitat improvement would be restricted to the river.	• Will result in some degree of transfer of flood risk. • Reduces the walking trail network and available terrestrial land by allowing brackish water to reactivate relict channels. • Greatest risk to properties adjacent to the Nature Preserve.	• Will result in some degree of transfer of flood risk. • Reduces the walking trail network and available terrestrial land by allowing brackish water to reactivate relict channels. • Requires consistent monitoring and maintenance of culverts to confirm fish usage and ensure no blockages occur.	• Habitat improvement would be restricted to the river. Maintaining the dike would maintain current occurrences of water entering French Creek Nature Preserve. • Requires monitoring and maintenance of LWD to ensure functionality. • Structure will require periodic inspection, maintenance, repairs over 25-year design life.
Opportunities	• Riparian cover could be restored along the left bank of French Creek. • A new freshwater pond could be established in the depression adjacent Highway 19A, southwest of the existing pond.	• LWD structures and habitat complexing within the Nature Preserve land could be used to improve aquatic habitat. • A new brackish pond could be established in the depression adjacent Highway 19A, southwest of the existing pond.	• LWD structures and habitat complexing within the Nature Preserve land could be used to improve aquatic habitat. • A new brackish pond could be established in the depression adjacent Highway 19A, southwest of the existing pond.	• Riparian cover may be able to be restored along the left bank of French Creek. Planting along the dike is not recommended without first engaging further with other government agencies. • A new freshwater pond could be established in the depression adjacent Highway 19A, southwest of the existing pond. • LWD placement could be extended farther upstream from the dike, to reduce the force of discharge aimed at the upstream end of the dike.

Threats	• Flood risk to neighbouring properties.
	• Potential for channel migration towards left bank.
	• Potential for river widening and increased sediment deposition.
	• Potential for changes to seasonal channel depth and width.
	• Erosion risk to parking lot.
	• Coastal and riverine hazards expected to increase over time due to ongoing climate change and sea level rise.
		• Greatest flood risk to neighbouring properties.
		• Greatest potential for channel migration towards the left bank.
		• Greatest potential for river widening and increased sediment deposition.
		• Changes seasonal channel depth and width.
		• Greatest erosion risk to parking lot relative to other options.
		• Greatest risk of erosion to properties adjacent the Nature Preserve relative to other options.
		• Changes existing freshwater and low-oxygen pond to a brackish water chemistry, which impacts species within the preserve dependent on freshwater.
		• Potential for eventual conversion to estuarine environment, which may change the types of species within the Nature Preserve.
		• Coastal and riverine hazards expected to increase over time due to ongoing climate change and sea level rise.
			• Flood risk to neighbouring properties due to:
			  • Reliance on closure of culvert gates prior to flooding.
			  • Continual flow through relict channels within Nature Preserve.
			• Risk of erosion to properties adjacent to the Nature Preserve.
			• Changes existing freshwater and low-oxygen pond to a brackish water chemistry, which impacts species within the preserve dependent on freshwater.
			• Coastal and riverine hazards expected to increase over time due to ongoing climate change and sea level rise.
			• Without monitoring and maintenance:
			  • The dike could become eroded or circumvented by flow over the left bank between the Highway 19A bridge and the dike.
			  • The tide gates could become blocked and malfunction.
				• Coastal and riverine hazards expected to increase over time due to ongoing climate change and sea level rise.
				• Without monitoring and maintenance:
				  • The dike could become eroded or circumvented by flow over the left bank between the Highway 19A bridge and the dike.
				  • The design life may decrease due to issues going unnoticed and unresolved.

4.6 Cost Estimate

High-level (conceptual) project cost estimates, excluding taxes, have been provided for the design phase, and construction phase. These are intended for preliminary planning purposes only. Further engineering and biological input are required to refine these values. The estimated costs are provided in Table 4.2 and are considered to be accurate within 50% (plus or minus) in accordance with a Class D cost estimate (CEBC and APEGBC, 2009). The following summarizes the basis of costs and key assumptions:

- Construction equipment and labour rates are provided from Island Equipment Owners Association 2024, 2024 to 2025 Blue Book rates, and NHC experience with construction projects. The rates are in 2024 dollars and are provided for planning purposes only.
- Construction costs are dependent on market conditions at the time of construction. Actual costs will be higher or lower than the estimates contained herein.
- Cost escalation (changing price for goods or services over time) has not been considered for these cost estimates.
- Engineering support during construction assumes site visits at specified check points and not continuous site supervision.
- Cost for an archeology assessment or archeology monitoring has not been included and may be required.
- Cost for a dike condition assessment and geotechnical investigations for the dike were not included.
- Cost to support a Dike Maintenance Act approval process has not been included and may be required.
- Cost to support an engagement or approval process with the Ministry of Transportation and Transit has not been included, and may be required if works are undertaken near Highway 19A.
- A 25% contingency was applied to project costs.
    - The EGBC Cost Estimate Classification Table (CEBC and APEGBC, 2009) was used as a reference, along with an estimation of project risk, and professional judgement to determine the appropriate contingency to apply. Estimated construction costs and professional services costs will be refined during detailed design.
    - The project risk was estimated to be moderate due to the early project stage: no designs have been developed, the length along French Creek left bank for installing LWD complexes is unknown, the numbers of required logs and ballast boulders are unknown, an assessment of the existing riprap protection has not been completed and therefore additional riprap armouring may be required.
    - Because the construction cost is below $500,000 and project risk was estimated to be moderate, the cost estimate classification was used as a reference in determining contingency, rather than undertaking a risk-register based approach. As this is a Class D cost estimate, the contingency applied was based off the estimated accuracy of the next lowest class (i.e., Class C with accuracy of 25% to 40%). Engineering judgement was used to

determine the appropriate contingency within this range. This contingency value is meant to mitigate the effect of fluctuating industry costs from the time that costs were estimated to when construction can be undertaken.

- Professional environmental services costs should be confirmed and refined by an environmental specialist. Costs include time for construction environmental monitoring, preparation of an environmental management plan, and permitting limited to Section 11 under the Water Sustainability Act, approval for changes in and about a stream under the Water Sustainability Act, Fish and Fish Habitat Protection Plan Request for Review. Other permits my be required and have not been accounted for. Costs do not include estimates for grant preparation, community or First Nation's engagement, administration fees, or post-construction monitoring.

Table 4.2 Class D (±50%) Construction cost estimate in 2024 dollars, rounded to the nearest $10,000, with 25% contingency, for designing and constructing French Creek Estuary Habitat Enhancement Option 4: supplementing riprap with LWD.

Task	Estimated Cost
Construction	
Site set-up & mobilization	$50,000
Riprap placement for uniform protection	$10,000
Ballasting & earthworks	$120,000
Site close-out	$10,000
Construction sub-total	**$190,000**
Professional Services	
Pre-construction monitoring efforts	$20,000
Engineering services – design	$70,000
Engineering services – during construction	$50,000
Environmental services – during construction	$30,000
Professional Services sub-total	**$170,000**
Project Totals	
Project sub-total	$360,000
Contingency (25%)	$90,000
Project Total	$450,000
Tax (5%)	$20,000
Project Total	**$470,000 (range from $240,000 to $710,000)**

Notes:

1. Costs presented reflect the assumptions and limitations listed in Section 4.6.
2. Cost-estimate is for planning purposes only.
3. Cost-estimate is in 2024 Canadian Dollars and does not include applicable taxes.
4. Actual costs may fluctuate depending on material supply, contractor availability, inflation, or other external cost increases. Costs assume a competitive bidding process and use of the Island Equipment Owners Associations unit rates 2024 and 2024 to 2025 Blue Book rates.
5. Cost escalation (changing price for goods or services over time) has not been considered for these cost estimates.
6. A 25% contingency has been applied to all project costs. Estimated construction costs and professional services costs will be refined during detailed design.

5 Conclusions

This project was to assess the design concept of removing the French Creek Dike downstream of Highway 19A and suggest alternative habitat enhancement options while keeping the dike in place for the purpose of improving fish habitat. From the analysis and discussions with the RDN, BC Parks Foundation, and MVIHES, habitat enhancement Option 4 is preferred. This option would maintain the dike and supplement the riprap armouring with LWD engineered structures. Of the options investigated, this was the only option that met both project objectives of preserving the habitat within the Nature Preserve and providing increased fish habitat. The main drawback of this option is that the anticipated design life is approximately 10 to25 years, which is less than the other options however, this is the option with the least risk and threats, and the most strengths and opportunities.

The riprap would be kept in place and LWD structures would be installed overtop to reduce the risk of erosion to the dike, reduce construction costs associated with riprap removal and relocation, and would allow more time for the RDN at the end of the LWD design life to install new protection for the dike. Keeping the riprap in-place and installing LWD overtop would allow the dike to continue to be protected at the end of the LWD design life. With this design option, riparian planting could be incorporated along the channel banks. Planting along the dike is not recommended without first engaging further with other government agencies with respect to the ownership and administration of the dike structure, including the Inspector of Dikes.

Monitoring should be conducted from the Highway 19A bridge to the parking lot at the end of Admiral Tyron Boulevard, even if a *do-nothing* approach is taken. It is important to monitor the existing structure for issues and determine baseline data for the environment so that changes can be understood and documented. Additionally, the damage noted at the end of the dike should be repaired. Once a chosen habitat enhancement option is constructed, the monitoring program should be updated to include specific design elements. Maintenance should be undertaken when needed.

6 Next Steps

In preparation for project implementation, the following next steps are recommended:

1. Investigate Required Permits and Approvals
    - Identify all permits and approvals at federal, provincial, and local levels
    - Consult with regulatory agencies to understand requirements, estimated timelines, and any project-specific conditions
    - Determine any additional studies or environmental assessments required for permitting
2. Obtain Project Funding
    - Use the information from the permit investigation phase to refine funding needs, addressing specific regulatory compliance costs and associated timelines

3. Baseline Monitoring
    - Conduct environmental assessments to establish baseline conditions, which may also fulfill specific permitting requirements
4. Prepare Detailed Design Drawings
    - Ensure design aligns with permit requirements and environmental considerations identified during initial consultations
5. Refine Estimated Construction Costs and Professional Services Costs
    - Integrate any costs associated with compliance, mitigation, or special environmental measures required for permits
    - Refine the Class D cost estimate (±50%) provided in this report to a Class B cost estimate (±15%) to be used for permitting and contractor tendering
6. Develop a Construction Environmental Management Plan
    - Tailor the plan to address potential impacts and meet permit requirements
7. Obtain All Permits and Approvals
    - With refined designs and management plans, submit final applications to secure all necessary permits
8. Select a Contractor to Construct the Project
    - Choose a contractor who can meet regulatory and environmental management requirements
9. Construct the Work
    - Carry out construction in compliance with permit conditions and the environmental management plan
10. Post-Construction Monitoring and Ongoing Adaptive Management
    - Monitor key parameters to assess how the system is changing over time in response to natural processes and project-related changes.
    - Assess the monitoring information, evaluate the results of the analysis, and integrate this knowledge into the decision-making process
    - Manage environmental impacts as required by permits and the adaptive management plan.

Monitoring is important to establish baseline conditions, document the construction, to track and evaluate the performance of the project over time, and to assess whether follow-up adaptive management actions are warranted. The following are some suggested measurable results that could be monitored for baseline conditions as well as post-construction monitoring; a professional biologist should be consulted to help develop the monitoring program:

- Abundance of fish (juvenile, and mature)

    - Minnow trapping on both the vegetated river right bank and where possible along the river left bank throughout the LWD structures
    - Snorkel surveys to count numbers and species of fish along both riverbanks
        - Baseline: determine differences between habitat preference, and obtain fish abundance data
        - Post-construction: determine differences relative to baseline
- Water quality parameters (dissolved oxygen, temperature, turbidity, salinity, water level)
    - Baseline: placement of loggers at the exposed riprap area on the left bank, within the deep pool in-river, and along the shaded right bank will allow the range in habitat features to be quantitatively assessed
    - Post-construction:
        - placement of loggers should be placed within the left bank LWD structures, in addition to the aforenoted loggers
        - a logger in this location would help indicate morphology changes due to the LWD structures
- Vegetation cover:
    - vegetation cover should be monitored between Highway 19A and the parking lot at the end of Admiral Tyron Boulevard
    - locations of particular interest are in-channel within the area covered by LWD, along both the channel left and right banks, and within a 3 m buffer to the channel for riparian cover
- Channel material and geometry:
    - Channel material and geometry should be documented immediately following construction, and annually or after substantial flood events over the following 2 to 3 years to track the changes post-project, with longer-term monitoring to be determined at the end of this period. This would allow any future shifts in channel alignment to be detected and enable monitoring of bedform changes along the LWD structures.

7 Closure

We appreciate this opportunity to work with the Regional District of Nanaimo and the Mid Vancouver Island Habitat Enhancement Society and trust this document meets your current needs. If you have any questions or requests, please feel free to contact the undersigned.

Sincerely,

northwest hydraulic consultants ltd.

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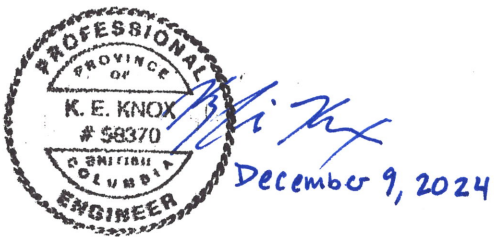

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