# ER 390

IN PARTNERSHIP WITH

# TETAYUT (SANDHILL / SHADY) CREEK RESTORATION:
## REMOVING BARRIERS TO FISH PASSAGE AT THE PAT BAY HIGHWAY (17) IN CENTRAL SAANICH, BC

**(Anderson, 2018)**

**Prepared by:** Andrew Anderson, EIT, AAg
BC MoTI Environmental Management Branch
Victoria, BC
V00866500

**Prepared for:** Val Schaefer, PhD, RPBio
Academic Administrator, Restoration of Natural Systems
University of Victoria

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## ABSTRACT

Tetayut (Sandhill/Shady) Creek is located in Central Saanich, BC where habitat connectivity issues have existed for decades as a result of a 54 m long concrete culvert under the Patricia Bay highway (Highway 17). The BC Ministry of Transportation and Infrastructure owned culvert is located approximately 2.2 km upstream of the Juan de Fuca Strait where it conveys water onto land owned by the Saanich Historical Artifacts Society. High velocity flows through the culvert have resulted in channel degradation and scour leading to a perched outlet that prevents the biologically important and culturally valued fish species in the Creek from accessing approximately 2.0 km of upstream aquatic habitat. Removal of this barrier required an understanding of the watershed processes as well as the expected discharges during periods of drought and flooding to evaluate the effectiveness of tailwater control modifications. Through careful data collection and desktop modelling it was determined that instream restoration works would promote fish passage while having little to no impact on the upstream hydraulics of the culvert. Co-operation with the Peninsula Streams Society was critical in the delivery of a timely and cost-effective solution that lead to the construction of two Newbury-style rock riffles that eliminated the perched culvert. A monitoring program is planned to determine if the upstream habitat sees recruitment of native salmonids over the next five years.

## ACKNOWLEDGEMENTS

The author would like to thank David Maloney, forest water management officer with the Ministry of Forests, Lands, Natural Resource Operations and Rural Development for the introduction to the Fish Passage Technical Working Group; Sean Wong, senior biologist with the Ministry of Transportation and Infrastructure (BC MoTI) for his mentorship, supervision and continued support of the practice of ecological engineering; Duane Hendricks, senior highway design engineer with BC MoTI for his drainage expertise and sense of humour; and Ian Bruce, executive coordinator of Peninsula Streams Society and the first ever graduate of the RNS program for his assistance and expertise of the instream restoration works at Tetayut Creek.

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# 1 BACKGROUND

The Patricia (Pat) Bay highway (Highway 17) was constructed in 1978 by the BC Ministry of Transportation and Infrastructure (BC MoTI) to facilitate the movement of goods and services across the Saanich Peninsula. It is unclear whether the Pat Bay highway replaced an existing culvert or if its construction resulted in the current 1500 mm diameter reinforced concrete pipe (RCP) through Tetayut Creek (the Creek), also known as Sandhill Creek or Shady Creek (48.5797°, -123.3986°). The highway crossing occurs approximately 2.20 km upstream of the mouth of the Creek where it empties into the Juan de Fuca Strait on the east side of the Saanich Peninsula.

Tetayut Creek flows north for approximately 9.0 km where its headwaters originate at Bear Hill near Elk Lake. The watershed is largely contained in the District of Central Saanich, one of the fastest growing districts in the region (Boeckh R. , 2004). The Creek is not only used for irrigation and livestock, it plays a fundamental role in preserving local genetic diversity of native fish species as well as the cultural heritage of Saanich First Nations (Boeckh R. , 2004).

Due to the nature of the culvert's long smooth barrel ideal for generating high velocity flows, a plunge pool over a metre in depth has formed in the channel downstream of the highway. Despite this pool being excellent fish habitat, the formation of the pool has resulted in a perched culvert 40 cm above the nearest downstream control elevation causing a major barrier to fish migration in the Creek.

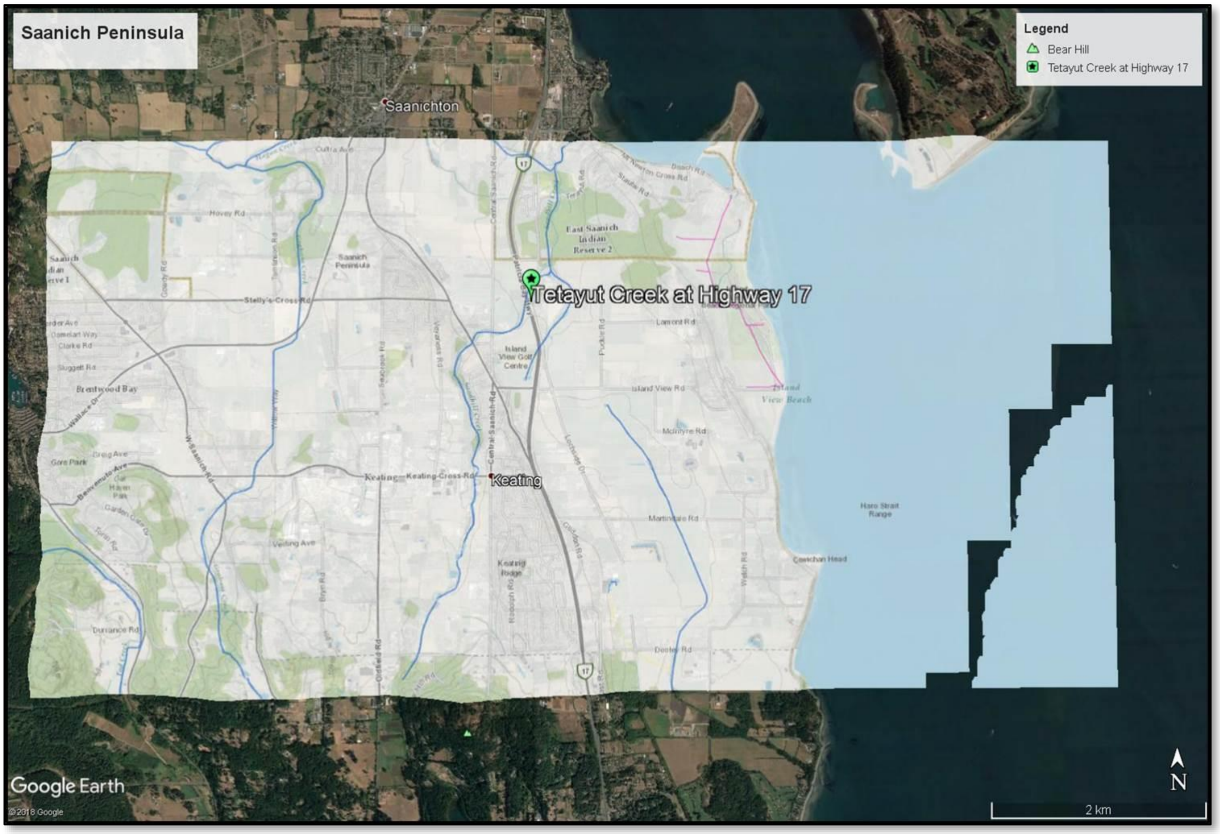

**Figure 1:** The project location is 10 km south of Sidney, BC on the Saanich Peninsula **(Google Earth, 2018)**

## 2 OBJECTIVES

The following objectives were established to support the goal of connecting year-round aquatic habitat in Tetayut Creek surrounding Highway 17:

- Survey the channel and determine restoration options;
- Determine which fish species are active in Tetayut Creek;
- Identify length of connected aquatic habitat upstream of Highway 17;
- Hydraulic modelling of peak flows and low flows before and after the restoration prescription;
- Construction of the instream works; and
- Monitor recruitment of fish upstream of the restoration, and re-introduce if necessary.

## 3 SCOPE

This project focuses on instream activities aimed at restoring fish passage to Tetayut Creek upstream of Highway 17. A full culvert replacement is not feasible as it is too costly and would result in serious traffic delays. Any barriers to fish passage downstream of BC MoTI’s right-of-way will not be evaluated nor will invasive species management of the riparian area be addressed.

## 4 TIMELINE

Removing barriers to fish passage at the Pat Bay highway began in April 2018 and was completed by September 2018. Monitoring and maintenance is anticipated for the next five years (Table 1).

**Table 1:** Timeline for the completion of restoration works at Tetayut Creek

| **Task** | **2018** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** | **November** |
| **Stakeholder Contact** | | — | — | — | — | — | | | |
| **Field Investigation** | | — | | | | | | | |
| **Survey** | | — | | | | | | | |
| **Drafting** | | — | — | | | | | | |
| **Design** | | | — | — | — | | | | |
| **Permitting** | | | | | — | — | | | |
| **Construction** | | | | | | | — | | |
| | **(2019, 2020, 2021, 2022, 2023)** | | | | | | | | |
| **Monitoring (Fish Salvage)** | Fry | Fry | | | | | | Spawners | Spawners |
| **Maintenance (Instream)** | | | | | | | — | | |

## 5 STAKEHOLDERS

The following organizations were identified as stakeholders in the Tetayut Creek stream restoration:

- *BC Ministry of Transportation and Infrastructure (BC MoTI)*: Owners of the perched culvert and financial contributors for the completion of the restoration. Restoration works were designed by senior biologist and manager of the Environmental Enhancement Fund (EEF) Sean Wong and construction coordinated by water resources specialist Andrew Anderson (EIT, AAg).

- *Peninsula Streams Society (PSS)*: Coordinators of stream restoration activities and habitat conservation on the Saanich Peninsula. The primary contacts for PSS are executive coordinator Ian Bruce (RPBio), and assistant coordinator Brian Koval (RPBio). Through the coordination efforts of the PSS, two additional stakeholders were identified:

    - *Michell Excavating Ltd (Michell)*: Local excavating company that provided in-kind services, both as a monetary contribution and in the form of heavy equipment during construction.

    - *Pacific Salmon Foundation (PSF)*: A federally incorporated non-profit charitable organization aimed at conserving and restoring wild salmon and their habitats. A monetary in-kind contribution was allocated through the PSS.

- *District of Central Saanich*: Municipality where the restoration works occurred (Appendix A).

- *Saanich Historical Artifacts Society (SHAS)*: Landowners where the project occurred.

## 6 APPROVAL

The restoration of Tetayut Creek was proposed by PSS who had been seeking funding for this project for nearly a decade. In April 2018, Ian Bruce and Brian Koval of PSS met with BC MoTI to discuss restoration opportunities and timelines. All parties were in agreement that this site was a priority and that restoration would take place during the appropriate 2018 instream work window. As owners of the perched culvert, BC MoTI committed to supporting the design and funding of the project.

**Figure 2**: Standing in Tetayut Creek downstream of the culvert looking upstream at the perched culvert **(Anderson, 2018)**

## 7 LEGISTLATIVE AUTHORITIES

A list of applicable statutes and their regulating agency for the instream works at Tetayut Creek is presented in Table 2.

**Table 2:** Applicable statutes requiring permitting or approval, adapted from “Module 10: Environmental Best Practices for Highway Maintenance Activities” **(2018)**

| Statute | Section / Regulation | Regulating Agency | Area of Regulation | Potential Approval or Permit Requirements |
|---|---|---|---|---|
| Fisheries Act | Section 35(1) | Fisheries and Oceans Canada (DFO) | Prohibits serious harm to fish which is defined as “the death of fish or any permanent alteration to, or destruction of, fish habitat that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery”. | Fisheries Act Authorization may be required if serious harm cannot be avoided. |
| Fisheries Act | Section 52 of Fishery (General) Regulations | Fisheries and Oceans Canada (DFO) | Fishing for experimental, scientific, educational, aquatic invasive species control purposes and/or public display. | Fishing license required. *This is not a valid license for threatened or endangered species (see SARA).* |
| Species at Risk Act (SARA) | Sections 32(1) and 33 | Environment and Climate Change Canada | Prohibits killing, harming, harassing, capturing or taking of any species protected under SARA, or the damage or destruction of a protected species residence (including any critical habitat that has been established). | Permit approval is required under the S73 of *SARA* for any otherwise prohibited activities. |
| Water Sustainability Act (WSA) | Sections 9, 10 and 11 | BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development | Protects water quality, habitat, and water users by regulating changes in and about a stream, water use, and groundwater use for anything other than domestic use. | Water license or use approval may be required under Sections 9 or 10 for water diversion or use.<br>Change Approval or Notification is required for works in and about a stream under Section 11. |
| Wildlife Act | Section 19 | BC Ministry of Environment & Climate Change Strategy | Provides definitions of wildlife and outlines the management of wildlife in BC. | Anyone intending to collect freshwater fish from non-tidal British Columbia waters requires a Fish Collection Permit under Section 19. *This is not a valid permit for threatened or endangered species (see SARA).* |

## 8 CULVERTS AND FISH PASSAGE

Culverts are instream structures that have the potential to act as barriers to fish movement by altering flow characteristics and disrupting habitat connectivity (Goodrich, Watson, Cramp, Gordos, & Franklin, 2018). Over time, an extended instream disturbance by a culvert can lead to localized extinction (extirpation) of a fish species from a watershed. Depending on its age and species, fish require different flow rates based on its individual swimming ability and habitat requirements. For this reason, effective culvert design balances the biophysical needs of a watershed with the engineering demands of the road structure.

It is not to say all culverts are designed purely to convey water; stream-simulated culverts exist and aim to maintain habitat connectivity, and are becoming increasingly more common. This is especially true in the design of new culverts for fish-bearing streams. Stream-simulated culverts have the primary function of mimicking natural conditions through the use of:

- An embedded closed bottom culvert (Figure 3), where the embedded material is made up of native bed materials and installed at a specified depth or ratio of the culvert diameter; or
- An open-bottomed structure that leaves the natural channel bed intact.

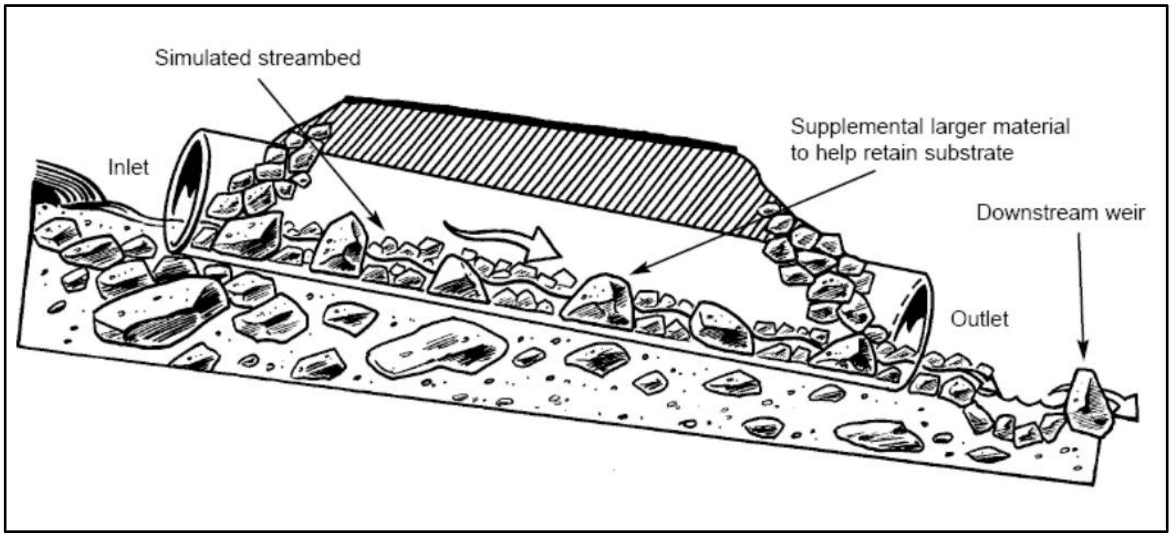

**Figure 3:** Embedded culvert installation with natural channel bed material and an appropriate gradient and outlet pool control. **(Fish-stream Crossing Guidebook, 2012)**

The use of a stream-simulated culvert greatly reduces the chance of barriers to fish passage forming. Unfortunately, the installation of a new culvert is outside the scope of this project as it would be too costly to fully replace the 54 m long RCP under Highway 17. Therefore one must have a better understanding of what constitutes the challenges posed by culverts from a biological perspective in order to apply a restoration prescription.

The cumulative effects of a problem culvert can be broken down into complete, partial, or temporal barriers to fish passage (BC Ministry of Transportation and Infrastructure, 2013). A *complete* barrier prevents all species and life stages from moving through the culvert, a *partial* barrier may impact only the smaller, younger, or weaker species while a *temporal* barrier limits the movement of fish seasonally based on flow conditions (BC Ministry of Transportation and Infrastructure, 2013). There are five (5) common types of barriers to fish that can result in a problem culvert situation, as adapted from the “Culverts and Fish Passage” guidelines from BC MoTI (2013):

1. High velocity within the culvert barrel. Water velocity can be an effective deterrent to fish movement when it exceeds a fish's swimming ability. A normal stream will contain many different landscapes such as pools, riffles, bars, side channels, eroded banks, woody debris, and rootwads. All of which are extremely important components for fish habitat and migration. There are two (2) factors that commonly impact velocity in a culvert barrel:

   - *Culvert length*: The longer the culvert the higher the velocity and thus harder for fish to swim through.

   - *Culvert grade*: Gradients higher than 3% can lead to high velocities that prevent fish migration and destabilize embedded materials within a culvert (if applicable).

   Depending on the species and age, fish have a limited duration that they can swim at high speeds (known as their burst speed) before they reach exhaustion. Overly long and/or steep culverts will prevent even the strongest swimmers from passing a culvert and reaching upstream habitat.

2. Excessive turbulence. Turbulence represents energy dissipation which results in reduced velocities and improves fish swimming performance. Too much turbulence can result in a barrier to upstream fish movement.

3. Insufficient water depth in the culvert. With hydraulically efficient flows comes shallow water depth. Where there is insufficient water depth (<0.2 m at the time of fish passage) the ability of the fish to swim is impaired. This can occur in overly steep and/or long closed bottom culverts or underneath leaky or improperly sealed open-bottomed structures.

4. Raised or elevated outlet. This occurs when the culvert outlet's invert elevation is above the downstream streambed control (Figure 4). An outlet drop forms from velocities eroding the downstream channel such that the channel bed degrades and an outlet scour pool forms (like that in Tetayut Creek). This phenomenon can also be referred to as a perched or hanging culvert. Under ideal conditions, some species of adult salmonids can leap over this obstacle if they are given a sufficient run from the outlet pool, but this is not always the case.

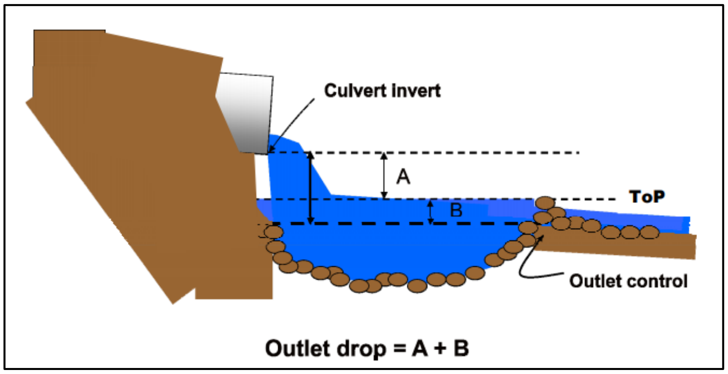

**Figure 4:** Determination of an outlet drop **(Protocol for Fish Passage Determination of Closed Bottomed Structures, 2011)**

5. Debris and sediment accumulation. Culverts are designed to be self-cleaning from a hydraulic perspective. During flood events, debris (stream bed material, vegetation, large woody debris) can become rafted at the inlet or lodged within the culvert. This presents both a physical barrier to fish and poses a flooding and geotechnical hazard to the road. This accumulation of debris can occur from a number of different factors:

    - Undersized culverts
    - Poor alignment to the natural channel
    - Low gradient
    - Improperly designed baffles (if applicable)
    - Unmaintained trash racks (if applicable)

Culvert retrofits can be applied to existing structures to modify flow requirements for fish passage and are often the preferred alternative if there is still adequate lifespan in the structure and/or the cost of a full replacement may not be feasible (BC Ministry of Transportation and Infrastructure, 2013). There are two (2) types of culvert retrofits as outlined in the BC MoTI guide for “Culverts and Fish Passage” (2013):

1. Baffles are designed and installed at specific heights and spacing within the culvert to promote suitable hydraulic conditions for fish passage. The baffles are typically constructed of metal and concrete and should be designed for low maintenance of the structures. Because of both debris accumulation and sediment transport concerns/failures, The BC Fish Passage Technical Working Group strongly discourages use of baffles for new culvert installations (Wong, 2018).

2. Tailwater control modifications correct elevated/perched outlets. This is accomplished by installing one or more rock weirs downstream of the culvert to raise the tailwater elevation and backflood the culvert. The addition of a tailwater control also has the benefits of reducing outlet velocities, providing pool habitat utilized by resting fish, increasing water depth in the culvert to make it more passible, and minimizing downstream erosion and sediment mobilization.

# 9 SITE CHARACTERISTICS

## 9.1 Survey

A topographic survey was conducted on April 18 and 19, 2018 by Kiara Robertson (AScT) with help from Andrew Anderson using a Nikon NIVO m series total station and survey rod. The survey extended 40 m upstream and 100 m downstream of Highway 17 (Appendix B). The topographic data collected by the total station consists of 3-dimensional coordinates in the form of UTM bearings and vertical elevation data. Survey data was collected at all inflection points near the channel and in the floodplain, including the channel banks, bottom of banks, and channel thalweg.

The topographic survey data in combination with the field descriptions of the culvert made it possible to generate a summary of the Highway 17 culvert (Table 3). It should be noted there is a second smaller culvert (650 mm diameter) that is 13.7 m in length which conveys ditch drainage from the adjacent biking and walking trail (the Lochside Trail) into the same outlet location. This culvert is not considered a significant contributor of runoff and will no longer be discussed in this report.

**Table 3:** Culvert summary

| **Highway 17 Culvert** | | | | | |
|---|---|---|---|---|---|
| Type | Embedment Depth (m) | Diameter (mm) | Length (m) | Slope (%) | Outlet Drop Height (cm) |
| Round RCP | 0 | 1500 | 54.3 | 0.63 | 40 |

Survey data helped to generate an approximate channel cross sectional profile with the characteristics described in Table 4. This information is based on an average of five of the seven channel cross sections measured during the survey. The two cross sections that were not included were not representative of typical channel measurements as they occurred immediately upstream and downstream of the culvert.

**Table 4:** Stream summary

| **Average Stream Channel Characteristics** | | | | | |
|---|---|---|---|---|---|
| Bankfull Channel Width (m) | Slope (%) | Left Bank Height (m) | Right Bank Height (m) | Left Bank Slope (degrees) | Right Bank Slope (degrees) |
| 6.0 | 1.05 | 1.15 | 1.25 | 32 | 21 |

## 9.2 CBS Field Form

To confirm the status of the Highway 17 culvert acting as a barrier to fish passage, the Closed Bottom Structure (CBS) Field Measurement Form developed by the Ministry of Environment (2011) was applied to the existing site conditions (Appendix C). This assessment has five categories related to culvert performance, all of which are used to determine a final score for the crossing. This includes:

- The depth of embedment in the culvert;
- The height of the outlet drop;
- The slope of the culvert;
- The stream width to culvert width ratio; and
- The length of the culvert.

The cumulative score of 32 placed the culvert into the barrier category presented in Table 5.

**Table 5:** Scoring for the Closed Bottom Culvert (CBS) field measurement form **(BC Ministry of Environment, 2011)**

| Cumulative Score | Result of Fish Passage Assessment |
|---|---|
| 0 - 14 | Passable |
| 15 - 19 | Potential Barrier |
| > 20 | Barrier |

## 9.3 Geography and Geology

The terrain surrounding Tetayut Ceek consists of rolling and undulating hills ranging from 2% to 30%. The soils are classified as Saanichton and Tagner by the BC Ministry of Environment (Soils of Southern Vancouver Island, 1985).

These unconsolidated marine derived sediments are primarily silty loams with imperfect drainage (BC Ministry of Environment, 1985), where it is suspected that groundwater seeps contribute to flow in the channel. The survey conducted in April 2018 confirmed dense clays in the channel and along the banks of the Creek downstream of the perched culvert (Figure 5) and sand and gravel bars upstream of the culvert (Figure 6). It is likely that all fine-grained sediments were deposited at the same time by the same marine depositional processes.

**Figure 5:** Dense, erosion resistant clay encountered along the banks of Tetayut Creek **(Anderson, 2018)**

## 9.4 Sediment and Debris Load

Low gradient channels like Tetayut Creek (1.05% channel slope near the culvert) lack the ability to transport large sediment (e.g. cobbles and boulders >75mm) and debris (e.g. coarse woody debris). The marine deposited sediments that make up the watershed are fine grained in nature, ranging in size from <0.063mm (silt and clay) to coarse gravels (up to 63mm) (International Organization for Standardization, 2017) (Figure 6). This implies there is a lack of large sediment throughout all reaches of the watershed. These assumptions were field confirmed by the absence of stranded debris and an absence of accumulated sediment at the inlet of the Highway 17 culvert, where converging flows have a tendency to deposit large materials that don't fit through the barrel of the culvert.

**Figure 6:** Gravel bar encountered during site visit where particle diameters range from 5 mm to 20 mm **(Anderson, 2018)**

Tetayut Creek is more inclined to accumulate debris in the channel as a result of riparian processes adjacent to the stream, including windfall or anthropogenic modifications. This was observed 30 m downstream of the culvert outlet where multiple wind fallen Western red-cedars (*Thuja plicata*) formed a log jam in the channel. These fallen trees provide important instream and riparian services such as bank stabilization, water temperature regulation, and habitat complexes that serve as resting places for fish while decreasing instream velocities. Decaying wood deposited in the channel is an important food source for macroinvertebrates in the stream who are eventually consumed by fish. As a result of these services, the coarse woody debris was retained in the channel.

## 9.5 Fluvial Classification

Stream classification is a complex process that depends on many variables related to environmental conditions, sediment source, transport capacity, and vegetation (Figure 7). For smaller and intermediate streams of British Columbia (bankfull width <20 m) this process can be simplified to three morphologies defined by The Channel Assessment Procedure Field Guidebook (BC Ministry of Forests and Ministry of Environment, Lands, and Parks, 1996). These classifications are:

1. Step-pool sequence
2. Cascade-pool sequence
3. Riffle-pool sequence

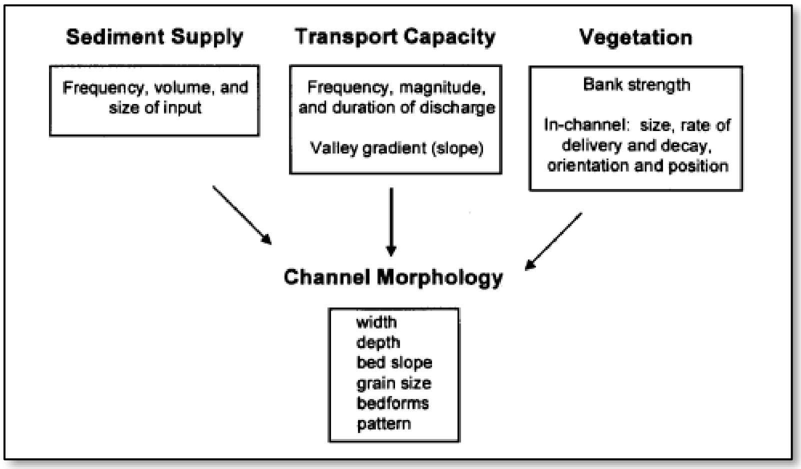

**Figure 7:** Determination of stream morphology from independent landscape and watershed variables **(Montgomery & Buffington, 1998)**

These morphologies are classified in Table 6 according to their dominant bed material and the presence of large woody debris (LWD). Large woody debris plays an important role as it can help form the pool sequence found in all the morphologies listed below.

**Table 6:** BC channel types and associated characteristics **(BC Ministry of Forests and Ministry of Environment, Lands, and Parks, 1996)**

| Code | Morphology | Sub-code | Bed material | LWD |
|---|---|---|---|---|
| RP | Riffle-pool | RPg-w | Gravel | Functioning |
| RP | Riffle-pool | RPc-w | Cobble | Functioning |
| CP | Cascade-pool | CPc-w | Cobble | Present, minor function |
| CP | Cascade-pool | CP-b | Boulder | Absent |

| Code | Morphology | Sub-code | Bed material | LWD |
|---|---|---|---|---|
| SP | Step-pool | SPb-w | Boulder | Present, minimal function |
| SP | Step-pool | SPb | Boulder | Absent |
| SP | Step-pool | SPr | Boulder-block | Absent |

Tetayut Creek can be defined as a naturally meandering stream with a low gradient and depositional areas containing gravelly bed materials. Given the nature of riffle-pool morphologies isolated to low gradient channels (<2%) (Thompson, 2018), it is fair to consider the reach of Tetayut Creek near Highway 17 a riffle-pool channel (Figure 8).

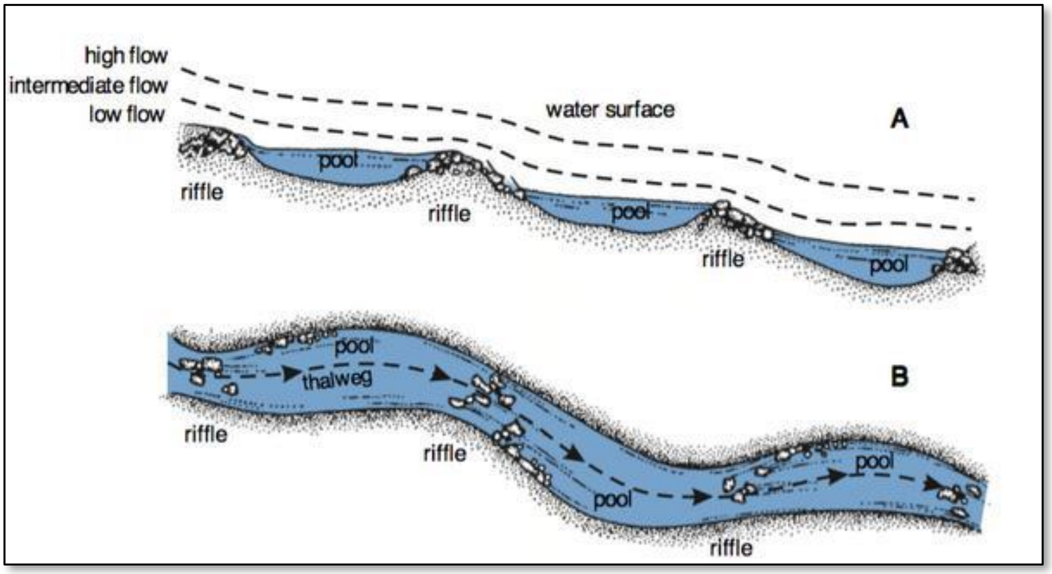

**Figure 8:** Riffle-pool morphology in plan and profile view **(Natural Stream Processes - River Course, 1999)**

## 9.6 Aquatic Organisms

Tetayut Creek is one of the most productive per unit area streams on Vancouver Island with few peers in the rest of the province according to Ron Ptolemy (Boeckh R. A., 2003). Mr. Ptolemy stated that empirical results show the Pat Bay highway plunge pool has an extreme value of 209 FPU's, or fish per 100m$^2$ unit area (Boeckh personal commmunication with Ron Ptolemy, 2003).

British Columbia's free map-based tools Habitat Wizard (BC Ministry of Environment, N.D.) and iMapBC (N.D.) were used to determine fish species in the channel. The results of Habitat Wizard yielded the Ministry of Environment generated Stream Report 920-140700 (Appendix D). This report details all the species present in the Creek, their last known observation date, stocking information, obstructions in the channel, water quality, and more. It was found that multiple anadromous[1] and freshwater fish species have used the channel historically, with the last known observations made in 2012 for Coho salmon

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[1] Anadramous - born in freshwater and migrate to the ocean as juveniles before returning to freshwater to spawn

(*Oncorhynchus kisutch*), Cutthroat trout (*Oncorhynchus clarkii*), and Sculpin (*Cottus sp.*) (Table 7).

**Table 7:** Summary of historic fish species in Tetayut Creek **(BC Ministry of Environment, N.D.) (Wong, Pers. communication, 2019) (BC Ministry of Environment)**

| Observation Date | | Species | | Status | Life cycle | Provincial Conservation Status |
|---|---|---|---|---|---|---|
| **Year** | **Month** | **Common name** | **Scientific name** | | | |
| 2012 | April | Coho Salmon | *Oncorhynchus kisutch* | Native | Anadromous | S4[1] (2000) |
| 2012 | December | Cutthroat Trout | *Oncorhynchus clarkii* | Native | Freshwater | S4 (2000) |
| 2012 | April | Sculpin | *Cottus sp.* | Native | Freshwater/brackish/ marine | SNA[2] |
| 2012 | April | Stickleback | *Gasterosteus sp.* | Native | Freshwater/brackish | S5[3] (2018) |
| 2012 | April | Threespine Stickleback | *Gasterosteus aculeatus* | Native | Freshwater/brackish | S5 (2018) |
| 1987 | January | Chum Salmon | *Oncorhynchus keta* | Native | Anadromous | S5 |
| 1984 | April | Sea-run Cutthroat Trout | *Oncorhynchus clarkii clarkii* | Native | Anadromous | S3[4]S4 (2004) |
| 1981 | March | Prickly Sculpin | *Cottus asper* | Native | Catadromous[5] | S5 (2010) |
| 1981 | March | Pumpkinseed | *Lepomis gibbosus* | Non-native | Freshwater | SNA |
| 1968 | January | Steelhead | *Oncorhynchus mykiss* | Native | Anadromous | S5 (2004) |

[1] S4 - apparently secure (BC Species and Ecosystems Explorer)

[2] SNA - not applicable (BC Species and Ecosystems Explorer)

[3] S5 - demonstrably widespread, abundant, and secure (BC Species and Ecosystems Explorer)

[4] S3 - special concern, vulnerable to extirpation or extinction (BC Species and Ecosystems Explorer)

[5] Catadromous - migrates from freshwater to the ocean to spawn

Habitat Wizard displayed a fish point upstream of the Pat Bay highway describing Coho salmon (*O. kisutch*) in 1977 (Figure 9) prior to the construction of the Pat Bay highway. This report coincides with observations made by farmers upstream of the highway who saw salmon carcasses as recent as the early 2000’s (Bruce, 2018).

Considering the barrier status of the culvert as determined by the CBS field form (Section 9.2), it is evident that runoff events since the 2000’s have either further degraded the channel and worsened the outlet drop such that it is no longer fish passable, or there was a very strong swimming cohort of Coho (*O. kisutch)* that were able to pass through the culvert under high flows.

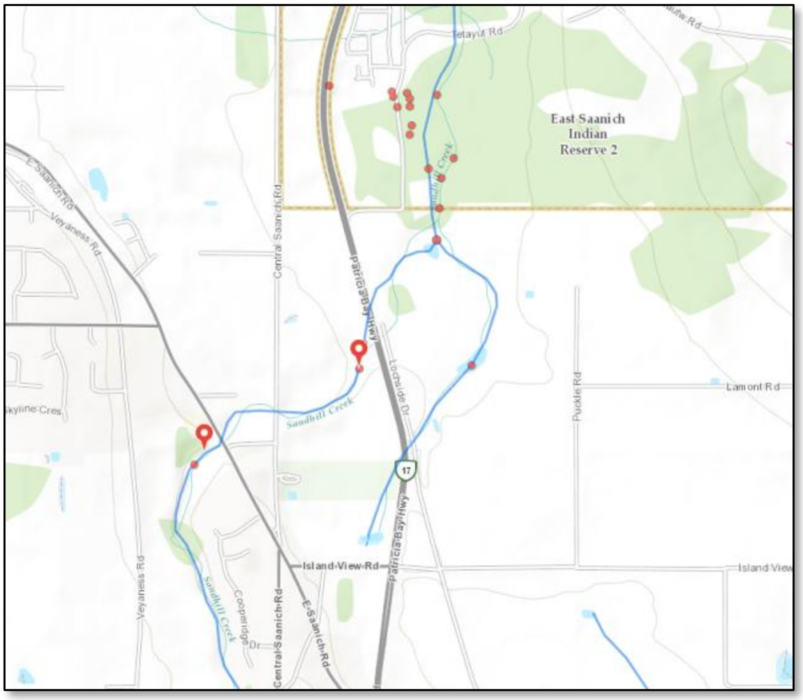


**Figure 9:** Screenshot from Habitat Wizard **(BC Ministry of Environment, N.D.)** (north at top of the page, NTS)

The digitized stream layer in iMapBC along with the 1:20,000 resolution base map layer named "Water – Dams, Falls, etc." was used to evaluate if there were any known barriers in the channel surrounding Highway 17. Despite this search showing no dams or falls, the April 2018 survey and site visit found a small irrigation dam installed 350 m upstream on a nearby farmer's property. When the dam is used to pond water during summer months for irrigation purposes it is considered a temporal barrier to fish passage (Figure 10). Stream Report 920-140700 indicates there is another dam near Keating Cross Rd. that blocks access to upstream habitat for fish species.

**Figure 10:** Looking downstream from Tetatyut Creek at concrete gravity dam with steel plate sluice gate (not present) 350 m upstream of Highway 17. Notice the sandy gravel substrate in the channel. **(Anderson, 2018)**

Ignoring the irrigation dam 350 m upstream (as it is only a barrier during summer months when there is low flow and salmonids aren't actively spawning) and assuming no other barriers to fish passage, over 2.0 km of instream habitat is made available with the restoration of the perched culvert at Highway 17.

## 9.7 First Nations and Archeological Sites

The RAAD (Remote Access to Archeological Data) database (BC Ministry of Forests, Lands, and Natural Resource Operations) was consulted to determine if there were any archeological sites or historic places near the culvert crossing  that would impact the construction process. The result of this search concluded there were no archeological sites at the crossing location meaning there is no need for an archeological assessment.

It is known from Appendix A that the Tsawout First Nation exists downstream of the crossing location (outside the scope of the project). They are one of the five bands that constitute the Saanich (WSANEC) Nations (Tsawout First Nations, 2019). One of the core beliefs of this nation is "that the islands, the salmon and the living things can be called upon for help to survive in this life" (Tsawout First Nations, 2019). This is an important reminder of the WSANEC people's traditional territories and the historic presence and value of salmon in Tetayut Creek and the Saanich Peninsula.

# 10 DESIGN

## 10.1 Restoration Prescription

A full culvert replacement is outside the scope of the project due to the estimated cost exceeding $1 million and the significant traffic delays associated with construction (Wong, Pers. communication, 2019). Given the expected remaining service life of the concrete culvert and the lack of operational concerns with the present alignment (e.g. debris accumulation or flooding), the retrofit options described in Section 8.0 are recommended and are summarized by the following: 1) baffle installation and 2) tailwater control modifications. A baffle installation would have no impact on the downstream condition of the culvert as it is meant to form a pool-riffle sequence within the culvert meaning the only viable option is the installation of a tailwater control.

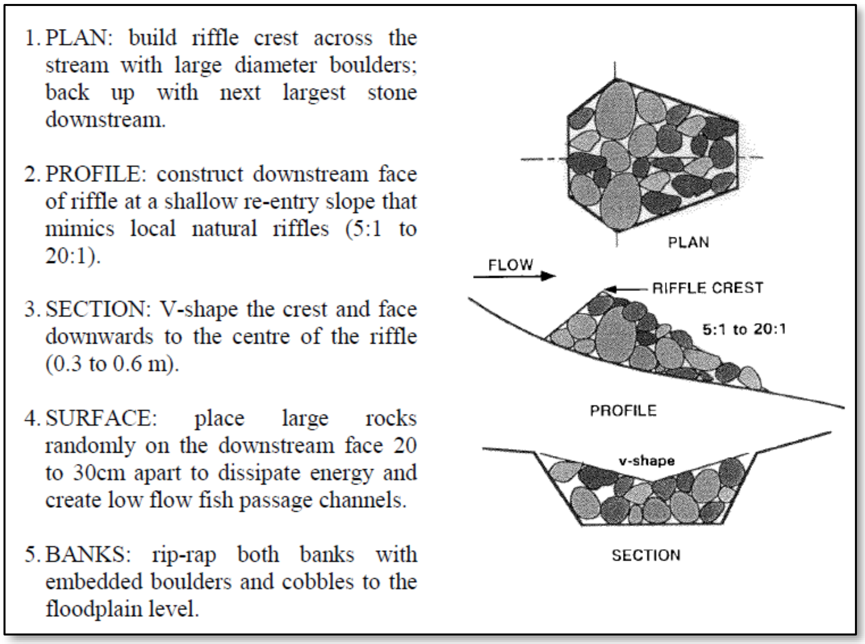
The tailwater control modification recommended for the restoration of riffle pool sequences in channelized streams is the Newbury-style rock riffle. This method was developed by Dave Bates, Marc Gaboury, and Robert Newbury specifically to enhance aquatic habitat complexity where it has been compromised. A properly designed rock riffle sequence is used to enhance pools, recruit gravel used for spawning, to aerate flows and assist with fish passage (Newbury, Gaboury, & Bates, Constructing Riffles and Pools in Channelized Streams., 1996).

## Riffle Spacing and Shape

The height of the first riffle must extend above the invert of the culvert to effectively backwater the perched culvert. Rather than backwater the culvert by a small margin, a height of 30 cm above the invert was selected such that pooled water would flood the entire outlet and extend upstream into the barrel thereby reducing the swimming effort required by fish to travel upstream. To ensure the first rock riffle serves its intended function of backwatering the culvert, a second riffle is required to backwater the toe of the first rock riffle ensuring hydraulic stability and further complexing the instream habitat through the formation of a true riffle-pool sequence.

The location of the first rock riffle is immediately downstream of the outlet pool at the highest thalweg elevation, decreasing the amount of rock required to build up the height of the riffle. The height of the riffle extends from the outlet pool control elevation (96.50 m) to 30 cm above the outlet invert (96.98 m), or 0.78 m. Upstream of the riffle crest a +/- 1.0 m long rounded gravel platform is added to the design to ensure spawning nests (redds) can be formed by spawning salmonids. Riffle spacing is four to six times the bankfull width (Newbury, Gaboury, & Bates, 1996) meaning the second riffle crest is installed between 24 m and 36 m downstream of the toe of the first riffle.

The shape of the rock riffle in plan view resembles a coffin, where the widest section extends up the banks of the channel (Figure 11). The riffle crest stabilizes the entire riffle structure thus it must be keyed into the channel with large rocks. The crest is v-shaped to promote the flow of water through a control elevation. During construction it is imperative that the riffle itself is well sealed so that during low flows water does not leak through the rocks but is instead conveyed over top of the structure.



1. PLAN: build riffle crest across the stream with large diameter boulders; back up with next largest stone downstream.

2. PROFILE: construct downstream face of riffle at a shallow re-entry slope that mimics local natural riffles (5:1 to 20:1).

3. SECTION: V-shape the crest and face downwards to the centre of the riffle (0.3 to 0.6 m).

4. SURFACE: place large rocks randomly on the downstream face 20 to 30cm apart to dissipate energy and create low flow fish passage channels.

5. BANKS: rip-rap both banks with embedded boulders and cobbles to the floodplain level.

**Figure 11:** Shape of constructed rock riffle **(Newbury, Gaboury, & Bates, 1997)**

### Material Selection

When selecting materials for instream works it is important to choose geological sources that aren't prone to acid rock drainage or are easily erodible. The volume of the appropriate rock source required is estimated by multiplying the height and length of the riffle crest by the bankfull width of the channel (Newbury, Gaboury, & Bates, Fish Habitat Rehabilitation Procedures, 1997). If this overestimates the volume of rock required, additional materials can be used to complex the pool habitats.

Rock materials used to construct the riffle have to be sized accordingly so they can withstand flooding without being displaced. Studies by Lane (Design of Stable Channels, 1955) and Chow (Open Channel Hydraulics, 1959) indicate that the relationship for a stable rock size can be described by the adapted tractive force equation:

$$\varphi_S = 1.5\gamma DS$$

Where $\varphi_S$ is diameter of the bed material (cm), 1.5 is a factor of safety, $\gamma$ is the unit weight of water (1000 kg/m$^3$), D is the depth of flow (m), and S is the slope of the downstream face of the riffle (Newbury, Gaboury, & Bates, Fish Habitat Rehabilitation Procedures, 1997). Full design specifications for both riffles were computed using the parameters described above by Wong (2018) and can be found in the comments section of Drawing 1 in Appendix B. When under the influence of the culvert outlet velocities, the rocks in the upstream riffle closest to the culvert require additional upsizing beyond the tractive force equations (Wong, Pers. communication, 2019).

## 10.2 Hydrology

The Saanich Peninsula is known for its Mediterranean climate and long growing season unique to the Coastal Douglas-fir moist maritime (CDFmm) biogeoclimatic (BEC) zone. Nuszdorfer et al. (1991) describes the CDFmm as a temperate zone with a mean annual temperature of 9.9°C and mean annual precipitation of 1000 mm, most of which falls as rain. The watershed upstream of the crossing is classified as a mix of agricultural (80%), residential (10%), and industrial (10%) land use based on an approximation from the Central Saanich official community plan (Appendix A). Watershed characteristics were assessed using a combination of 25 m resolution Digital Elevation Model (DEM) data from BC TRIM in QGIS and Google Earth (2018) found in Table 8.

**Table 8:** Summary of watershed characteristics

| Map Label | Watershed Elevation Range (m) | Aspect | Area (km$^2$) | Average Slope (%) | Stream Length (km) |
|---|---|---|---|---|---|
| Tetayut Creek at Highway 17 | 22-225 | NE | 3.07 | 1.7 | 3.5 |

### Design Flow Analysis

Table 1010.A of the BC Supplement to the TAC Geometric Design Guide (2007) specifies the design return period for hydraulic structures, including culverts. Most road culverts less than

3.0 metres span are to be designed for the 100-year peak instantaneous return period, with local and low volume roads to be designed for the 50- to 100-year peak instantaneous return period. Most bridges and culverts in excess of 3.0 metres span are to be designed for the 200-year peak instantaneous return period.

The BC Water Sustainability Regulation (2018), Section 39(1)(a) states that "the installation, maintenance or removal of a culvert for crossing a stream for the purposes of a road, trail or footpath, if all the following conditions are met: (vii) the culvert capacity is equivalent to the hydraulic capacity of the stream channel or is capable of passing the 1 in 200 year maximum daily flow without the water level at the culvert inlet exceeding the top of the culvert".

As per Section 1020.06 of the BC Supplement to the TAC Geometric Design Guide (2007), multiple calculation methods should be used in order to best estimate flow rates. With this in mind, the design flow was calculated using both empirical and statistical methods followed by a factor of safety adjustment based on engineering judgement and future climate scenarios.

The discharge calculations described below are for the 100-year instantaneous peak event. This is meant to serve as an illustrative example, where a summary of all design flows (2, 5, 10, 25, 50, 100, and 200-year peak instantaneous events) for Tetayut Creek are displayed in Figure 15.

**Method 1: Rational Method**

The Rational Method tends to over predict flow volumes as watershed size and complexity increases by assuming rainfall hits the entire watershed with a simultaneous peak, and it does not account well for non-converging hydrograph peaks within the watershed. The Rational Method is best used on watersheds less than 10 km$^2$ in size, therefore this method provides a good upper bound. The Rational Method is described by the following:

$$Q_p = \frac{CiA}{360}$$

Where $Q_p$ is the peak flow (m$^3$/s), $C$ is the runoff coefficient which depends on soil type and land use, $i$ is the rainfall intensity (mm/hr) for the design return period, $A$ is the area of the watershed (307 ha) and 1/360 is a metric conversion factor.

The dimensionless runoff coefficient $C$ was estimated at 0.30 using Table 1020.A (BC Ministry of Transportation and Infrastructure, 2007) for agricultural areas with flat terrain (<5%). This was raised to 0.45 considering approximately 20% of the watershed is industrial or residentially zoned, both of which have significantly higher percentages of impervious surfaces yielding higher runoff volumes. This was multiplied by 1.25 for the 100-year return period in small watersheds as per Section 2.4.5 of the RTAC Drainage Manual (Transportation Association of Canada, 1982) resulting in a runoff coefficient of 0.563.

To determine the rainfall intensity $i$, the time of concentration in the watershed must first be calculated. This was accomplished using an average of the most appropriate values obtained from the Water

Management Method, the Hathaway method, the SCS Curve Number method and the Bransby-Williams formula described in detail in Section 1020.07 of the BC Supplement to the TAC Geometric Design Guide (BC Ministry of Transportation and Infrastructure, 2007). The average value was found to be 2.0 hours or 120 minutes. Using this as the storm duration on the short duration rainfall intensity-duration-frequency (IDF) chart for the nearby weather station at the airport Victoria (1018621) (Government of Canada, 2014), it was found that the rainfall intensity for a 100-year storm event is 14 mm/hr.

$$Q_{100} = \frac{0.563 * \left(14 \frac{mm}{hr}\right) * 307ha}{360} = 6.72 \ {}^{m^3}\!/_{s}$$

The total discharge for the 100-year peak event at Tetayut Creek using the Rational Method is 6.72 $m^3/s$.

**Method 2: BC Streamflow Inventory (BCSI) Method**

The BC Streamflow Inventory (BCSI) method accounts for snowmelt and freshet related peaks based on regional gauged watersheds, and is based on the following relationship identified by Coulson and Obedkoff (1998).

$$Q_A = (Q_{100km^2})\left(\frac{A}{100km^2}\right)^{0.785}$$

Where $Q_A$ is the flow rate in the specified watershed ($m^3/s$), $Q_{100km^2}$ is the flow rate determined from the isolines for a 100 $km^2$ watershed ($m^3/s$) and $A$ is the watershed area (3.07 $km^2$). Using iMapBC's 100-year isoline layer, the $Q_{100km^2}$ isoline value was determined to be 80 $m^3/s$ (Figure 12). Using the Coulson and Obedkoff (1998) relationship, the total discharge for the 100-year peak event is 5.19 $m^3/s$.

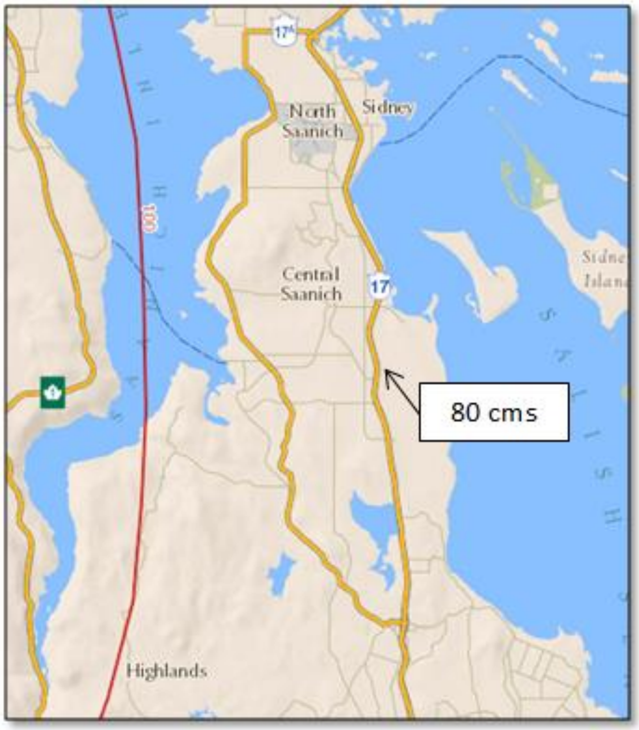


**Figure 12:** $Q_{100}$ discharge estimate for 100km$^2$ watershed using BCSI isolines **(iMapBC, N.D.)** (north at top of the page, NTS)

### Method 3: SCS Peak Flow

The SCS Peak flow is an empirical method for small urbanized watersheds that depends on unit peak discharge $(q_u)$, drainage area $(A_m)$, runoff $(P_e)$ and a ponding/swamp factor $(F_p)$ to calculate the peak discharge $(q_p)$. All units are imperial as this method was developed in the United States by the Natural Resources Conservation Service, formerly known as the Soil Conservation Service (SCS). The SCS Peak flow is described using the following:

$$q_p = q_u * A_m * P_e * F_p$$

The unit peak discharge depends on rainfall distribution types that have been mapped for the U.S. as shown in Figure 13. Assuming a type IA distribution based on map extrapolation of the distribution extents, the peak discharge, $q_u$ was determined from Exhibit 4-IA as 84 cfs/mi$^2$ per inch of runoff (csm/in) (U.S. Department of Agriculture, 1986). This calculation also requires the calculation of a runoff depth $(P_e)$ based on an assumed 24-hour storm length.

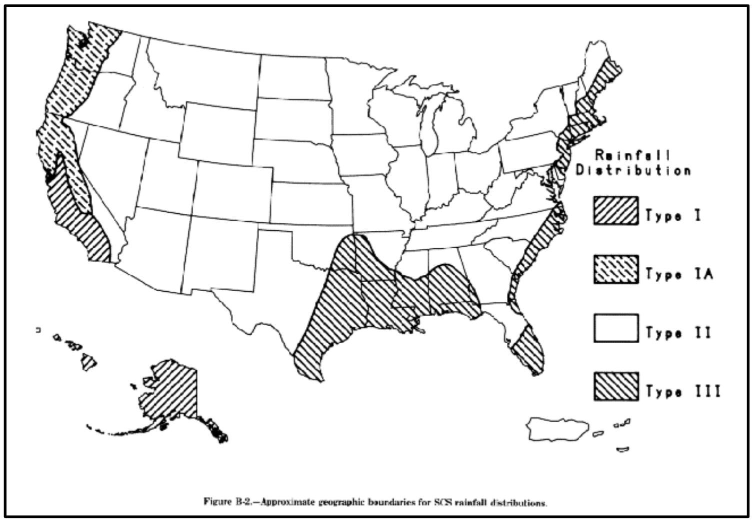


**Figure 13**: Figure B-2 from TR-55 **(U.S. Department of Agriculture, 1986)**

Using a swamp/pond factor, $F_p$ value of 0.87 and converting the watershed area $(A_m)$ from 3.07 km$^2$ to 1.19 mi$^2$ and solving for $q_u$, you get 229.4 ft$^3$/s or 6.50 m$^3$/s using the SCS Peak Flow method.

### Method 4: Station Frequency Analysis

Water Survey of Canada (Government of Canada, 2018) gauge stations can be used as surrogates to model a target watershed; this process is called a station frequency analysis. This includes a comparison of the slope, elevation range, representative BEC zone, aspect, amount of storage in the watershed, if the stream is regulated, watershed area, and determining if the gauge has sufficient years of peak flow data to develop an accurate statistical model of the target watershed. As luck would have it, Tetayut Creek had a stream gauge 50 m downstream of the culvert that operated for 17 years between 1993 and 2009 (08HA060 – Sandhill Creek at Pat Bay Highway). Statistical analysis of this gauge station yields an accurate model of flow levels at the crossing location based on the almost identical watershed size. A summary of the comparison of the watershed at the crossing location to that of gauge station 08HA060 is presented in Table 9.

**Table 9:** Comparison of the Highway 17 crossing location to downstream Gauge Station 08HA060

| ID | Name | Average Slope (%) | Watershed Elevation Range (m) | Representative BEC Subzone | Aspect | Watershed Area (km$^2$) | Years active | Peak inst. $Q_{100}$ (m$^3$/s) |
|---|---|---|---|---|---|---|---|---|
| | Tetayut Creek at Highway 17 | 1.70 | 22-225 | CDFmm | Northeast | 3.07 | | |
| 08HA060 | Sandhill Creek at Pat Bay Highway | 1.70 | 22-225 | CDFmm | Northeast | 3.10 | 17 | 5.32 |

Using the maximum instantaneous peak flow data and two pieces of free statistical software (HEC-SSP and CumFreq), flow rates for the 100-year peak instantaneous event were computed for 10 statistical distributions at gauge station 08HA060. The most representative statistical distributions were selected to calculate an average peak instantaneous discharge of 5.32 m$^3$/s.

### Summary of Discharge Calculations

A summary of watershed characteristics and the 100-year peak instantaneous discharge for the methods described above is presented in Table 10.

**Table 10:** Summary of 100-year peak instantaneous discharge calculations

| Map Label | Rainfall Intensity, i (mm/hr) | Time of Concentration, Tc (hours) | Rational Method | | BCSI Q (m$^3$/s) | SCS Peak Q (m$^3$/s) | Station Frequency Analysis Q (m$^3$/s) |
|---|---|---|---|---|---|---|---|
| | | | Coefficient C | Q (m$^3$/s) | | | |
| Tetayut Creek at Highway 17 | 14.0 | 2.00 | 0.56 | 6.72 | 5.19 | 6.50 | 5.32 |

Given the overall similarity between the calculated discharges, the Station Frequency Analysis discharge (5.32 m$^3$/s) was chosen to represent the crossing location due to the fact that stream gauge 08HA060 was historically located on this reach of Tetayut Creek.

### Climate Change Influenced Factor of Safety

The influence of climate change on increasing storm event intensity combined with increased urbanization will result in amplified discharge rates following precipitation events. This is anticipated to worsen the height of the perched culvert, decreasing fish pass-ability if there is no intervention.

The University of Western Ontario (UWO) has developed a tool for deriving rainfall IDF curves for future climate scenarios (University of Western Ontario, 2018). The tool uses 24 climate models to estimate future rainfall intensity for standardized storm durations and return period frequencies. This system allows users to select from low (RCP 2.6), moderate (RCP 4.5), and severe (RCP 8.5) climate change scenarios.

The ratio of the future rainfall intensity to the historic rainfall intensity was used to model the worst case climate change scenario. This required calculating the future IDF value assuming an additional 50 year lifespan of the RCP culvert, resulting in the 100-year return period climate intensity scenarios for the year 2069 (Table 11).

**Table 11:** Summary of historic and future IDF values (Year 2069)

| Time of Concentration (hours) | Return Period (Years) | IDF Historical Value using GEV Distribution (mm/hr) | IDF RCP 2.6 for the year 2069 (mm/hr) | IDF RCP 4.5 for the year 2069 (mm/hr) | IDF RCP 8.5 for the year 2069 (mm/hr) |
|---|---|---|---|---|---|
| 2.0 | 100 | 12.21 | 15.74 | 15.49 | 15.37 |

Table 11 demonstrates that RCP 4.5 produced the highest rainfall intensity under future climate scenarios. This is consistent with other similarly-derived rainfall-based climate factors found throughout British Columbia, and means that the worst case scenario would be represented as:

$$Climate\ Change\ based\ Factor\ of\ Safety = \frac{RCP\ 4.5}{Historic\ GEV} = \frac{15.49}{12.21} = 1.27$$

This method is rudimentary; however, scaling global climate models to local watersheds is imprecise at best. Producing climate change adjustment predictions using such scaling would require creating a watershed model incorporating these additional projected climate considerations. The level of effort involved would be much larger, out of proportion to the scale of this project, and would produce a local prediction which is tenuous at best.

### 200-year Extrapolation to Determine Rainfall Intensity Factor of Safety

To satisfy the BC Water Sustainability Regulation (2018) requirement of passing the 1 in 200 year daily flow, the ratio of the 200- to 100-year rainfall intensities was evaluated to determine a scaling factor for the $Q_{100}$ discharge to arrive at a $Q_{200}$ discharge. This value was subsequently compared to the climate change influenced 1 in 100 year peak discharge to determine the larger, design-based value. This process may overestimate the $Q_{200}$ max daily discharge; however, this provides an additional layer of surety with respect to satisfying the Water Sustainability Regulation.

To arrive at the 200-year rainfall intensity, the existing rainfall intensity values from the Victoria Airport (1018621) IDF curve (Government of Canada, 2014) were plotted against the return period on a normal-lognormal plot, and the 200-year intensity (shown in red in Figure 14) was extrapolated using a lognormal trendline. The ratio of 200-year/100-year rainfall intensities was found to be 1.05.

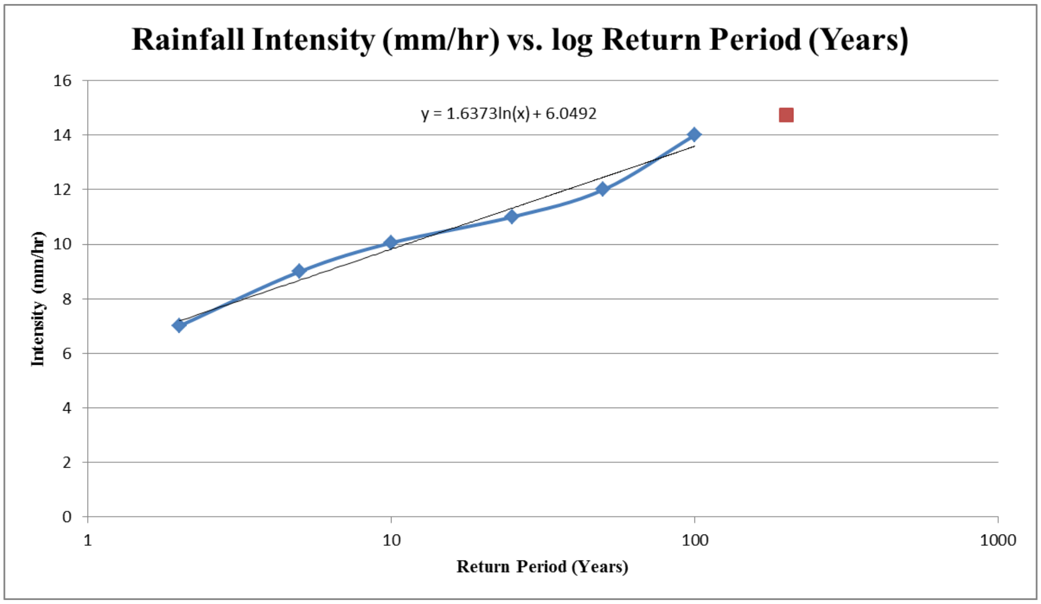


**Figure 14:** Plot of Victoria Airport (1018621) weather station rainfall intensity (mm/hr)

Comparing the climate change influenced factor of safety (1.27) to the rainfall intensity based factor of safety (1.05), the climate influenced 1 in 100 year peak instantaneous event yields a more conservative discharge, and therefore will pass the 200-year max daily flow as required by the Water Sustainability Act Regulation section 39 (2018).

### Design Discharge

The final design discharges are the product of the peak instantaneous flows multiplied by the climate change factor (Appendix E). The design discharge for all return periods can be found in Figure 15.

| | |
|---|---|
| $Q_{100}$ discharge (Pre-climate change) | 5.32 $m^3/s$ |
| Climate Change Factor of Safety | 1.27 |
| $Q_{100}$ discharge (climate change adjusted) | 6.75 $m^3/s$ |

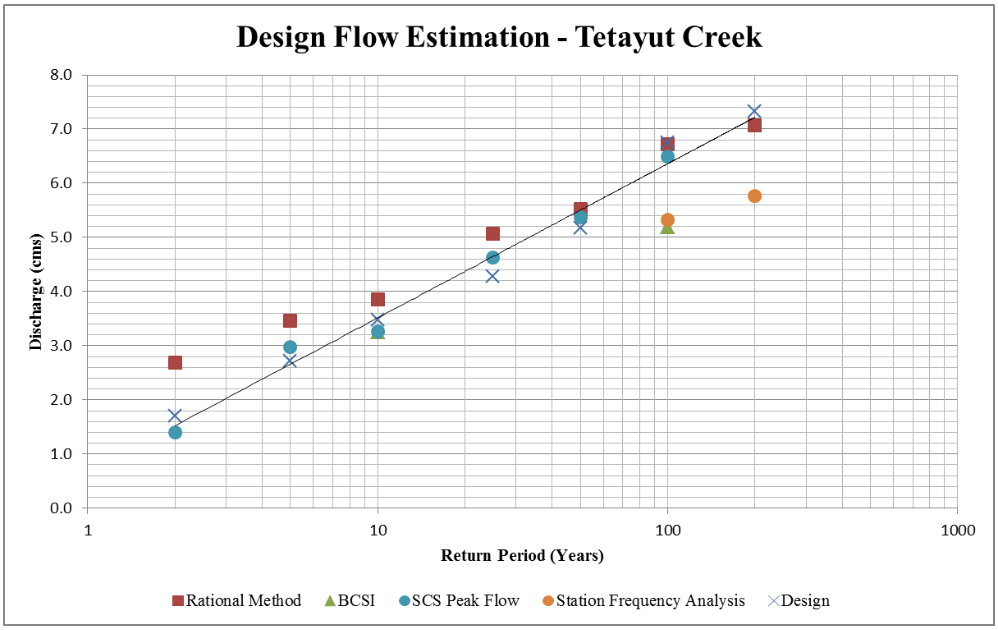


**Figure 15:** Summary of peak instantaneous design flows

## 10.3 Hydraulic Modelling

The purpose of hydraulic modelling is to compare pre- and post-restoration conditions to determine the functionality of the restoration prescription. This is meant to verify that habitat connectivity is established during typical low flows and to determine if the restoration works impact flood elevations upstream of the culvert under peak flows. The input parameters required by the hydraulic model include:

- Geometric cross-sections from the survey;
- Roughness coefficients representing the channel, floodplain, and culvert; and
- Discharge.

The combination of water flowing through a specified geometry with a defined roughness provides a visual representation of the water surface elevation (Figure 16). This water elevation is what is used to assess the performance of the riffles.

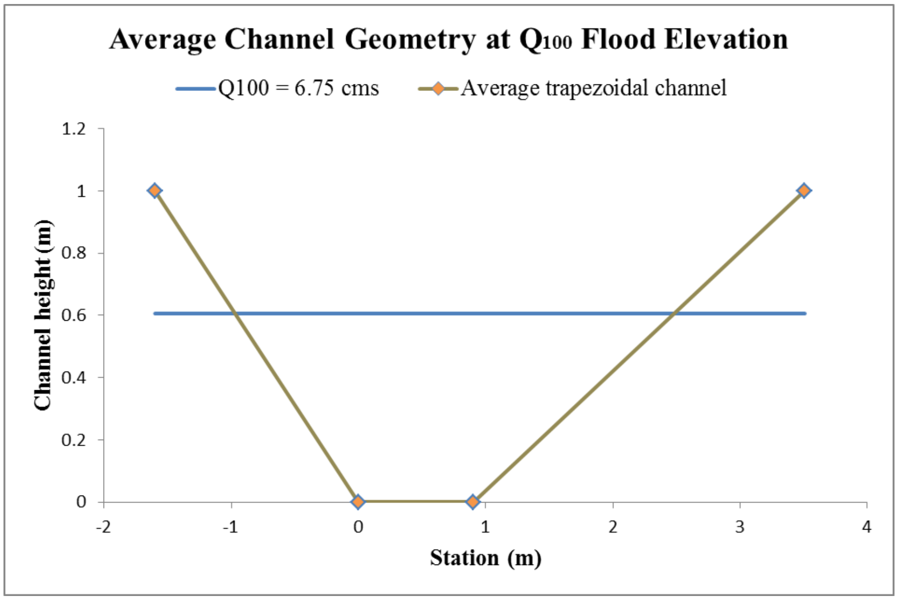


**Figure 16:** Average channel geometry of Tetayut Creek from survey data presented in Table 4 with $Q_{100}$ flood elevation

The roughness coefficients selected for the channel, floodplain, and RCP culvert were 0.04, 0.07, and 0.01 respectively. These values were conservative estimates from RTAC's Drainage Manual Volume 1 (1982) shown in Table 12, where lower values indicate a smoother surface (less friction).

**Table 12:** Manning's roughness coefficients adapted from RTAC volume 1 **(1982)**

| Description | Manning's n range |
|---|---|
| **Closed Conduit** | |
| Reinforced Concrete Pipe (RCP) | 0.012 |
| Corrugated Steel Pipe (CSP) (unpaved) | 0.021 – 0.033 |
| Steel Pipe | 0.009 – 0.011 |
| **Unlined Open Channels** | |
| Uniform earth section: clean and weathered | 0.018 – 0.020 |
| Fairly uniform earth section: grass, some weeds | 0.030 – 0.035 |
| Rock lined channel: smooth and uniform | 0.035 – 0.040 |
| **Natural Stream Channels (Minor streams <30 m at flood stage)** | |
| Fairly regular section: Some grass and weeds | 0.030 – 0.035 |
| Fairly regular section: dense weeds with flow depth > weeds | 0.035 – 0.050 |
| Fairly regular section: Some weeds, dense willows on banks | 0.060 – 0.080 |

Hydraulic modelling was performed in HEC-RAS (the Hydrologic Engineering Center's River Analysis System) a software developed by the US Army Corps of Engineers. The channel was modelled over the entire surveyed reach, where additional cross-sections were interpolated by HEC-RAS. Models of the surveyed channel both with and without the two Newbury-style rock riffles were run at low flow (determined to be 0.01 $m^3/s$ from the mean monthly summer flow data at gauge station 08HA060) and the expected $Q_{100}$ discharge (6.75 $m^3/s$). The results of this modelling are displayed in Figures 17 through 20.

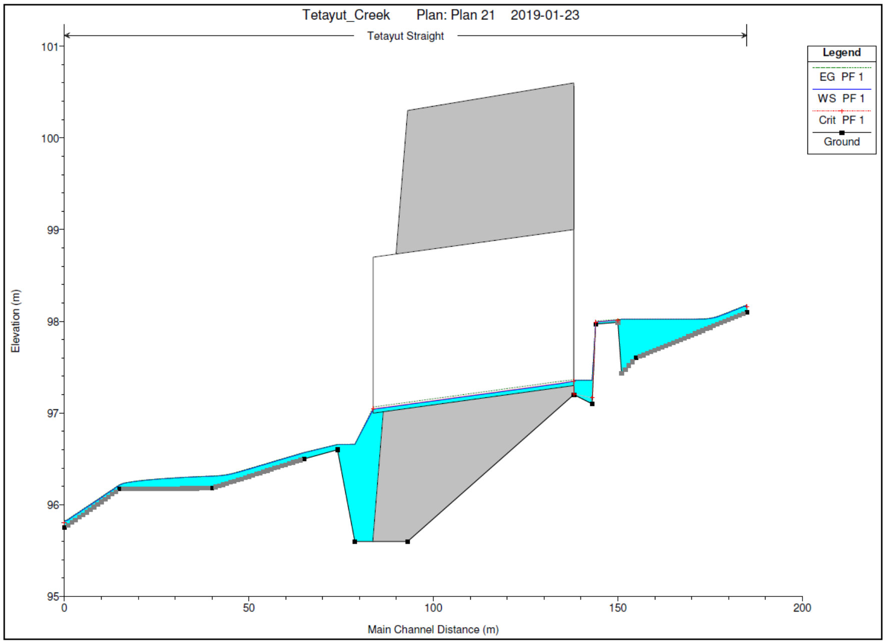


**Figure 17:** Culvert before instream riffle construction with 40 cm outlet drop at low flow

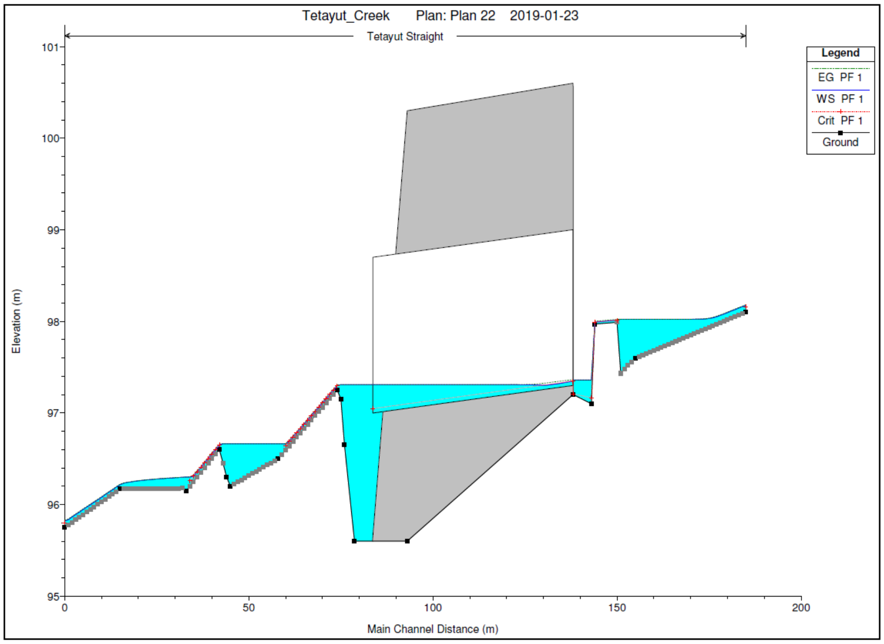


**Figure 18:** Restored riffle-pool channel morphology with backwatered culvert at low flow

Figures 17 and 18 demonstrate that the restoration works flood the culvert sufficiently under low flow conditions, eliminating the perched culvert.

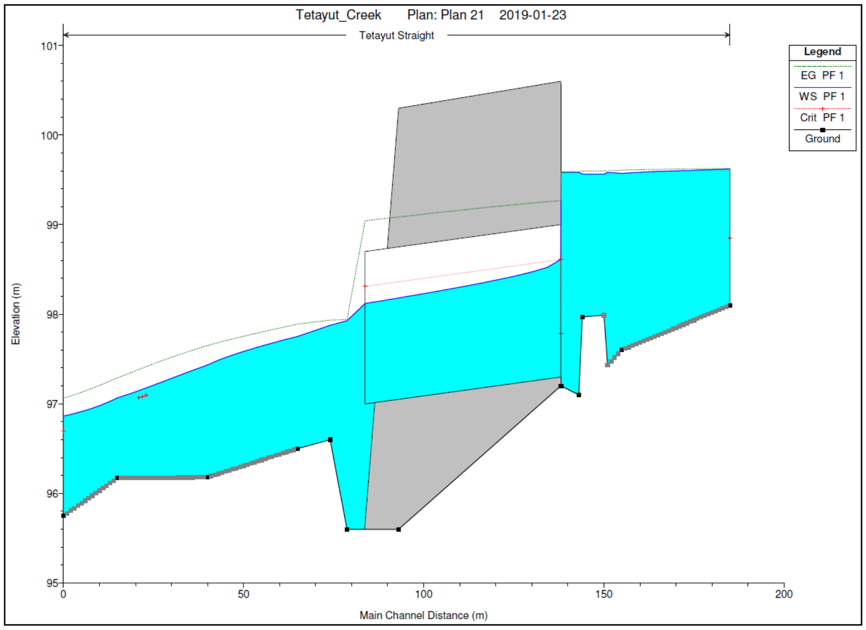


**Figure 19:** Culvert before instream riffle construction at $Q_{100}$ discharge

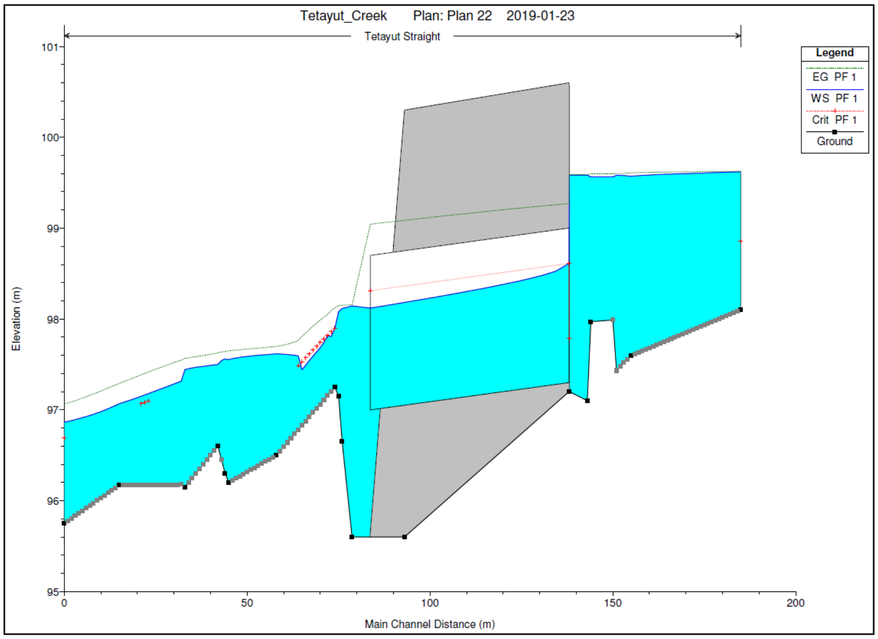


**Figure 20:** Restored riffle-pool channel morphology at $Q_{100}$ discharge

Figures 19 and 20 demonstrate that the riffle construction has no impact to the flood elevation upstream of the culvert (approximately 99.6 m) under the design discharge for a 1 in 100 year flood event in Tetayut Creek. Model validation that the restored channel eliminates the perched culvert without interfering with upstream flood stage hydraulics means the design is ready for construction.

## 11 CONSTRUCTION

Prior to construction, permitting and approvals to work instream were required. Approval for instream works during the appropriate fisheries timing window was applied for and granted to Brian Koval under section 11 of the BC Water Sustainability Act. This permit found in Appendix F required:

- The appropriate erosion and sediment control measures to be installed during construction;
- Having an Environmental Monitor (Brian Koval) onsite while doing instream work;
- The isolation of flow through the use of pumps and check dams (Figure 21);
- Fish collection permit(s) for fish salvage (Appendix F); and
- The works to be completed between June 21, 2018 and October 1, 2018.

**Figure 21:** Looking upstream at outlet where pumps are working to isolate the scour pool **(Anderson, 2018)**

Fish salvage permits were obtained for both federally (anadramous) and provincially regulated (freshwater) species. These permits were applied for and received by Ian Bruce and Brian Koval and can be found in Appendix F.

Construction occurred between September 24th and 27th, 2018 and included the following field staff:

- Ian Bruce (PSS) – Project Manager
- Brian Koval (PSS) – Environmental Monitor
- Grant McPherson (PSS contractor) – Fisheries Technician

- Jeremy (Michell) – Excavator Operator
- Walter Langer (AllTerra Spider Excavating Ltd) – Spider Excavator Operator
- Andrew Anderson (BC MoTI) – BC MoTI representative and supporting Environmental Monitor

**Figure 22:** In channel looking upstream at dewatered channel where excavator is breaking ground to toe in the keystone rocks of the first/upstream riffle crest **(Anderson, 2018)**

**Figure 23**: In channel looking upstream at completed first/upstream riffle **(Anderson, 2018)**

The riffle construction was field fit from the original design based on site conditions. This included moving the first/upstream riffle crest (Figures 22 and 23) approximately five metres downstream from the proposed location due to easier excavator access to the Creek. The second/downstream rock riffle

(Figures 24 and 25) was also moved up approximately five metres to match the spacing requirements of the riffle-pool sequence proposed by Newbury et al (1997), this also landed the riffle on a meander bend where the additional rock serves as bank protection.

**Figure 24:** Looking downstream from left bank at second/downstream riffle prior to construction **(Anderson, 2018)**

To prevent dewatering of the riffles at low flow, clay fill was provided in-kind by SHAS. The clay was used to pack the rocks together in combination with repurposed sediment from the channel to prevent leakage through the coarse rock fill. A pond liner provided by Ian Bruce was used at the base of the upstream riffle as an extra precaution to prevent leakage due to the naturally porous in-situ materials.

**Figure 25**: Looking downstream from left bank at completed second/downstream riffle **(Anderson, 2018)**

Each morning after dewatering and isolating the work areas, approximately two dozen Cutthroat trout (*Oncorhynchus clarkia*) (Figure 26) and one to three Stickleback (*Gasterosteus sp.*) were salvaged. This was performed by Brian Koval and Andrew Anderson using dip nets and electrofishing gear.

**Figure 26:** Salvaged cutthroat trout **(***Oncorhynchus clarkia*) parr **(Anderson, 2018)**

The construction of the two riffles led to the model-anticipated backwatered culvert depicted in Figure 27.

**Figure 27:** Submerged and backwatered outlet **(Anderson, 2018)**

## 12 FINANCIAL SUMMARY

The final cost came in at $18,473.47 approximately $450.00 less than the project proposal estimate of $18,920 (Appendix G). These costs are broken down into professional services, overhead, equipment/materials/supplies, travel costs, and permitting (Table 13).

In-kind services included the use of Michell's excavator and clay fill from SHAS along with monetary contributions from the PSF ($4,000) and Michell's ($3,500) totalling $7,500. The remaining expenditures of $10,973.47 were covered by BC MoTI's EEF budget allocated by senior biologist Sean Wong.

**Table 13: Summary of expenditures**

| | |
|---|---|
| Professional Services | |
| Executive Coordinator (50hrs @ $80/hr) | $ 5,720.00 |
| Stewardship Coordinator (12hrs @ $35/hr) | $ 420.00 |
| Assistant Coordinator (40hrs @ $32/hr) | $ 1,935.89 |
| Overhead | |
| Executive Coordinator - 5% GST | $ 286.00 |
| Assistant Coordinator - EI/CPP | $ 163.15 |
| Equipment/Materials/Supplies | |
| AllTerra (excavator) | $ 3,557.58 |
| Michell (rock) | $ 5,770.67 |
| PSS (pump rental) | $ 281.88 |
| PSS (fuel) | $ 75.37 |
| Travel | |
| PSS (mileage) | $ 237.93 |
| Permits | |
| PSS (fish salvage) | $ 25.00 |
| Summary of expenditures | |
| **TOTAL** | **$ 18,473.47** |

## 13 MAINTENANCE AND MONITORING

Maintenance of the riffles and spawning platforms is anticipated as the channel is unlikely to recruit similarly sized materials through fluvial processes. In order to facilitate maintenance activities, a surplus of both spawning gravel and cobble to boulder sized rocks have been stockpiled in the riparian area adjacent to the restoration works. Although costs are expected to be minimal as rock placement will occur by hand, any future funding is anticipated from BC MoTI's Environmental Programs. Labour will be performed by Andrew Anderson and supporting in-kind contributions.

Monitoring is anticipated in both the spring and fall months for the years 2019 through 2023 both upstream and downstream of the culvert outlet where Ron Ptolemy indicated the extremely high fish per unit area relative to other Vancouver Island streams (Boeckh personal commmunication with Ron Ptolemy, 2003). Spring monitoring is aimed at capturing newly emerged fry to determine which species are spawning in this reach. Fall monitoring is aimed at identifying which salmonids are spawning in the Creek, and if they are able to pass through the culvert. Fish salvage for these activities comes at no cost and only requires provincial permitting (no DFO permits required) if the works are performed by the province (Wong, Pers. communication, 2019). Labour and additional materials will be supported from in-kind contributions and BC MoTI's Environmental Programs.

Outplanting of appropriate Coho (*Oncorhynchus kisutch*) stock (sourced from the Goldstream Volunteer Salmonid Enhancement Association) may be required if the native populations are severely depressed or extirpated (Wong, Pers. communication, 2019). Proper outplanting can be a means to help re-build and establish populations with the goal of naturally sustaining runs (Wong, Pers. communication, 2019). It is possible that outplanted Coho (*O. kisutch*) have adipose fin clips that would make them visible for 2020 returns and beyond (Wong, Pers. communication, 2019).

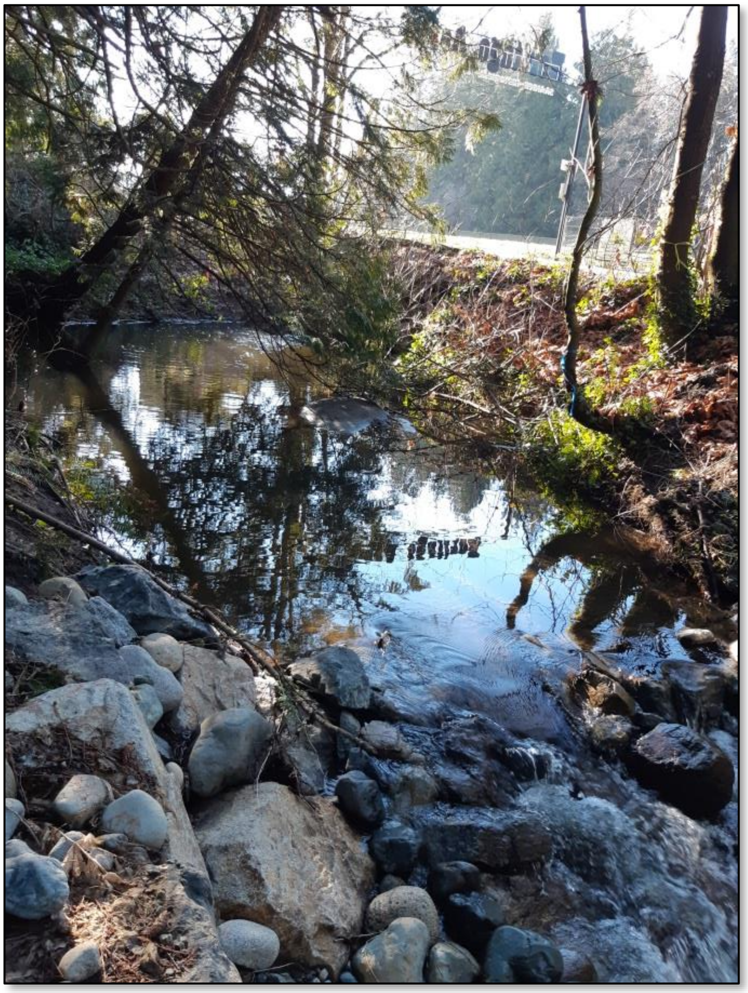


**Figure 28:** January 2019 - standing on the right bank looking upstream towards culvert at pool habitat created from the first/upstream riffle crest four months after construction **(Anderson, 2018)**

## 14 REFERENCES

Anderson, A. (2018). Field Photos.

BC Ministry of Environment. (1985). *Soils of Southern Vancouver Island.* Victoria.

BC Ministry of Environment. (2011, August). Protocol for Fish Passage Determination of Closed Bottomed Structures. Victoria, BC, Canada.

BC Ministry of Environment. (2018). *Water Sustainability Act*. Retrieved from Water Sustainability Regulation: http://www.bclaws.ca/civix/document/id/complete/statreg/36_2016

BC Ministry of Environment. (n.d.). *BC Species and Ecosystems Explorer*. Retrieved from http://a100.gov.bc.ca/pub/eswp/

BC Ministry of Environment. (N.D.). *Habitat Wizard - Fish Presence Check*. Retrieved from http://maps.gov.bc.ca/ess/hm/habwiz/

BC Ministry of Forests and Ministry of Environment, Lands, and Parks. (1996). *Channel Assessment Procedure Field Guidebook.* Forest Practices Code.

BC Ministry of Forests, Lands, and Natural Resource Operations. (n.d.). *Remote Access to Archeological Data (RAAD)*. Retrieved from https://www.for.gov.bc.ca/archaeology/accessing_archaeological_data/RAAD_overview.htm

BC Ministry of Forests, Lands, Natural Resources and Rural Development and the Department of Fisheries and Oceans. (2012). Fish-stream Crossing Guidebook. BC: Crown Publications, Queen's Printer.

BC Ministry of Transportation and Infrastructure. (2007). *BC Supplement to TAC Geometric Design Guide.*

BC Ministry of Transportation and Infrastructure. (2013). Culverts and Fish Passage.

BC Ministry of Transportation and Infrastructure. (2018). *Module 10: Environmental Best Practices For Highway Maintenance Activities.* Retrieved from BCIT Road Area Manager Course Updates.

Boeckh, R. (2004). *Towards Resolving the Conflict Between Public and Private Interests in the Management of Sandhill Creek.* M.A. Thesis.

Boeckh, R. A. (2003, 09 23). Boeckh personal commmunication with Ron Ptolemy.

Bruce, I. (2018). (A. Anderson, Interviewer)

Chow, V. T. (1959). *Open Channel Hydraulics.* New York, NY: McGraw-Hill.

Coulson, C. H., & Obedkoff, W. (1998). *BC Streamflow Inventory.* BC Ministry of Environment, Lands and Parks.

Goodrich, R. H., Watson, R. J., Cramp, L. R., Gordos, A. M., & Franklin, E. C. (2018). Making culverts great again: efficacy of a common culvert remediation strategy across sympatric fish species. *Ecological Engineering*, 143-153.

Google Earth. (2018). Satellite Imagery. BC.

Government of Canada. (2014, December 21). *Engineering Climate Dataset*. Retrieved from ftp://ftp.tor.ec.gc.ca/Pub/Engineering_Climate_Dataset/IDF/

Government of Canada. (2018). *Real-Time Hydrometric Data*. Retrieved from Water Survey of Canada: https://wateroffice.ec.gc.ca/search/real_time_e.html

iMapBC. (N.D.). *Spatial Tools*. Retrieved from https://arcmaps.gov.bc.ca/ess/hm/imap4m/

International Organization for Standardization. (2017). Geotechnical investigation and testing - Identification and classification of soil - Part 1: Identification and description. *ISO 14688-1*.

Lane, E. W. (1955). Design of Stable Channels. *ASCE Transactions 120*, 1234-1279.

Merriam-Webster. (2018). *Salmonid*. Retrieved from Dictionary: https://www.merriam-webster.com/dictionary/salmonid

Montgomery, D. R., & Buffington, J. M. (1998). *Channel Processes, Classification, and Response.* River Ecology and Management.

NC State University. (1999). *Natural Stream Processes - River Course.*

Newbury, R. W., Gaboury, M. N., & Bates, D. J. (1996). Constructing Riffles and Pools in Channelized Streams. *European Center for River Restoration 96.* Silkeborg, Denmark.

Newbury, R. W., Gaboury, M. N., & Bates, D. J. (1997). In L. a. Ministry of Environment, *Fish Habitat Rehabilitation Procedures* (pp. 12-11).

Nuszdorfer, F. C., Klinka, K., & Demarchi, D. A. (1991). *Ecosystems of British Columbia: Chapter 5.* Victoria, BC: Ministry of Forests.

RTAC. (1982). *Drainage Manual*. Ottawa: Roads and Transportation Association of Canada.

Thompson, D. M. (2018). Pool-Riffle Sequences. *Reference Module in Earth Systems and Environmental Sciences*.

Transportation Association of Canada. (1982). *Drainage Manual Volume 1.* Ottawa.

Tsawout First Nations. (2019). *About Tsawout First Nations*. Retrieved from http://www.tsawout.com/about-tsawout

U.S. Department of Agriculture. (1986). *Urban Hydrology for Small Watersheds TR-55.*

University of Western Ontario. (2018). *IDF_CC Tool 3.0*. Retrieved August 2018, from Computerized Tool for the Development of Intensity-Duration-Frequency Curves under Climate Change – Version 3.0: http://www.idf-cc-uwo.ca/

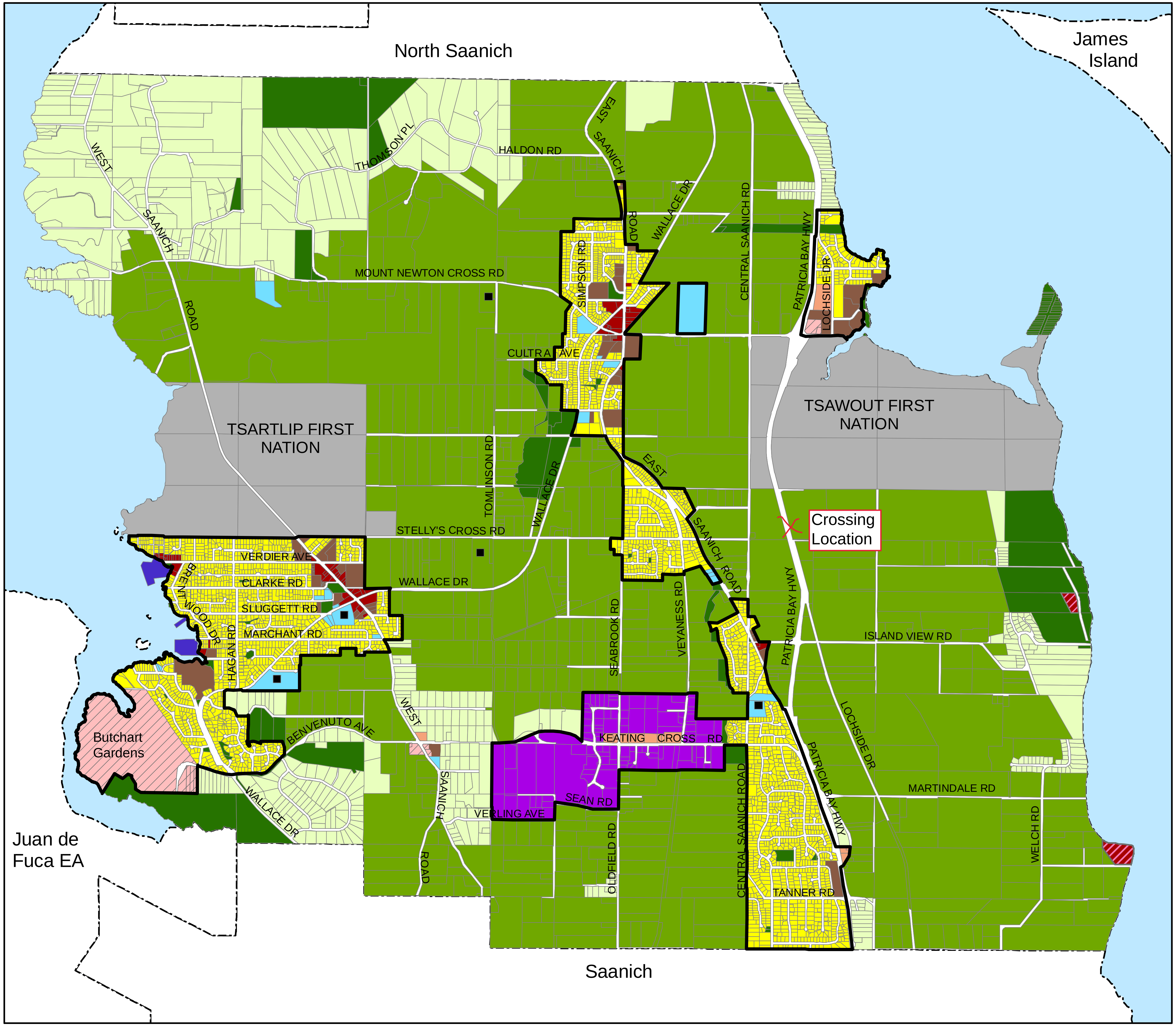
Wong, S. (2018). Design of Restoration Precription at Tetayut Creek.

Wong, S. (2018). Use of Baffles in Culvert Retrofits.

Wong, S. (2019). Pers. communication. (A. P. Anderson, Interviewer)

# APPENDIX A

[CENTRAL SAANICH OFFICIAL COMMUNITY PLAN]



# Central Saanich Official Community Plan

## Schedule A: Land Use Plan

## Legend

- Urban Settlement Area Boundary
- 🟨 Residential
- 🟫 Multi-Family Residential
- ▨ Rural
- 🟩 Park
- 🟩 Agricultural
- 🟥 Commercial/Mixed-Use
- ▨ Temporary Commercial
- 🟧 Arterial Commercial
- ▨ Tourist Commercial
- 🟪 Industrial
- 🟦 Marina
- 🟦 Civic/Institutional
- ⬜ First Nations Lands
- ■ School

N

Kilometers

0 0.4 0.8 1.2 1.6 2

Adopted: November 3, 2008
Amended: January 11, 2010 - Bylaw no. 1671
October 4, 2010 - Bylaw no. 1714
January 21, 2013 - Bylaw no. 1786
December 16, 2013 - Bylaw No. 1792
June 16, 2014 - Bylaw No. 1836

# APPENDIX B

[TOPOGRAPHIC SURVEY]

# KEY MAP

N.T.S.

## NOTES

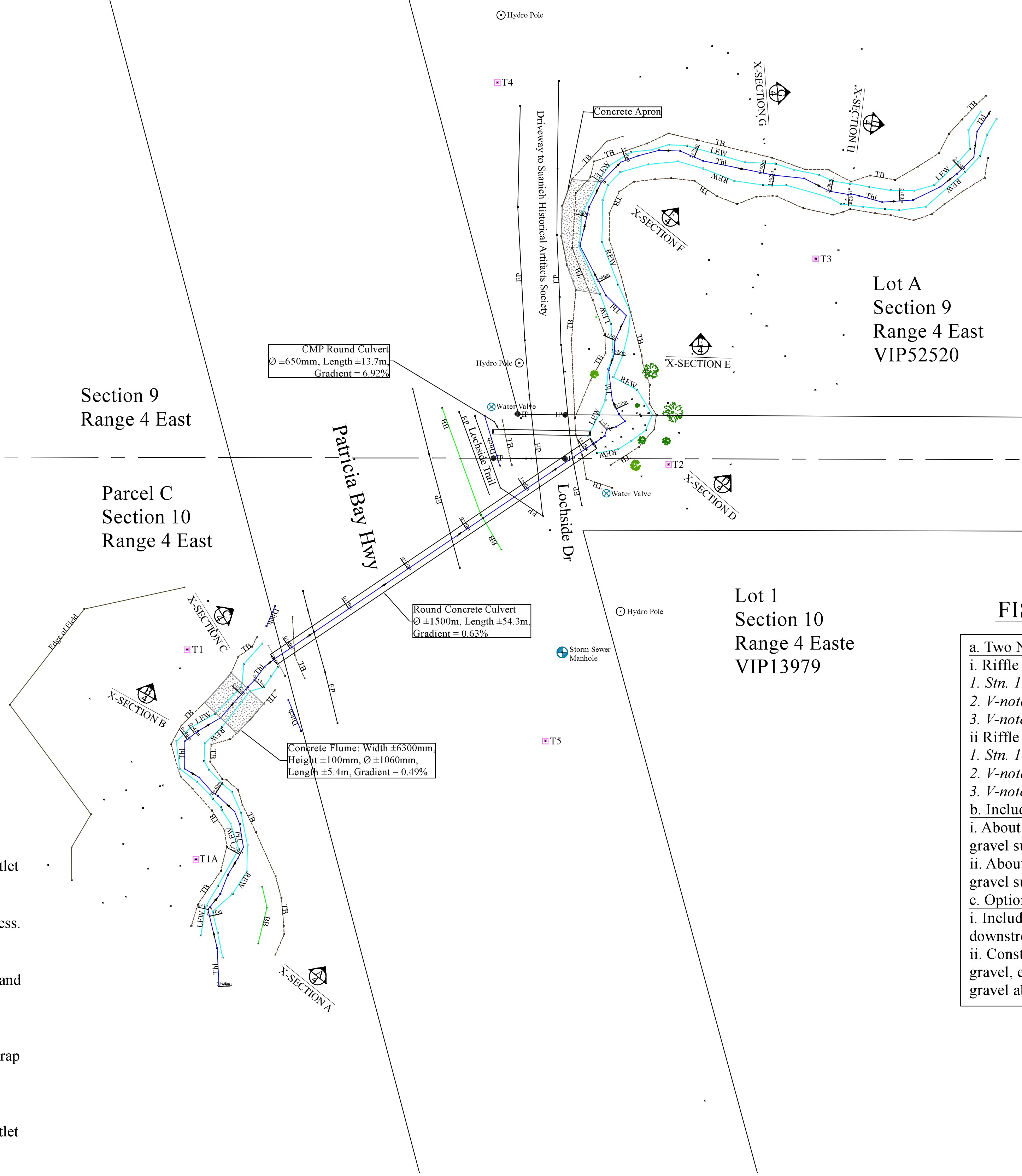
1. All elevations and dimensions are in meters and decimals thereof unless otherwise noted.
2. Horizontal bearings are derived from Plan VIP70820, Reference Plan of Part of: Lot A, Section 9, Range 4 East, South Saanich District, Plan VIP52520.
3. Northing, Easting and Elevation are assumed. Traverse Hub T1 set at N 1000.000m, E 1000.000m, Elevation 100.000m. T1 is a 250mm length of rebar.

Topographic surveys were carried out in Apr. 18-19 2018 by Kiara Robertson and Andrew Anderson.

## COMMENTS

a. Works will be done and field layout by or under the supervision of a fish habitat restoration specialist.
b. Use durable clean angular riprap 0.7-0.8mØ along crest of Riffle 1 – because of extreme velocities at culvert outlet the rock along Riffle Crest 1 is upsized for stability to account for increased scour and erosion risk.
c. Use durable clean angular riprap 0.5-0.7mØ along toe of Riffle 1 and crest and toe of Riffle 2.
d. Use durable clean angular riprap 0.3-0.6mØ in core and along banks of riffles a minimum of 0.5m riprap thickness.
e. Seal voids of riprap with fluvial materials, such as pitrun gravel, containing sand to boulders.
f. Create a v-notch low flow thalweg within the middle 1/3 of channel.
g. Complex riffle surface using partially embedded with rocks 0.5-0.6m Ø partially exposed sticking (embedment and exposures about 1/3 to 2/3 of Ø) for additional roughness and complexity.
h. Remove and replace concrete armour as necessary for riffle construction.
i. Avoid placement of riprap into pools, and only use along pools for woody debris revetments or if evidence of excessive erosion and scour (e.g. along road embankment along culvert) to maintain pool habitat and excessive riprap use.
j. Fill and plant riprap along banks with native live cuttings and shrubs, and incorporate growing medium above bankfull height, such as gravel and soil mix into voids.
k. Use durable clean angular riprap 0.7-0.8mØ along crest of Riffle 1 – because of extreme velocities at culvert outlet the rock along Riffle Crest 1 is upsized for stability to account for increased scour and erosion risk.

Fish Passage Restoration Prescription,
Sean Wong, May 8, 2017



N

## LEGEND

| | |
|---|---|
| LEW | Left edge water |
| REW | Right edge water |
| Thl | Thalweg |
| ➘ | Flow direction |
| × | Spot elevation |
| TB | Top bank |
| BB | Bottom bank |
| EP | Edge of pavement |
| ◕ | Storm Sewer Manhole |
| ⊗ | Water Valve |
| ○ | Hydro pole |
| ▫ T2 | Traverse hub |
| ✿ | Cedar |
| ✿ | Maple |
| ▨ | Concrete |
| ● IP | Iron pin |
| — | Legal boundary |

## FISH PASSAGE RESTORATION DESIGN

a. Two Newbury Rock Riffles
i. Riffle 1
*1. Stn. 121 to 137*
*2. V-notch of crest at 97.25m (raising outlet grade about 0.75m)*
*3. V-notch of toe at 96.5m*
ii Riffle 2
*1. Stn. 150 to 159*
*2. V-notch of crest at 96.6m (raising outlet grade about 0.75m)*
*3. V-notch of toe at 96.15m*
b. Include Spawning Platforms
i. About 1m long upstream of Riffle 1 about 0.4-0.5m deept of gravel with gravel surface about 97.1m± i.e. 15cm below riffle crest 97.25m
ii. About 2m long upstream of Riffle 2 about 0.4-0.5m deep of gravel with gravel surface about 96.45m± i.e. 15cm below riffle crest 96.6m
c. Optional
i. Include anchored woody debris in pools upstream of Riffles 1 and 2 and downstream of Riffle 2
ii. Construct additional spawning platforms e.g. if existing undesirable gravel, excavate material around Stn 166 to 180 and backfill with spawning gravel about 0.4-0.5m deep

SCALE 1:750
0 7.5 15 30

K. Robertson, AScT,
Environmental Technologist
Survey & Drafting

2658 Hay Rake Road
Nanaimo, B.C., V9R 6W7

kiara.robertson87@gmail.com

Drawn by: K.R. | DATE: May. 14, 2018 | Approved by: S.W.

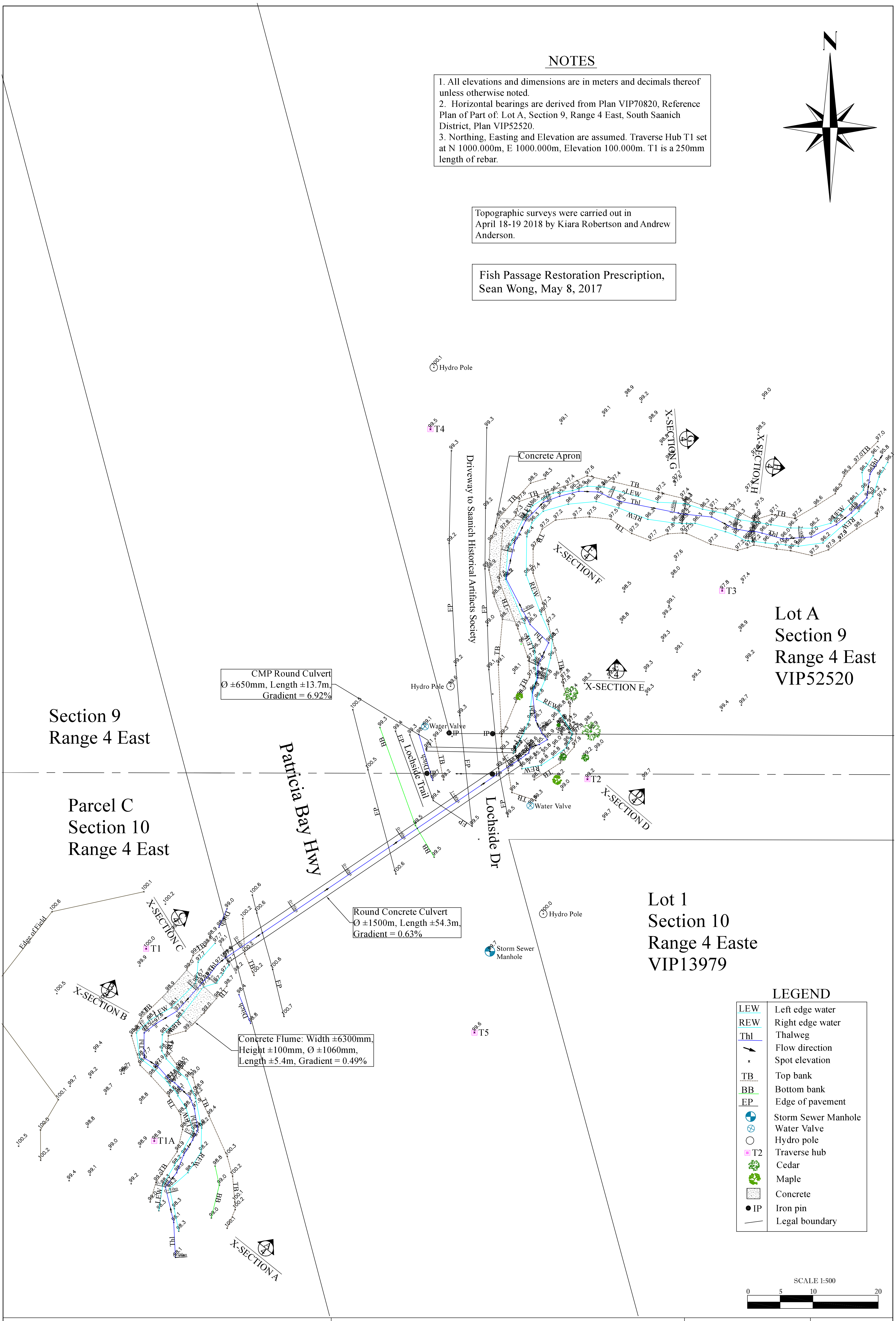
Tetayut/Sandhill Creek Culvert Replacement and Creek Restoration - Overall Plan View - Draft for Discussion

For M.O.T Environmental Management - Sean Wong, Senior Biologist

BRITISH COLUMBIA
Ministry of Transportation and Infrastructure

DWG. No: 2018-05-04
PAGE 1 OF 6
REVISION NO. 1

FILE NAME: TETAYUT_SANDHILL CREEK PLAN_PROFILE MAY 14_2018.DWG



## NOTES

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Topographic surveys were carried out in April 18-19 2018 by Kiara Robertson and Andrew Anderson.

Fish Passage Restoration Prescription, Sean Wong, May 8, 2017

CMP Round Culvert
Ø ±650mm, Length ±13.7m,
Gradient = 6.92%

Round Concrete Culvert
Ø ±1500m, Length ±54.3m,
Gradient = 0.63%

Concrete Flume: Width ±6300mm,
Height ±100mm, Ø ±1060mm,
Length ±5.4m, Gradient = 0.49%

## LEGEND

| | |
|---|---|
| LEW | Left edge water |
| REW | Right edge water |
| Thl | Thalweg |
| ➘ | Flow direction |
| × | Spot elevation |
| TB | Top bank |
| BB | Bottom bank |
| EP | Edge of pavement |
| ◕ | Storm Sewer Manhole |
| ⊗ | Water Valve |
| ○ | Hydro pole |
| ▪ T2 | Traverse hub |
| ✿ | Cedar |
| ✿ | Maple |
| ▨ | Concrete |
| ● IP | Iron pin |
| — | Legal boundary |

Kiara Robertson, AScT - Environmental Technologist
Survey & Drafting

2658 Hay Rake Road
Nanaimo, B.C., V9R 6W7
kiara.robertson87@gmail.com

Drawn by: K.R.
DATE: May 14, 2018

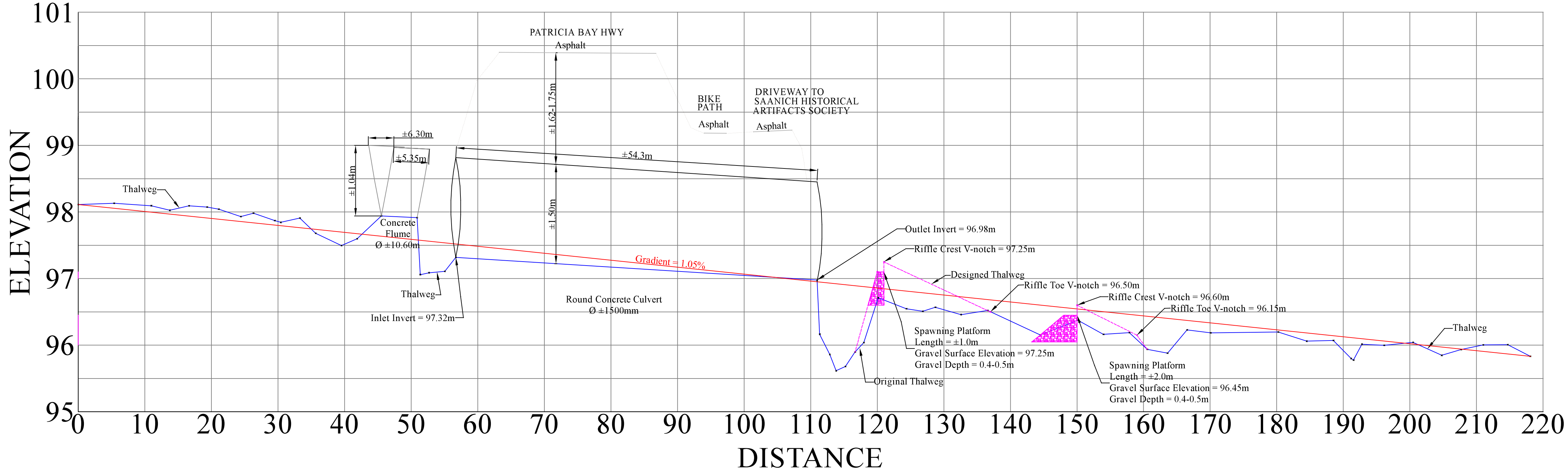
# Emily Creek Culvert Replacement and Creek Restoration - Highway 19A/Walker Road Crossings - Draft Version

For M.O.T Environmental Management
Sean Wong, Senior Biologist

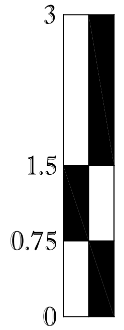
DWG. No: 2018-05-04
PAGE 2 OF 6
REVISION NO. 1

FILE NAME: TETAYUT_SANDHILL CREEK PLAN_PROFILE MAY 14_2018.DWG

# TETAYUT/SANDHILL CREEK PROFILE



ELEVATION
SCALE 1:75



## SCALE

HORIZONTAL 1:750
VERTICAL 1:75

K. Robertson, AScT,
Environmental Technologist
Survey & Drafting
2658 Hay Rake Road
Nanaimo, B.C., V9R 6W7
kiara.robertson87@gmail.com

Drawn by: K.R.
DATE: May 14, 2018
Approved by: S.W.

Tetayut/Sandhill Creek Culvert Replacement and Creek Restoration - Profile - Draft for Discussion

For M.O.T Environmental Management - Sean Wong, Senior Biologist

BRITISH COLUMBIA
Ministry of Transportation and Infrastructure

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PAGE 3 OF 6
REVISION NO. 1

FILE NAME: TETAYUT_SANDHILL CREEK PLAN_PROFILE MAY 14_2018.DWG

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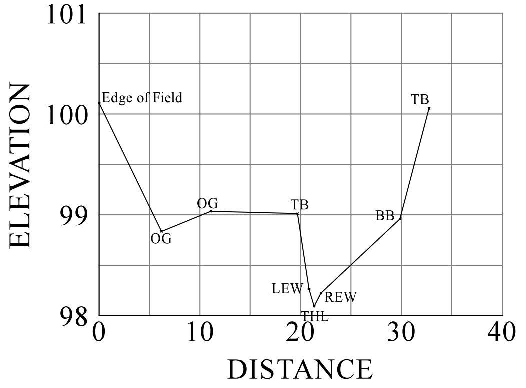
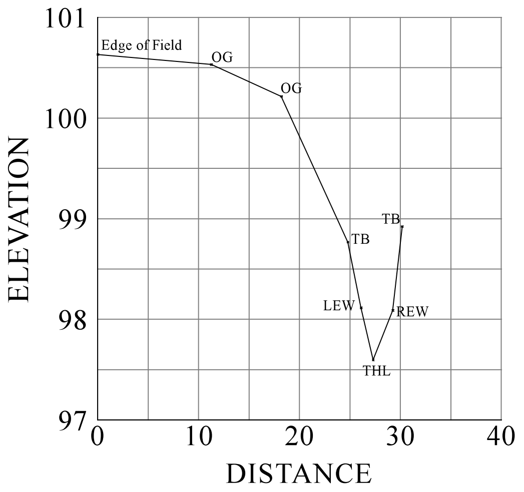
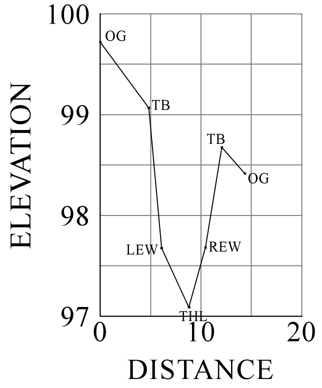


## STATION 0+41, X-SECTION B



## STATION 0+53, X-SECTION C



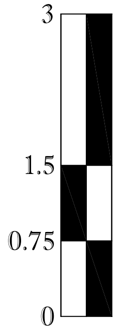
## LEGEND

| | |
|---|---|
| OG | ORIGINAL GROUND |
| LEW | LEFT EDGE WATER |
| REW | RIGHT EDGE WATER |
| TB | TOP BANK |
| BB | BOTTOM BANK |
| THL | THALWEG |

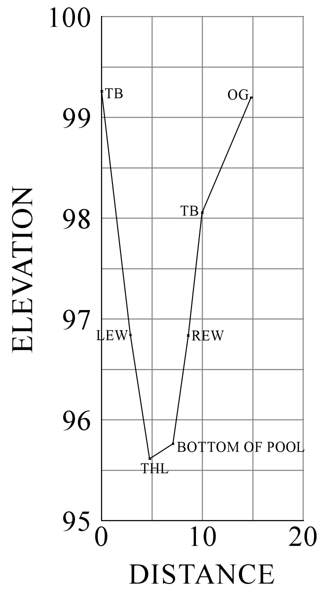
## SCALE

HORIZONTAL 1:750
VERTICAL 1:75

ELEVATION
SCALE 1:75



## STATION 1+15, X-SECTION D



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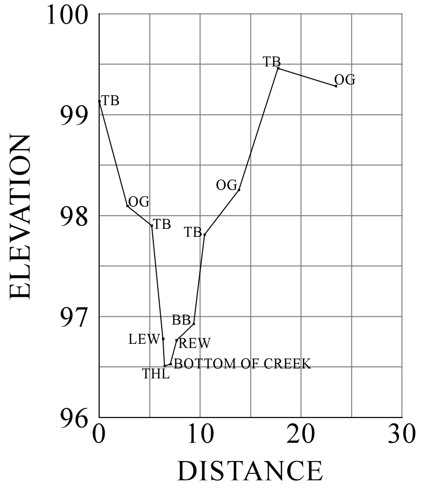

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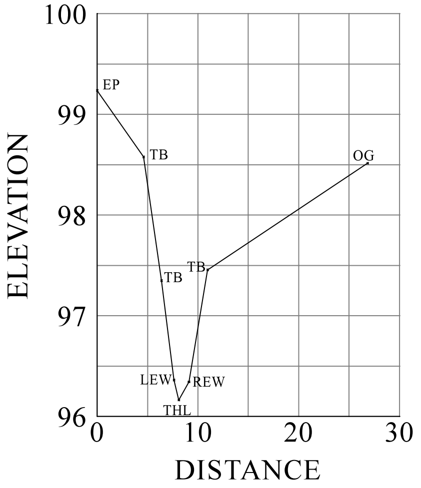

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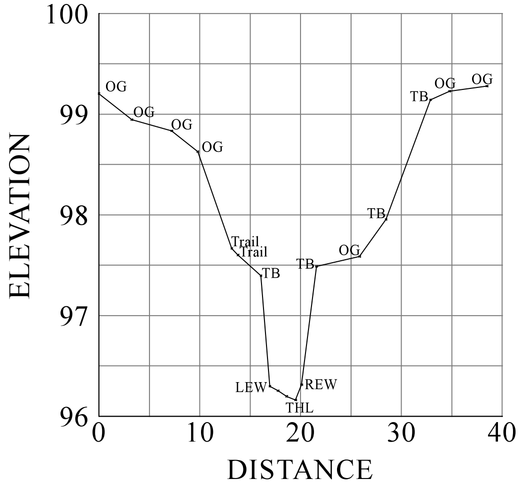

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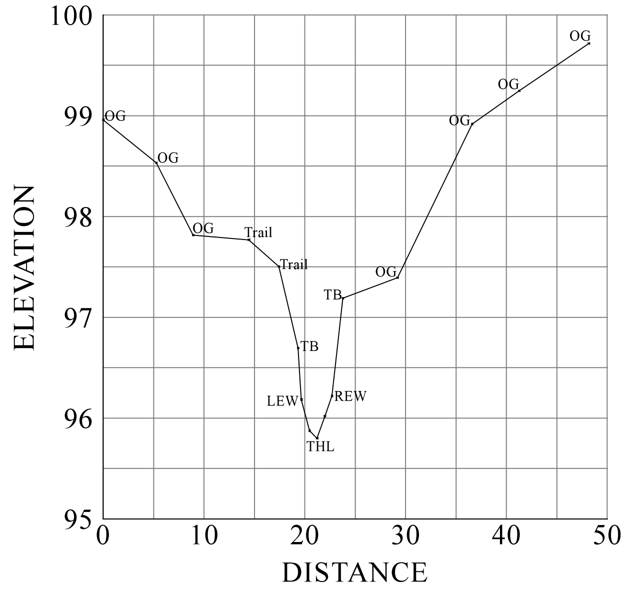

2658 Hay Rake Road
Nanaimo, B.C., V9R 6W7

K. Robertson, AScT,
Environmental Technologist
Survey & Drafting

kiara.robertson87@gmail.com

Drawn by: K.R.

DATE: May 14, 2018

Approved by: S.W.

### Tetayut/Sandhill Creek Culvert Replacement and Creek Restoration - Mainstem X-Sections - Draft for Discussion

### For M.O.T Environmental Management - Sean Wong, Senior Biologist

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REVISION NO. 1


Corner Upstream of Concrete Flume - Facing Upstream


Upstream end of Concrete Flume - Facing Downstream


Downstream end of Concrete Flume


Location of T1


View towards Highway from T1


Inlet

View Facing North towards Entrance of SHAS and Lochside Trail


Outlet


Outlet Pool


Location of T2


View towards Road from T2


View towards Outlet from T2

K. Robertson, AScT,
Environmental Technologist
Survey & Drafting

2658 Hay Rake Road
Nanaimo, B.C., V9R 6W7

kiara.robertson87@gmail.com

Drawn by: K.R.
DATE: May 14, 2018
Approved by: S.W.

## Tetayut/Sandhill Creek Culvert Replacement and Creek Restoration - Photos - Draft for Discussion

## For M.O.T. Environmental Management - Sean Wong, Senior Biologist

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PAGE 5 OF 6
REVISION NO. 1

FILE NAME: TETAYUT_SANDHILL CREEK PLAN_PROFILE MAY 14_2018.DWG


View facing downstream from T2


Concrete Apron - Facing Upstream


Downstream of Corner below Concrete Apron - Facing Downstream


View Facing Upstream from T3

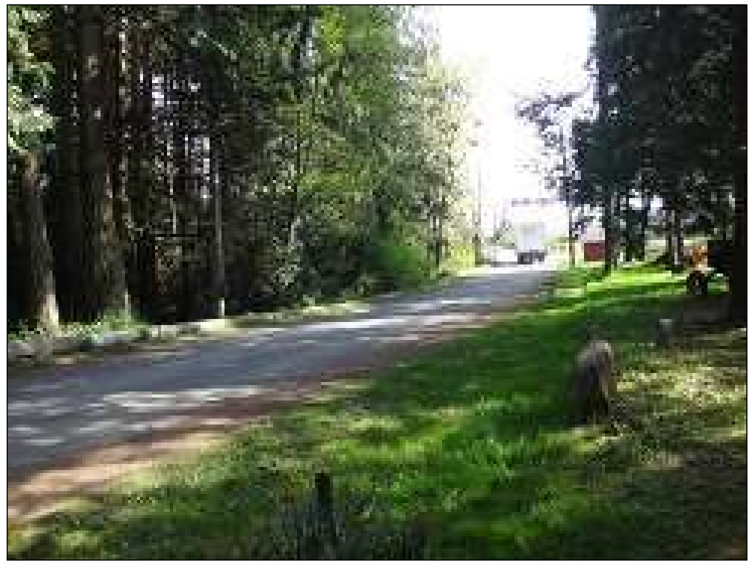

View Facing Towards Creek from T3


Riffle at X-Section H


Corner Downstream of T3 - Facing Downstream


Downstream Extent of Survey - Facing Downstream


Location of T4


View from T4 - Facing South


View towards Creek from T4


View from T5 - Facing North

K. Robertson, AScT,
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2658 Hay Rake Road
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PAGE 6 OF 6
REVISION NO. 1

# APPENDIX C

[CBS FIELD FORM (BC MINISTRY OF ENVIRONMENT, 2011)]

Appendix 1: Closed Bottom Structure (CBS) Field Measurement Form

# Closed Bottom Structure (CBS) Field Measurement Form

## Location and Overview Data

| | | | |
|---|---|---|---|
| *Date of Assessment* | May 14, 2018 | | |
| *PSCIS Crossing ID* *(only needed if this is a re-assessment)* | NA | | |
| *My Crossing Reference* | @ SHAS entrance | | |
| *Crew Members* | Andrew Anderson | | |
| *UTM/GPS (NAD 83)* | ~~*Zone*~~<br>(lat | ~~*Easting*~~<br>long) | ~~*Northing*~~ |
| | = (48.5797°, | | -123.3986°) |
| *Stream Name* | Tetayut (sandhill) Creek | | |
| *Road Name* | Pat Bay Hwy (#17) | | |
| *Road Km Mark* | NA | | |
| *Road Tenure* | MOTI | | |

## Stream Information

| | | | |
|---|---|---|---|
| *Channel Width* *Stream Width Ratio* | *Avg. Channel Width* (m) | *Culvert Dia.* (m) | *SWR* |
| | 5 | 1.5 | 3.3 |
| *Stream Slope (%)* | 1.05% | | |
| *Beaver Activity* | *Yes* [✓ *No*] | | |
| *Fish Sighted?* | [✓ *Yes*] *No* | | |
| *Valley Fill* | *DF* [✓ *SF*] *BR* | | |
| *Habitat Value* | *Low* *Medium* [✓ *High*] | | |

## Field Observations and Assessment Measurements

| | | | |
|---|---|---|---|
| *Crossing Type* | *OBS* [✓ *CBS*] *Other* | | |
| *Crossing Subtype* | *Bridge, Pipe Arch, Wood Box Culvert,* [✓ *Round Culvert,*] *Oval Culvert, Concrete Box, Ford* | | |
| *Culvert Diameter or Span for OBS (m)* | ~~150~~ 1.5m | | |
| *Culvert Length or Width for OBS (m)* | 54.3m | | |
| *Continuous Embeddedment?* | *Yes* [✓ *No*] | | |
| *If Embedded, Average Depth of Embeddedment* | *Inlet*<br>0 *m* | *Outlet*<br>0 *m* | *Average*<br>0 *m* |
| *Resemble Channel?* | *Yes* [✓ *No*] | | |
| *Backwatered?* | *Yes* [✓ *No*] | | |
| *If Backwatered, to what Percentage* | NA | | |
| *Fill Depth (m)* | 1.62m to 1.75m | | |
| *Outlet Drop (A+B)* | *Invert-ToP (A)* = 38cm | *ToP – BoC (B)* = 2cm | *OD* (cm) |
| | 96.98 – 96.6 | 96.6 – 96.58 | 40cm |
| *Outlet Pool Depth (m) (C-B)* | *ToP –BoP (C)* | *ToP – BoC (B)* | *OPD* (m) |
| | 96.6 – 95.6 | 96.6 – 96.58 | 1.02m |
| *Inlet drop* | *Yes* [✓ *No*] | | |
| *Culvert Slope (%)* | 0.63% | | |

## Recommendations

| | |
|---|---|
| *Culvert Fix* | *RM OBS SS ASM* [✓ *BW*] |
| *Recommended Diameter or Span (m)* | NA |

Comments:

**Fish Barrier Scoring[1]**

| Risk | Embedded[2] | value | (40cm)<br>Outlet drop | value | (0.63%)<br>Slope | value | $(\frac{5}{1.5})$<br>SWR | value | (54.3m)<br>Length | value |
|---|---|---|---|---|---|---|---|---|---|---|
| low | > 30 cm. or > 20% of Diameter and continuous | 0 | < 15 | 0 | < 1 | [✓ 0] | < 1.0 | 0 | < 15 | 0 |
| mod | < 30 cm. or 20% of Diameter but continuous | 5 | 15 - 30 | 5 | 1 - 3 | 5 | 1.0 - 1.3 | 3 | 15 – 30 | 3 |
| high | No embeddment or discontinuous | [✓ 10] | > 30 | [✓ 10] | > 3 | 10 | > 1.3 | [✓ 6] | > 30 | [✓ 6] |

Total = 32
∴ barrier

*Notes*

1. For the barrier determination of multiple culverts, use the metrics from the pipe lowest in elevation at the outlet. For pipes installed at the same elevation at the outlet, add diameters for SWR criteria and use the highest slope, and length measurement.

2 Properly embedded culverts are considered passable as per natural stream channel. No further consideration of other surrogates is required.

| Cumulative Score | Result |
|---|---|
| 0 - 14 | passable |
| 15 - 19 | potential barrier |
| [✓ > 20] | [✓ barrier] |

# APPENDIX D

[STREAM REPORT 920-140700]

# Ministry of Environment

## HABITAT WIZARD STREAMS REPORT

Jan. 17, 2019

## WATERBODY INFORMATION

| | |
|---|---|
| Name: | SANDHILL CREEK |
| Alias: | SHADY CREEK |
| Alias (2): | |
| UTM Co-ordinate (Stream Mouth): | UTM: 10 470913, 5382283 |
| Primary Mapsheet: | 092B11 |
| Primary Region: | Vancouver Island |
| Watershed Code: | 920-140700 |
| Waterbody Identifier: | 00000VICT |
| Stream Length (m): | 5.5 |
| Stream Order: | 2 |
| Stream Magnitude: | 3 |

## SPECIES PRESENT

| FISH SPECIES | LAST KNOWN OBSERVATION DATE |
|---|---|
| Chum Salmon | 01-JAN-87 |
| Coho Salmon | 26-APR-12 |
| Cutthroat Trout | 12-DEC-12 |
| Cutthroat Trout (Anadromous) | 02-APR-84 |
| Fish Unidentified Species | 22-MAY-80 |
| Prickly Sculpin | 11-MAR-81 |
| Pumpkinseed | 11-MAR-81 |
| Sculpin (General) | 26-APR-12 |
| Steelhead | 01-JAN-68 |
| Stickleback (General) | 26-APR-12 |
| Threespine Stickleback | 26-APR-12 |

## STOCKING INFORMATION

| DATE | SPECIES | RELEASED | STOCK | LIFE STAGE | HATCHERY |
|---|---|---|---|---|---|
| 02-APR-84 | Cutthroat Trout (Anadromous) | 954 | SANDHILL | FRY | Vancouver Island Hat |
| 01-APR-83 | Cutthroat Trout (Anadromous) | 6 | SANDHILL | ADULT | Vancouver Island Hat |
| 01-APR-83 | Cutthroat Trout (Anadromous) | 1 | SANDHILL | ADULT | Vancouver Island Hat |
| 01-APR-83 | Cutthroat Trout (Anadromous) | 2 | SANDHILL | ADULT | Vancouver Island Hat |
| 24-MAR-83 | Cutthroat Trout (Anadromous) | 2724 | SANDHILL | SMOLT | Vancouver Island Hat |
| 01-MAR-83 | Cutthroat Trout (Anadromous) | 1 | SANDHILL | ADULT | Vancouver Island Hat |
| 01-MAR-83 | Cutthroat Trout (Anadromous) | 17 | SANDHILL | ADULT | Vancouver Island Hat |

| | | | | | |
|---|---|---|---|---|---|
| 02-APR-82 | Cutthroat Trout (Anadromous) | 2349 | SANDHILL | SMOLT | Vancouver Island Hat |
| 30-MAR-82 | Cutthroat Trout (Anadromous) | 2794 | SANDHILL | SMOLT | Vancouver Island Hat |
| 06-APR-81 | Cutthroat Trout (Anadromous) | 1331 | SANDHILL | SMOLT | Vancouver Island Hat |
| 30-MAR-81 | Cutthroat Trout (Anadromous) | 3417 | SANDHILL | SMOLT | Vancouver Island Hat |

## OBSTRUCTIONS

| DESCRIPTION | HEIGHT | LENGTH | COMMENTS |
|---|---|---|---|
| Culvert | | | |
| Dam | 0 | 0 | (ACCESS TO REST OF MAINSTEM IS BLOCKED BY A SERIES OF DAMS NEAR KEATING CROSS ROAD REF# = 19-2) |
| Dam | | | (ACCESS TO REST OF MAINSTEM IS BLOCKED BY A SERIES OF DAMS NEAR KEATING CROSS ROAD REF# = 19-2) |
| Dam | 0 | 0 | |
| Dam | | | |
| Log jam | 0 | 0 | (PASSIBLE WINDFALLS THROUGHOUT (1975) REF# = 19-1) |
| Log jam | 0 | 0 | |
| Logs | | | (PASSIBLE WINDFALLS THROUGHOUT (1975) REF# = 19-1) |
| Logs | | | |
| Persistent Debris | | | |

## ONLINE WATER LEVELS

| REFERENCE URL |
|---|
| |

This water body has online water level information available from Environment Canada and the Province of BC. Use the link(s) above to go directly to the station information on the BC River Levels website.

## WATER QUANTITY INFORMATION

The most current water survey information is available from the following Water Survey of Canada wel

http://scitech.pyr.ec.gc.ca/waterweb/selectProvin provides access to real-time water station in

http://www.wsc.ec.gc.ca/hydat/H2 provides access to archived water station information

## REFERENCES

| REFERENCE ID | REFERENCE TITLE |
|---|---|
| 14-35 | B.C. MOELP Fish Stocking Records |

| | |
|---|---|
| 14-9 | MOELP Stream classification overview. |
| 19-1 | PRELIMINARY CATALOGUE OF SALMON STREAMS AND SPAWNING ESCAPEMENTS OF STATISTICAL AREAS 19 AND 20 (VICTORIA - SOOKE) PAC/D-77-9. |
| 19-11 | PERSONAL INFORMATION NOVEMBER, 1987. |
| 19-2 | SEA RUN CUTTHROAT TROUT IN THE GREATER VICTORIA AREA - THEIR PRESENT STATUS AND OPPORTUNITIES FOR ENHANCEMENT. |
| 19-4 | LAKES OF THE VICTORIA AREA; A CURSORY EVALUATION WITH SOME MANAGEMENT RECOMMENDATIONS. |
| 19-6 | LAKE AND STREAM INVENTORY OF THE CAPITAL REGION DISTRICT. (VICTORIA, B.C.) |
| 19-7 | PERSONAL INFORMATION ABOUT STREAMS WITHIN STATISTICAL AREA 19 BY FISHERIES OFFICER. APR.17,1986. |
| DFP001 | Addition of zones & points re: FISS maps for fish distribution for G.I.S. display purposes |
| NUSEDS-SUM | NUSEDS Database |
| RABOBST-SUM | RAB Obstructions |
| RABSVY-175150 | RAB / 092B11093A |
| RABSVY-175151 | RAB / 092B11094A |
| RABSVY-175152 | RAB / 092B11095A |
| RABSVY-175155 | RAB / 092B11097A |
| RABSVY-175156 | RAB / 092B11098A |
| RABSVY-175157 | RAB / 092B11099A |
| RABSVY-182069 | RAB / 092B11100A |
| RABSVY-182070 | RAB / 092B11101A |
| RABSVY-182072 | RAB / 092B11103A |
| REL-SUM | RELEASE Database |
| STLHD-SUM | STEELHEAD Database |
| WSCANDB | LIST OF ALL WATER SURVEY CANADA STATIONS IN B.C. AND YUKON, OCTOBER 1, 2000. |

## TRIBUTARY STREAMS

| 1:50,000 WATERSHED CODE | GAZETTED NAME | UTM | EASTING | NORTHING |
|---|---|---|---|---|
| 920-140700-04400 | Unnamed tributary - 00000VICT - 306240 | 10 | 470818 | 5382079 |
| 920-140700-21700 | Unnamed tributary - 00000VICT - 306241 | 10 | 470781 | 5381100 |

## STREAM SURVEY DATA

| | | | | | |
|---|---|---|---|---|---|
| **SURVEY DATE:** | **05/08/1983** | **AGENCY:** | | | |
| **Project Name:** | | | | | |
| **Mapsheet** | 092B11 | **Average Channel Width** | 4.1 | **Stream Order** | |
| **UTM Zone** | | **Width Measurements** | 1 | **Surveyed Length** | |
| **UTM Easting** | | **Relative Water Level** | | **Gradient (%)** | |
| **UTM Northing** | | **Water Temperature (C)** | 14 | **Conductivity** | |
| **Site Number** | 5 | **Intermittent Indicator** | | **No Visible Chan** | |
| **Source** | RAB | **Dewatering Indicator** | | | |

| | | | | | |
|---|---|---|---|---|---|
| **SURVEY DATE:** | **05/08/1983** | **AGENCY:** | | | |
| **Project Name:** | | | | | |
| **Mapsheet** | 092B11 | **Average Channel Width** | 4.1 | **Stream Order** | |
| **UTM Zone** | | **Width Measurements** | 1 | **Surveyed Length** | |
| **UTM Easting** | | **Relative Water Level** | | **Gradient (%)** | |
| **UTM Northing** | | **Water Temperature (C)** | 14 | **Conductivity** | |
| **Site Number** | 5 | **Intermittent Indicator** | | **No Visible Chan** | |
| **Source** | RAB | **Dewatering Indicator** | | | |

| | | | | | |
|---|---|---|---|---|---|
| **SURVEY DATE:** | **11/03/1981** | **AGENCY:** | | | |
| **Project Name:** | | | | | |
| **Mapsheet** | 092B11 | **Average Channel Width** | 5.7 | **Stream Order** | |
| **UTM Zone** | 10 | **Width Measurements** | 1 | **Surveyed Length** | |
| **UTM Easting** | 470835 | **Relative Water Level** | | **Gradient (%)** | |
| **UTM Northing** | 5382120 | **Water Temperature (C)** | 7.5 | **Conductivity** | |
| **Site Number** | 4 | **Intermittent Indicator** | | **No Visible Chan** | |
| **Source** | RAB | **Dewatering Indicator** | | | |

| | | | | | |
|---|---|---|---|---|---|
| **SURVEY DATE:** | **11/03/1981** | **AGENCY:** | | | |
| **Project Name:** | | | | | |
| **Mapsheet** | 092B11 | **Average Channel Width** | 5.7 | **Stream Order** | |
| **UTM Zone** | 10 | **Width Measurements** | 1 | **Surveyed Length** | |
| **UTM Easting** | 470835 | **Relative Water Level** | | **Gradient (%)** | |
| **UTM Northing** | 5382120 | **Water Temperature (C)** | 7.5 | **Conductivity** | |
| **Site Number** | 4 | **Intermittent Indicator** | | **No Visible Chan** | |
| **Source** | RAB | **Dewatering Indicator** | | | |

| | | | | | |
|---|---|---|---|---|---|
| **SURVEY DATE:** | **22/05/1980** | **AGENCY:** | | | |
| **Project Name:** | | | | | |
| **Mapsheet** | 092B11 | **Average Channel Width** | 5.1 | **Stream Order** | |
| **UTM Zone** | | **Width Measurements** | 1 | **Surveyed Length** | |
| **UTM Easting** | | **Relative Water Level** | | **Gradient (%)** | |
| **UTM Northing** | | **Water Temperature (C)** | 9.5 | **Conductivity** | |
| **Site Number** | 3 | **Intermittent Indicator** | | **No Visible Chanr** | |
| **Source** | RAB | **Dewatering Indicator** | | | |

| | | | | | |
|---|---|---|---|---|---|
| **SURVEY DATE:** | **22/05/1980** | **AGENCY:** | | | |
| **Project Name:** | | | | | |
| **Mapsheet** | 092B11 | **Average Channel Width** | 5.1 | **Stream Order** | |
| **UTM Zone** | | **Width Measurements** | 1 | **Surveyed Length** | |
| **UTM Easting** | | **Relative Water Level** | | **Gradient (%)** | |
| **UTM Northing** | | **Water Temperature (C)** | 9.5 | **Conductivity** | |
| **Site Number** | 3 | **Intermittent Indicator** | | **No Visible Chanr** | |
| **Source** | RAB | **Dewatering Indicator** | | | |

| | | | | | |
|---|---|---|---|---|---|
| **SURVEY DATE:** | **22/05/1980** | **AGENCY:** | | | |
| **Project Name:** | | | | | |
| **Mapsheet** | 092B11 | **Average Channel Width** | 2.8 | **Stream Order** | |
| **UTM Zone** | 10 | **Width Measurements** | 1 | **Surveyed Length** | |
| **UTM Easting** | 469980 | **Relative Water Level** | | **Gradient (%)** | |
| **UTM Northing** | 5380370 | **Water Temperature (C)** | 9 | **Conductivity** | |
| **Site Number** | 2 | **Intermittent Indicator** | | **No Visible Chanr** | |
| **Source** | RAB | **Dewatering Indicator** | | | |

| | | | | | |
|---|---|---|---|---|---|
| **SURVEY DATE:** | **22/05/1980** | **AGENCY:** | | | |
| **Project Name:** | | | | | |
| **Mapsheet** | 092B11 | **Average Channel Width** | 2.8 | **Stream Order** | |
| **UTM Zone** | 10 | **Width Measurements** | 1 | **Surveyed Length** | |
| **UTM Easting** | 469980 | **Relative Water Level** | | **Gradient (%)** | |
| **UTM Northing** | 5380370 | **Water Temperature (C)** | 9 | **Conductivity** | |
| **Site Number** | 2 | **Intermittent Indicator** | | **No Visible Chanr** | |
| **Source** | RAB | **Dewatering Indicator** | | | |

| | | | | | |
|---|---|---|---|---|---|
| **SURVEY DATE:** | **20/05/1980** | **AGENCY:** | | | |
| **Project Name:** | | | | | |
| **Mapsheet** | 092B11 | **Average Channel Width** | 2 | **Stream Order** | |
| **UTM Zone** | 10 | **Width Measurements** | 1 | **Surveyed Length** | |
| **UTM Easting** | 470555 | **Relative Water Level** | | **Gradient (%)** | |
| **UTM Northing** | 5380873 | **Water Temperature (C)** | 10 | **Conductivity** | |
| **Site Number** | 1 | **Intermittent Indicator** | | **No Visible Chann** | |
| **Source** | RAB | **Dewatering Indicator** | | | |

| | | | | | |
|---|---|---|---|---|---|
| **SURVEY DATE:** | **20/05/1980** | **AGENCY:** | | | |
| **Project Name:** | | | | | |
| **Mapsheet** | 092B11 | **Average Channel Width** | 2 | **Stream Order** | |
| **UTM Zone** | 10 | **Width Measurements** | 1 | **Surveyed Length** | |
| **UTM Easting** | 470555 | **Relative Water Level** | | **Gradient (%)** | |
| **UTM Northing** | 5380873 | **Water Temperature (C)** | 10 | **Conductivity** | |
| **Site Number** | 1 | **Intermittent Indicator** | | **No Visible Chann** | |
| **Source** | RAB | **Dewatering Indicator** | | | |

## ADDITIONAL INFORMATION

Please see the Fisheries Information Data Queries (FIDQ) for additional and more detailed queries of fish and fish habitat information: http://www.env.gov.bc.ca/fish/fidq/index

Please check the Ecological Reports Catalogue (EcoCat) for reference material and data that is available for online distribution: http://www.env.gov.bc.ca/ecocat/

# APPENDIX E

[BCMOTI DESIGN CRITERIA SHEET FOR CLIMATE CHANGE RESILIENCE]

# *Appendix E (as per Technical Circular T-06/15)*

## BCMoTI Design Criteria Sheet for Climate Change Resilience
## Highway Infrastructure Design Engineering and Climate Change Resilience
## Ministry of Transportation and Infrastructure
## (Separate Criteria Sheet per Discipline)

| | |
|---|---|
| Project: | Tetayut Creek Restoration |
| Type of work: | Estimate discharge for Newbury style riffle construction |
| Location: | District of Central Saanich, BC |
| Discipline: | Hydrology / River Engineering |

1. Is this project within an area subject to extreme weather events? If so, what type of extreme weather events?
2. What applicable elements of the project design or infrastructure may be vulnerable, or at most risk to extreme weather events?
3. What projections or analyses have been completed to assess the potential impact of applicable extreme weather events?
4. What project design strategies or criteria/parameter modifications have been incorporated into the design to address infrastructure vulnerability?

Sample Table Format (optional)

| **Design Component - Perched Culvert Backwatering** | **Design Life or Return Period** | **Design Criteria + (Units)** | **Design Value Without Climate Change** | **Change in Design Value from Future Climate** | **Design Value Including Climate Change** | **Comments / Notes / Deviations / Variances** |
|---|---|---|---|---|---|---|
| Tetayut Creek at Highway 17 | 100 year | Flow Rate ($m^3/s$) | 5.32 | +27% | 6.75 | Discharge estimates were based on the Rational Method, BC Streamflow Inventory, SCS Peak Flow method, and a Station Frequency Analysis from a gauge station that used to exist on Tetayut Creek (1993-2009). For small watersheds (~1km²) the Rational Method provides a good estimate due to its conservative nature, but considering there was a gauge station that previously existed on this reach of the Creek, the Station Frequency Analysis is considered the best estimate.<br>The 27% climate change factor of safety is based on the ratio of the future/existing 100 year rainfall intensity (mm/hr) at the calculated time of concentration to the hazard site |

## Responses to Screening Questions & Further Explanatory Notes / Discussion (as required):

*The purpose was to determine the expected $Q_{100}$ flow rate to model the impacts of two instream Newbury style riffles installed to backwater a perched culvert for the purpose of fish passage. It was determined that design flow rates could be impacted by climate change. The projected rainfall intensity increase was estimated using the IDF-cc tool (University of Western Ontario).*

Recommended by: Andrew Anderson (EIT) *(Print Name / Provide Seal, Signature & Date)*

Engineering Firm: BC Ministry of Transportation and Infrastructure (BCMoTI)

Accepted by BCMoTI Consultant Liaison: (For External Design): ______________________________

Deviations and Variances Approved by the Chief Engineer: ______________________________

(Program Contact: Dirk Nyland, Chief Engineer BCMoTI)

# APPENDIX F

[PERMITS]

# Tetayut Creek Section 11 Notification 2018

**From: Roden, Jacqueline FLNR:EX <Jacqueline.Roden@gov.bc.ca>**
**Date: Thu, Jun 21, 2018 at 10:40 AM**
**Subject: Response to Section 11 Notification ~ 1004217 - Tetayut Cr**
**To: "peninsulastreams@gmail.com" <peninsulastreams@gmail.com>, "iandouglasbruce@gmail.com" <iandouglasbruce@gmail.com>**

Habitat Officer Grant Bracher has reviewed your application and you may proceed with your proposed changes with the following conditions:

- Take appropriate erosion and sediment control measures;
- Have an Environmental Monitor onsite while doing instream work;
- Instream work is to be conducted in isolation of flowing water through the use of pumps and check dams;
- A fish collection permit will be required for fish salvage; and
- Complete work on or before September 15, 2018.

Notifications received by this office will be used to plan and carry out on-site inspections and monitoring during and after the works are completed.

This email provides direction under Section 11 of the Water Sustainability Act only, and does not constitute permission or consent under any other Act or Authority. It is your responsibility to consult with Fisheries and Oceans Canada (DFO) and the local government (municipality or regional district) to determine if there are any additional requirements for your proposed works.

Thank you,

*Jacqueline Roden*

Administrative Assistant
Phone (250) 751-7352
Forest Lands, Natural Resource Operations and Rural Development

# RE: Peninsula Streams - Tetayut Creek Section 11

**Hello Brian,**

**I extended the Notification to October 1, 2018. The same conditions apply. New Notifications are not required for an extension of a Notification.**

**Sincerely,**

**Grant**

***Grant Bracher, Ph.D., P.Ag., R.P.Bio.***
***Ecosystem Biologist***
***Ministry of Forests, Lands and Natural Resource Operations and Rural Development***
***2080 Labieux Road***
***Nanaimo BC V9T 6J9***
***Tel. 250 751-3221***
***Fax. 250 751-3103***
***Grant.Bracher@gov.bc.ca***

BRITISH COLUMBIA
Ministry of
Forests, Lands and
Natural Resource Operations

## FISH COLLECTION PERMIT
### Fish Salvage

File: 34770-20

Permit No.: NA18-354675

Permit Holder: Peninsula Streams Society – Ian Douglas Bruce
9860 West Saanich Road, North Saanich BC V8L 4B2

Authorized Persons: Brian Koval

Pursuant to section 19 of the *Wildlife Act*, RSBC 1996, Chap. 488, and section 18 of the Angling and Scientific Regulations, BC Reg. 125/90, the above named persons are hereby authorized to collect fish for scientific purposes from non-tidal waters subject to the conditions set forth in this Permit:

**Permitted Sampling Period: June 25, 2018 to September 15, 2018**

**Permitted Waterbodies: West Coast Region – Sandhill Creek (Tetayut Creek) (920-140700)**

**Permitted Sampling Techniques: Dip Netting and Electrofishing (subject to permit terms and conditions)**

**Potential Species: CCT (subject to permit terms and conditions)**

**Provincial Conditions: (Permit holders must be aware of all terms and conditions):**
See Appendix A.

**Region Specific Conditions:**
See Appendix A.

**Authorized by:**
**Mike Stalberg**
**Deputy Regional Manager**
**Recreational Fisheries & Wildlife Programs**
**West Coast Region**

Date: June 21, 2018 Permit Fee $25

**Any contravention or failure to comply with the terms and conditions of this permit is an offense under the *Wildlife Act*, RSBC 1996, Chap. 488 and B.C. Reg. 125/90.**

# Appendix A: Fish Collection Permit Conditions

*Any Variation of the following terms and conditions will require explicit authorization by the appropriate regional Fish & Wildlife Section Head.*

**Provincial Conditions**

1. This collecting permit is not valid
    - in national parks,
    - in provincial parks unless a Park Use Permit is also obtained,
    - in tidal waters,
    - for eulachon or for salmon* other than kokanee, or
    - for collecting fish by angling unless the permit holder and crew members possess a valid angling licence.

   This collecting permit is only valid for species listed as threatened, endangered or extirpated under the Species at Risk Act (SARA) **in conjunction with a permit issued under Section 73 of SARA from Fisheries and Oceans Canada.**

   *Contact the Department of Fisheries and Oceans for fish collecting permits for salmon, eulachon or SARA listed species (see Appendix B).

2. The permit holder (or the project supervisor) named on the application for a scientific collection permit will carry a copy of this permit while engaged in fish collecting and produce it upon request of a conservation officer, fisheries officer or constable.

3. Any specimens surplus to scientific requirements and any species not authorized for collection in this permit shall be immediately and carefully released at the point of capture.

4. Fish collected under authority of this permit shall not be used for food or any purpose other than the objectives set out in the approved application for a scientific collection permit. The permit holder shall not sell, barter, trade, or give away, or offer to sell, barter, trade or give away fish collected under authority of this permit. Dead fish shall be disposed of in a manner that will not constitute a health hazard, nuisance or a threat to wildlife.

5. No fish collected under authority of this permit shall be
    - transported alive unless authorized by this permit, or
    - transplanted unless separately authorized by the Federal/Provincial Fish Transplant Committee.

6. The permit holder shall, within 90 days of the expiry of this permit, submit a report of fish collection activities. Interim reports may also be required and shall be submitted as required by the permit issuer. All submissions must be filed electronically to: http://www.env.gov.bc.ca/fish_data_sub/index.html

   Reporting specifications, information and templates are available from this website and outline the mandatory information requirements. Prior notification of submission or questions regarding data report standards can be made to: fishdatasub@gov.bc.ca

7. This collecting permit is subject to cancellation at any time and shall be surrendered to a conservation officer on demand or to the issuer upon written notice of its cancellation.

8. This permit is valid only for the activities approved on the application form and in accordance with any restrictions set out therein.

9. This permit is valid only for trained, qualified staff named in the Application. The permit holder will comply with all Worker's Compensation Board requirements and other regulatory requirements. Permit holders are responsible for ensuring staff members listed on the permit are properly certified for specific sampling methods or activities (e.g. electroshocking).

10. Any workers not listed on the permit must be supervised by the permit holder or one of the additional persons as named on the permit.

# Appendix A: Fish Collection Permit Conditions Continued

11. All sampling equipment that has been previously used outside of B.C. must be cleaned of mud and dirt and disinfected with 100mg/L chlorine bleach before using in any water course to prevent the spread of fish pathogens (e.g. Whirling disease) and / or invasive plant species. Any washed off dirt or mud must be disposed of in a manner such that it cannot enter a watercourse untreated.

12. No electrofishing is to take place in waters below five degrees C.

13. No Sampling of Fish in waters over twenty degrees C.

14. Electrofishing may not be conducted in the vicinity of spawning gravel, redds, or spawning fish, or around gravels which are capable of supporting eggs or developing embryos of any species of salmonid at a time of year when such eggs or embryos may be present.

15. Angling must only occur in accordance with the regulations specified in the current BC Freshwater Fishing Regulations Synopsis.

**Region Specific Conditions**

**West Coast Region**

- Within the boundaries of Management Units 1-1 through 1-13, there shall be no electrofishing in: (1) streams above 630 meters elevation, (2) in anadromous rivers from January 1 to June 30, (3) or any lake tributaries from January 1 to June 30.
- All sampling gear follow Association of Professional Biologists' advisory practice bulletin #5. Practice Advisory – Didymo, see: http://a100.gov.bc.ca/pub/eirs/viewDocumentDetail.do?fromStatic=true&repository=BDP&documentId=9469
- The permit holder must advise the West Coast Region of sampling activities 24 hrs. prior to field operations. Please complete the following notification form: http://www.env.gov.bc.ca/pasb/reports/fish/permit_notify1.html

# Appendix B: Table 1 - Species at Risk

The following are species at risk that have been listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as either endangered, threatened or a species of special concern. Species also listed under the Species at Risk Act (SARA) are identified with an asterisk, and are subject to additional permitting requirements through the Federal Department of Fisheries and Oceans (DFO).

| Common Name | Scientific Name |
|---|---|
| Benthic Paxton Lake Stickleback | **Gasterosteus sp.* |
| Benthic Vananda Creek Stickleback | **Gasterosteus sp.* |
| Limnetic Paxton Lake Stickleback | **Gasterosteus sp.* |
| Limnetic Vananda Creek Stickleback | **Gasterosteus sp.* |
| Nooksack Dace | **Rhinichthys sp.* |
| Morrison Creek Lamprey | **Lampetra richardsoni* |
| Vancouver Lamprey (Cowichan Lake Lamprey) | **Lampetra macrostoma* |
| Cultus Pygmy Sculpin | **Cottus sp.* |
| Shorthead Sculpin | **Cottus confusus* |
| Hotwater Physa | **Physella wrighti* |
| Limnetic Enos Lake Stickleback | *Gasterosteus sp.* |
| Benthic Enos Lake Stickleback | *Gasterosteus sp.* |
| Salish Sucker | *Catostomus sp.* |
| Speckled Dace | *Rhinichthys osculus* |
| Charlotte Unarmoured Stickleback | *Gasterosteus aculeatus* |
| Columbia Mottled Sculpin | *Cottus bairdi hubbsi* |
| Giant Stickleback | *Gasterosteus sp.* |
| Green Sturgeon | *Acipenser medirostris* |
| Umatilla Dace | *Rhinichthys umatilla* |
| West Slope Cutthroat Trout | **Oncorhynchus clarki lewisi* |
| White Sturgeon | *Acipenser transmontanus* |

Applications for permits to specifically collect and retain listed species must be reviewed by the appropriate provincial expert, who will screen permits to ensure that any impacts on listed species are acceptable. For white sturgeon the contact is Steve McAdam (steve.mcadam@gov.bc.ca). For listed non-game freshwater fish the contact is Jordan Rosenfeld (jordan.rosenfeld@gov.bc.ca).

Fisheries and Oceans Canada
Pêches et Océans Canada

| | |
|---|---|
| Licence Number: | XHAB 68 2018 |
| Valid From: | 01-Jun-2018 |
| Expiry Date: | 31-Oct-2018 |

This licence and/or permit is issued under the authority of SECTION 52 OF THE FISHERY (GENERAL) REGULATIONS.

This licence and/or permit authorizes the person(s) listed below, subject to the following terms and conditions, to collect the species and quantity of fish identified below for: Scientific purposes. Non-compliance with any condition of this licence and/or permit may result in the cancellation of this licence and/or permit.

**Licence/Permit Activity Description:**

In 2018 the Tetayut Creek Pat Bay Highway Culvert Remediation Project aims to supply passage for fish passage past the culvert.

Before work begins the site will be isolated and water pumped around for the duration of the project. Fish will be salvaged from the site by electrofishing and dipnetting as water level decreases. Fish will be transported upstream from the site and released into upper Tetayut Creek as soon as possible. Once work is complete, flow will be returned to normal.

**Licence Holder:**

FIN: 139759
9860 WEST SAANICH ROAD
SAANICH BC V8L 5K5

PENINSULA STREAMS SOCIETY

Contact Number: 250-363-6596
Fax Number: 250-363-6470

**Contact Party:**

FIN: 39644 BRUCE, IAN DOUGLAS

Contact Number: 250-656-9414

**Individuals or groups assisting with the authorized activity:**

Members of Peninsula Streams Society and any indiviuals working under their direction

**Species, Quantity of Fish, Area(s) and Gear:**

| | |
|---|---|
| **Species:** | COHO SALMON (Oncorhynchus kisutch); CHUM SALMON (Oncorhynchus keta); |
| **Gear:** | Dip Net<br>Electroshocker |
| **Licence Area:** | PFMA 19-5; Tetayut Creek |
| **To be Retained:** | 0 |
| **Additional Descriptions:** | Non-retention of juvenile anadromous salmonids. |

**Reporting Requirements:**

**Electronic Report - DFO** **Due Date** 30-Nov-18

Please send Electronic Report to Andrew.Campbell@dfo-mpo.gc.ca on or before the specified due date. See terms and conditions for reporting requirements.

**Additional Information:**

The licence holder is responsible for notifying the local DFO office when and where sampling will occur. Prior to smolt fence and trap installation, please notify the DFO office of the installation, operation and removal schedule as well as the personell involved and licence number. See terms and conditions of this licence below for more information.

**Terms and Conditions:**

The DFO Office responsible for the area in which fishing shall take place, shall be notified on each occasion prior to fishing and collection of samples. Notification shall occur by telephone during normal business hours. If you are unable to notify the local office on evenings or weekends, advise the DFO Radio Room at 1-800-465-4336 prior to sampling. Port Hardy District (250) 949-6422, Fax 949-6755 Campbell River District (250) 850-5701, Fax 286-5854 Nanaimo District (250) 754-0230, Fax 754-0309 Victoria District (250) 363-3252, Fax 363-0191 Port Alberni District (250) 720-4440, Fax 724-2555

This licence authorizes collections to be made by the licensee and employees, volunteers and students of the licensee provided that all persons, other than minors who are engaged in activities under the authority of this licence, are carrying suitable photo identification to be produced upon request of a Fishery Officer or Guardian.

Copies of this licence must accompany the collecting personnel, be on board any collecting vessel and be carried with the transport vehicle at all times during collection and transport of samples. The licence must be produced upon the request of a Fishery Officer or Guardian.

It is the responsibility of the licence holder to ensure that samplers are experienced and competent in the fish collection methods authorized in this licence.

Electrofishing is not permitted in the vicinity of spawning salmon or redds. A trained and certified electrofisher operator must be a part of the electrofishing crew.

All gear left unattended must be clearly labelled with the Licence Number and must not interfere with the public right of navigation.

All live fish must be released unharmed into the water body or course from which they originated and as near as possible to the location from which they were sampled.

No sampling of non-anadromous fish species and steelhead is to be undertaken unless prior approval has been provided by the BC Ministry of Environment.

Section 32 (1) of the federal Species at Risk Act prohibits killing, harming, harassing, capturing or taking an individual of a wildlife species which is listed on Schedule 1 as an extirpated species, an endangered species or a threatened species. Refer to the SARA Public Registry at http://www.sararegistry.gc.ca to determine if species at risk may be in your research area and to apply for a permit if required.

This licence may be amended or revoked by the Department prior to the expiry date if deemed necessary.

An Electronic Collection and Sampling Report will be required by DFO at the end of the project in the excel spreadsheet provided to the licence holder by email at the issueance of this licence. See reporting details for report due date and email address to send the report to.

Licence Number: XHAB 68 2018
Valid From: 01-Jun-2018
Expiry Date: 31-Oct-2018

By signing on this document, the person(s) listed below, agree to be bound by the terms and conditions that pertain to each person as an individual and to the group as a whole.

**139759** Ian Bruce 1-Jun-18
FIN Licence Holder - Print Name Signature Date

Laura Brown MAY 04 2018
Issued by: Laura Brown, South Coast Area Director Date
Fisheries and Oceans Canada

Licence Printed: 27 April 2018
Licence Prepared By: Andrew Campbell

# APPENDIX G

[PROJECT PROPOSAL]

# ER 390

## FINAL PROJECT OUTLINE

# TETAYUT (SANDHILL) CREEK RESTORATION: REMOVING BARRIERS TO FISH PASSAGE AT THE PAT BAY HIGHWAY

**Prepared by:** Andrew Anderson, EIT, A.Ag.

**Prepared for:** Val Schaefer, Ph.D., R.P.Bio.
Academic Administrator, Restoration of Natural Systems
University of Victoria

**Submitted on**: September 30th, 2018

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# 1.0 BACKGROUND

Tetayut Creek (formerly known as Sandhill Creek) runs through the Saanich Peninsula of Vancouver Island, BC (Figure 1). The Saanich Peninsula is known for its Mediterranean climate and long growing season unique to the Coastal Douglas-fir moist maritime (CDFmm) biogeoclimatic (BEC) zone. Nuszdorfer et al. (1991) describes the CDFmm as a temperate zone with a mean annual temperature of 9.9°C and mean annual precipitation of 1000 mm, most of which falls as rain. Today, the majority of the Peninsula has been altered from its original forested landscape into urban and agricultural space due to the high livability and productivity of the region. Major consequences associated with the loss of forests are the alteration of natural drainage systems, impacting water quality and stream length, both of which are crucial to the success of native salmonids[1].

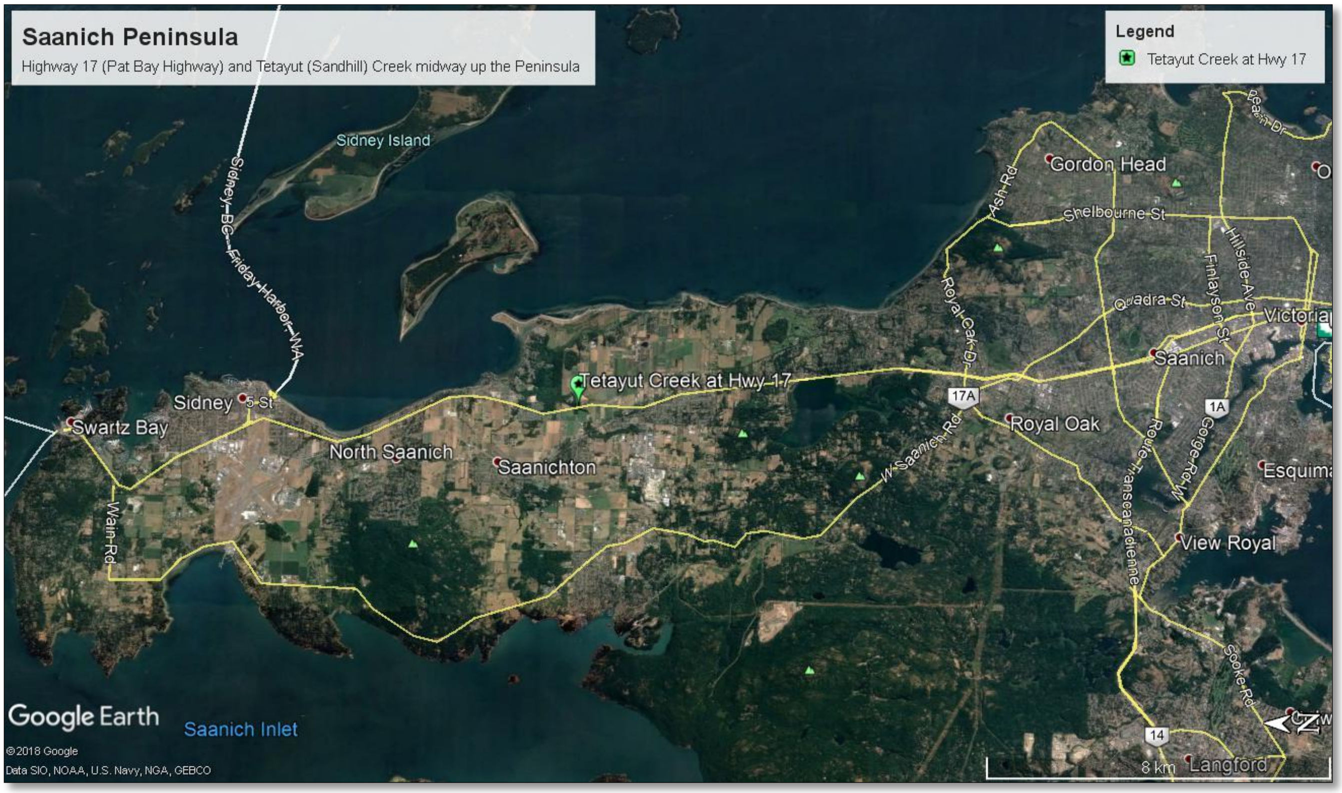

**Figure 1: Saanich Peninsula (Google Earth, 2018)**

In 1978 the construction of the Patricia (Pat) Bay Highway (Highway 17) by British Columbia's Ministry of Transportation and Infrastructure (MOTI) required the installation of a 54 m long, 1.5 m diameter round concrete culvert at Tetayut Creek (the Creek). This forced the Creek underground approximately 2.2 km upstream of where it flows into the Juan de Fuca Straight. Though the details of the culvert entrance and exit at installation are unknown, local farmers have described salmon carcasses in Tetayut Creek upstream of the Pat Bay highway crossing as recent as the early 2000's (Bruce, 2018). This demonstrates salmonid use of the Creek and full passage through the concrete culvert under fall and winter spawning flows.

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[1] Fish from the Salmonidae family (including salmon or trout) that have the last three vertebrae upturned (Merriam-Webster, 2018)

Over the years, the influence of climate change on increasing storm event intensity combined with increased urbanization has resulted in greater discharge in Tetayut Creek following precipitation events. As the runoff passes through the smooth concrete culvert under the Pat Bay highway, the flow increases in velocity until it reaches the culvert outlet where scour is actively undermining the outlet and forming a large pool. This has resulted in a perched culvert 38 cm above the nearest downstream thalweg[2] elevation (control elevation), causing a major barrier to fish migration in the Creek.

## 2.0 APPROVAL

The restoration of Tetayut Creek was approved by my employer, the BC Ministry of Transportation and Infrastructure who have provided funding for the instream works at the Pat Bay highway crossing.

## 3.0 CO-OPERATORS

The following organizations are stakeholders in the Tetayut Creek stream restoration:

- BC Ministry of Transportation and Infrastructure (MOTI): Owners of the perched culvert.
- Saanich Historical Artifacts Society (SHAS): Landowners where the restoration activities will occur.
- Peninsula Streams Society (PSS): Coordinates stream restoration and habitat conservation on the Saanich Peninsula.

## 4.0 OBJECTIVES

The following objectives were established to support fish passage at Tetayut Creek under Highway 17:

- Identify length of useable, connected aquatic habitat upstream of Highway 17.
- Identify fish species in Tetayut Creek.
- Survey the stream channel and identify restoration options.
- Restore fish passage to Tetayut Creek.
- Reintroduce native salmonids (if necessary) and monitor recruitment to the Creek annually.

## 5.0 SCOPE

This project will focus on instream works to restore fish passage upstream of the 54 m long culvert in Tetayut Creek under Highway 17. A full culvert replacement is not feasible as it is too costly and would result in serious traffic delays on the Pat Bay highway.

Invasive species management is outside the scope of this project despite the high density of invasive english ivy (*Hedera helix*) in the riparian zone. Additionally, any barriers to fish passage downstream of the SHAS-owned land will not be restored.

## 6.0 METHODOLOGY AND SCHEDULE

This project has seven (7) tasks described in Table 1. They can be summarized by the following:

- Stakeholder contact and permissions will be obtained prior to restoration planning.

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[2] When looking at the cross-section of a stream, it is the lowest elevation in the channel

- Field investigation includes a field assessment using the BC Ministry of Environment's protocol for monitoring the effectiveness of fish passage through closed bottom structures (2011) and collecting a detailed survey of the existing stream and culvert.
- Design the appropriate restoration prescription.
- Drafting both the raw field data as well as the final design.
- Construction management includes all the pre- and post-construction work including:
    - Acquiring the appropriate permitting for instream works and fish salvage
    - Coordinating contractors and materials
    - Pumping bypass flows, coordinating excavators, and conducting fish salvage
- Monitoring fish species based on the fish salvage results and historical records.

**Table 1: Tasks and their Associated Schedule**

| Task | 2018 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | January | February | March | April | May | June | July | August | September | October | + |
| Contact Stakeholders | 🟦 | 🟦 | 🟦 | | | | | | | | |
| Field Investigation | | | | 🟨 | | | | | | | |
| Survey | | | | 🟩 | | | | | | | |
| Drafting | | | | 🟪 | 🟪 | | | | | | |
| Design | | | | | 🟥 | 🟥 | | | | | |
| Construction Management | | | | | | | | | 🟥 | | |
| Monitoring | | | | | | | | | | ▨ | ▨ |

## 7.0 BUDGET

The total cost is approximately $19,000 and can be divided into seven (7) categories as shown in Table 2.

**Table 2: Cost Estimate**

| Task | Unit | Unit Cost | Cost |
|---|---|---|---|
| Site Prep (hours) | 3 | $ 60.00 | $ 180.00 |
| Excavator (hours) | 32 | $ 150.00 | $ 4,800.00 |
| Rock Truck (hours) | 5 | $ 500.00 | $ 2,500.00 |
| Rock ($m^3$) | 40 | $ 50.00 | $ 2,000.00 |
| [1]Equipment (N/A) | 1 | $ 1,000.00 | $ 1,000.00 |
| Labour (hours) | 96 | $ 70.00 | $ 6,720.00 |
| Contingency (10%) | 1 | $ 1,720.00 | $ 1,720.00 |
| | | **Total** | **$ 18,920.00** |

[1] Equipment costs include pumps, lay-flat hose, fuel, buckets, nets, electro-fishing gear, and shovels.

## 8.0 DELIVERABLES

A final report summarizing the entire procedure will be prepared as the main deliverable.

## 9.0 ER 400

This project will be presented to SHAS upon completion.